Coastal Erosion Information

Inventory and recommendations for state of environment monitoring

Taranaki Regional Council
Private Bag 713
STRATFORD

November 2009

Document #597335
#668749 (Appendix II)
#668760 (Appendix III)

Executive Summary

The Taranaki coast is an eroding one. Coastal erosion studies undertaken in the late 1980s by the Taranaki Catchment Commission showed that the entire Taranaki coastline is eroding at long term average rates between 0.05 m/year and 1.89 m/year with exceptions at the Patea and Stony (Hangatahua) river mouths where the coast was accreting. Erosion rates differ at different locations, primarily due to differences around the coast in geology, coastal orientation, proximity to river mouths and matters such as dune management.

Recalculating erosion rates has occurred at specific locations around the coast through monitoring programmes, or for applications for subdivisions or for coastal activities such as pipelines or coastal protection structures. However, there has not been a comprehensive reassessment of regional erosion rates since the late 1980s work.

The purpose of this report is to summarise the information on coastal erosion rates for the Taranaki coast that is already available from monitoring, surveying, aerial photographs and maps and to identify where further information gathering should be focused.

The report identifies reaches of coast where better understanding coastal erosion rates is important for management perspectives. The following reaches have been selected on the basis of level of existing or future use and development; the existence of baseline information from which to monitor changes; opportunities for partnerships with businesses or where the reach is representative of a longer stretch of coast:

- Mokau to Pariokariwa - Tongaporutu (~2.5 km), Whitecliffs (~2 km) and Te Kuwhatahi Stream (~3 km)
- Pariokariwa to Turangi Road - Urenui and NE cliffs (~3 km), Onaero (~2 km), Wai-iti (1-2 km) and Mimi (~2 km)
- Turangi Road to Port – Waitara to Port (~12 km) and Motunui (1-2 km)
- Port to Stony – Paritutu (~2 km) and Oakura to Pitone Rd
- Stony to Cape Egmont - Stony River (~2.5 km) and Cape Egmont to Puniho Road (~10 km)
- Cape Egmont to Opunake - Opunake (1-2 km), Tai Road Subdivision (1-2 km) and Arawata Road (1-2 km)
- South of Opunake to Inaha - Kaupokonui (1-2 km)
- Inaha Stream to above Patea – Inaha (1-2 km), Ohawe beach (~2 km) and Fonterra outfall
- Patea to Waitotara - Caves Beach (1-2 km), Waverley, Waiinu Beach, Patea river mouth (1-2 km) and Waipipi Subdivision.

Recommendations for each priority reach are made according to whether there is the opportunity to build on existing information or if a baseline of information needs to be established. The resulting recommendations essentially then form the basis for the development of a regional state of environment monitoring programme for coastal processes (erosion and accretion) that builds on existing information, and focuses on monitoring sites where there are significant assets or likely pressure for development.

The report made use of a coastal information inventory developed by the Council in partnership with the Department of Conservation in 2004 and built on that inventory through tracking down other reports and information. The intention, as it is with the coastal information inventory, is to ultimately make all information on coastal erosion processes available to the community, consultants, stakeholders through publically accessible web based databases.

The report has been prepared through a collaborative approach by the Taranaki Regional Council, New Plymouth District Council and South Taranaki District Council. The report was peer reviewed, and assistance provided in developing the recommendations, by Rick Liefting of Tonkin Taylor, whose expertise and valuable assistance is acknowledged.

It is important to note the following **disclaimer**:

This report summarises existing information on coastal erosion around the coast, derived from a review of the files and literature. No attempt has been made to verify the accuracy of the data presented, or the assumptions the data was based on. It is prepared as a **guide** to the **available information** in good faith with a desire to inform and be helpful in planning where future monitoring should be undertaken. It is NOT to be relied on as constituting definitive coastal erosion data for purposes other than what it is intended for.

Table of Contents

1 INTRODUCTION 7

1.1 Purpose of the report 7

1.2 Structure of the report 7

2 BACKGROUND 8

2.1 Planning provisions 8

2.2 What is coastal erosion and accretion? 9

2.3 Overview of features of the Taranaki coast 10
- a. Geology 10
- b. Taranaki sediment sources 10
- c. Wave environment 11
- d. Sediment movement 11
- e. Taranaki wind environment 12
- f. Cliff erosion 12

2.4 Coastal erosion in light of climate change 13

2.5 Coastal protection structures in Taranaki 14

2.6 Overview of coastal erosion information for the Taranaki region 15

2.7 Options for future information gathering 17

3 COASTAL EROSION INFORMATION FOR THE REGION BY COASTAL UNIT 19

3.1 Mokau River to Pariokariwa Point 19
- a. Description of the area 20
- b. Assets, pressures and coastal protection 20
- c. Existing estimations of coastal erosion 21
- d. Recommendations for further information gathering 22

3.2 Pariokariwa Point to Waiau Stream (Buchan's Bay) 23
- a. Description of the area 23
- b. Assets, pressures and coastal protection 24
- c. Existing estimations of coastal erosion 26
- d. Recommendations for further information gathering 29

3.3 Waiau Stream to the Port – i.e. Waitara, Bell Block, airport and New Plymouth foreshore 30
- a. Description of the area 30
- b. Assets, pressures and coastal protection 31
- c. Existing estimations of coastal erosion 34
- d. Recommendations for further information gathering 39

3.4 Port to Stony River – including Oakura 41
- a. Description of the area 41

b. Assets, pressures and coastal protection 42
c. Existing estimations of coastal erosion 43
d. Recommendations for further information gathering 46

3.5 Stony River to Cape Egmont 47
a. Description of the area 48
b. Assets, pressures and coastal protection 48
c. Existing estimations of coastal erosion 49
d. Recommendations for further information gathering 49

3.6 Cape Egmont to Mangahume Stream (south-east of Opunake) 51
a. Description of the area 52
b. Assets, pressures and coastal protection 52
c. Existing estimations of coastal erosion 53
d. Recommendations for further information gathering 53

3.7 Mangahume Stream (South-east of Opunake) to Inaha Stream 55
a. Description of the area 55
b. Assets, pressures and coastal protection 55
c. Existing estimations of coastal erosion 56
d. Recommendations for further information gathering 56

3.8 Inaha Stream to just above Patea 57
a. Description of the area 57
b. Assets, pressures and coastal protection 58
c. Existing estimations of coastal erosion 58
d. Recommendations for further information gathering 61

3.9 Patea to Waitotara 62
a. Description of the area 62
b. Assets, pressures and coastal protection 63
c. Existing estimations of coastal erosion 63
d. Recommendations for further information gathering 64

4 SUMMARY OF RECOMMENDATIONS 66

5 REFERENCES 69

6 APPENDICES 73

6.1 Appendix I: Taranaki erosion assessment sites Gibb(1978) 73

6.2 Appendix II: Taranaki Coastal Series Maps (TCC, 1987) 75

6.3 Appendix II: Taranaki Coastal Resources, Aerial Plans, 1987 77

1 Introduction

1.1 Purpose of the report

The purpose of this report is to summarise the information on erosion rates for the Taranaki coast that is already available and to identify where further information gathering should be focused.

1.2 Structure of the report

Section 1 of the report sets out the purpose and structure.

Section 2 provides background information on the relevant planning provisions, and nature of the geology, sediment movement, wave environment etc of the Taranaki region including a brief discussion on climate change and its implications for coastal erosion rate monitoring. It summarises information available for the whole coast. The different methods available for either building on existing information or establishing baseline information for specific sites are then discussed.

Section 3 then examines available information for each of nine coastal units. The coastal units have been derived on the basis of geology, wave environment, nature of coastal erosion and to coordinate with district council boundaries:

- Mokau to Pariokariwa Point
- Pariokariwa Point to Waiau Stream
- Waiau Stream to the Port
- Port to Stony (Hangatahua) River
- Stony River to Cape Egmont
- Cape Egmont to Opunake
- Opunake to Inaha Stream
- Inaha Stream to Patea
- Patea to Waitotara.

New Plymouth seawall foreshore

For each coastal unit, the report provides a map of the area, a description of the area's geology, and an overview of assets, pressures and existing coastal protection works. Existing information on coastal erosion is then summarised from published reports, monitoring, surveying, aerial photographs and maps.

Within each coastal unit, priority areas for further information gathering are then identified. These reaches are selected on the basis of current and future development pressures, existing information, the ability to extrapolate from the reach to the whole coastal unit and opportunities for developing partnerships with businesses that may also have an interest in obtaining good monitoring information of coastal erosion rates. Methods described in section 2 are then recommended for particular stretches of coast within each coastal unit.

2 Background

2.1 Planning provisions

The Resource Management Act 1991 tasks regional councils with the function of controlling the use, development or protection of land in the coastal marine area, including the avoidance or mitigation of natural hazards (s30(1)(d)(v)). Territorial authorities have the function of controlling any actual or potential effects from the use, development or protection of land for the purpose of the avoidance or mitigation of natural hazards (s31(1)(b)(i)).

The *Regional Policy Statement for Taranaki, 2009 (*'RPS') includes objectives and policies relating to reducing the risks to the community from natural hazards in issue 10. The objective aims '*To avoid or mitigate natural hazards within the Taranaki region by minimising the net costs or risks of natural hazards to people, property and the environment of the region.'*

The policies include improving community awareness, responsibility and planning for the avoidance and mitigation of natural hazards (policy NH1) and locating new subdivision, use and development so that the need for hazard protection works is avoided (policy NH2). The RPS stresses the role of natural features to avoid or mitigate natural hazards (policy NH3) and sets out criteria for assessing the appropriateness of works and activities to modify natural hazard processes (policy NH4). Method 6 states that the Council will develop and maintain hazard information including coastal hazards in partnership with territorial authorities.

The *Regional Coastal Plan for Taranaki* (the RCP) identifies the risks of coastal erosion in issue seven, particularly for Oakura, New Plymouth urban area, Bell Block, Waitara River mouth, Onaero and Urenui Beach because of the proximity of these urban areas to eroding coastlines. The objectives in the Plan are:

OBJ 7(a) To reduce the susceptibility of people, property and the coastal environment of Taranaki to loss or damage by coastal erosion or flooding.

OBJ 7(b) To avoid as far as practicable, the need for natural hazard protection works in the coastal marine area and to avoid, remedy or mitigate adverse effects on the environment that result from implementation of natural hazard protection works.

The RCP notes that the Council will monitor the coastal marine area and the effectiveness of the plan through a number of methods, including 'consideration of the results of methods used in conjunction with territorial authorities to monitor coastal erosion'.

Coastal erosion near Tongaporutu at Te Kuwhatahi.

Policy 7.1 allows for coastal protection works, but only in relation to existing use where the positive effects outweigh the adverse effects. It lists a number of matters that will be considered in making decisions on protection structures. These include the probability of the works succeeding, the public benefit in enabling the regional community to provide for its economic wellbeing, health and safety, the significance of the asset to be protected, the effects on the environment, measures previously undertaken to avoid the need for such works and alternatives.

Policy 7.4 requires consideration of the ability of natural features and systems to provide a natural defence to erosion.

2.2 What is coastal erosion and accretion?

Coastal erosion is defined as 'the process of episodic removal of material at the shoreline leading to a loss of land as the shoreline retreats landward'. The processes involved in coastal erosion include not only the work of the sea, but also that of the wind, migrating river mouths and tidal inlets, coastal landslides and tectonics (Gibb, 1994).

The high energy marine environment means that much of the North Taranaki coast experiences long-term erosion trends. However, the rates of erosion along the coast are not constant, and are influenced by factors such as the continental shelf width, coastal aspect and local geology.

Other drivers of coastal erosion also include:
- Relative sea-level rise;
- Long-term sea-level fluctuations;
- The frequency and magnitude of storm surges;
- Tide range;
- Storminess and wave and/or swell conditions;
- Rainfall patterns and intensity, and their influence on fluvial and cliff sediment supply; and
- Geomorphology and geological make up of the coast.

The rate of erosion of sea cliffs in particular, depends on the following factors (Lumsden, 1995):
- Available wave energy producing both impact and abrasion (this can be altered by refraction and diffraction of waves from reefs and off-shore bathymetry);
- The presence of absence of a protective beach at the base of the cliffs and type of material forming the beach;
- The lithology of the sea cliffs and their resistance to erosion;
- Geologic structure, including jointing, folding and faulting;
- The heights and slope of the sea cliff;
- Human activities and surface drainage;
- Seismic activity;
- Groundwater flows; and
- Meterological conditions.

Coastal accretion is defined as 'the product of deposition of material at the shoreline, leading to a gain of land as the shoreline advances seaward' (Gibb 1994). Static shorelines are defined as those where the net erosion rate is less than 0.02 m/year over approximately the last one hundred years.

Coastal accretion has been a feature of some areas of the Taranaki coast for many years, such as at the mouth of the Stony (Hangatahua) River.

2.3 Overview of features of the Taranaki coast

a. Geology

The Taranaki coast has two clearly distinctive types of geology. The first is that dominated by the influence of Mount Taranaki (the 'lahar' coast) stretching from Buchan's Bay, just west of Onaero) to Inaha Stream near Hawera). The second dominant geology occurs in north Taranaki and south of Inaha, and is more strongly influenced by the erosion of Tertiary derived marine sediments, and generally referred to as the 'papa' coast.

The lahar coast is influenced by Mount Taranaki and its associated deposits which form the 'ring plain'. The uplift of the ring plain in conjunction with erosion associated with variations in sea level has resulted in a cliffed coastline (ranging from 2 m to 30 m) with varying rates of erosion, occasionally broken by river mouths. Sand beaches and sand dunes are associated with these river mouths, however the dunes are narrow in extent. Another feature of this coast is the boulder reefs that have been created through erosion of the lahar materials. These reefs can be considerable in extent. For example, Turangi reef at Waitara extends as a subtidal boulder field some 5 km or more offshore.

Although the shoreline of the lahar coast ends at Turangi Road, it is also important to note that the offshore apron of volcanic derived debris extends as a boulder field out to approximately the 20 m depth contour line, and this continues as far as Urenui.

Erosion of the 'papa' coast (in the north, and in the south) has resulted in an almost continuously cliffed coastline. Cliff heights range from 15-30 m (with the exception of the Whitecliffs). Erosion rates tend to be higher than on the lahar coast. Sand beaches occur at the base of these cliffs and reefs are rare. Even where reefs are present they are not extensive and do not exert a major influence on nearshore water movements. The cliffs of the papa coasts are broken by a number of rivers.

b. Taranaki sediment sources

Erosion in the Pyramid Stream above the Stony (Hangatahua) River.

Inputs to the Taranaki sediment budget are dominated by erosion of Mount Taranaki. The ring plain rivers and streams deliver sediment to the coast. Recent erosion events of the upper catchments of a number of rivers on the upper slopes of the mountain have added substantial sediment to the coastal system (e.g. the Stony River).

Rivers draining 'papa' catchments in the north and south deliver only suspended sediments to the coast, i.e. they do not contribute to the sediment budget. Similarly mass erosion of the papa mudstone cliffs does not significantly contribute to the sediment budget as it rapidly breaks down to muds and silts which are easily transported as suspended load offshore and alongshore.

c. Wave environment

The Taranaki wave climate has been described in detail by Ewans and Kibblewhite (1992), McComb (2001), Croskey (2007) and Cowie (2009). The wave conditions have also been described in numerous other consultancy reports relating to beach erosion, offshore facilities designs, port developments and projects such as the Opunake surfing reef.
Waves approach the Taranaki coast from three main sources:

1. Far field swells originating in the Southern Ocean. These are typically long period waves (10-16 s) and regularly produce significant wave heights exceeding 6 m. They approach Taranaki from the southwest.
2. Locally-generated seas. These waves are produced by local wind effects, and vary around the Taranaki Headland. For example, the summer southwesterly seabreeze that accelerates between Oakaura and Waitara can generate 1-2 m sea state. In South Taranaki, strong southerly and southeasterly winds frequently build an energetic sea state. Typically, these waves have short periods (3-7 s).
3. Tasman Sea storms. Low pressure systems and frontal systems in the Tasman Sea can generate waves that approach the Taranaki coast from a wide range of directions (i.e. north to southwest).

The dominant wave energy source is the far field swells and wind seas from the westerly quarter. The Taranaki wave climate is often described as being energetic in a regional sense, exhibiting a distinct seasonal modulation in wave heights (i.e. higher in the winter months) but can receive large storm activity at any time of the year.

There is a well defined gradient in the mean wave energy around the Taranaki Headland, and this is due to the combined effects of topographical sheltering, refraction shadowing and frictional attenuation. The highest energy region is near to the Cape, which is the most exposed location and the average seabed slope is the steepest (i.e. deep water is closest to the shore). Wave energy decreases to the south towards Opunake, and from Opunake to Ohawe there is increasing shelter from the deep ocean swells from the Southern Ocean. However, this coast is exposed to the southerly seas from the Greater Cook Strait region. North of the Cape, the mean wave heights gradually decrease towards Waitara. Much of this decrease is because the incoming swell waves are approaching oblique to the coastline. As the waves refract (or bend) toward the shore, there is a shadow zone created for the coastline further to the northeast. Beyond Waitara, much of the sheltering is simply topographic. The sheltering effects of the Taranaki Headland extend as far north as Tongapourutu.

d. Sediment movement

When waves approach a coastline at an oblique angle, a long-shore current is established flowing parallel to the coastline in the nearshore zone. This current is significant in that it is responsible for net transport of sand or other beach material along the coast.

Sediment supply to North Taranaki beaches is described by Gibb (1996). He discusses the northeast longshore drift of sand from both coastal erosion processes and rivers draining the mountain. The predominance of swell and wind waves from the west and southwest creates a predominant longshore drift to the north, north of Cape Egmont. Sediments derived from Mount Taranaki can be found on Ninety Mile Beach at the top of the North Island.

The Port interrupts this flow of sediment by trapping between 128,000 m^3 and 173,000 m^3 of sand per anum since 1889 (Gibbs 1996). It has been estimated the longshore sediment transport potential along beaches such as Fitzroy and East End to be in the order of 110,000-160,000 m^3/year, of which only 40,000 m^3/year is being satisfied by sand bypassing the harbour (Hicks and Gibb 1980 cited in Tonkin and Taylor, 2001). Gibbs (1996) attributed the fact that the adjacent coastlines are eroding at river mouths to indicate that the Waiwhakaiho, Waiongana and Waitara rivers are contributing insignificant supplies to nourish the North Taranaki beaches. More recent erosion event in the headwaters of these catchments, particularly the Waiwhakaiho may alter this.

In South Taranaki beach sand is also derived from ironsand originating from Mount Taranaki. Beach sand moves constantly in a southeasterly direction within the breaker zone in this longshore drift process (Rush, 2006). This means that structures or headlands perpendicular to the drift of the sand interrupt its flow, allowing sand to build up on one side of the barrier but be eroded from the other side.

A study by the Taranaki Catchment Commission in 1982 concluded that erosion of Taranaki beaches occurs mainly during the winter. It was concluded that although some autumn and spring storms occur, most damage occurs between May and August. It was noted that different beaches were found to act differently under similar storm conditions and attributed this to local geographic and possibly bathymetric factors. It was also noted that the presence of high cliff headlands affected the littoral processes influencing the erosion or deposition of sand.

e. Taranaki wind environment

Taranaki and New Zealand are dominated by weather system approaching from the west. This means that Taranaki experiences a lot of westerly weather with strong onshore, erosional winds from the west, southwest and northwest.

The dominant annual wind directions are southeast and west (windrose on page 43 of Pohokura AEE). Southeast winds are the most common (about 25% of the time) and westerly winds are also frequent (about 20%). On average the southeasterly winds are not as strong as the westerly winds, and are more common in autumn/winter with westerlies more common in spring/summer. The strongest winds generally occur in spring (Pohokura AEE Vol 3).

f. Cliff erosion

Sedimentary rocks in cliffs in the 'papa' areas of north and south Taranaki are relatively young geologically speaking, so are soft, unconsolidated and easily eroded. Cliffs with waves lapping at the base at high tide are vulnerable to episodic erosion events with the steep faces falling away catastrophically. Compounding this process is groundwater seepage through the cliffs which intensifies after heavy rain. When the top layers are saturated, they are extremely sensitive to collapse. The fallen cliff material is dumped at the back of the beach, forming temporary relieve from further cliff erosion, until being eventually redistributed by wave action (Rush, 2006).

2.4 Coastal erosion in light of climate change

Drivers of coastal erosion such as relative sea-level rise, long term sea-level fluctuations, the frequency and magnitude of storm surges, rainfall patters and their influence on sediment supply are all likely to be influenced by climate change (MfE, 2008).

Different types of cliff/beach will respond differently to climate change. For example, the effects of climate change on cliffs will be highly dependent on how resistant their geology is to erosion. Erosion of cliffs composed of sedimentary materials will continue at similar or slightly higher rates, rates of undermining are unlikely to increase markedly. The rate of erosion of sedimentary cliffs will be much more sensitive to changes in weather – drying and heavy rainfall.

