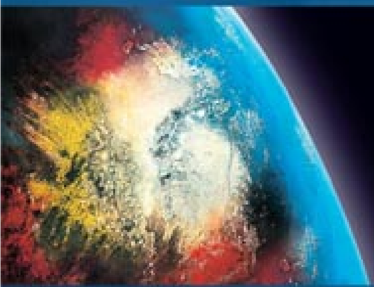
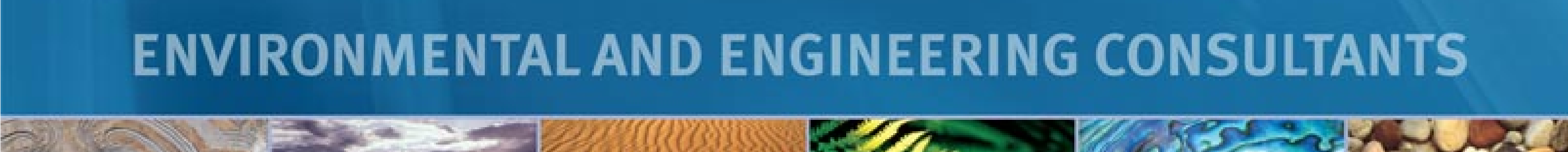
Tonkin & Taylor



ENVIRONMENTAL AND ENGINEERING CONSULTANTS



# REPORT

**Wellington City Council**

**Island Bay Seawall Alternatives Analysis**
**Coastal Processes Assessment**

## Report prepared for:

**WELLINGTON CITY COUNCIL**

## Report prepared by:

**Tonkin & Taylor Ltd**

## Distribution:

| | |
|---|---|
| **WELLINGTON CITY COUNCIL** | **10 copies** |
| **Tonkin & Taylor Ltd (FILE)** | **1 copy** |

**May 2014**

**T&T Ref: 29595**

# Table of contents

# Executive summary

Tonkin & Taylor Ltd. (T&T) have been commissioned by Wellington City Council (WCC) to undertake a high level assessment of coastal processes operating within Island Bay, likely future shoreline evolution and effects on the existing infrastructure, and evaluation of potential future management options to improve long-term resilience.

Island Bay is a pocket embayment located on the Wellington South Coast. The bay is orientated south to southeast and partially protected by Taputeranga Island, located approximately 400 m offshore. The bay is relatively stable in its present form with no long-term erosion or accretion trends discernable, although is likely subject to limited storm erosion processes. The active part of the beach extends to the upper swash limits, or around 2.5 to 3 m RL, 15 to 20 m behind the high water line.

The northern embayed beach is backed by a continuous sloped concrete revetment which dates back to the 1930's when the Esplanade was first constructed along the foredune crest across Island Bay. A recurved upstand wall was added later, presumably to reduce the incidence of wave overtopping and wind-blown sand. The straight seawall alignment differs to the naturally crescentic beach and the central portion of wall is located within the active beach zone (i.e. 5 to 10 m behind the current typical high tide line) and more frequently affected by coastal processes or wave impact and erosion.

The central part of the seawall and the backing roadway was damaged by a severe storm event in June 2013, estimated by T&T to have a return period in excess of 50 years. Before committing to fully reinstating the wall, WCC are wanting to assess the feasibility of using softer engineering approaches for the longer-term management of the bay.

This assessment has evaluated the technical feasibility of several potential long-term management options. These options have included:

***Option A: Retain wall in present alignment***

*The seawall would be maintained in its present alignment with the damaged section repaired, maintained and raised as required in the future.*

*Estimated cost: $550,000 to $1,150,000*

***Option B: Beach replenishment to protect wall***

*The seawall would be maintained in its present alignment with the damaged section repaired. Approximately 12,500 m$^3$ of imported sand would be added to the beach to widen the berm by 5 m along a 300 m beach length between the stormwater outfalls to the south and headland to the east.*

*Estimated cost: $1,200,000 to $1,900,000*

*($1,700,000 to $2,900,000 including provisional for long-term measures if required)*

***Option C: Relocate wall to stable beach planform***

*The straight seawall between the outfalls and surf club would be realigned to the natural beach planform and the road and pavement realigned fully or partially behind the wall.*

*Estimated cost: $1,900,000 to $2,200,000*

***Option D: Remove wall and restore coastal dunes***

*The straight seawall between the outfalls and surf club and the backing road and footpath would be removed, dunes established and traffic diverted along inland roads.*

*Estimated cost: $850,000 to $1,500,000 ex. traffic configuration costs*

Estimated costs do not include costs associated with detailed design, consenting, construction supervision, contingency or traffic management (Option D).

Of these options, Option A is the lowest cost but ongoing repair and upgrade of the wall will likely be required due to higher sea levels and beach recession due to climate change.