The 'drivers ' of coastal change that are expected to be influenced by climate change are (R.Bell, T.Hume, 2002):

- Winds (extreme storms and prevailing windiness);
- Waves (extreme storms and prevailing wave climate);
- Sea-level variability (season, interannual ENSO and interdecadal IPO cycles);
- River flow (extreme storms and base flows);
- Storms and cyclones (incidence, intensity, tracks, storm surge);
- Ocean and coastal currents; and
- Sediment supply to the coast.

Climate change impacts are likely to exacerbate coastal erosion but the influences will be more complex involving inter-connections between relative sea-level rise, long term sea-level fluctuations, the frequency and magnitude of storm surges, storminess and wave conditions and rainfall patterns and their influence on river and cliff sediment supply (Bell et al, 2008).

Coastal response to climate change will be a complex mix of these drivers. The most complex impacts of climate change will be on sediment supply to the coastline – with heavier rainfall during storms leading to more sediment down rivers. This is particularly relevant in Taranaki with the likely increase in rainfall, along with increased rainfall intensities during severe rainstorms. MfE (2008) notes that where changes in sediment delivery to the coast are an important consideration, sediment delivery from river systems will need to be determined based on detailed specific investigations and an assessment of how sediment volumes may change under future rainfall protections carried out.

Global mean sea levels have risen by an average of 1.8 mm per year over the period 1961-2003 and by 1.7 mm per year over the entire 20th century (MfE, 2008). For planning and decision timeframes out to the 2090's the following has been recommended (MfE,2008):

1. a base value sea-level rise of 0.50 m relative to the 1980-1999 average, along with
2. an assessment of the potential consequences from a range of possible higher sea-level rises (particularly where impacts are likely to have high consequence or where additional future adaption options are limited). At the very least, all assessment should consider the consequences of a mean sea-level rise of at least 0.8 m relative to the 1980-1990 average.

NIWA has advised NPDC (Bell et al, 2008) that climate change, and in particular increased sea-levels, will tend to lead to a reduction in the standard of protection provided by existing structures due to a variety of reasons, including frequency of overtopping, exposure to greater depths at the structure, greater wave reflection from defence structures and increased scour of the beach at the toe and steepening of the foreshore. They note that climate change impacts on coastal erosion are too complex to predict, but there is likely to be exacerbated erosion in some locations – particularly along the papa coast where increased sea-levels will result in higher water levels at the toe of cliffs.

2.5 Coastal protection works in Taranaki

Protection works in the open coast area are a response to the erosive nature of the coastline and are undertaken to protect developments that have historically occurred in the coastal environment.

Construction of rock boulder sea walls along the back of the beach is a commonly used coastal protection structure in Taranaki. In total permits for 104 coastal protection structures have been issued by the Council. Sixty four consents have been issued for protection structures along the open coast at Urenui, Middleton Bay, Oakura, New Plymouth near Kawaroa Park, Bayly Road, Bell Block and Waihi Beach. Some consents issued have been for existing structures and others for renewals. In the estuary zones, consents for coastal protection structures have been issued for the Waitara, Urenui, Oakura and Patea rivers and the Te Henui Stream. In areas of outstanding value, 22 consents have been issued for coastal erosion protection purposes in the Mohakatino and Tongaporutu estuaries and on Waiiti Beach (protecting a private campground).

There is an estimated 11.6 km of seawall protection structures which equates to 4% of the 295 km Taranaki coastline. About 2 km of these have been consented over the last five years. A number of coastal protection structures are subject to consent monitoring programmes. Historically, erosion protection structures have been established in areas where development has occurred close to the eroding coast.

Rock rip rap protection in front of the Oakura Surf Life Saving Clubrooms.

Of the 104 current protection works structures on the Council's database, twenty eight of these are owned by district councils or the regional council. These are protecting public assets. Eight protection works are owned by companies e.g. Fonterra, Vector, Transrail to protect infrastructure assets. Sixty eight protection structures are owned by private individuals for the purpose of protecting private property.

The coastal protection structures along the New Plymouth foreshore have been noted as contributing to the erosion process down the coast by changing wave access to the foreshore cliffs and banks, thus limiting the supply of sediment available to the beach and foreshore system (OCEL, 1994).

Other types of coastal protection works include renourishment of beaches, groynes and offshore wave barriers, as well as dune management and stormwater management. These are discussed in OCEL (1994) and McComb et al, (2005).

2.6 Overview of coastal erosion information for the Taranaki region

The first comprehensive review of coastal erosion rates for the region appears to have been undertaken by Gibb in 1978. Data from this research is set out in Appendix I. The Taranaki Catchment Commission built on this information through analysis of aerial photos in 1987. This produced two reports and a set of coastal erosion maps (included in Appendix II) and aerial plans with rates of erosion (Appendix III).

Since then little comprehensive work on erosion rates has been undertaken, aside from specific pieces of work for developments (e.g. for Kupe or Pohokura pipelines), for subdivisions (although many subdivision consents have relied on the work undertaken in the 1980s) and monitoring for asset protection (e.g. work undertaken for the gas pipeline, for the New Plymouth airport).

Beach profiles were established by the Taranaki Catchment Commission in the 1980s, but unfortunately the benchmark information of where these profiles commenced has been lost (Tararanaki Catchment Commission, 1982). Subsequently, a few beach profiles have been established for compliance monitoring of structures which in addition, may provide valuable information on regional erosion rates, and some beach profiles have been recently established for long term monitoring. These are discussed for each of the relevant coastal units.

Historic aerial photos exist for some areas of the coast. For example, NZ Aerial Mapping have historic aerial photographs of Oākura from 1943 to the present at around decadal time scales, where there are also oblique photos from Whites Aviation taken in 1949, 1958, 1984 and 1975. Requesting searches of the NZAM historic photo database would be required for undertaking the recommendations set out in this report for specific stretches of coast according to the method recommended. The Council holds a number of aerial photo mosaics compiled by NZ Aerial Mapping Ltd for Lands and Survey. These are set out in Table 1.

Table 1: Council held aerial photo mosaics

Year of aerials	Reference	Map title
1950	NZMS 3 Sheet N108/5	Paritutu
1950	NZMS 3 Sheet N108/8	Okato
1950	NZMS 3 Sheet N108/6	Omata
1951	NZMS N129/9	Kakaramea
1951	NZMS N129/5	Hawera
1951	NZMS N129/4	Ohawe
1956	NZMS N128/3	Puketapu Rd – Kaupokonui St
1962	NZMS N137/5	Marahau (Waiinu beach)
1962	NZMS N136/3	Patea
1962	NZMS N137/3	Durie (Waverley Beach)
1971	NZMS N118/8	Opunake
1971	NZMS N118/5	Rahotu
1971	NZMS N118/2	Pungarehu

Puke Ariki holds historic photos of the coast. For those stretches of the coast where this report recommends establishing a baseline of erosion rates using all historic information (method 3 below) investigating the historic cadastral maps held by Puke Ariki will be necessary.

An example of early cadastral survey maps held by Puke Ariki.

Pat Greenfield, a photographer in North Taranaki has undertaken a long term study of erosion rates through cataloging the changing cliff face through photography[1]. In 2003, Pat photographed Te Kawau Pa, north of Rapanui, and photographed in sequence, the entire coastline from Rapanui all the way south to Whitecliffs, a trek of approximately 11km. This took six months to complete, but these images now stand as a template against which all future events can be compared, and are held by Puke Ariki, available for future research.

Aerial photos taken in the mid 1990s are unlikely to be useful for monitoring coastal erosion because of the scale. The scale is 1:27,500, i.e. assuming a measuring accuracy of +/- 0.5 mm, this equates to a +/- 13.75 m margin of error, which is greater than the amounts of erosion likely to be measured. Aerial photos of the region were again taken in 2001 (Nominal scale 1:10,000, source scale 1:50,000) and again in 2007. These latest photos were photographed by NZ Aerial Mapping Limited in 2007. The specifications for the 2007 orthophotos are listed in Table 2.

Table 2: Specification for 2007 aerial photos

Specification	Detail
Coordinate system	NZTM and NZMG
Image tile layout	Urban = NZTM and NZMG 1:500 tiles Rural = NZTM and NZMG 1:5,000 tiles
Tile dimensions	Urban = 240 m x 360 m (NZTM) and 250 m x 375 m (NZMG) Rural = 2400 m x 3600 m (NZTM) and 2500 m x 3750 m (NZMG)
Ground sample distance	Urban = 0.1m Rural = 0.75m
Positional accuracy	Urban = +/- 0.3 m (for 90% of measured points) Rural = +/- 3.0 m (for 90% of measured points)
Building displacement	+/- 1.4 m of objects 3 m high (for 90% of measured points)
Radiometry	24-bit colour
Delivery format	Uncompressed TIFF files with associated TFW and TAB files and MrSID/SDW files.

[1] http://www.pukeariki.com/en/stories/arts/ProfoundPhotography.htm
http://www.nzgeographic.co.nz/articles.php?ID=172

2.7 Options for future information gathering

The following sections of the report make recommendations for further information gathering for priority areas. These recommendations are based on building on existing information for priority areas, or establishing baseline information for priority areas where none exists at the moment. To undertake this work, there are several different methods available, each offering different levels of accuracy and different levels of cost. The more intensive methods would be more easily defended in an environment court type situation, should the consequences of the information become contentious. These are all matters that will need to be weighed up in following through on the recommendations. The various methods referred to later in the report are as follows:

<u>Method 1: Updating existing erosion rate information using the 2007 aerial photos</u>

This method would entail using the coastal erosion maps derived by the Taranaki Catchment Commission in the 1980s (which used information from Gibbs, specific transect lines, analysis of historic photos and cadastral information) and comparing them with the 2007 aerial photos. The following steps would be involved:

- Digitalising of the TCC maps;
- Aligning the maps electronically with the 2007 maps (georeferencing them);
- Using the D-SAS software, or similar methodology, to establish numerous electronic transects along the particular stretch of coast and calculate end-point erosion rates (i.e. the difference between the earliest information and the 2007 aerials); and
- Summarise this information to calculate an erosion rate from 1943 (or the date used in the TCC maps) to 2007.

This method would be relatively inexpensive in terms of time, but could compound any errors in the original data. Some of the original calculations were derived from cadastral information, which is often not clear – i.e. early lines on cadastral maps depicting the coast line are sometimes unclear as to whether they refer to the toe of the dune, the top of the cliff etc.

<u>Method 2: Re-calculating historic erosion rates from 1940s aerials and comparing with 2007</u>

This method would entail re-examining the original 1940s photographs, orthorectifying them so they are comparable with the 2007 photos and recalculating the end erosion rates (i.e. between 1940s and 2007). It would be used for those stretches of coast that had not previously been studied, or where there were concerns about the accuracy of the earlier work. The following steps would be involved:

- Orthorectifying the 1940 aerial photos (NZAM stereo method);
- Using the D-SAS software, or similar methodology, to establish numerous electronic transects along the particular stretch of coast and calculate end-point erosion rates (i.e. the difference between the 1940s photos and the 2007 aerials); and
- Summarise this information to calculate an erosion rate from 1940s to 2007.

This method would be more expensive (orthorectifying the historic photos is highly technical), but would produce a more defensible calculation of erosion rates. Where the rates are used to then establish hazard lines in planning documents that may be contentious, this method may be more appropriate.

Method 3: Establishing a baseline of coastal erosion rates using all historic information.

This method would be used for those stretches of coast that had not previously been studied. It would establish a baseline for future monitoring and would basically involve a similar exercise to that undertaken by the TCC, but using more recent aerial photos.

As with the methods above, it would calculate the 'end-point' erosion rate, i.e. the differences between two dates, but would use all available historic information to do this, i.e. aerial photos and cadastral maps from the 1880s.

The following steps would be involved:

- Orthorectifying all available historic aerial photos (NZAM stereo method) and digitalising early cadastral maps;
- Using the D-SAS software, or similar methodology, to establish numerous electronic transects along the particular stretch of coast and calculate end-point erosion rates; and
- Summarise this information to calculate an end point erosion rate from the 1880s to 2007.

This method would be more expensive than the previous two methods as it would involve hunting out the earlier cadastral information, and determining which cadastral lines were accurate. However, it would be defensible and provide a good baseline of information for future monitoring.

Method 4: Calculating erosion rates from surveyed information

The final method would involve building on method 3 by undertaking on-the-ground current surveying of the current position of the coast, rather than relying on aerial photography alone. It would be the most expensive method of those listed, but also the most defensible and therefore most appropriate for specific applications for activities such as subdivisions or new pipelines or where there are regionally significant assets within the hazard zone.

3 Coastal erosion information for the region by coastal unit

3.1 Mokau River to Pariokariwa point

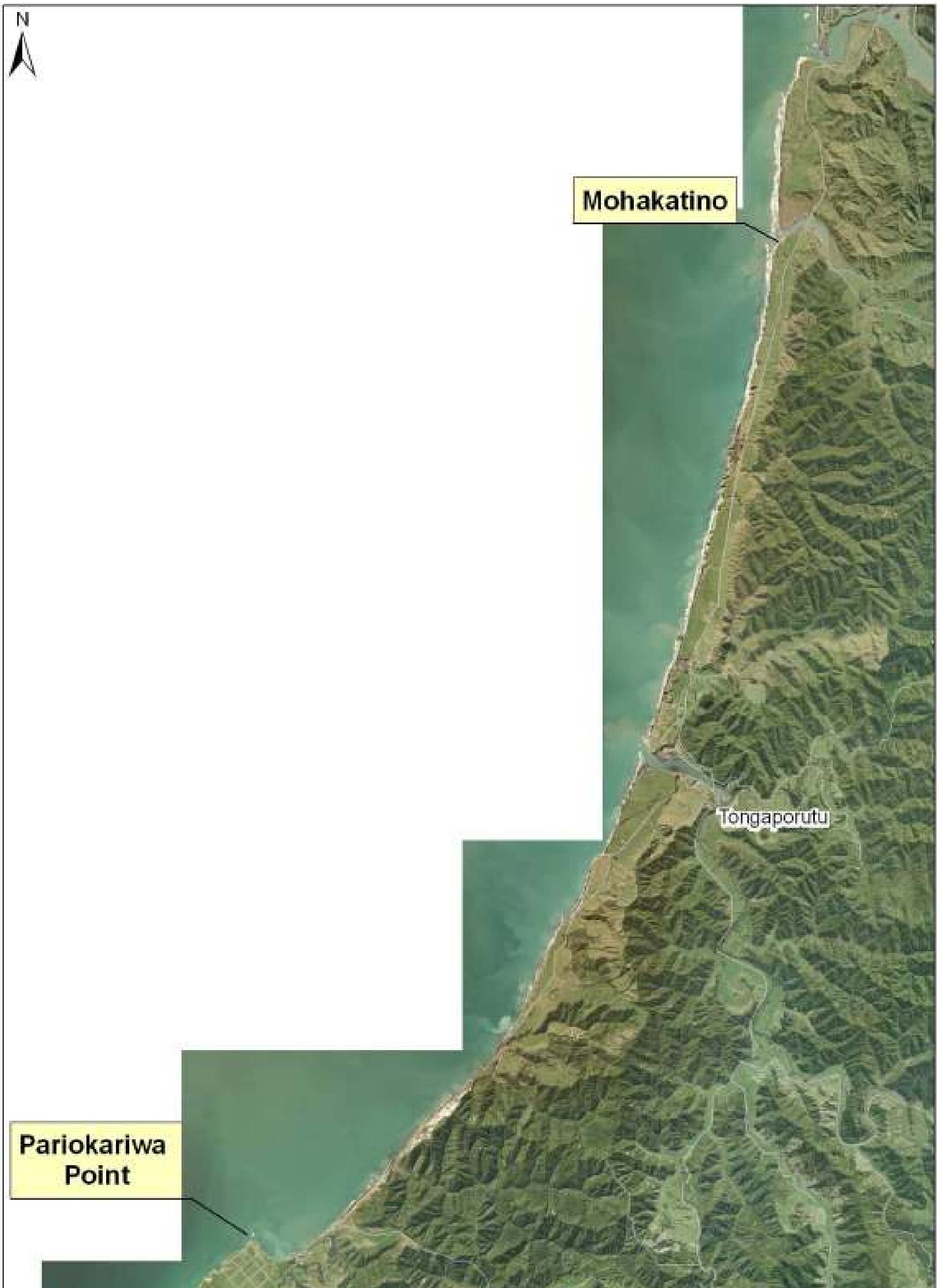


Figure 1: North Taranaki coast between and Mohakatino and Pariokariwa point

a. Description of the area

The northern most coastal unit in the Taranaki region is described as that stretch of coast just south of Mokau to Pariokariwa point and Pukearuhe (Figure 1). The coastal boundary of the New Plymouth District and Taranaki Region is located immediately south of the Mokau River. This coastal unit is dominated by an almost continuous rugged cliffed coastline formed from uplifted marine sediments forming a marine terrace. Some intertidal and offshore reefs exist along the coast, although their seaward extent is less extensive than the volcanic reefs of the ring plain coast.

This coastal unit is dissected by two major rivers (Mokakatino and Tongaporutu) and several smaller streams. Limited intertidal sand deposits of Taranaki iron sand at the base of the cliffs result in the majority of the coast being only accessible at lower stages of the tide. There are more extensive sand deposits around the river mouths, with sand deposits extending up into the estuaries.

The Mohakatino estuary is one of the least modified estuaries in North Taranaki (DOC, 1997). The beach area is not developed and forms a sandspit covered by marram grass and lupins backed by estuary (TCC, 1988). Surrounding the area is farmland and 20-30 m high cliffs. The Tongaporutu estuary is a small estuary of around 40 hectares relatively unmodified and containing extensive mudflats. Hardwood forests, bluffs and offshore stacks surround the estuary.

b. Assets, pressures and coastal protection

There are two small residential settlements adjacent to the Mohakatino and Tongaporutu estuaries. The Tongaporutu settlement for example, consists mainly of holiday baches with various seawalls protecting these baches from estuary erosion. Coastal permits for these are held by the bach owners.

These two residential settlements are more at risk of inundation through flooding, and/or storm surge, or from river bank erosion rather than coastal erosion. This report does not make recommendations for information gathering required in relation to inundation or coastal surge risks. These will need to be a separate exercise.

With the exception of Ngati Tama conservation areas at White Cliffs, the remainder of coast is dominated by pastoral farming, with a few residential buildings.

There is a cluster of 3-4 dwellings just north of Mohakatino River, another similar sized cluster between Mohakatino River and Rapanui Stream and numerous dwellings between Rapanui Stream and Tongaporutu River. There is one dwelling at Clifton Road and a new meetinghouse at Tongaporutu.

Overall this coast currently has low development pressure, although recent subdivisions have taken place around Te Kuwhatahi, Pilot Road, and Pukearuhe. The biggest potential threat from coastal erosion is to SH3 at Te Kuwhataihi (see photo on page 8).

An early attempt at coastal erosion protection was in 1986 when boulders from the Whitecliffs beach were replaced at the toe of the cliff in an attempt to slow the erosion rate. This was initially advised against by the Taranaki Catchment Commission as it was considered that the boulders would have assisted the waves to break in deeper water, rather than on the toe of the cliff.

In 2005, erosion of this coastline threatened to expose the Maui-Auckland gas pipeline at the Twin Creeks embayment where the rate of erosion had significantly increased in recent years due to the partial callapse of the protective headland at the mouth of the embayment (Gibbs, 2005; NGC, 2006). This led to a realignment of the pipeline. Installation of an erosion protection structure on the coast was not a preferred long term option as the lining would need to be keyed into the bedrock siltstone, which is at least 10 m below the sand level at Twin Creeks. It was also noted that in order to build the 100 m long rock protection works, excavation of the material on the beach is likely to accelerate erosion of the remaining material around the pipeline along with a high potential for adverse effects on the coastal marine area.

c. Existing estimations of coastal erosion

Gibb (1978) estimated erosion rates at six sites along this coastal unit ranging from -0.09 m/year to -2.0 m/year (Appendix 1). The Taranaki Catchment Commission (TCC) undertook further work in 1987, particularly in an area of the Tongaporutu River and Waikiekie Stream to Tutapuha Stream. The resulting erosion rates, derived from either the TCC or the Gibbs work are summarised in Table 3 and set out on the Taranaki Coastal Series Map 1 (Appendix II).

Table 3: Existing estimations of coastal erosion from Mohakatino to Pariokariwa Point

	m/year	years	Comments
Mohakatino	-0.09	1888-1972	
Rapanui Stream	-0.11	1896-1966	
Tongaporutu - cliffs	-0.14	1884-1979	top stable, slow toe erosion.
Tongaporutu - estuary	-0.16	1883-1945	SH3 will be threatened
Waikiekie to Tutapuha	-0.74	1946-1979	
Tutaphua to Ohanga	-0.37	1946-1979	
Whitecliffs	-1.89	1880-1975	
Pukearuhe road end	-0.38	1937-1969	
Pariokariwa Pt	-0.50	1955-1975	

Mohakatino
No long term erosion rate for the beach, but Gibb (1978) found rate of -0.09 m/year (1888-1979) on cliffs to south of river mouth.