A significant volume of imported sand is required for Option B which may provide amenity benefits due to the wider beach but may also have adverse ecological impacts. The option is high cost due to the volume of sand required and may require ongoing maintenance and/or future upgrade of the seawall.

Option C is technically feasible although also high cost due to the costs of removing and rebuilding a long section of seawall. The option is sustainable in the long-term as the replacement wall can be built to withstand wave forces and higher sea levels if recession back to the wall ever occurs (potentially after 2065).

Option D is lower cost and technically feasible, although space is limited between the future beach alignment and private property at the end of Reef St. Wind-blown sand and dune roll-over with future beach recession may be problematic and require wind fencing and/or maintenance and issues associated with traffic re-routing would require detailed assessment.

# 1 Introduction

Island Bay is a pocket embayment located on the Wellington South Coast (Figure 1). The embayment is orientated south to southeast and exposed to wave energy propagating out of Cook Strait, although is partially protected by Taputeranga Island, located approximately 400 offshore. The pocket embayment is crescentic in planform at its northern end and transitions in the southwest to a salient in the lee of Taputeranga Island and a small nearshore reef. The beach is defined on its eastern side by a small rocky headland and to the southwest by the Sirens Rocks.


*Figure 1 Island Bay Location (source: Wellington Regional Council GIS)*

The northern embayed beach is backed continually by a vertical seawall and transitions to sand dunes backed by a road and cliffs to the southwest. A severe storm event occurred in June 2013 bringing extremely large offshore waves, strong onshore winds and super elevated water level. The event, estimated by Tonkin & Taylor Ltd. (T&T) to have a return period in excess of 50 years, caused damage to the central part of the seawall and to the backing roadway (Figure 2). Before committing to fully reinstating the wall, WCC are wanting to assess the feasibility of using softer engineering approaches for the longer-term management of the bay.

*Figure 2 Damage to the Island Bay seawall following the June 2013 Storm Event (image: WCC)*

T&T have been commissioned by Wellington City Council (WCC) to undertake a high level coastal process assessment and evaluation of potential management options to assist in the development of an Island Bay alternatives analysis.

Engineers from T&T inspected the site on 12 February 2013 and met with Council Staff to discuss limitations and opportunities for future management of the bay. This report reviews the historical development and existing coastal processes operating within Island Bay, assesses likely future trends and hazard potential and evaluates the potential management options in terms of:

a. Technical feasibility

b. Effect on coastal processes

c. Likely capital cost

d. Potential long-term risk/management requirements.

# 2 Coastal processes

## 2.1 Environmental conditions

### 2.1.1 Wind

Wind in Wellington is primarily orientated in a north-south direction, with around 65% of wind occurring from the North and 35% from the South (Figure 3). Island Bay is exposed primarily to southerly winds which may induce onshore waves and cause wind-blown sand. Strong winds occur from both the north and south directions, although the strongest winds (30 m/s) have tended historically occurred from the south with sustained winds during the June 2013 event reaching 29 m/s with an estimated 15 year return period.

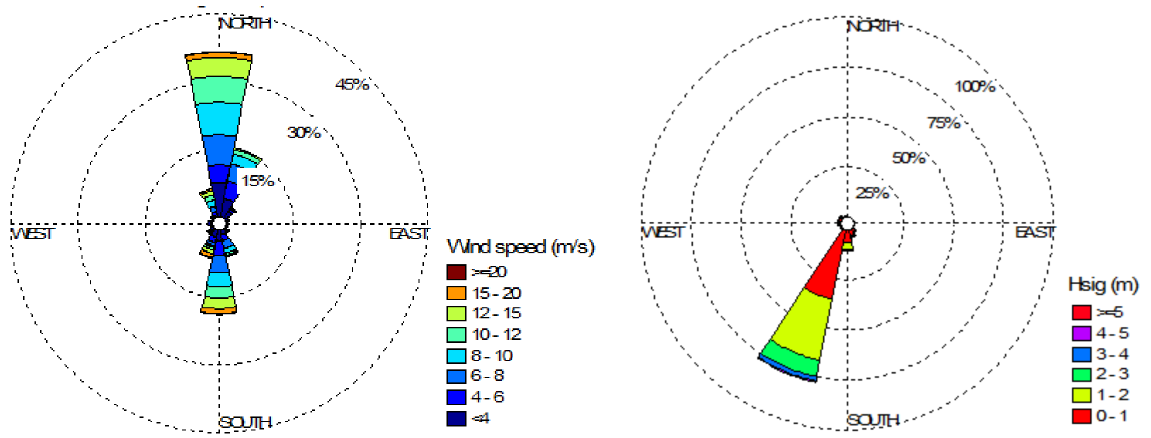



*Figure 3 Wind rose at Wellington Airport (1960 – 2013). Wave Climate at Baring Head (source: Metocean hindcast dataset 1979 – 2012)*

### 2.1.2 Waves

Waves on the Wellington south coast occur from the southerly quarter with waves from the south-southwest being predominant (Figure 3). Island Bay faces south to southeast and is therefore exposed to such waves, although the sheltering effect of Taputeranga Island means that waves arriving at the beach are refracted with lower incident wave height than occur offshore. Due to the refractive processes, the bay planform is likely to be relatively insensitive to offshore direction with all waves becoming generally aligned to the south east as they reach the beach. However, waves arriving from the southeast are likely to undergo less refraction and are therefore less reduced in height than waves from the south to southwest.