Tongaporutu
Much of the sand bars within the estuary have been lost and near the river mouth erosion is limited to sand loss from the foot of the cliff. To the west of the road, the houses are right on the shore edge, with historic erosion rate of -0.16 m/year (1882-1945) but area is now protected by a low seawall. Estuary has experienced significant sand movement, the most recent from the gas pipeline crossing work (TCC, 1988).

The seacliffs show maximum erosion rates of -0.44 m/year (1883-1979). Average erosion rate of -0.14 m/year (1884-1979)(TCC, 1988). The top of the cliff is essentially stable with slow erosion of the toe (TCC, 1987 coastal series map 1 in Appendix II).

The Tongaporutu coastal erosion datasheet produced by TCC (sheet 1 of Appendix III) was based on an aerial survey flown 1979 and mapped in 1986 (Map No. AP1699/1). This showed high water tide mark 1883, where the toe of the dune was in 1883, the foredune in 1945, and the edge of cliff 1945, 1967 and 1979.

Whitecliffs North
For the Waikiekie Stream to Tutapuha Stream the TCC calculated a mean rate of -0.74 m/year (1946-1979) and maximum rate of -1.23 m/year (1946-1979). The cliff top is eroding at double the time the rate of the toe, probably due to groundwater seepage (TCC, 1987 coastal series map 1 in Appendix II). The coastal erosion datasheet produced by TCC for this stretch of coast is sheet no. AP 1699/2 in Appendix III.

For the rest of that stretch, the TCC calculated an erosion rate average -0.37 m/year and highest rate of -0.65 m/year (1946-1979), south of Waikiekie Stream(TCC, 1988). Between the two streams erosion rate is higher due to water seepage softening cliff substrate.

d. Recommendations for further information gathering

<u>1. Tongaporutu/Whitecliffs update</u>
For monitoring the state of the environment of this section of coast, it is recommended that the information obtained by the TCC be updated for the open coast sections (i.e. leaving the analysis of changes to the estuary area to a separate project). This would involve updating the Tongaporutu (~2.5 km) and Whitecliffs (~2 km) maps through incorporation of the most recent aerial photography (i.e. method 1 of the methods outlined in section 2.7).

It is recommended that this work be undertaken through a collaborative partnership arrangement with Vector, building on the work they have undertaken (but unable to supply for this project) with respect to erosion rates around the Twin Creeks area in relation to the gas pipelines.

<u>2. SH3 around Te Kuwhatahi Stream (~3 km)</u>
The second priority area is that along SH3 around Te Kuwhatahi Stream. This area is at potential risk from erosion due to caves forming and leading to cliff collapse. It is recommended that method 2 or 3 described in section 2.7 above be used for a 3 km stretch of coastline from Awaawaroa to Awahahae Stream in order to establish a sound baseline for future monitoring.

It is recommended that this work be undertaken through a collaborative partnership arrangement with Transit given the risks to SH3, particularly as it would provide Transit with sound monitoring information upon which to base future risk assessment work.

3.2 Pariokariwa Point to Waiau Stream (Buchan's Bay)

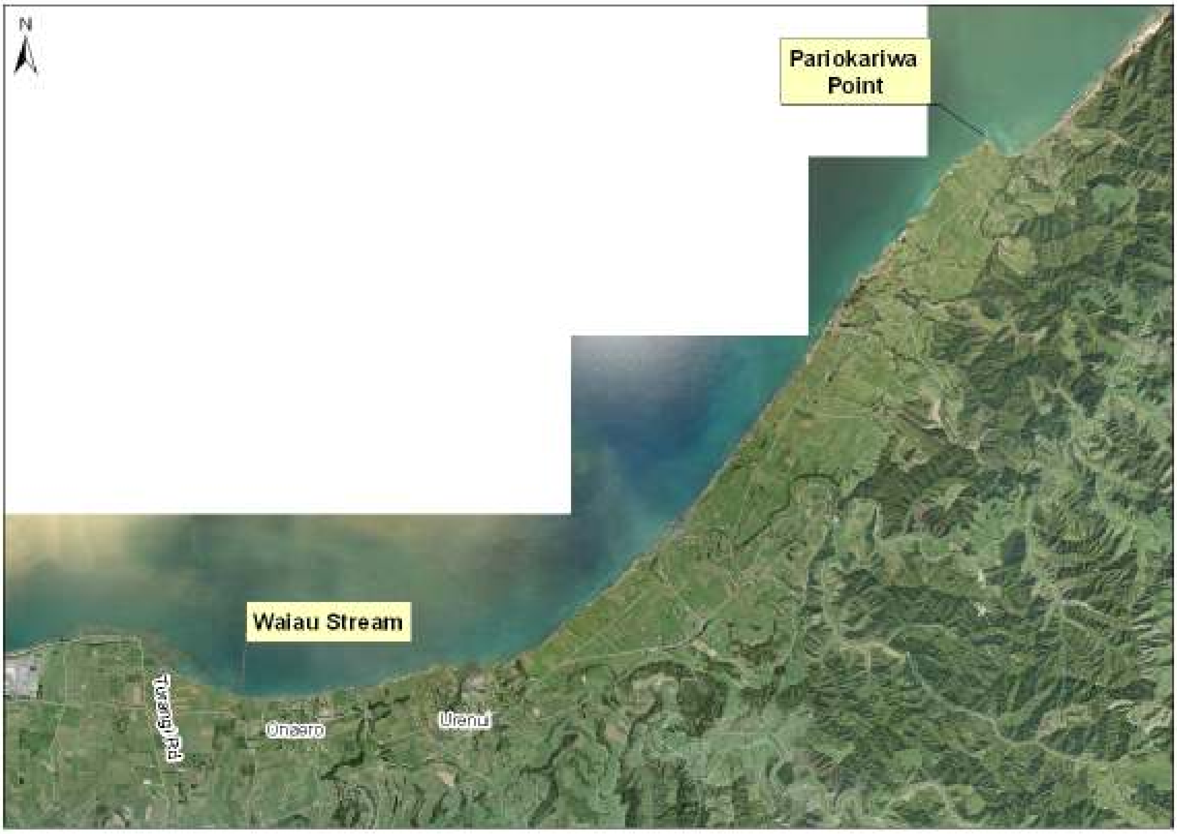


Figure 2: Coast from Pariokariwa Point to Waiau Stream

a. Description of the area

The second coastal unit stretches from the Waikaramaramara Stream at Pukearuhe to the Waiau Stream between Onaero and Turangi Road (Figure 2). It is part of the northern papa coast and is dominated by an almost continuous cliffed coastline formed from uplifted marine sediments.

Some intertidal and offshore reefs exist along the coast, although their seaward extent is somewhat limited compared to the volcanic reefs of the ring plain coast. The cliff is dissected by three major rivers (Mimi, Urenui and Onaero) and several smaller streams. These rivers drain mudstone catchments and deliver only suspended silts and muds to the coast.

The Urenui, Onaero and Wai-iti beaches consist of mixed sand and cobble deposits derived from erosion of Taranaki volcanic deposits that form the Taranaki ring plain. These sediments have been transported north by waves and associated nearshore currents to where favourable conditions at the respective river mouths have allowed for their deposition on the wavecut platforms. The beaches are each situated between papa headlands. The papa headlands, or cliffed promontories, protect the beaches from storm events, but once eroded away, the beach areas become vulnerable to erosion until the sea has carved out new promontories.

The beaches at the base of the cliffs are accessible only at lower stages of the tide. More extensive sand deposits exist around the river mouths, with sand deposits extending up into the estuaries. In late 1950's race horses would train at the wide sandy/cobble Onaero Beach at low tide, attesting to the extensive beach present back then. Wai-iti Beach contains fossilised tree stumps within the beach foreshore.

The vertical cliffs composed of Miocene siltstone/mudstones overlaid by Quaternary sand clays and clay sands (which are weaker with greater potential for erosion). Coastal processes have been described as one of 'sand starvation, cliff erosion and a littoral drift to the north'. Turangi Beach is described as a 'feeder beach' for Onaero (TCC, 1978).

b. Assets, pressures and coastal protection

There are four settlements along this coast: Wai-iti Beach, Urenui Beach, Onaero, and the main residential settlement at Onaero Beach. The Motukari Place subdivision at Onaero Beach is possibly the first example of a coastal hazard zone setback in New Zealand (TCC, 1978). The NPDC owned Recreation Reserve, set up as a coastal hazard zone in recognition of the historical erosion rates within this area at the time of subdivision in the 1970's.

Camp grounds exist at Urenui, Wai-iti and at the Onaero River mouth.

The remainder of coast is dominated by pastoral farming, with a few residential buildings. There are residential dwellings very close to the coastal cliff to the immediate north-east of the Mimi River, and a new residential development at Carrs Road.

This coast currently has low to moderate development pressure. The biggest potential threat to increase the coastal hazard is the subdivision of land and residential development between Turangi Road, SH3, Carrs Road, Johnson Road, and Pukearuhe Road and the cliff. Recent subdivision has taken place between the Mimi River and Wai-iti Beach.

Coastal cliffs at Onaero, North Taranaki

At Wai-iti, there is the Wai-iti Castle and various other cliff top properties mostly built well back from the cliff. A recent development has upgraded the previous motor camp to an upmarket holiday resort with cabins within the New Plymouth District Plan coastal hazard zone. At Onaero estuary there are existing batches further upstream between the reserve and SH3 but not at a significant coastal erosion hazard risk, they may still be within the hazard zone because of surge and flood risks.

At Onaero Beach there is potential for ongoing residential subdivision and development to the west. The existing seawall is being outflanked by erosion. The seawall is regularly overtopped during storm surges from the northwest. There have been two stages of residential development at Onaero Beach. The first stage is protected by a rock rip rap seawall but front dwellings are still subject to the effects of storm surge overtopping the seawall. Thirteen existing dwellings are within the coastal hazard zone with two to three dwellings partially within that zone.

There was gravel and sand extraction from the beaches up until the early 1960s (TCC 1978).

Coastal protection

Historically at Onaero, boulders were dropped in front of receding banks (1974), concrete blocks from old building foundations dropped over cliff edge (1977), an attempt to build a retaining wall – but this was swept away (TCC, 1978). Historic ad hoc seawall measures were removed and the 220 m long boulder rock seawall was reconstructed by NPDC in the late 1990's. There is now no beach present at high tide, and limited beach at low tide.

House and seawall at Onaero

At Wai-iti Beach, a boulder revetment protection has been approved over distance of 293 m from the stream at the south end of Wai-iti Beach to an area of existing large boulder protection in the north. This protects the holiday camp noted above.

In the early 1970's the then Clifton County Council attempted to solve the erosion problem through the erection of protection measures in place of the collapsed headland, between the seastack known as Lion Rock and the eastern headland. These works were unsuccessful, and the remains, including railway irons and some boulders, were able to be seen at extreme low tides (TRC, 2001) but these were required to be removed through conditions on a later consent.

In 1996 it was recommended (Gibb, 1996) that a preferred option of managed retreat, or a combination of stabilisation of the eastern headland and beach-dune renourishment be undertaken. This was met with considerable community resistance and disapproval. That same year the New Plymouth District Council (NPDC) undertook beach modification for sand harvesting and foredune reshaping purposes. TRC (2001) noted that coastal erosion at the western end of Urenui Beach was successfully managed since 1997 under this coastal permit. It is also noted that a small section of the foredune close to the river mouth had been successfully replanted with spinifex, a recognised New Zealand native foredune sand binding plant species.

Cobbles were also placed at the eastern end of the beach in July 1997. Monitoring of this trial showed that the deposited cobbles were re-distributed along Urenui Beach, particularly toward the river mouth, but failed to halt the continued erosion at the eastern end of Urenui Beach in front of the golf course.

In 2001, the New Plymouth District Council built a 295 m long boulder rip rap seawall (TRC, 2001). McComb *et al*. (2005) noted that the seawall has 'fixed' the local coastal orientation, and this alignment is was now exacerbating the erosion on the central and western foreshore. Permission for extending the rock rip rap seawall by a further 311 m was granted in 2008 (TRC, 2007).

c. Existing estimations of coastal erosion

Gibb (1978) estimated erosion rates at 13 sites along this section of coast from -6 m/year to -0.12 m/year (Appendix I). The Taranaki Catchment Commission undertook specific erosion rate monitoring at the Mimi River mouth (sheet no. AP 1699/3, in Appendix III), at the Urenui River mouth (sheet no. AP 1699/4, in Appendix III) and at the Onaero River mouth (sheet no. AP 1699/5). The TCC work was based on cadastral information and on an aerial survey flown 1984 and mapped in 1985. This information, along with information from Gibbs 1978 is summarised on the Taranaki coastal series map 2 (in Appendix II) and in the following table.

Table 4: Existing estimations of coastal erosion for stretch of coast from Pariokariwa point to Turangi Road

	m/year	years	Comments
Along coast south	-0.29	1866-1969	
Mimi road – north of mouth	-0.36	1967-1984	
Mimi road – south of mouth	-0.36	1967-1984	
Spot surveys of Urenui	-0.33	1883-1975	
(equidistant)	-0.26	1883-1975	
	-0.16	1883-1960	
	-0.23	1883-1960	
	0	1883-1958	
Urenui – east of mouth	-1.29	1970-1980	accretion at mouth, rapid erosion at golfcourse.
Urenui - river	-0.22	1943-1984	bank in front of town
Urenui – est of mouth	-0.40	1943-1984	
Spots to Onaero	-1.07	1883-1958	
	-0.53	1883-1958	
Onaero beach	-0.55	1882-1937	

Mimi river
TCC (1987) found an average rate of erosion of -0.34 m/year (1943-1984) with maximum rate of -0.67 m/year (1943-1984). This high rate is due to movement of the river mouth. South of the river mouth an average rate of erosion of -0.36 m/year was found, with the Mimi spit accreting at +2.1 m/year (1943-1984) (sheet no. AP 1699/3, in Appendix III and Taranaki coastal series map 2 in Appendix II).

Urenui beach
Extensive studies of erosion have been undertaken at Urenui Beach (Gibb, 1978; Gibb 1996; TCC, 1987). Historic erosion rates have been recorded up to 1.07 metres per year, with reports of erosion rates at the eastern end of the beach up to 6 metres per year following the collapse of the eastern headland in the late 1960's. The retreat was greatest at the eastern end of the beach in front of the Urenui golf course. There was less erosion at the western end of the beach, with reports of some periods of accretion (TCC, 1987) (sheet no. AP 1699/4) and summarised in Taranaki coastal series map 2 in Appendix II.

In 1996 the pattern and rate of shoreline movements were quantified by comparing historic shoreline positions from 1983 to 1996 (Gibb, 1996). A transparent overlay with 6 shorelines surveyed between 1883 and 1996 (113 years) was compiled by NZ Aerial Surveys at 1:2,000 scale (Plan Reference 1088 sheet 2) from which rates of erosion and accretion were derived (Appendix 1 of Gibb, 1996). Forecast shoreline positions were plotted for Urenui for 2050 and 2100. (Pg 32 and 33 of Gibb, 1996).

In 2007, aerial photos from 1943, 1984 and 2001 were analysed for the resource consent application to extend the rock protection work (Figure 3) (from Tonkin and Taylor 2007). This analysis identified low rates of erosion at the western end from 1943 to 2001 of -0.14 m/yr, although this rate increased to -0.54 m/yr from 1984 to 2001. The eastern end of Urenui beach showed a shoreline retreat of -0.65 m/yr between 1943 and 2001, with an increase to -0.97 m/yr between 1984 and 2001.

To verify the changes estimated from the aerial photographs, an assessment was also made of shoreline change from beach profiles at survey points 100W, 200W and 300W (see Figure 3) which had data from 1987 to 2003, comparable to the period 1984 to 2001 (Tonkin and Taylor, 2007 reported on in TRC, 2007). Trends from the profiling also had to be interpreted with caution due to the relatively low number of profiles and datum and origin difference. However, there appeared to be an underlying trend of erosion of around -0.2 m/year at 100W and 200W, with around -0.1 m/yr erosion at 300W.

Comparing results from these two different sources confirmed long term erosion retreat at the western end, but probably at lower rates than suggested by the aerial photograph analysis. Therefore the rate of -0.54 m/yr erosion is likely to be an upper bound rate of retreat, with a rate of around -0.2 m/yr considered more representative of a longer term trend.

Figure 3: ***Urenui shoreline analysis shown on 1984 aerial photograph.***

The western section of Urenui Beach has a lower rate of historic erosion than the eastern section. The closest dwelling is approximately 30 metres, and the road is approximately 12 m, from the existing erosion scarp. Therefore, at a rate of retreat of around -0.2 m/yr it would have taken approximately 150 years for the erosion scarp to reach the baches, and around 60 years to reach the road. At the upper bound rate of retreat of -0.54 m/yr it would have taken approximately 55 years to reach to baches, and around 22 years to reach the road (TRC, 2007). This area is now protected by a sea wall, but the erosion processes will continue on the seaward side of the seawall altering the nature of the Urenui Beach over time.

A beach profile monitoring programme has commenced with the establishment of six permanent benchmarks at Urenui (Table 5). Initial surveys were undertaken on 28 January 2003 to establish the sites, although there is also historic information available for these profiles (G.Howarth, pers comm.). These positions are "virtual benchmarks", as their positions are not permanently ground marked, and are re-established as needed for profile surveys. Regular monitoring of these positions is required for the NPDC structures at Urenui. Information should in the future provide good local information for these specific sites

Table 5 Urenui beach profiling sites

Cross-section name	GPS		Location
NP058.28 CP	2630435.29	6245178.32	West end of beach
NP058.38 CP	2630529.91	6245210.63	Centre of baches
NP058.48 CP	2630626.03	6245238.18	Access steps east end of baches
NP058.58 CP	2630718.57	6245278.22	Western end of revetment
NP058.68 CP	2630820.75	6245284.63	Centre of revetment
NP058.78 CP	2630911.51	6245312.65	Eastern end of revetment

Onaero

Erosion at Onaero has been recorded for 1956-1965 as a 2.5 m/year rate. Survey plans showed a 93 year span of erosion where cliff recession amounted to 38m average (0.41 m/year) (TCC 1978.)

TCC (1987) and Taranaki coastal series map 2 (Appendix II) showed average rate of erosion for the Onaero area as -0.32 m/year (1945-1981) with maximum rate of -0.5 m/year (1945-1981). The beach at Onaero River mouth accreted between 1945 and 1958 at +1.5 m/year before then stabilising (TCC, 1987). The coastal series map 2 notes that both the western headland and the west end of the beach have been reclaimed and protected. Erosion rates of up to -1.0 m/year have been observed at the eastern end of the beach. The TCC produced an erosion data sheet for Onaero (aerial survey flown 1984, mapped 1985, map No. 1699/5).

There is a compliance monitoring programme at Onaero involving beach profile monitoring. This involves three permanent benchmarks at Onaero (Table 6). Information should in the future provide good local information for these specific sites. The beach profile information is valuable for compliance monitoring and for specific site monitoring.

Table 6 Onaero beach profile sites

Cross-section name	GPS (NZTMP)	
NP054.76CP	5683097.721	1717037.717
NP054.86CP	5683078.734	1717154.883
NP054.91CP	5683104.641	1717198.545

d. Recommendations for further information gathering

Four priority areas have been identified for further information gathering (in priority order):

1. Urenui cliffs north and south of the beach

While substantial work has been undertaken on the erosion rates of the Urenui Beach, the rates estimated for the cliffed coastline section of Urenui have not been updated since the work undertaken by the TCC in the 1980s. It is therefore recommended that a 1 km stretch of the cliffed section of the Urenui TCC map be updated using method 1 described in section 2.7 (updating the TCC work with analysis of the 2007 aerial photos).

It is also recommended that the erosion rate of a 1 km section of the cliffs just immediately north of the Urenui TCC map be assessed using either method 2 or 3 in order to establish a baseline for future monitoring.

2. Onaero

It is recommended that the 2 km stretch covered by the TCC Onaero map is updated using 2007 aerial photos (i.e. method 1 described in section 2.7).

3. Wai-iti

The Wai-iti section of this coastal unit has a slightly different orientation to the rest of the unit, making it likely to respond to coastal erosion pressures differently to the rest of the unit. It is therefore recommended that a 1-2 km stretch be established taking in the Wai-iti Beach area to establish baseline information along the lines of that established for other sections of the coast by the TCC in the 1980s, i.e. use of either method 2 or 3 described in section 2.7. This would then establish a baseline for future monitoring.

4. Mimi coast

It is recommended that the 1.8 km stretch covered by the TCC Mimi map (Appendix III) be updated using 2007 aerial photos, i.e. method 1 in section 2.7.

3.3 Waiau Stream to the Port

Figure 4: Coastline from Wairau Stream to the Port

a. Description of the area

The third costal unit extends from Buchanan's Bay (between Pariokariwa Point and the Waiau Stream) which is the northern most extent of the Taranaki ring plain volcanic coast to Port Taranaki. It includes Waitara, Bell Block, airport and New Plymouth foreshore. The coast has extensive offshore and intertidal rocky reefs, as a result of coastal erosion of volcanic material. There are also areas of perched sandy beaches, and associated fore dunes. For example, in front of the Methanex Motuni Plant there is a sandy intertidal beach, bracketed by extensive rocky reefs of Otaraoa and Epiha. An offshore reef provides shelter to this area of coast.

The Waitara embayment is dominanted by the Waitara river mouth and river mouth protection works. Airdale reef forms the eastern 'headland' to the coastal embayment, and extends 400-500 m offshore from mean low water. East of the river, the beach is a wide mixed sand and cobble beach, backed by a low grass-covered foreshore bank (TCC, 1988). The Waitara River supplies a bedload of sand, gravel and boulders derived from the Egmont Volcanic Zone to nourish the coast (Gibb, 1996a).

The Waiongana River has small estuary. The close by airport is fronted by large cliffs that vary in height from 5 m to 20 m. Below these cliffs is a narrow sand and cobble beach backed by a steep cobble berm which is largely covered at high tide (TCC, 1988). The cliffs are composed of a layer of black sands overlying brown ash, overlaying organic rich tempras resting on volcanic material (Bevean, 2002). Some layers present a subvertical face which is prone to erosion.

The Bell Block Beach is composed of mixed sand and cobbles, and occasionally exposed rock from the wave cut platform. It is confined by the Mangati reef at its western end and by the coastal cliffs in front of the airport at its eastern end (TCC, 1988). To the west of Mangati road, there were extensive sand dune deposits, noted in 1988 to be unvegetated and eroding rapidly (TCC, 1988).

The city of New Plymouth lies along a section of coastline consisting of intertidal platform extensively exposed giving the appearance of a number of small finger reefs between patches of boulders and cobbles. Sand is limited to small patches on the platform and along the foreshore (Tonkin & Taylor, 2001). Numerous ad hoc seawalls erected at various stages throughout historic times were consolidated in 1990's into rock rip rap seawall, including provision of the Coastal Walkway. This area was once a sandy coast with abundant foredunes (1880s), but now there is no beach or foreshore at high tide, and only limited areas of sandy foreshore at low tide.

The Port area from Paritutu to the Lee Breakwater is a highly modified coastal environment including Port Taranaki and the New Plymouth Power Station.

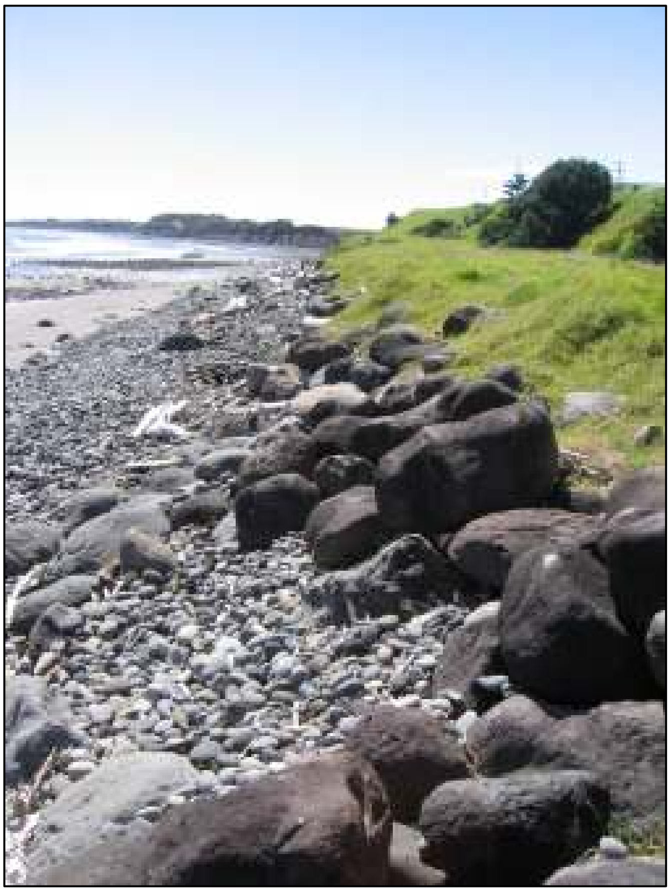
b. Assets, pressures and coastal protection

The Waitara River was historically used as a port with a long history of training walls and moles (Gibb 1996, Tonkin and Taylor 2001). A number of works have been undertaken within the coastal marine area in the mouth of the river.

The New Plymouth Airport is a major asset along this section of coast. The Taranaki Catchment Commission undertook planting work at the western end of the main runway to stabilise the sand dunes. Beaven (2002) includes suggestions for a seawall.

Bell Block is a coastal settlement situated between New Plymouth and Waitara. There is a long history of coastal protection works. Concerns regarding erosion in the late 1970's/early 1980's resulted in the construction of a boulder rock rip rap seawall. The area has a long history of gradual erosion, with the shoreline at the Bell Bock Recreational Reserve between Mangati and Wills Streets being marked by a 2 to 2.5 m erosion scarp prior to the construction of protection works.

In 1989 the existing Bell Block seawall was extended to the northeast by 200 m to a total length of about 640 m. The



Seawall at Bell Block

extension stopped approximately 50 m from the boundary to the property of Mr McLean. Subsequently, the occurrence of accelerated erosion on the McLean property since the 1989 extension has been the subject of much debate since 1990, and the subject of two independent reports (Lumsden, 1993 and 1995). Survey work undertaken in 1990 (document #683669, NPDC data) showed an average erosion rate over 50 years of 0.6-0.7 m/year in this specific spot.

In June 2004, the seawall was extended further by about 70 m to the east. The existing seawall had a length of about 640 m, but stopped about 50 m short of the eastern edge of Wills Road. In May 2005, the rock protection was further extended by 30 m, to the west and into the mouth of the Mangati Stream.

Numerous beach re-nourishment and inshore dumping of dredge material trials have been undertaken at Fitzroy and East End over the past 30 years in an attempt to maintain sand levels and prevent erosion (Tonkin & Taylor, 2001). These have involved placing sand at East End, pumping dredged material ashore at East End and other renourishment trials to the east of the port which would have indirectly benefited these beaches due to the longshore transport of material (Tonkin & Taylor, 2001). Monitoring by NPDC reported on in 1994 showed a loss of sand from this beach at rates of 2000 to 3000 m^3 per year over the last 40 years (OCEL, 1994,p41).

Between Waiwhakaiho and Fitzroy the foreshore is backed by vegetated dunes. The NPDC continues to undertake a proactive role in the management of the dune system including appropriate dune plantings.

History of beach protection at East End is described in TCC (1988, pg 21). A boulder rock rip rap seawall extending from East End to the mouth of the Te Henui Stream (a distance of about 290 m) was constructed in 1995, and then extended to 355 m in 2005. Beach nourishment was proposed in 1995 (OCEL, 1995). Beach profiles showed an average net loss of sea and of 2,800 m^3/year from dune system as the beach system sought to compensate for the loss of coastal sand supply.

In 1994 the NPDC looked specifically at the coast between the East End Surf Club and the Te Henui Stream. Active and severe erosion was occurring through this section and was threatening a number of the important assets which exist on the land behind the proposed seawall site. These assets consist of the East End Surf Lifesaving Clubrooms, roading access to a significant reserve area, numerous recreational facilities as well as the major sewage pumping station and associated sewer lines which are situated nearby. As a consequence, a rock seawall was constructed between the Te Henui Stream mouth and the East End Surf Club. The NPDC then applied for a coastal permit to deposit up to 20,000 m^3 per year of sand onto East End Beach to restore a balance to the sediment budget of the East End and Fitzroy beach systems (OCEL, 1995).

The Te Henui landing site presents the transition zone between the wide sandy beaches to the east, and the narrower and predominantly rocky intertidal regions immediately to the west (McComb and Beamsly, 2000, p.20). A small sandy beach exists to the west of the Te Henui groyne (constructed in 1979) in an area commonly known as Boulder Bay. This beach is backed by a vertical concrete wall and boulder rock rip rap armouring. This protection represents the start of the New Plymouth seawall protection.

In front of New Plymouth City there is an almost continuous seawall from the mouth of the Te Henui Stream through to the Lee Breakwater, a distance of some 3.5 km. This length of seawall was constructed on an adhoc basis throughout the 20th century.


Vickers seawall at Bell Block

The erosion rate for this section of coast is deemed to be essentially zero, however, this is dependent solely on the level of maintenance of the seawalls (TCC, 1988). The erosion processes occurring in front of the seawall will continue. Extensive development continues behind the seawall on the assumption that this coastal protection structure will continued to be maintained indefinitely.

Table 7: Summary of pressures and assets for this coast

Area	Pressure and assets
Motunui	• Oil & gas Industry - Pohokura Gas Field, and Methanex Motunui. • Residential cluster on Turangi Road, including 1-2 very at risk dwellings. • 66/68 Turangi Road residential dwellings very close to cliff but not within the hazard zone. • 70 and 72 Turangi Road – new subdivision – potential building pressure.
Waitara	• Erosion of the Waitara Golf Course . • Waitara East - Te Rohutu Block in the hazard zone. • Waitara West – no pressure yet but potential for future coastal subdivision. • Residential dwellings at Waitara East - Te Rohutu Block and Waitara West mostly set back from the coast, but a few existing dwellings in the hazard zone.
Waiongana	• Airport • Low pressure yet but potential for future coastal subdivision.
Bell Block	• End effects associated with Bell Block seawall east of Wills Road. • Increasing coastal property values. • Increased ongoing seawall maintenance costs. • Residential developments along Wanaka Terrace off Mangati Road, and Tiromoana Crescent off Wills Road, are very close to the coast.
Waiwhakaiho to Hickford Park	• Reserve – but pressure in the location of the coastal walkway. • Subdivision potential landward of Hickford Park. • Potential New Plymouth Golf course coastal subdivision. • Extension of the coastal walkway.
City foreshore area	• Continued sediment/sand budget deficit from Port Taranaki. • Risk from ongoing erosion in front of the seawall. • Ongoing and increased seawall maintenance costs. • Coastal property values, and development trends.

c. Existing estimations of coastal erosion

Extensive work was undertaken on this coastal unit by the Taranaki Catchment Commission building on earlier work undertaken by Gibb. These are listed in Table 8. The TCC work included the preparation of coastal erosion maps for seven specific sites:

- Waitara East, sheet no. AP 1699/6
- Waitara West, sheet no. AP 1773/7 (Appendix III)
- New Plymouth Airport, sheet no. AP 1773/8 (Appendix III)
- Bell Block Beach, sheet no. AP 1773/9
- Waiwhakaiho River, sheet no. AP 1773/10
- Fitzroy, sheet no. AP 1773/11
- Kawaroa Park, sheet no. AP 1773/12.

Table 8: TCC /Gibb coastal erosion rates:

	m/year	years	Comments
Waipapa stream	-0.43	1919-1975	Motunui synfuels plant
Airdale reef	2.89	1913-1958	
Waitara River – east of mouth	-1.57	1913-1981	
Waitara river – west of mouth	-0.81	1945-1981	
½ Waitara to Waiongana	-0.51	1945-1981	
Airport NS runway	-0.32	1917-1964	
- ½ way	-0.96	1917-1964	
- Puketapa	-0.76	1917-1976	
Wills Road	-0.37	1852-1976	
Waihowaka stream	-0.32	1945-1981	east of stream – NE part eroding fastest.
Bell Block Beach	-0.38 - -0.70		(Rates before seawall)
Mangati stream	-1.50	1905-1981	
Waiwhakaiho River (east)		1970-1981	max accretion at mouth of +2.84m/year
Waiwhakaiho (west)	-0.67	1945-1981	
Fitzroy Beach	-0.06	1842-1958	
East end beach (NE)	-0.58	1842-1958	
East end beach (SW)	-0.59	1842-1958	
Seawall	-0.54	1905-1944	seawall built 1944
Port Taranaki to seawall	-0.46	1905-1945	east of Huatoki

Motunui

The area in front of the Methanex Motunui Plant has been described as a sandy intertidal beach, bracketed by the extensive rocky reefs of Otaraoa and Epiha, which along with offshore reef provides shelter to this section of the coast thus reducing erosion rates. Gibb (1979) calculated erosion rate of 0.43 m/year at Otaraoa Road (based on data from 1917 - 1975). In 2002 the Pohokura AEE noted that similar rates of erosion have not been observed at Motunui since the Methanex Motunui Plant was constructed, and attributed this to the cobbled upper beach acting as a 'soft' armouring to the shoreline compared to other North Taranaki coastal areas.

McComb, (2003) examined the shoreline and cliff line positions using data from a 50-year history of aerial photographs for the area from Otaraoa Road to Epiha Road. This report noted that the Motunui shoreline is dynamic, exhibiting periods of significant erosion as well as accretion. There is a trend of increasing erosion along the coast from Otaraoa Road to Epiha Road.

The main periods of erosion that were observed were between 1945 and 1958, and between 1965 and 1970. From 1981 to 1994 the overall rate of erosion reduced and accretion occurred in the central regions of the Motunui Beach. At the Pohokura offshore pipeline location, the shoreline has retreated a total of 15 m over the period 1945-1994. However, the rate of erosion has not been constant, with 1945-1970 exhibiting erosion of 35 m and subsequent accretion of 20 m occurring from 1970 to 1994. Between 1994 and the present time, the foreshore has accreted a further 9 m. The top of the vegetated cliff remained reasonably stable over the period, with localised retreats of up to 12 m, but mostly in the order of 3 m.

Table 9 below, from McComb (2003), sets out the average erosion rates for four sections of coast, with section 1 in the table below being the area closest to Otaraoa Road. Sections are illustrated in Figure 4.8 of that report.

Table 9 Average net erosion rates between 1945 – 1994 (m/yr) and total erosion (m) for each section of the Motunui Coast (Source: McComb 2003) .

	Section 1	Section 2	Section 3	Section 4
Net erosion rate (m/yr)	0.32	0.71	0.83	1.10
Total erosion (m)	15.57	34.74	40.77	53.66

The Pohokura AEE notes that 'a quantification of the erosion rates and shoreline response is an outcome of the environmental studies that are presently being conducted' (p45). This means there may be opportunities for working collaboratively with Shell Todd Oil Services Ltd (STOS) on erosion monitoring.

Waitara

TCC work showed erosion rates east of river mouth to have a mean rate of -1.57 m/year (1913-1981), mean rate of -1.37 m/year (1945-1981), with maximum rates of -2.41 m/year (1913-1981), -1.56 m/year (1945-1981) and a maximum rate of -3.98 m/year between 1970 and 1981. The highest rates are closest to the river mouth and on the headland section of the golf course. Earlier work (Agnew, 1976) commented that 'the discovery of Maori skeletons on the Waitara foreshore last month is said to be caused by erosion of about 40 m extent in the last century.'

West of the river mouth, the TCC work calculated a mean rate of -0.81 m/year (1945-1981), with maximum rates of -1.37 m/year (1913-1981) and -2.07 m/year.

TCC (1988) showed an average rate of erosion for the western beach of -0.54 m/year (between 1945 and 1981) with the rate varying from -0.26 m/year to -0.87 m/year. East of the river shows consistent, rapid, long term erosion – with the highest erosion rates observed anywhere in North Taranaki (TCC, 1988).

TCC erosion map 1773/7 (Waitara west) mapped rates between Waitara River and Waiongana Stream. This found a mean rate of -1.26 m/year (1911-1981), a mean rate of -0.51 m/year (1945-1981), and a maximum rate of -0.87 m/year (1945-1981). The Taranaki coastal series map 3 (Appendix II) notes that the erosion rate is basically even across the sheet with little difference between the dune and cliffed sections.

A report on the performance of the Waitara groynes assessed profile changes between February 1997 and November 1999 (Gibb, 1999). The eastern beach had accreted significantly since the construction of the new groyne. The western beach had also accreted and was considered to have reached full capacity about the end of 1998. It was also noted that the river bar had a height of 2.8 metres above MLWS with a volume of about 55,000 m^3. Gibb (1999) considered that the bar had accreted about 5,000 m^3 per month during 1999. It was noted that the bar could last for anywhere between 1 to 14 years depending on when it was destroyed by the next major flood event.

Eight beach profiles and permanent benchmarks have been set up on both east and west beach (Table 11). These profiles have historic data from previous monitoring (TRC, 2008).

Table 10 **Waitara beach profile sites**

Cross-section name	GPS (NZTMP)	
NP043.48 CP	5683809.170	1706114.188
NP043.60 CP	5683844.070	1706237.556
NP043.69 CP	5683849.223	1706318.860
NP043.85 CP	5683812.264	1706515.075
NP043.92 CP	5683836.911	1706584.664
NP044.00 CP	5683854.330	1706651.996
NP044.11 CP	5683871.143	1706757.603
NP044.19 CP	5683895.239	1706839.133

New Plymouth Airport (between Waitara and Bell Block)
Beaven (2002) noted that three surveys had been undertaken locating the top of the cliff line. These show a retreat of 135 m over 81 years (1917 to 1998). The three surveys indicate an overall rate of retreat of 1.67m/year:
- 1.27 m/year between 1917 and 1964
- 1.72 m/year between 1964 and 1993
- 5.00 m/year between 1993 and 1998 – it is not clear whether this increase in rate of erosion shows a real trend or is unusually high due to cyclonic storms which resulted in a major cliff retreat. However, overall rate of erosion has accelerated significantly since 1964.

Erosion has been attributed to less seasonal onshore offshore movement of sand, and reduction of longshore movement of sand (littoral drift) leading to degradation of beaches exposing the underlying cobbles and gravels, and the toe of the cliffs becoming exposed to the forces of wave action (Beaven, 2002).

The New Plymouth Airport manager advises that a particular mast fell into the sea in March 2009. This mast was located at a point on the contour line predicted to be cliff edge in 2003. This highlights that the estimations of coastal erosion were conservative, but not far out.

Some questions were raised in reviewing the information in the Beaven (2002) report about the accuracy of the data, and the methodology used. For example, it is unclear if the lines produced were from survey data or from aerial photos, and other questions remain about the methodology. This is one reason why further analysis of aerial photo data is recommended for this reach of coast.

The rates reported in Beaven (2002) significantly differed from those reported in TCC 1988 – which reported an accretion of +0.28 m/year (1845-1981) towards the Waiongana River mouth and behind Kunene reef, but an average rate of -0.67 m/year (1917-1981) and a maximum rate erosion rate of -1.17 m/year (1917-1981) behind Puketapu reef, where the coast is cliffed (TCC, 1988, coastal erosion map 1773/8 (New Plymouth airport) (Appendix III). The erosion rate increases towards the south west.

The erosion rates depicted on a survey plan completed by New Plymouth District Council in 1991 also posed a range of erosion rates (document #683687) for two transects: a) 1917-64 = 39.2 m in 47 years, average 0.8 m/year; 1964-91 = 40.8m in 27 years, average erosion rate 1.5 m/year; and 1917-1991 = 80 m in 74 years, an average of 1.1 m/year. B) 1917-64 = 21.1 m in 47 years, an average of 0.4 m/year; 1964-91 = 28.4 m in 27 years, an average of 1.0 m/year; 1917-1991 = 49.5 min 74 years, an average erosion rate of 0.7 m/year.

Bell Block
Photo data show an average erosion rate of -0.32 m/year along section of coastline between Mangati and Willis Roads (TCC, 1988). Dunes west of Mangati Road were rapidly eroding (erosion rate of -1./3 m/year to -2.8 m/year between 1970 and 1981) (TCC, 1988).

TCC coastal erosion map 1773/9 (Bell Block beach), as summarised on coastal series map 3 (in Appendix II), found east of Waihowaka Stream a mean rate of -0.32 m/year (1945-1981) and a maximum rate of -0.79 m/year (1945-1981). The coast to the north eastern edge was found to be eroding at the fastest rate with the erosion rate reducing towards Bell Block. The TCC work showed an overall average rate of -1.5 m/year (1905-1981) and an average rate of -2.07 m/year (1970-1981) with high erosion rates on bare sand dunes.

Lumsden (1995) calculated erosion rates for distances from the north-east end of the Bell Block seawall. These rates highlighted the episodic nature of coastal erosion. Average erosion between 1993 and 1995 was determined to be 2.92 m/year along the McLean's property, but only 0.99 m/year north of McLean's property. This was attributed to a number of factors. Table 11 sets out the erosion rates determined for transects remote from the north-east end of the Bell Block seawall (by survey).

Table 11 Erosion rates remote from the North-eat end of Bell Block seawall (indicating rates of erosion for a section of coast unprotected by seawalls) (Lumsden, 1995)

Distance from north-east end of wall (m)	1917-1964 (m/yr)	1964-1991 (m/yr)	1991-1993 (m/yr)	1993-1995 (m/yr)
975	0.83	0.91	-	-
1600	0.65	1.38	0.54	0.85
1940	0.52	1.19	0.66	0.93
2390	0.42	1.05	1.24	1.78
2570	0.50	1.20	1.44	2.79

Four profiles and permanent benchmarks have been set up for beach profile monitoring beach (Table 12). These profiles have historic data from previous monitoring (TRC, 2008).

Table 12: Bell Block Beach Profile locations

Cross-section name	GPS (NZTMP)	
	Northing	Easting
NP035.65 CP	5680090.710	1699600.703
NP035.85 CP	5680277.116	1699661.955
NP036.00 CP	5680416.903	1699718.680
NP036.19 CP	5680592.059	1699779.400

Waiwakaiho river mouth to Bell Block
OCEL Consultants (2009) has recently undertaken coastal erosion rate assessment drawing on aerial photos. Data was only used from 1973 to take into account the influence of the Waiwakaiho groyne structure. Erosion rates for 10 profiles (illustrated in OCEL 2009) are set out in Table 13.

Table 13: Erosion rate data from OCEL Consultants (2009)

Profile	Historical erosion rate (m/year)	Period (years)	Years
1[2]	-0.09	32	1975-2007
2	-0.98	32	1975-2007
3	-0.75	32	1975-2007
4	-0.47	32	1975-2007
5	+0.05 (-0.35)	32 (14)	1975-2007 (93-07)
6	-0.53	32	1975-2007
7	-0.47	32	1975-2007
8	-0.51	14	1993-2007
9	-0.32	14	1993-2007
10	-0.30	14	1993-2007

Fitzroy Beach – Waiwakaiho River mouth
Profile data is held by NPDC who have been surveying the beach for many years (TCC,1988). Historical and photogrammetric data examined by TCC in 1987 showed erosion rates varying between -0.24 m/year to -0.42 m/year (1905-1981), however, the system was very complex, especially around the Te Henui stream mouth.

TCC coastal erosion map 1773/10 (Waiwhakaiho river) summarised on coastal series map 3, showed:
(i) east of Waiwhakaiho river – erosion towards east, but accretion around river mouth with a maximum rate of +2.84 m/year (1970-1981). This area previously showed long term erosion.
(ii) west of Waiwhakaiho river – mean rate of -0.67 m/year (1945-1981), maximum rate -0.74 m/year (1945-1981). The highest rate near the river mouth has been stabilised by the rock groynes.

TCC coastal erosion map 1773/11 (Fitzroy beach) summarised on coastal series map 3, showed:
(i) east of Te Henui stream – consistent erosion at the northern edge of the sheet, with some accretion near Te Henui. Mean rate of -0.24 m/year (1945-1981). Low rates of erosion and accreation in part are due to protection works.
(ii) west of Te Henui stream – coastal section protected by a seawall. Prior to construction, the area was eroding at -0.54 m/year (1905-1944).

Surveys of East End Beach profiles prior to construction of the seawall (January 1995) were forwarded to Council in July 1995. The location of beach profiles for East End Beach Protection are set out on a survey plan in document # 683641 (dated 1994) with accompanying profile data. In accordance with the monitoring requirements of the consent, four beach profiles were set up and surveyed in August 1995 for monitoring purposes (TRC, 2008).

[2] Note: Profile 1, while producing a net retreat of 0.09 m/year over 32 years has shorter term rates between -3.59 m/year and +1.22 m/year. This represents a very dynamic section of coastline.

Historic information exists for Waiwhakaiho (NPDC data). The survey plan of the marks for the beach profiles undertaken for a beach survey from Waiwhakaiho to Bell Block in 1986 are in document # 683660 and #683660.

New Plymouth foreshore
Prior to construction of seawall, erosion had been estimated at 0.53 m/year (TCC map AP1773, based on survey data 1905-1950). While the seawall has all but halted the coastal erosion, some downcutting at the toe of the seawall has been observed. Gibb (1983) examined survey data from 1965-1983 and estimated downcutting of reef platform at Te Henui Stream of the order of 48.5 mm/year. Steel pins have been installed in the reef, but have not been resurveyed to determine if this significant level of downcutting continues.

TCC coastal erosion map 1773/12 (Kaworoa Park) summarised on coastal series map 3, noted that the entire area of coastline is artificial, either reclaimed and or protected by seawalls. East of Huatoki stream the coast historically showed erosion at -0.46 m/yr (1905-1945). Further data is held by the NPDC.

d. Recommendations for further information gathering

<u>1. Waitara to Port</u>
Given the levels of pressure and assets along this stretch of coast, it is recommended that the work carried out by the TCC in the 1980s is updated for the entire 17 km stretch of this coastal unit. This would involve updating the maps using 2007 aerial photography information (method 1 of the methods described in section 2.7).

It will be particularly important to update the information for the remaining sections of this coast that are not protected by coastal protection (namely the Waiongana coast and between Waiwhakaiho and Bell Block) in order to provide an estimation of coastal erosion rates that may otherwise be occurring elsewhere along the coastal unit were it not for the ongoing maintenance of the coastal protection structures.

This would complement beach profile monitoring work being undertaken for specific sites in relation to consent structure monitoring.

<u>2. New Plymouth Airport cliffs</u>
In light of the significance of the airport as a regional asset and the potential risk from coastal erosion identified by Beavan in 2002, it is recommended that in addition to the aerial photo analysis discussed above for the Waitara to Port stretch, that detailed survey work be undertaken, using method 4 described in section 2.7.

<u>3. Waiwhaikho to Bell Block</u>
In light of proposed plans to extend the coastal walkway, consideration should be given to undertaking method 4, in addition to the aerial survey analysis undertaken by OCEL Consultants 2009.

<u>4. Motonui</u>
Erosion rate information was gathered for STOS (McComb 2003) establishing an erosion rate between 1945 and 1994, providing baseline information for future monitoring. To build on this information in a manner consistent with recommendations made for elsewhere along the

coast, it is recommended that further analysis of erosion rates be undertaken using the 2007 aerial photos (i.e. method 2 or 3 described in section 2.7). Undertaking this work would however depend on partnerships being developed with Methanex and STOS to resource the work.

3.4 Port to Stony River

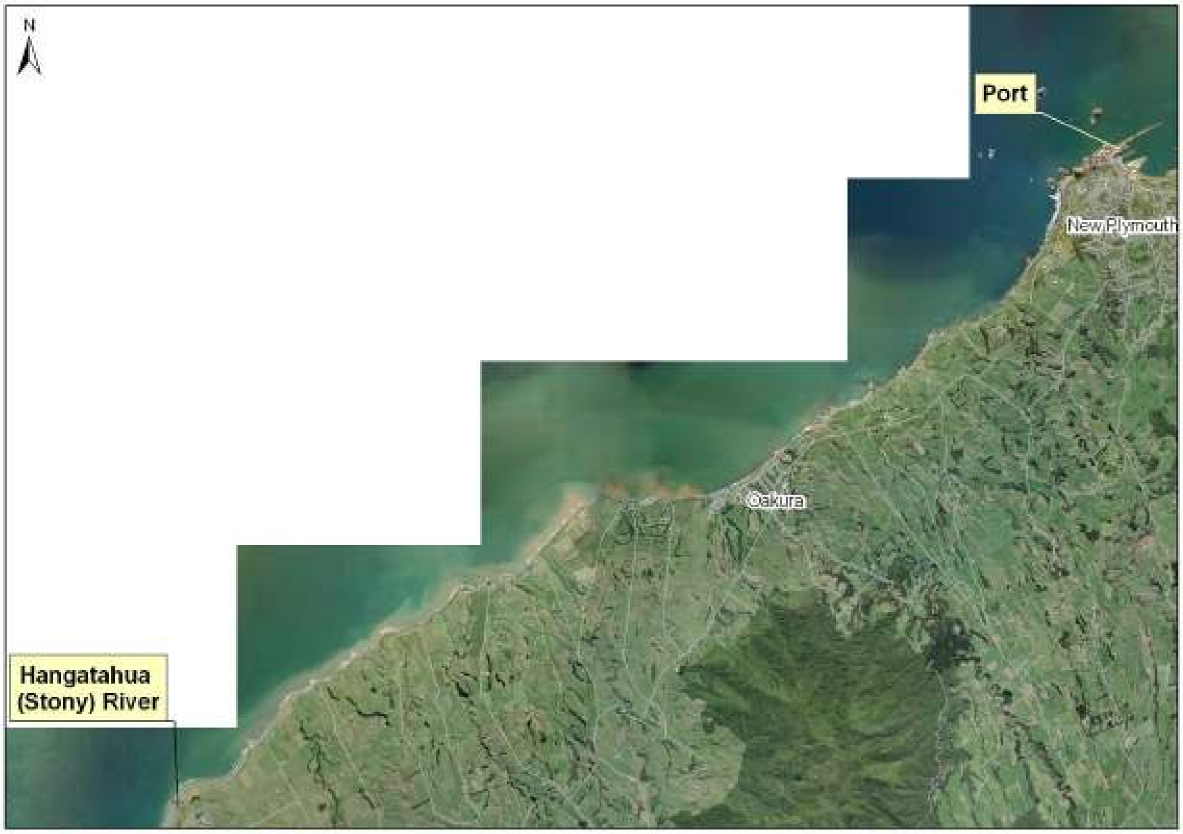


Figure 5: Coastline from the Port to Stony (Hangatahua) River

a. Description of the area

This coastal unit is part of the Taranaki ring plain coast. The coast has extensive offshore and intertidal rocky reefs, as a result of coastal erosion of volcanic material. Wide sandy beaches, and associated fore dunes, in front of relatively stable coastal cliffs. The coast from Paritutu to Herekawe stream is described as comprised of lahar cliffs topped with easily eroding marine terrace deposits and ash beds.

This area is understood to be relatively stable, and this is reflected in the majority of the coastal cliffs being well vegetated, indicating a long period of stability. The stability is in part due to a combination of factors including extensive offshore reefs, buffering of the coastal cliffs by foreshore beach and dune sand deposits and the orientation of the coast to the predominant west-southwest weather and waves. This section of coast is currently dominated by sand accretion.

Paritutu, or 'Back Beach' as it is more commonly known, is situated on the western edge of New Plymouth City and the Sugar Loaf Island (Ngā Motu) Marine Protected Area. The beach is formed by sands deposited over eroded volcanic basement rock and wedged up against coastal cliffs, thereby limiting the beach width at high tide. The sand beach extends from the base of Paritutu through to the western end of the Omata Tank Farm.

OCEL (1994) noted that a sand tombolo, extending approximately 0.5 km along the shore, had formed in the wave shadow area of the inshore islands of Motuotamatea (Snapper Rock), Pararoki (Seagull Rock) and Mataora (Round Rock). Beyond this area it was noted there was approximately 0.4 km of the solid rock base of Paritutu.

Oakura is a small coastal settlement about 8 km southwest of New Plymouth. Oakura Beach is situated between the reefed headlands of Ahu Ahu and Weld Roads, and the rocky cliffed coastline to the north of the Oakura River. A sand berm may develop at the backshore to the immediate north of the Oakura River, particularly during highly accretional periods of fine weather (TRC, 1998). Extending the length of the township, the wide sandy beach is approximately 2km long, backed by small dunes. The beach comprises of a thin veneer of sand overlying an intertidal boulder platform. Sand deposits are the exception, rather than the normal coastal landform (TRC, 1998). Offshore there are cobble and boulder reefs.

Oakura Beach is a predominantly medium to fine grained sandy beach, occupying a shallow embayment. The sand deposits are contained between an extensive reefed headland to the southwest and coastal cliffs with a smaller reef at the northeastern end of the bay. However, patches of pebbles and well rounded cobbles are not uncommon, especially at the mouths of the streams draining to the beach, and at the back of the beach. It is important to note that the sand is a veneer deposit overlying the wave cut platform eroded from the volcanic deposits. This is reflected in the fact that small boulder reefs are present in the intertidal zone, appearing at low tide toward the mouth of the Oakura River, and to the southwest of the motor camp. During extremely strong and persistent periods of erosion the sand veneer may be eroded to an extent that the underlying wave cut platform is exposed. Sand volumes at Oakura are highly variable. Currently the sand 'slug' from the Stony (Hangatahua) River is providing ample sand supply for Oakura Beach.

The Stony (Hangatahua) River has created a pronounced delta due to large sediment load carried by the river (massive erosion in headwaters triggered by 1998 floods). The delta comprises of extensive sand dunes with gravel and boulder deposits. Sand dunes were mostly vegetated with sand dune vegetation (TCC, 1988), but not currently.

b. Assets, pressures and coastal protection

Oakura

Historically the Oakura Beach from Waimoku stream east, was used as a source of material for Port Taranaki (TCC erosion map 1775/15 (Oakura) (Appendix III).

There are ongoing issues with coastal erosion at this beach, exacerbated by the close proximity of houses to the beach on the seaward side of Messenger Terrace. Assets along this section of coast include Oakura Campground and 53 residential properties on seaward side of Messenger Terrace. GV (1997) showed property values ranging from $90K to $320K with an average valuation of approx $220K. Current GV values would be much higher.

Rock protection along Oakura Beach

TCC (1987) noted that erosion in the 1970's caused concern to house owners, and as a result various protection works ranging from car tyre seawalls to gabions were erected to reduce foreshore erosion, but that since the early 1980's the beach has recovered and most of the protective works are now buried under sand deposits. It also noted that land on which the surf club is sited did not exist in 1923, according to cadastral survey, so is reclaimed land (TCC, 1987; OCEL, 1994; and McComb et al, 2005).

There has been a piecemeal pattern of rock revetments along the beach, as land owners have tried to protect their properties. These revetments are all constructed to different design criteria, displaying different degrees of adequacy in fulfilling their protection functions. NPDC has a coastal permit for rock rip rap along the public areas of the beach. Consequently boulder rip-rap toe protections now extend from mouth of Wairua Stream to mouth of Oakura River mouth (about 1050 m).

It is recognised that the erosion events of the late 1970's pushed the erosion scarp/vegetation line even closer to buildings than the current position, therefore there is the potential for this to occur again. It is also considered likely that the natural cyclic patterns of erosion and accretion observed at Oakura Beach over the last several decades will continue into the future. This would see boulder protection works covered in sand during the peak of accretion cycles and exposed during the peak of erosion cycles (TRC, 2004).

TCC erosion map 1775/15 (Oakura) (as summarised on Taranaki coastal series 4 in Appendix II) noted that from Waimoku Stream east, the upper beach has been modified with boulder armouring at the toe of the cliff (TCC, 1987).

There have been recent coastal subdivisions along this stretch of coast, especially at Wright Road and Tapuae.

Ahu Ahu Road to Perth Road
There are three main accessible beach areas along this stretch of coast. In 1988, there was good dune development indicating a stable or accreting environment (Timaru stream) (TCC, 1988), but this is not still relevant today.

There has been recent subdivision at Ahu Ahu Road, Lower Timaru Road, Greenwood Road, Lower Pitone Road, Lower Timaru Road and Perth Road. A new house has recently been built on the cliff top at the end of Kaihihi Road.

Other nearby pressures from Hampton Road to Stony River include coastal subdivision – especially Kaihihi Road and the Kumera Patch surf break. The Coast Road has eroded just west of Hampton Road.

c. Existing estimations of coastal erosion

Erosion rate information was gathered for this stretch of coast by Gibb (1979) and TCC (1987). Three erosion sheets were produced by TCC and summarised in the Taranki Coastal Series map 4 (Appendix II) and Table 14. These were:

- Paritutu-Harekawe Stream – sheet no. AP 1773/13
- Beach Road north and south – sheet no. AP 1773/14 (Waireka)
- Waimoku stream east and west – sheet no. AP 1775/15 (Oakura) (Appendix III).

Table 14: Erosion rates from Gibb and TCC for this coastal unit

	m/year	years	Comments
Paritutu to Herekawe Stream	-0.45	1894-1981	
Herekawe Stream to south	-0.29	1896-1981	
Beach Road (north)	-0.43	1950-1981	
Beach Road (south)	-0.25	1950-1981	
Waimoku Stream (east)	-0.2	1950-1981	
Waimoku Stream (west)	-0.67	1970-1981	(only eroding since 1970, accretion before that)
Otupata Stream	+0.67	1865-1961	
Leith Road	0	1892-1975	

Paritutu or Back Beach

Photogrametry (TCC, 1988) showed relatively slow erosion rate (average -0.22 m/year (1950-1981) west of Herekawe stream. Higher rate behind Mataora Island (-0.58 m/year) (1950-1981). This erosion reflected the impact of recreational users on sand dune areas (TCC, 1988). To southwest beyond Waireka reef, an average rate of -0.25 m/year (1950-1981) was measured.

TCC coastal erosion data (map 1773/13, Paritutu Beach) summarised in Taranaki coastal series map 4 (Appendix II) reported a mean rate of erosion between Paritutu and Herekawe stream of -0.45 m/yr (1894-1981), with a maximum rate of -1.23 m/year (1970-1981). The highest rates of erosion are observed at the points of public access to the beach.

The same map notes for Herekawe Stream south, a mean rate of -0.29 m/yr (1896-1981) and a maximum rate of -0.40 m/year (1896-1981).

TCC coastal erosion data (map 1773/14, Waireka), as summarised in Taranki coastal series map 4, notes the following:
(i) North of Beach Road, a mean rate of -0.43 m/year (1950-1981) and a maximum rate of -0.63 m/yr (1950-1981)
(ii) South-west of Beach Road, a mean rate of -0.25 m/year (1950-1981) and a maximum rate of -0.47m/yr (1950-1981). Most of this coastal section is eroding at a slow rate with some parts of the cliff being stable. The map notes that this area was the site of the IWD coastal landfill and additional erosion data is held by the TCC and IWD. This information has not been tracked down.

Oakura Beach

Goldsmith (1978) produced an independent report entitled *'Beach Erosion, Oakura and neighbouring beaches 1977-1978'*. Goldsmith considered that erosion at Oakura, when compared with neighbouring beaches to the southwest, had been exacerbated by human activity, particularly by the:

- introduction of foreign vegetation and soils to the beach dune areas;
- Flattening of and encroachment into the dune areas;
- Culverting and bridging of streams within lose proximity to the foredune;
- Excessive pedestrian traffic on dunes;
- Inappropriate seawalls and the like; and
- Lowering of the sea bed by the removal of boulders.

Goldsmith considered that the best option for remediation was to reduce the adverse human impacts, and encourage the return and redevelopment of a healthy well vegetated dune system to act as a natural buffer against erosional storm events.

The then Taranaki Catchment Commission (TCC) also produced a report in 1978 entitled

'Oakura Foreshore Erosion'. The TCC report concluded that Oakura is a valuable recreational area for Taranaki people, and New Zealanders in general, its uniqueness and ease of access promoting the beach as one of the most popular in the province, and that the beach must therefore be protected as a national asset. It was noted that the high energy coast generally accreted in summer and eroded in winter, with large profile variations, but that the right conditions [waves, winds and tides] could result in large daily variations. The beach lacks an appreciable dune system, and has a negative sediment budget, so therefore seasonal and longer term cycles are overridden by a net loss of sand and ultimate dune toe recession. It was noted that some sections along Messenger Terrace have already lost fifty percent of the original section area and the erosion will continue, endangering buildings and even lives.

TCC(1988) included 1 :2500 aerial photo hazard maps. Oakura was included in this report and the Coastal Hazard Zone adopted for the northern end of the beach was 33 m, which essentially equated to the seaward edge of the Messenger Terrace roadway. The TCC 1988 report noted that:

- photogrammetric data suggests that the beach is essentially stable with small localised areas accreting or eroding, and that erosion associated with stream mouths and access points is more significant than the marine processes;
- most of coat fronting Messenger Terrace has been stable with a slow rate of erosion (-0.2m/year 1940-1981) with some movement around the mouth of Wairau Stream;
- the stability of the beach is surprising considering the amount of rock and boulders removed to build the breakwater at Port Taranaki; and
- Oakura Beach marks a change on the coast, from erosional beaches to the northeast, to stable or slowly accretional beaches to the southwest.

Natural accretion rates of between +1.27 and +0.4 m/year (1950-1981) were observed (TCC, 1988).

TCC erosion map 1775/15 (Oakura) (aerial photo 1981, Appendix III) (as summarised on Taranaki coastal series 4, Appendix II) noted that east of the Waimoku Stream, much of the coastline is stable or accreting artificially, with a mean rate of -0.20 m/year (1950-1981). West of the Waimoku Stream, the coast accreted between 1950 and 1970, however between 1970 and1981, it eroded at a mean rate of -0.67 m/year with a maximum rate of -1.00 m/year (1970-1981).

Between the Oakura River and the Wairau Stream, Oakura Beach is predominantly backed by a coastal cliff/terrace, which forms the backshore. The exception to this is where houses have been built seaward of the coastal cliff/terrace [sections 1 to 17]. Erosion and or retreat of the coastal cliff/terrace is considered to be a permanent loss. Erosion of the coastal cliff/terrace at Oakura can arise from several influencing factors. Terrestrial erosion can result in the retreat of the coastal cliff/terrace through weathering, down slope movement, and erosion from water run off. Terrestrial erosion is considered to be a minor component influencing the retreat of the coastal cliff/terrace at Oakura. Direct wave attack is considered to represents the highest potential for the retreat of the coastal cliff/terrace at Oakura Beach. Wave attack of the coastal cliff/terrace can arise in two forms. Under prolonged erosion conditions the protective sand berm can be eroded exposing the toe of the coastal cliff/terrace to the erosion processes of wave action. However, the coastal cliff/terrace may also be eroded by extreme storm surge events overtopping the sand berm therefore directly attack and eroding the coastal cliff/terrace at the back of the beach (TRC, 1998).

McComb et al (2005) undertook detailed topographic surveys of the Oakura Beach. The report concluded that historical data clearly indicate that the Oakura shoreline is dynamic, exhibiting periods of erosion and accretion during the 54 years covered by the aerial photographs. In front of the camp ground, much of the measured accretion is due to leveling and reclamation in the region of the Holiday Park. Along the section to the west of the camp the shoreline has experienced an average retreat of 0.1 m/year, and the total erosion was 3.1 m since 1970 (averaged over the entire section). It is probable that the dunes in this area were modified between 1970 and 1981, and the clay fill may be seen in the present day erosion scarp. It is likely that current erosion of the dunes in this area (i.e. where the recent dune management has been undertaken by the NPDC) is simply the re-establishment of the equilibrium beach position.

d. Recommendations for further information gathering

1. Paritutu

It is recommended that the map derived by the TCC work for the Paritutu stretch of coast be updated using 2007 aerial photos (i.e. method 1 of the methods outlined in section 2.7). This stretch of coast is indicative of the coastal unit as a whole, and is therefore appropriate for state of environment monitoring.

2. Oakura

There are three components to the recommendations for Oakura:

- Develop a consent monitoring programme in conjunction with the structures licenced to property owners on the seaward side of Messenger Terrace (TRC, 2008). This would complement the consent monitoring required of NPDC for their structures. It could include the use of the beach profile established by Cowie et al, (2009).
- Update the TCC Oakura map (2 km of coast) using 2007 aerial photos and information from McComb et al (2005) (i.e. method 1 from section 2.7).
- Establish a baseline of information for the stretch of coast beyond Oakura which is subject to current and future subdivision pressures. It is recommended that a stretch of cost from 1 km past Oakura River down to lower Pitone Road (a total length of 4.7 km). This would see the establishment of a baseline (i.e. method 2 or 3 of the methods in section 2.7) for this stretch of coast.

3.5 Stony River to Cape Egmont

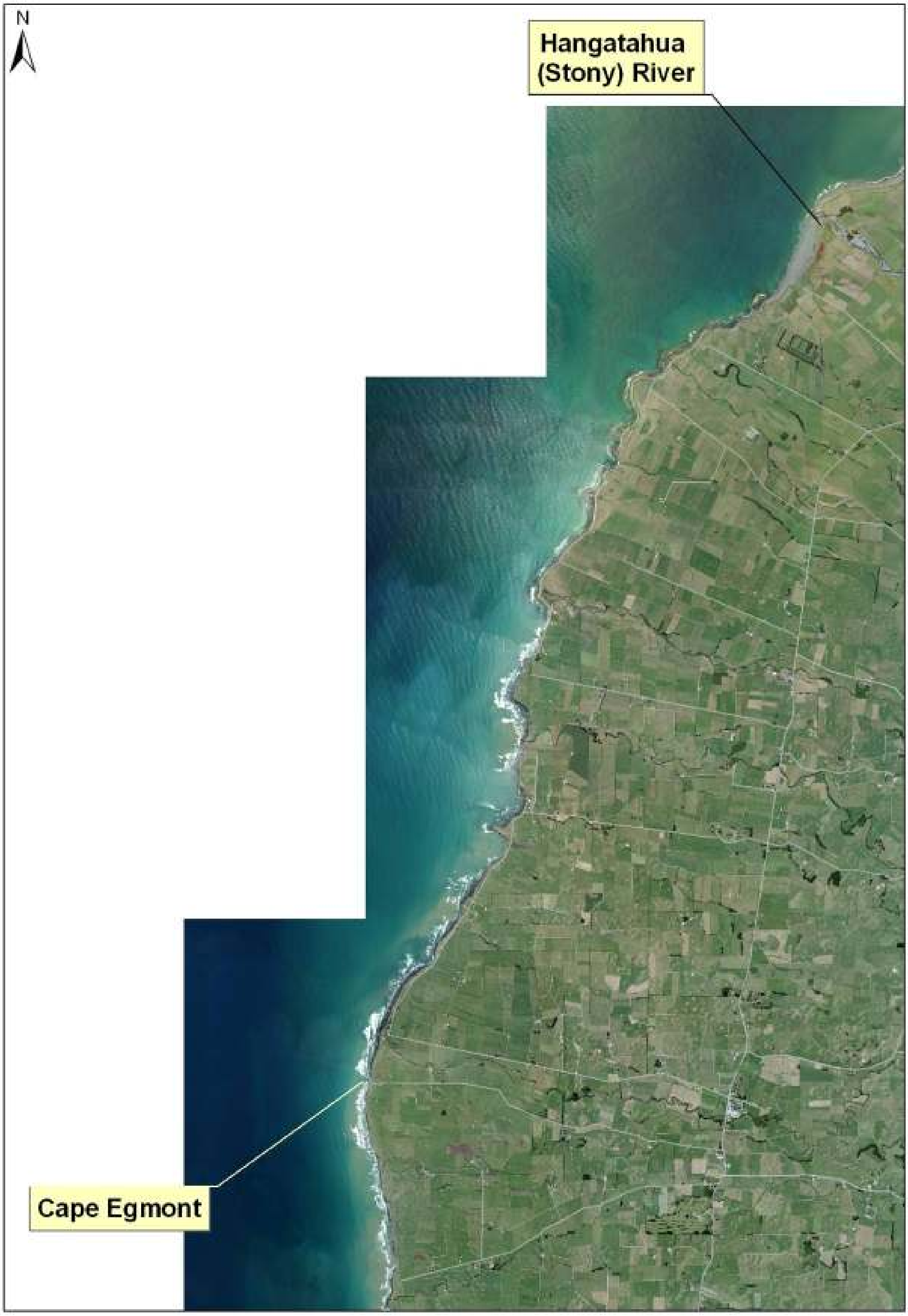


Figure 6: South of Stony River to Cape Egmont

a. Description of the area

This coastal unit extends from the Hangatahua (Stony) River (including also the stretch of coast immediately east of the mouth of the Stony River which is strongly influenced by sediment from the river) to Cape Egmont (the southern boundary of the New Plymouth District). It is a surf coast with numerous high quality surfing breaks. The coastal unit is predominantly a rugged rocky coast backed by smaller coastal cliffs, rocky foreshores and extensive offshore reefs. The exception is Komene Beach on the south west flank of the Stony River delta. In terms of erosion, this section of the Taranaki coastline is relatively stable, largely because of the extensive reef systems offshore, however, it is an erosive landform.

Hangatahua (Stony) River coastline, November 2008

Massive amounts of sediment from the eroding Hangatahua (Stony) River catchment enter this section of coast. Research is being conducted by Masters student, Nicola Cowie, into the changes to coastal geomorphology from this slug of sediment into the system. She has good data on coastal changes from aerial photo analysis and beach profiles and good data on sediment characteristics (sediment texture, mineralogy) and offshore substrate data. The research involves undertaking sediment transport modelling and a sediment budget.

Since the initial collapse in 1998, the adjacent coastal shoreline has experienced a continuous influx of dense 'black' titanomagnetite-rich volcanic sands from the Stony River. These sediments are being rapidly transported to the north-east by the energetic wave climate, creating upper-shore sandy beaches on what is normally a rocky boulder coast devoid of sand (Cowie et al, 2009).

This study focuses on onshore geomorphology and sediment characteristics of this coast in June, September and November 2008. Results indicate that there has been a decrease in the beach sediment volume and mean grain size with distance north-east of the Stony River. This "sand lens" is predominantly transported only when high tides coincide with energetic wave conditions.

b. Assets, pressures and coastal protection

There are a number of coastal residences on Maori land between Bayly Road and Pungarehu Road.

The whole coast line has high recreation values (particularly for surfing) and this has led to an increase in subdivsions. For example there has been recent subdivisions at Puniho Road, Porikapa Road, Stent Road/Coast Road, and Bayly Road/Anglers Ave. The South

Bayly Road seawall looking south

Taranaki District Council has recently amended the status of subdivision in the coastal protection area, making it discretionary rather than a controlled activity. They anticipate that this will slow down the rate of subdivision along this stretch of coast.

Assets include Cape Egmont Boat Club and the Bayly Road Boat Ramp, Waikirikiri Komene Lagoon (Significant Natural Area) and the Warea Redoubt. The Bayly Road boat ramp is a modified turanga waka.

In terms of coastal protection works, there is an STDC seawall on the coast at the end of Bayly Road.

c. Existing estimations of coastal erosion

Gibb (1979) undertook erosion rate work for this stretch of coast. His results are summarised in Table 15.

Table 15: Gibb (1979) erosion rates:

	m/year	years	Comments
Stony River	+1.53	1970-1981	
Stent Road – north of	+0.14	1881-1953	This suggestion of accretion at these sites is surprising, and brings into question this work, suggesting that an update is timely.
Stent Road – south of	+0.28	1881-1953	
Warea Road	+0.19	1881-1953	

An application for a subdivision at the end of Porikapa Road (Warea) compared the current position of the mean high water mark to that when it was last surveyed (around the 1890s) and concluded that there had been little movement of the coastline (Juffermans Surveying Ltd, letter to STDC dated 10.12.03). This was attributed to the hard sandstone layer on the land, which is stable and forms a 'seawall'.

TCC erosion map (based on 1981 aerial photo) 1773/16 notes (as summarised in Taranaki coastal series map 5, Appendix II), that the entire coastal section is accreting due to the sediment input of the Stony River. However, the new land is largely comprised of sand dune deposits and is susceptible to wind erosion if the vegetation cover is broken. Mean rate of accretion is +1.53 m/year (1970-1981), maximum rate, 1970-1981 of +2.18 m/year, or a maximum rate of +0.97 m/year (1903-1981).

Cowie et al, (2009) established beach profiles and used aerial photos from 1997 and 2007 to calculate comparisions of the coast before and after the erosion event in the Hangataua (Stony) River. Beach profiles included one immediately south of the Stony River, one immediately north of the river, one 3 km north of the river (Kaihihi surf beach), one at Ahu Ahu Beach (11 km from the Stony River), two at Oakura Beach and one at Back Beach (Paritutu) (approximately 22 km north of the Stony River).

d. Recommendations for further information gathering

1. Cape Egmont to Puniho Road

There is currently only sketchy information on erosion rates of this section of the coast. It is recommended that to establish a baseline of information, that a 10 km stretch between Cape Egmont and Puniho Road be examined in terms of historic rates. This would involve use of method 2 or 3 from section 2.7 above.

2. The Stony River

There is already a sound baseline of information from the Taranaki Catchment Commission on the accretion of the coastline at the mouth of the Stony River. This has been supplemented with the establishment of beach profiles through the student research being undertaken. As the most accretional land form in coastal Taranaki, this site has significance for state of environment monitoring. It is recommended that the following be undertaken:

- An update of the TCC information (using method 1 described in section 2.7);
- Extension of the aerial survey work to Kaihihi Road; and
- Incorporating of beach profile data into BPAT software for future monitoring.

It is recommended that this cover the extent of coast in the TCC series map to Kaihihi Road.

3.6 Cape Egmont to Mangahume Stream (south-east of Opunake)

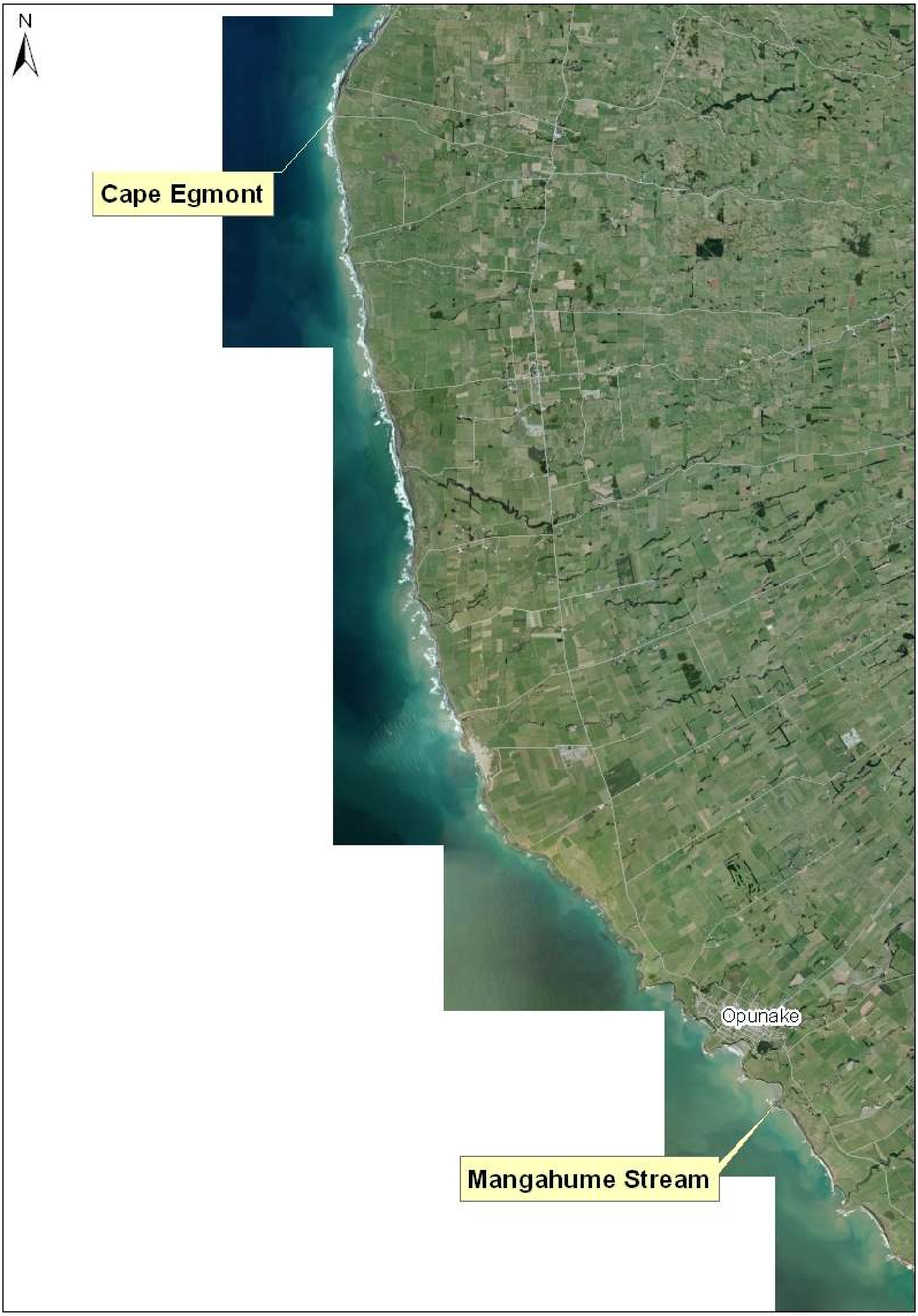


Figure 7: Coastline from Cape Egmont to Mangahume Stream (south-east of Opunake)

a. Description of the area

The lahar section of coast from Cape Egmont to Opunake is a rugged coastline dominated by coastal cliffs, rocky foreshore and extensive offshore reefs. This section of the Taranaki coast receives the full force of the dominant south-westerly swells. Where there are relatively thick laharic beds, the cliffs are least affected by erosion, but where there are relatively thick ash beds and thin laharic beds, the cliffs can fail, collapsing onto the boulder beach below. Such landslip leads to a net retreat of the clifftop.

There is a significant sandy coastline between Tipoka Road and Tai Road (Sandy Bay), an unusual feature on this section of coast. There is limited access to the coast via road ends.

At Opunake, seacliffs form adjacent promontories NW and SE of Middleton Bay. There is evidence of erosion of these headlands, but it is unclear if they are indicative of other headlands.

b. Assets, pressures and coastal protection

There has been increased pressure for subdivisions for rural/coastal living along this section of coast. For example, there have been recent subdivisions at Tipoka Road, Tai Road Oaonui, and Arawhata Road, Opunake, and a subdivision at Mangahume Stream which is immediately adjacent to a cliffed coastline.

Other assets include the House for Karen and the Opunake Wastewater Treatment Plant. At Opunake there is the Opunake Beach camp and boat ramp.

In terms of coastal protection works, there has been minor toe protection carried out at Opunake Beach, and a seawall associated with the boat ramp at Middleton Bay. These structures are subject to a compliance monitoring programme (TRC, 2008b)

Retaining wall at Opunake Beach

Another feature with potential influence on coastal processes is the partially completed Opunake Beach surf reef.

At Middleton's Bay a number of local factors have been identified that contribute to erosion:

- periodic discharge of stormwater through a breach in the foredune allowing stormwaves to locally erode the dune;
- surface runoff in the parking area adjacent to the commercial fishing shed eroding the dune scarp;
- groundwater outflow adjacent to the fishing shed lowering beach levels;
- seawall at SE of the Bay locking up sand that would otherwise be available to the beach;
- minor end effects during very severe wave storms; and
- trail bikes and occasional uncontrolled pedestrian traffic destroying dune-binding vegetation on the face of the foredune.

c. Existing estimations of coastal erosion

Gibb (1979) calculated erosion rates for this section of coast. His results are summarised in Table 16.

Table 16: Gibb (1979) erosion rates:

	m/year	years	Comments
Tipoka road	-0.55	1937-1959	
Waiare stream (north)	-0.91	1937-1959	
Pehu stream	+1.14	1880-1959	
Oaonui	0	1881-1950	

At Middleton Bay:
Clifftop retreat of the seacliffs at each end of Middleton Bay between 1959 and 1997 was 1-10 m/year, with net annual rates of -0.03 to -0.26 m/year. Adjacent to the sewage pump station on the SE promontory, long term erosion rates are of the order of -0.20 to 0.25 m/year (Gibbs, 2002).

Beach erosion occurs in Middleton Bay during E-SE gales and accompanying short, steep SE swell. Sand is transported offshore exposing an underlying boulder beach. The eroded sand is then transported clockwise in the Bay forming a subtidal sand bar attached to the SE headlined. During W-SW swell conditions, sand is transported onshore and the boulder substrate is buried beneath accreted beach sand. Dune formation would take place during strong SW winds after the formation of a relatively wide dry backshore on the beach (Gibbs, 2002).

Ground photos provide qualitative indication of changes over 3.7 years (1998-2002) – approximately 1-2 m of dune retreat NW of washout, and 5-8 m retreat adjacent to the commercial fishing shed.

Tai Road and Arawata Road
For the Sandy Bay area, rates of erosion at Tai Road were estimated through using survey lines of the 1918 and 1977 cliff edge and then estimating the probable cliff edge in 2104 (BTW surveyors limited, Dec 2004). This concluded that the erosion rate to the Esplanade Reserve boundary, 2 m back from the cliff is -0.8 m/year, and then from that point a rate of -0.2m/year will occur.

Around the Arawata Road end, Willis (2006) plotted survey lines from 1977 and 2005 and from this derived erosion rates (ranging from -0.21 m/year to -0.11 m/year) and from this estimated the coastline in 50 years using erosion rate of -0.21 m/year.

d. Recommendations for further information gathering

<u>1. Opunake</u>
The top priority for additional information gathering is around Opunake. This area is an important recreation site and where the majority of development is, and where most likely to occur in the future. Of particular interest is what is happening to the headlands, which perform a protection function for the beaches of Opunake.

In specific relation to Middleton's Bay, Gibbs (2002) noted that 'If it is necessary to accurately quantify the erosion rate, then a precise ground survey could be conducted and the present duneline and cliffline positions plotted on the existing survey plan at 1:1,000 scale (file no. 1015103) prepared by RHB Gilberd, Registered Surveyor in September 1998. Plan is held by STDC and shows cliffline, duneline and MHWM positions between 1959 and 1997'.

There is a component of compliance monitoring at Middleton Bay (TRC, 2008b) for the structures there.

This report recommends that baseline coastal erosion rate information be gathered for a stretch of coast off Opunake, between Heimama Stream and Mangahume Stream (a total of 4 km). This would involve use of either method 2 or 3 described in section 2.7.

2. Tai Road subdivision at Sandy Bay

While a good baseline of information has been established through work undertaken for the subdivision consent applications, this area should be included in the state of environment monitoring work. It is therefore recommended that the stretch of coast between Oaonui Stream amd Teikiwanui Stream (approximately 1.5 km) be surveyed using either method 2 or 3 described in section 2.7.

3. Arawata Road subdivision area

While a good baseline of information has been established through work undertaken for the subdivision consent applications, this area should be included in the state of environment monitoring work. It is therefore recommended that a short stretch (approximately 2 km) be surveyed using either method 2 or 3 described in section 2.7.

3.7 Mangahume Stream (South-east of Opunake) to Inaha Stream

Figure 8: Coastline from south-east of Opunake to Inaha Stream

a. Description of the area

The section of coast from Mangahume Stream to Inaha Stream is the final section of the lahar coast (Figure 8). It is a cliffed coastline dissected by numerous ring plain rivers and streams. Cliffs west of Inaha Stream are dominated by volcanic geology forming part of the Taranaki Ring Plain (Browne, 2004). There is only limited access from numerous road ends and access to the numerous surf breaks is accessed through privately land at the good will of the land owners.

There is a small area of sand dunes (around the mouth of the Kaupokonui Stream) which is unusal for this coast. There are also highly significant historic sites associated with this area (moa hunters' middens).

b. Assets, pressures and coastal protection

There are subdivisions along South Road between Waiteika Road and Opunake. These subdivisions have a generous setback of about 200 m.

Historically there was extraction of 36,600 m^3 of gravel 1945-1960 from Raine Rd (Gibb 1979). There are no coastal erosion protection structures along this section of coast.

There is one settlement Kaupokonui Beach.

c. Existing estimations of coastal erosion

Gibb (1979) calculated rates of erosion for this section of coast. His results are summarised in Table 17.

Table 17: Gibb (1979) erosion rates:

	m/year	years	Comments
Punehu	0	1920-1976	
Pihama	0	1920-1976	
Glen Road	0	1920-1976	
Normanby Road	-0.16	1879-1930	
Winks Trig	-0.34	1872-1976	
Raine Road	-1.11	1940-1976	extraction of 36,600 m^3 of gravel 1945-1960.

One site in this area assessed for coastal erosion rate for the Kupe AEE (Location 5 – shore crossing site). Cliff regression at shore crossing site for Kupe was calculated as 0.1 m/year (average) ranging from 0-0.2 m/year (Maunsell Ltd, 2004).

d. Recommendations for further information gathering

It is recommended that baseline erosion rate information be gathered for a small stretch on either side of the Kaupokonui River (~3 km) using method 2 or 3 from section 2.7. This stretch includes the area of sand dunes around the mouth of the Kaupokonui (a highly significant cultural historic site) and a section of cliff. This would establish a baseline for future monitoring. From this information, it would then be feasible to determine how relevant the work undertaken for the Origin Energy Horizontal Drilling Site (Maunsell, 2004, discussed more fully in the following section) is for this section of coast.

3.8 Inaha Stream to just above Patea

Figure 9: Inaha Stream to just above Patea

a. Description of the area

The transition from ring plain volcanic cliffs to marine sediment cliffs occurs around the general Inaha Road area, thus this next coastal unit, from Inaha to Patea is part of the 'papa coast'. The coastal cliffs are comprised of soft and easily eroded sedimentary rock – mainly mudstones and sandstones (Browne, 2004). The shoreline is one of sand beaches with some papa reefs (Rush, 2006), and an almost continuous cliff with limited beach access at lower stages of the tide. The coastal cliff is dissected at three locations by three main rivers, Waingongoro River, Tangahoe River and Manawapou River. Coastal cliffs of the South Taranaki Bight have attracted numerous geological investigations over the years on account of prolific abundance of marine fossils.

For example, the main Hawera beach, Ohawe Beach is backed by 10m high cliffs eroded into alluvial sediments. It is comprised of steep high tide beach – sand and coarse gravel, and a horizontal low tide beach covered by sand and mantle of cobbles and large boulders Single (1996).

Te Rangatapu Reserve at Ohawe is of great significance to the Ngā Ruahine-Rangi iwi (Single 1996).

Cliffs are retreating, as waves lapping at the cliff base at high tide destabilise the steep faces, which then fall away catastrophically. Compounding the process is groundwater seepage through the seacliffs. The fallen material provides temporary relief from further cliff erosion as it keeps the waves away from the base of the cliff (Rush 2006).

b. Assets, pressures and coastal protection

This section of coast is characterised by cliffs with little pressure or development. The key strategic assets along this stretch of coast include:

- Origin Energy pipelines (through the horizontal directional drilling site);
- Ohawe village and boat ramp; and
- The Fonterra/South Taranaki District Councl wastewater outfall.

In addition, there is the Oeo marae, pipeline corridor close to the coast, redoubts around the mouth of the Manawapou river, the Manaia wastewater treatment plant and wellsites between lower Manutahi road and Patea.

Historically there was extraction of 14,000 m^3 of gravel 1940, Manawapou south (Gibb 1979), and quarrying of sands and graves from Ohawe beach prior to 1955 and during the 1960's (Single, 1996).

In terms of coastal protection, there are two groynes at Ohawe beach formed by relocation of natural boulder cover in 1965 to provide sheltered area for boat launching. In 1996 the western groyne was intact and the eastern groyne was disjointed. Single (1996) concluded that it was unlikely that the groynes in themselves had had a detrimental effect on the cliffs of Ohawe and also unlikely that they have protected the cliffs from erosion. Fontera have a small (1-200m) boulder seawall to protect the cliff from erosion at their outfall location.

c. Existing estimations of coastal erosion

Gibb (1979) calculated erosion rates for this section of coast. His results are summarised in Table 18.

Table 18: Gibb (1979) erosion rates

	m/year	years	Comments
Ohawe Beach (north)	-0.63	1871-1966	
Ohawe beach (south)	-0.63	1871-1966	
Ohawe beach (south)	-1.29	1945-1960	
Hauroto Road	-0.32	1902-1930	
Siggs trig	-0.60	1908-1958	
Manawapou (north)	-0.64	1974-1976	
Manawapou (north)	-1.0	1953-1976	
Manawapou(south)	-0.67	1874-1976	extraction of 14,000 m^3 of gravel 1940
Manawapou (south)	-0.87	1953-1976	
Manutahi Road	-0.42	1874-1927	
Power House Road	-0.05	1901-1976	

For Ohawe Beach Gibb (1978) found retreat of 51 m between 1871 and 1959, and 9 m between 1959 and 1966, giving annual rates of retreat of 0.58 m/year and 1.29 m/year respectively, and a long term average of 0.63 m/year. For the lower Pleistocene cliffs the total retreat between 1871 and 1966 was 60 m giving a long term rate of 0.63 m/year (Gibb 1978).

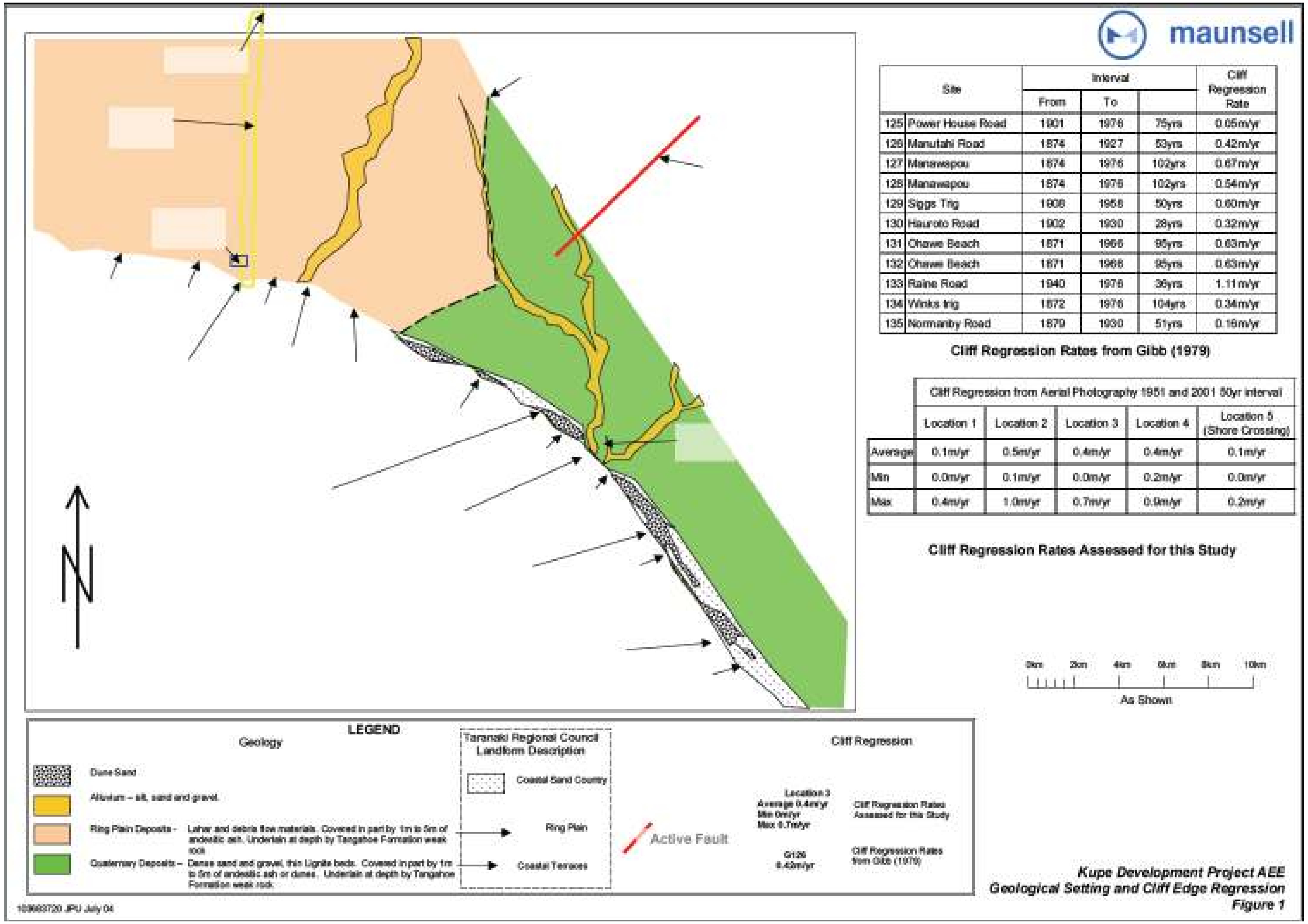
Long term rate of cliff retreat calculated from map (1871) and aerial photos (1951, 1972, 1984 and 1993 and field measurements of 1996) a long term rate of cliff retreat of 0.48 m/year was calculated Single (1996). The rate of retreat between 1951 and 1996 was markedly less than earlier rates of retreat at 0.12 m/year. The long term erosion rate appears to have slowed down between 1951 and 1984 (average of 0.03 m/year) but more rapid since 1984 (0.35

m/year). Localised erosion from the car park by the boat club between 1984 and 1996 estimated at about 0.58 m/year.

Maunsell Ltd (2004) describe the cliffs along the coastal section between Inaha and Patea as actively regressing. Previous work indicates an erosion rate of 0.05m/year to 1.11m/year (Gibb, 1979). For the Kupe project, aerial photography from 1951 and 2001 was viewed and the coast location plotted at the same scale for each of the five sites in the project (four sites located within this coastal unit). Five locations investigated with the average erosion rates ranging from 0.1 m/year to 0.5 m/year and the maximum rates ranging from 0.2 m/year to 1.0 m/year (see Table 19 and Figure 10, taken from Maunsell Ltd 2004). The erosion rates calculated through this work were consistent with the rates derived by Gibbs. This indicates that the erosion rates calculated for this specific stretch of coast could be extrapolated to the entire stretch of coast between Inaha to Ohawe, although the most conservative rates should be used.

Table 19: Cliff regression from aerial photography 1951 and 2001, 50 year interval

	location 1	location 2	location 3	location 4
Average (m/year)	0.1	0.5	0.4	0.4
Min (m/year)	0.0	0.1	0.0	0.2
Max (m/year)	0.4	1.0	0.7	0.9



	Site	Interval From	Interval To		Cliff Regression Rate
125	Power House Road	1901	1976	75yrs	0.05m/yr
126	Manutahi Road	1874	1927	53yrs	0.42m/yr
127	Manawapou	1874	1976	102yrs	0.67m/yr
128	Manawapou	1874	1976	102yrs	0.54m/yr
129	Siggs Trig	1908	1958	50yrs	0.60m/yr
130	Hauroto Road	1902	1930	28yrs	0.32m/yr
131	Ohawe Beach	1871	1966	95yrs	0.63m/yr
132	Ohawe Beach	1871	1966	95yrs	0.63m/yr
133	Raine Road	1940	1976	36yrs	1.11m/yr
134	Winks trig	1872	1976	104yrs	0.34m/yr
135	Normanby Road	1879	1930	51yrs	0.16m/yr

	Cliff Regression from Aerial Photography 1951 and 2001 50yr interval				
	Location 1	Location 2	Location 3	Location 4	Location 5 (Shore Crossing)
Average	0.1m/yr	0.5m/yr	0.4m/yr	0.4m/yr	0.1m/yr
Min	0.0m/yr	0.1m/yr	0.0m/yr	0.2m/yr	0.0m/yr
Max	0.4m/yr	1.0m/yr	0.7m/yr	0.9m/yr	0.2m/yr

Figure 10: Erosion rates calculated around the Origin Energy Horizontal Drilling Site. From Maunsell, 2004.

d. Recommendations for further information gathering

1. Around Inaha – the Origin Energy horizontal drilling location.

The erosion rate work undertaken by Origin Energy (Maunsell, 2004) as part of their resource consent application for the Kupe Project provides a sound baseline for future erosion rate monitoring. It is recommended that method 2 or 3 of section 2.7 be used to survey a short stretch of the coast on either side of Inaha (approx 2.5 km from Orangi Tuapeka to Raine Road) in collaboration with Origin Energy.

2. Around the Fonterra outfall

Given the strategic importance of this asset, monitoring erosion rates around the structure should be undertaken through the consents monitoring programme. Monitoring is a requirement of the consent for this structure. A short stretch on either side of the outfall (approx 2.5 km) should be surveyed using either methods 2 or 3, and possibly even 4 given the importance of this asset.

3. Ohawe beach

Given the proximity of Ohawe Beach to the Origin Energy site above, information gathered for that site could be extrapolated to the Ohawe beach site. A short section of the Ohawe Beach coast should be surveyed using method 2 or 3 to assess how comparable the Origin Energy data is.

3.9 Patea to Waitotara

Figure 11: Patea to Waitotara coastline

a. Description of the area

The stretch of coast in South Taranaki from Patea to Waitotara is quite a different type of coastline from the rest of Taranaki as it is composed of a mixture of coastal cliffs and sandy beaches (Figure 11).

The coastal cliffs are comprised of soft and easily eroded sedimentary rock – mainly mudstones and sandstones. This rock is commonly referred to as 'papa'. Just off the coast exist some papa reefs (Rush, 2006).

Southeast from Patea the dominance of the coastal cliffs gives way to sand beaches backed by dunes and sand country, with the exception of coastal cliffs from Waipipi to Caves Beach area, and the cliffs east of Waiinu.

Cliffs are retreating, as waves lapping at the cliff base at high tide destabilise the steep faces, which then fall away catastrophically. Compounding the process is groundwater seepage through the sea-cliffs. The fallen material provides temporary relief from further cliff erosion as it keeps the waves away from the base of the cliff (Rush 2006).

Because of fairly uniform and non-resistant nature of the rocks along the coast, promontories or sea stacks are seldom produced. If present they are small and short-lived features. At Waverley Beach the sea has carved picturesque caverns and ravines from the mudstone in the cliff. Such features occur at zones of weakness, such as faults or joint planes. There are a few fault zones intersecting the coastline (Rush 2006).

The Patea River mouth is a highly dynamic section of this coastal unit, strongly influenced by the river mouth and the moles. There is both significant erosion and accretion happening on either sides of the river.

The beach and dune topography of the north beach at Patea is a result of human activities – controlling of the rivermouth for navigation purposes which led to sand aggregation. Shand (2006) describes three areas of the north beach at Patea – a northern sector characterised by a pingao foredune with severe blow outs, a certral sector which is protected from sand blow outs by the green waste platform, and the southern sector with isolated dune hummocks, backed by the green waste platform. The main issue of concern in this area is the management of sand blown into dwellings and utilities.

b. Assets, pressures and coastal protection

The Waverly, or Caves Beach settlement has about 40 residential dwellings located within 30-75 m of the coastal cliffs at potential risk from coastal erosion. Further development is not envisioned in this particular reach of the coast.

The new coastal subdivision at Waipipi at the end of Waverley Beach Road has been set back greater than 100 m from the coastal cliffs.

The Wai-inu Beach settlement is situated greater than 100m from the coast thereby minimising the coastal erosion hazard risk.

Gas pipelines across Patea estuary are a key asset vulnerable to coastal and estuary processes. There has been a long history of erosion in the Patea River estuary – as evidence by old protection works (STDC, 1990). There is a cyclic pattern to sand levels in the Patea estuary (file notes in STDC, 1990). In 1974 the houses close to the shoreline were threatened with advancing sand and remedial action was taking by planting the sand area with marrum grass. This area was then dramatically eroded in the 1970's. 200 tonnes of rock was placed in a line about 8 m in front of the eroding dune.

In the 1980's 6,000 m^3 of sand was placed on the foreshore in an attempt to restore a sand spit to the estuary area and so protect the gas pipeline. In the late 1990's a gap between the seawall and wave guide was filled to allow sand build up in the 'Pipe line Bay'. Build up of sand was noticed after completing this work. Floods in 1990, or possibly even earlier, caused considerable erosion that may have been exacerbated by the filling of the gap in the seawall – or it may have existed before the heavy floods.

Historic iron sand mining occurred at Waipipi between 1971 and 1989.

c. Existing estimations of coastal erosion

Gibbs (1979) undertook some erosion rate assessment. His results are summarised for this stretch of coast in Table 20.

Table 20: Existing estimations of coastal erosion from Gibbs 1979

	m/year	years	Comments
Patea (north)	+0.99	1872-1976	
Patea(north)	+2.05	1939-1976	
Patea (south)	0	1872-1976	
Patea (south)	-0.85	1905-1976	

Trig 'T'	-0.72	1904-1954	

During the application for the subdivision at Waipipi, cliff survey in 1906 was compared with that surveyed in 2005, and indicated that the coastal cliff edge has eroded back approximately 35 m in the last 100 years to the north of Wairoa Stream with a somewhat greater erosion rate to the south of Wairoa Stream. This gave an average rate of approximately 0.35 m/year (similar to the general erosion rates calculated for Mowhanau beach (just out of Wanganui) by Johnsone of 0.35 m/year and rates calculated by Gibb of 0.7 m/year (MWH, 2006).

Aitkinson (2003) (cited in Rush, 2006), noted that the Patea River will likely break through behind the southeast mole and the river entrance will be lost entirely, due to the ongoing retreat of the coast to the southeast.

Coastal resources maps exist for the Waitotara River mouth, the Wainui Beach west, Wainui Beach east and Ototoka Stream. These were prepared by the Department of Lands and Survey in 1983 and appear to be based on 1982 and 1942 aerials. The 1800 cadestral lines are included on the maps, but it is unclear if these are based on toe of foredune or top of cliffs.

Shand (2006) investigated the coastal processes occurring around the Patea River mouth for an application by South Taranaki District Council for a consent for the control of sand movement at Patea Beach using various techniques, including the use of vegetative material to trap sand. This investigation included study of all available vertical and oblique aerial photos, digitising them and transforming features using standard photogrammetric procedures. The report summarises the history of sand stabilisation in the area, particularly to the north of the river mouth. This highlighted that the effects of the sand stabilisation works, particularly through depositing green waste on the sand areas, has led to the establishment of a green waste 'platform' between the original cliff and the crest of the original foredune.

d. Recommendations for further information gathering

1. Caves Beach, Waverley

This area is a priority for further information because there is a residential settlement close to the coast, and there is little existing information. It is recommended that a baseline needs to be established for a stretch of coast of approximately 1km by the Caves Beach settlement area, using either methods 2 or 3 described in section 2.7.

2. Patea river mouth

The Patea River mouth is a priority area for monitoring because of the dynamic and changing nature of the area, coupled with the assets there. Monitoring requirements at the Patea river mouth are a combination of site specific beach profile monitoring to assess the impacts of the groynes, the sand trapping programme being carried out though the use of dumping green waste (STDC, 2007) and broader state of environment monitoring to assess the impacts of the training moles on regional erosion rates. The following recommendations are made:

- Compliance monitoring of the effects of the groynes, and green waste dumping programme through beach profiles; and
- The establishment of baseline coastal erosion information using method 2 or 3 for a stretch of coast on either mouth to determine the magnitude of natural changes in

shoreline position away from the influence of the mouth, and so to determine the true effects of the river training structures.

However, it is noted that risks to the Patea Beach settlement from flooding and storm surges would not be addressed through the monitoring described above. This report has not endeavoured to make recommendations for work necessary to assess or monitor risks from storm surges.

3. Waipipi subdivision area

While the Waipipi subdivision was based on calculations of erosion rate by survey, and is set back from the coast, there would be value in including a short stretch in the regional monitoring programme using either method 2 or 3 in order to establish a base line for future monitoring. This could be combined with number 1 above.

4. Wai-inu Beach settlement

While probably more stable than the Caves area, it would be worthwhile obtaining baseline information on the erosion rates of the coast by Waiinu Beach using either method 2 or 3. This is of lower priority than the stretches above.

4 Summary of recommendations

This report has identified four ways of obtaining updated coastal erosion rate information for the region, targeting priority stretches of coast where there is either existing information to build on, or a level of pressure from development. These were discussed in section 2.7:

- Method 1: Updating existing erosion rate information using the work undertaken by the Taranaki Catchment Commission in 1987 and using the 2007 aerial photos;
- Method 2: Calculating historic erosion rates using aerial photos from the 1940s and 2007;
- Method 3: Establishing a baseline of coastal erosion rates using all historic information, including early cadastral information and aerial photos; and
- Method 4: Calculating erosion rates using on-the-ground survey.

The primary objective of the state of environment monitoring programme is to derive an estimation of the regional rate of coastal erosion. Thus it is intended to extrapolate information obtained for the specific reaches identified to the rest of the coastal unit. The recommendations in this report are no substitute for more detailed monitoring of specific sites or for more detailed investigations using site specific surveying prior to development such as subdivisions.

The report has recommended either method 2 or 3 for stretches of coast without previous information. It is proposed that prospective tenders would provide cost estimates for undertaking the two levels of accuracy allowing the councils and relevant corporate partners (such as Transit, STOS, Origin Energy or Fonterra) to select the method according to both the level of accuracy required and the estimated cost.

The work of Gibb in 1979 provides some clues as to what historic data is either available or has been previously deemed reliable (Appendix I), i.e. for specific sites he selected the years on which to base his estimates, and presumably this was based on the availability and accuracy of the historic information available. This will assist with identifying the level of work required to undertake method 3 for particular stretches of coast.

Table 21 sets out for each stretch of coast recommended in this report the length of coast, which method has been recommended and grid references for each reach (data in document #674778 and GIS files: coastal points to and from in GIS\Policy and Planning\coastal points).

The next steps for this project will be to seek tenders from coastal consultants to undertake the work recommended.

Table 21: Summary of recommendations

Coastal unit	Reach	Approx length (km)	Method	From		To	
				NZTM easting	NZTM northing	NZTM easting	NZTM northing
Mokau to Pariokariwa point	Tongaporutu	2.5	1	1737793	5703562	1737793	5703562
	Whitecliffs	2.0	1	1735786	5699149	1735786	5699149
	Te Kuwhatahi	3.0	2 or 3	1739320	5708911	1739320	5708911
Pariokariwa Point to Waiau Stream	Urenui	2.0	1	1720912	5683767	1720912	5683767
	NE Urenui cliffs	1.3	2 or 3	1722133	5684426	1722133	5684426
	Onaero	2.0	1	1717438	5684083	1717438	5684083
	Wai-iti	2.0	2 or 3	1727169	5689886	1727169	5689886
	Mimi	1.8	1	1725129	5687253	1725129	5687253
Waiu Stream (east of Turangi Rd) to the Port	Waitara West	1.5	1	1704695	5684489	1704695	5684489
	New Plymouth	2.2	1	1701732	5683502	1701732	5683502
	Bell Block	2.0	1	1699514	5681436	1699514	5681436
	Waiwhakaiho	6.0	1	1695416	5682285	1695416	5682285
	Motunui	2.0	2 or 3	1709794	5683887	1709794	5683887
Port to Stony River	Pariitutu	2.0	1	1687752	5676405	1687752	5676405
	Oakura Beach	2.0	1	1681406	5671284	1681406	5671284
	Oakura to Pitone	4.7	2 or 3	1676907	5668122	1676907	5668122
Stony River to Cape Egmont	Puniho Rd	10.0	2 or 3	1664895	5652420	1664895	5652420
	Stony River	2.5		1670619	5664929	1670619	5664929
	Stony River Kaihihi	1.5	2 or 3	1671267	5664095	1671267	5664095
Cape Egmont to Mangamahume Stream	Opunake	4.0	2 or 3	1674476	5630721	1674476	5630721
	Tai Road	1.5	2 or 3	1668106	5637773	1668106	5637773
	Arawhata Road	2.0	2 or 3	1670509	5635194	1670509	5635194
Mangamahume Stream to Inaha Stream	Kaupokonui	3.0	2 or 3	1692479	5618654	1692479	5618654
Inaha Stream to just above Patea	Inaha	2.5	2 or 3	1701660	5617550	1701660	5617550
	Fonterra	2.5	2 or 3 or 4	1711872	5612572	1711872	5612572
	Ohawe Beach	2.0	2 or 3	1703472	5617187	1703472	5617187
Patea to Waitotara	Waverley	3.0	2 or 3	1740136	5589391	1740136	5589391
	Patea River	4.0	2 or 3	1729198	5595494	1729198	5595494
	Waiinu	2.0	2 or 3	1750409	1739189	1750409	1739189

5 References

Agnew, R. 1976. Beach Investigations for New Plymouth City Council. Fitzroy Sediment Report. Prepared by Smith, McNaught and Company Ltd.

Aitkinson, P. 2003. Stability of Patea River entrance. Contract report prepared for STDC by Duffil Watts and King Ltd [report not seen].

Beaven, D. 2002. *New Plymouth Airport Coastal Erosion Protection Options*. Prepared for New Plymouth District Council by Apex Consultants.

Bell, R; Hume, T. 2002. Climate change impacts on coastal margins. In *Abstracts of Coastal and Storm Hazards, Building understanding of hazards affecting coastal margins*.

Bell, R; Stephens, S; Ramsay, D. 2008. *New Plymouth District – Coastal Hazards and Climate Change.* Report prepared by NIWA for New Plymouth District Council.

Browne, G.H. 2004. *South Taranaki Bight Sedimentary Geology Literature Review*. Prepared for ASR Limited and Maunsell limited.

BTW Surveyors. 2004. Application for subdivision consent – South Road, Opunake.

Cowie, N. A; Healy, T.R; McComb, P.J. 2009. Sediment Flux on the High Energy Taranaki Coast, New Zealand. *Journal of Coastal Research, Special Issue 56, 2009.*

Gibb, J. 1978. Rates of coastal erosion and accretion in New Zealand. *NZ Journal of Marine and Freshwater Research 12 (4): 429-56.*

Gibb, J. 1979*. Late Quarternary Shoreline Movements in New Zealand*. Unpublished PhD thesis. Lodged in the library, Victoria University of Wellington.

Gibb, 1994. Standards and information requirements for assessing coastal hazard zones for New Zealand. Prepared for the Department of Conservation.

Gibb, J.G. 1996. *Strategic Options for the Sustainable Management of Coastal Erosion Along Urenui Beach, New Plymouth District*. Report prepared for New Plymouth District Council.

Gibb, J.G. 1996. *Strategic options for the training moles at the Waitara River Mouth, Tai Haururu, New Plymouth District*. Report prepared for New Plymouth District Council.

Gibb, J.G. 1999. *Performance of the Waitara River Mouth Groynes*. Report to the New Plymouth District Council on the beach profile data from monitoring the east and west gryones [in consent file: NPDC 4600].

Gibb,J. 2002. *Managing Erosion Hazard at Middleton Bay, Opunake, South Taranaki District*. Report prepared for South Taranaki District Council.

Gibb, J. 2005. *Potential threat from seacliff retreat to the Kapuni and Maui pipelines along the Tongaporutu coast, North Taranaki*. Consultancy Report prepared for Natural Gas Corporation, New Plymouth. November 2005. 36p + Appendicies A-C [Report not seen].

Goldsmith, 1978. *Beach Erosion, Oakura and neighbouring beaches 1977-1978.*

Kirk, 1980. *Coastal Erosion at New Plymouth – Sand transport past the port and options for beach renourishment.* Report to the New Plymouth Foreshore Erosion Committee.

Lumsden, J. 1993. *Report on Shoreline Erosion Adjacent to the Bell Block Seawall, North Taranaki.* Report Prepared for the New Plymouth District Council.

Lumsden, J. 1995. *Report on Shoreline Erosion Adjacent to the Bell Block Seawall, North Taranaki.* Report Prepared for the Taranaki Regional Council.

Maunsell Ltd, 2004. *Kupe Gas Project AEE. Geology and Geomorphology*. Prepared for Origin Energy Resources (Kupe) Ltd.

McComb, P and Beamsley, B. 2000. *Telstra Saturn Aqualink Project: An Evaluation of the Te Henui Landing Site.* Prepared for Telstra Saturn by ASR.

McComb, P. 2003. *The Motunui Shoreline: A report on the stability of the coastline, beach and nearshore regions of Motunui*. Report No. 02272-01 prepared for STOS.

McComb, P. Aikinson, P, Mead, S & Lefeuvre, J. 2005. *Urenui Beach – A review of coastal management and assessment of options.* Report prepared for the New Plymouth District Council by ASR.

McComb, P.; Mead, S. and Lefeuvre, J., 2005. *Oakura Beach – An investigation of the shoreline erosion along the western beach*. Report prepared for the New Plymouth District Council, ASR Ltd, New Zealand, 26p.

Ministry for the Environment. 2008. *Coastal Hazards and Climate Change. A Guidance Manual for Local Government in New Zealand*.

MWH 2006. Waipipi Subdivision Geotechnical Investigation and Coastal Erosion Report. Prepared for Forest Management of New Zealand.

MWH 2006a. *Assessment of Environmental Effects: Coastal Permit to erect, place and maintain a new 311 sea defence structure at Urenui beach*. Report prepared for New Plymouth District Council[Document #320272].

NGC. 2006. *Kapuni-Auckland Pipeline TwinCreeks Tongaporutu Erosion Pipeline Protection and Relocation Works*. Application submitted to the Taranaki Regional Council.

OCEL Consultants Limited. 1994. *Coastal Erosion Strategy*. Report prepared for the New Plymouth District Council.

OCEL Consultants Limited. 1995. AEE for Coastal Application to place sand dregings on East End beach for purpose of beach renourishment. Prepared for New Plymouth District Council.

OCEL Consultants Limited. 2009. *New Plymouth District Council Coastal Walkway Extension Waiwakaiho River – Bell Block. Report on Coastal Erosion Issues for Locating Walkway*. Report prepared for the New Plymouth District Council.

Pohokura Gas Field Development. 2002. Applications for Resource Consent Pohokura Gas Field Development. Volume 3.

Rush, M. 2006. *Netting Coastal Knowledge. A report into what is known about the South Taranaki-Whanganui Marine Area*. Published by Department of Conservation, Wanganui Conservancy.

Taranaki Catchment Commission, 1978. *Onaero Beach Report*.

Taranaki Catchment Commission, 1978a. *Oakura Foreshore Erosion.*

Taranaki Catchment Commission, 1982. *Report on sand movement and coastal erosion on North Taranaki Beaches.*

Taranaki Catchment Commission, 1987*. Coastal Erosion Hazard Assessment for Clifton County.*

Taranaki Catchment Commission, 1987*b. Coastal Erosion Series maps.*

Taranaki Catchment Commission, 1988. *Coastal Erosion Hazard Assessment for North Taranaki District and New Plymouth City.*

Taranaki Regional Council, 1998. *Integrated management of the coastal erosion hazard on the Oakura coastline between the Oakura River and the Wairau Stream*. Draft report[#404178].

Taranaki Regional Council, 2001. Memorandum: *Officer Report prepared for application for coastal permit 5761 to erect, place and maintain a 295 metre boulder rock rip rap seawall in the coastal marine area on the eastern end of the Urenui Beach foreshore for coastal erosion protection purposes [#18179].*

Taranaki Regional Council, 2004. Memorandum*: Officer Report for applications to erect, place and maintain boulder rip rap toe protection in the coastal marine area on the Oakura foreshore [#21049].*

Taranaki Regional Council, 2007. Memorandum: *Officer Report prepared for application coastal permit 7077 to erect, place and maintain a 311 metre boulder rock rip rap seawall, including a boat ramp, to the west of, and adjoining, the existing 295 metre seawall in the coastal marine area of the Urenui Beach foreshore for coastal erosion protection purposes [#323529].*

Taranaki Regional Council, 2007a. *NPDC Coastal Structures Monitoring Programme Report 2002-2007. Technical Report 2007-92.*

Taranaki Regional Council, 2008. *NPDC Coastal Structures Monitoring Programme Report 2007-2008. Technical Report 2008-44.*

Taranaki Regional Council, 2008a. *STDC Coastal Structures Monitoring Programme Monitoring Report. 2007-2008. Technical Report 2008-43.*

Tonkin and Taylor,2001. *Taranaki Regional Council Compliance Monitoring Programme for Coastal Structures*. Unpublished Report to the Taranaki Regional Council.

Tonkin and Taylor , 2007. *Shoreline Assessment for Consent Application*. Prepared for the Taranaki Regional Council to assist with assessing consent #7077 [#304298].

Shand, R.D. 2006. *Patea Beach Green Waste Management Strategy. Part 1. Coastal change and historical sand stabilization works*. Report prepared for the South Taranaki District Council by Coastal Systems (NZ) Ltd [in consents file STDC 6088].

Shand, R.D. 2006. *Patea North Beach Sand Stability Investigation Part 2. Sand Management Plan.* Report prepared for the South Taranaki District Council by Coastal Systems (NZ) Ltd [in consents file STDC 6088].

South Taranaki District Council. 2007. Patea Beach Management Plan [in consents file STDC 6088].

Single, M.B, 1996. *Ohawe Beach Coastal Processes and Erosion Hazard*. A Report to Te Rangatapu Reserve Trustees and Zansha Technical Ltd.

South Taranaki District Council. 1990. *Report on Patea River Beach Erosion.*

Willis, B. 2006. Application for subdivision consent – Arawhata Road.

Williams, G. 1997. *Oakura Beach Coastal Protection. Assessment of Effective Options*. Report prepared for Taranaki Regional Council [in #404178].

6 Appendices

6.1 Appendix I: Taranaki erosion assessment sites Gibb(1978) (excel file: #640813)

		NZ Map Grid		NZTM			
		Northing	Easting	Northing	Easting	Years	Rate
123	Patea	6158000	2637600	5596277	1727558	1872-1905	1.82
	Patea					1905-1976	-0.85
124	Patea	6158000	2637300	5596277	1727258	1872-1905	-1
	Patea					1905-1939	1.74
	Patea					1939-1976	2.05
125	Power House Road	6162900	2631500	5601174	1721456	1901-1976	-0.05
126	Manutahi Road	6166900	2628700	5605173	1718655	1874-1927	-0.42
127	Manawapou	6169900	2626600	5608171	1716553	1874-1953	-0.61
	Manawapou					1953-1976	-0.87
128	Manawapou	6171000	2625900	5609271	1715853	1874-1953	-0.53
	Manawapou					1953-1976	-1
129	Siggs Trigg	6175000	2620800	5613268	1710751	1908-1958	-0.6
130	Hauroto Road	6178200	2614600	5616464	1704550	1902-1930	-0.32
131	Ohawe Beach	6179000	2613000	5617263	1702950	1871-1966	-0.63
132	Ohawe Beach	6179200	2612600	5617463	1702550	1871-1959	-0.58
	Ohawe Beach					1959-1966	-1.29
133	Raine Road	6179200	2611700	5617463	1701650	1940-1976	-1.11
134	Winks Trig	6179900	2608000	5618161	1697951	1872-1976	-0.34
135	Normanby Road	6180400	2603900	5618658	1693851	1879-1930	-0.16
136	Glen Road	6181000	2601800	5619257	1691751	1912-1947	0
137	Pihama	6188500	2587700	5626748	1677650	1920-1976	0
138	Punehu	6189000	2587200	5627247	1677150	1920-1976	-0.09
139	Oaonui	6201000	2577400	5639238	1667346	1881-1950	0
140	Waiaha	6209500	2575600	5647734	1665541	1880-1937	0.7
	Waiaha					1937-1959	2.27
141	Tipoka	6210100	2575500	5648334	1665441	1880-1937	0.74
	Tipoka					1937-1959	-0.91
142	Tipoka Trig V	6210700	2575300	5648934	1665241	1880-1937	0.39
	Tipoka Trig V					1937-1959	-0.55
143	Warea River	6218700	2577000	5656932	1666935	1881-1953	19
144	Stent Road	6219100	2576800	5657332	1666735	1881-1953	28
145	Stent Road	6219800	2577000	5658032	1666934	1881-1953	14
146	Leith Road	6228900	2585600	5667135	1675525	1892-1975	0
147	Ahu Ahu Road	6231400	2590500	5669638	1680422	1865-1961	0.21
148	Oakura	6231500	2591400	5669739	1681322	1865-1961	0.67
149	Oakura	6231700	2591900	5669939	1681821	1865-1961	0.33
150	Harekawe Stream	6237000	2598200	5675243	1688116	1925-1975	0
151	New Plymouth	6238800	2603700	5677047	1693613	1842-1901	-0.17
						1901-1921	-0.5
						1921-1944	-0.39
						1944- seawall built	
152	New Plymouth	6238700	2604300	5676947	1694213	1842-1921	-1.09
153	Fitzroy Beach	6239000	2604600	5677247	1694513	1842-1958	-0.59
154	Fitzroy Beach	6239400	2605000	5677647	1694912	1842-1958	-0.58
155	Fitzroy Beach	6239700	2605300	5677948	1695212	1842-1958	-0.86

156	Fitzroy Beach	6240200	2605700	5678448	1695611	1842-1958	0.08
	Fitzroy Beach					1881-1887 harbour breakwater built	
157	Bell Block	6242300	2608600	5680550	1698509	1907-1974	-0.42
158	Wills Road	6242300	2609900	5680551	1699809	1852-1945	-0.25
	Wills Road					1945-1950	-2.38
	Wills Road					1950-1957	0
	Wills Road					1957-1970	-0.69
	Wills Road					1970-1976	-0.15
159	Puketapu Trig	6242800	2610400	5681051	1700308	1917-1945	-0.71
	Puketapu Trig					1945-1950	-2.5
	Puketapu Trig					1950-1957	0
	Puketapu Trig					1957-1964	-1.37
	Puketapu Trig					1964-1970	-0.41
	Puketapu Trig					1970-1976	-0.07
160	Airport	6243700	2611500	5681952	1701408	1917-1964	-0.96
161	Airport	6244400	2612000	5682652	1701907	1917-1964	-0.32
162	Waitara	6245700	2616900	5683956	1706805	1913-1958	-2.89
163	Otararoa Road	6245500	2620100	5683758	1710005	1919-1975	-0.43
164	South Onaero	6244900	2626900	5683164	1716804	1882-1937	-0.55
165	South Onaero	6245100	2628000	5683365	1717904	1882-1931	-0.12
166	North Onaero	6245100	2628500	5683365	1718404	1883-1958	-0.53
167	North Onaero	6245200	2629100	5683466	1719004	1883-1958	-1.07
168	Urenui	6245300	2630700	5683567	1720604	1970-1975	-6
169	Brown trig	6246300	2632300	5684568	1722203	1883-1958	0
170	Old North Road	6246900	2633000	5685169	1722902	1883-1980	-0.23
171	Old North Road	6247400	2633700	5685669	1723602	1883-1980	-0.16
172	Carrs Road	6247700	2634100	5685970	1724001	1883-1975	-0.26
173	Carrs Road	6248000	2634300	5686270	1724201	1883-1975	-0.33
174	Mimi Trig	6248900	2635200	5687171	1725100	1880-1975	-0.38
175	Pukearuhe Road	6254600	2639600	5692874	1729495	1866-1969	-0.29
176	Pariokariwa Pt	6255700	2641100	5693975	1730994	1955-1975	-0.5
177	Monument	6256000	2641900	5694276	1731794	1937-1969	-0.38
178	Parininihi Trig	6258200	2644200	5696478	1734092	1880-1975	-1.89
179	White Cliffs	6261800	2646400	5700080	1736288	1955-1975	-2
180	Rapanui Stream	6266000	2648100	5704281	1737984	1896-1966	-0.11
181	Mohakatino	6272100	2649700	5710383	1739579	1888-1974	-0.5
182	Mohakatino	6272800	2649800	5711083	1739678	1888-1974	-0.09

6.2 Appendix II: Taranaki Coastal Series Maps (TCC, 1987)

1. Clifton County – Mohakatino River to Pariokariwa Point (#650459)

2. Clifton County – Waiiti to Motunui (#650461)

3. Clifton County, North Taranaki District County and New Plymouth City – Waitara to the Port (#650462)

4. North Taranaki District – Port to Kaihihi Stream (#650471)

5. North Taranaki District and Egmont County – Kaihihi Stream to Waitaha Stream (#650470)

6.3 Appendix III: Examples of Taranaki Coastal Resources, Aerial Plans, 1987

Note: These maps have been scanned for future digitalising of the lines and erosion rate information at a high resolution. Attached are examples only.

1. Tongaporutu (#650476)
2. Whitecliffs North (#650481)
3. Mimi (#650468)
4. Urenui (#658737) (not included here)
5. Onaero (#650473) (not included here)
6. Waitara East (#658739) (not included here)
7. Waitara West (#650479)
8. New Plymouth Airport (#650469)
9. Bell Block Beach (#650453) (not included here)
10. Waiwhakaiho River (#650480) (not included here)
11. Fitzroy (#650464) (not included here)
12. Kawaroa Park (#650466) (not included here)
13. Paritutu (#650474) (not included here)
14. Waireka (#650478) (not included here)
15. Oakura (#650472)
16. Stony River (#650475) (not included here)