The peak offshore significant wave height during the June 2013 storm of $H_s$ = 9.6 m was the largest on record, although both ex-tropical cyclone Giselle (April 1968 - Wahine Storm) and the February *1936* ex-tropical storm were anecdotally of similar magnitude. While waves within Island Bay during the event would have been significantly smaller, video captured by NIWA show substantial wave energy reaching the seawall at the back of Island Bay.

### 2.1.3 Water levels

**Astronomical tide**

Astronomical tides result from the influence of the sun and moon on the earth. Tide levels for Cadastral and Engineering purposes at Queens Wharf, Wellington are provided by LINZ (2013) and shown in Table 1. Levels for Island Bay are expected to be similar to those in Wellington.

**Table 1 Astronomical tidal levels for the 2012 - 2013 period (LINZ, 2013)**

| | Chart Datum[1] (m CD) | WVD-53[2] (m RL) |
|---|---|---|
| 1% AEP value (Stephens et al. 2009) | 2.23 | 1.32 |
| Highest Astronomic Tide (HAT) | 1.87 | 0.96 |
| Mean High Water Spring (MHWS) | 1.77 | 0.86 |
| Mean High Water Neap (MHWN) | 1.45 | 0.54 |
| Mean Sea Level (MSL) | 1.09 | 0.18 |
| Mean Low Water Neap (MLWN) | 0.70 | -0.22 |
| Mean Low Water Spring (MLWS) | 0.45 | -0.47 |
| Lowest Astronomical Tide (LAT) | 0.38 | -0.54 |
| Chart Datum (CD) | 0 | -0.92 |

1 Chart Datum is 3.002m below BM K80/1 (ABPB)

2 Relative to Wellington vertical datum (1953) which is 0.91 m above Chart Datum

**Storm tide**

Water levels are periodically elevated above predicted tidal levels by the combination of barometric setup from low atmospheric pressure and wind stress from winds blowing along or onshore. The combination of these are known as storm surge. The combination of the mean level of the sea, astronomical tide and storm surge is known as storm tide. Stephens et al. (2009) assessed annual maxima sea level at Queens Wharf, Wellington and derived a 100 yr ARI storm tide level of 1.32 m, approximately 0.45 m above the MHWS level.

Water levels at Queens Wharf during the June 2013 storm event were determined by T&T (2013) to be approximately 1.3 m corresponding to an average recurrence interval of approximately 50 years. This value is was 0.6 m above the predicted tide height (LINZ, 2013) at the time indicating a significant storm surge accompanied the storm event.

**Cyclic and long-term change**

The mean sea level can fluctuate on time scales ranging from months to decades due to seaonsal effects, the effects of El Nino-Southern Oscillation (ENSO) and the Interdecadal Pacific Oscillation (IPO). These fluctuations may cause variation in local water level by up to 0.25 m (MfE, 2004).

Bell and Hannah (2012) found the average rise in relative sea-level for the Wellington region over the last 100 years has been 2.05 ± 0.15 mm/year with higher rates over the last several years. This has been attributed to recent slow slip tectonic events in the Wellington region which have lowered land levels (Stephens et al., 2009).

### 2.1.4 Climate change

Ongoing changes in the global climate are predicted to result in acceleration of sea level rise in coming decades. The Ministry for the Environment guidelines (MfE, 2008) recommend a base value SLR of 0.5 m by 2100 with consideration of the consequences of SLR of at least 0.8 m with an additional SLR of 10 mm per year beyond 2100 as sea levels are expected to continue rising after 2100.

Future changes to wind, wave and rainfall are also possible but guidance is less clear.

## 2.2 Existing structures

Island Bay is a heavily modified urban beach with development beginning in the early 1900's with a roadway constructed along the foredune crest in approximately 1906 (Figure 4). The road was formalised by the 1930s (Figure 5) with a seawall constructed in two stages. The first stage was a sloped concrete revetment (Figure 6), presumably to protect the road from wave erosion and/or overtopping. A recurved upstand wall was added later (Figure 2), presumably to decrease the occurrence of wind-blown sand and periodic wave overtopping.

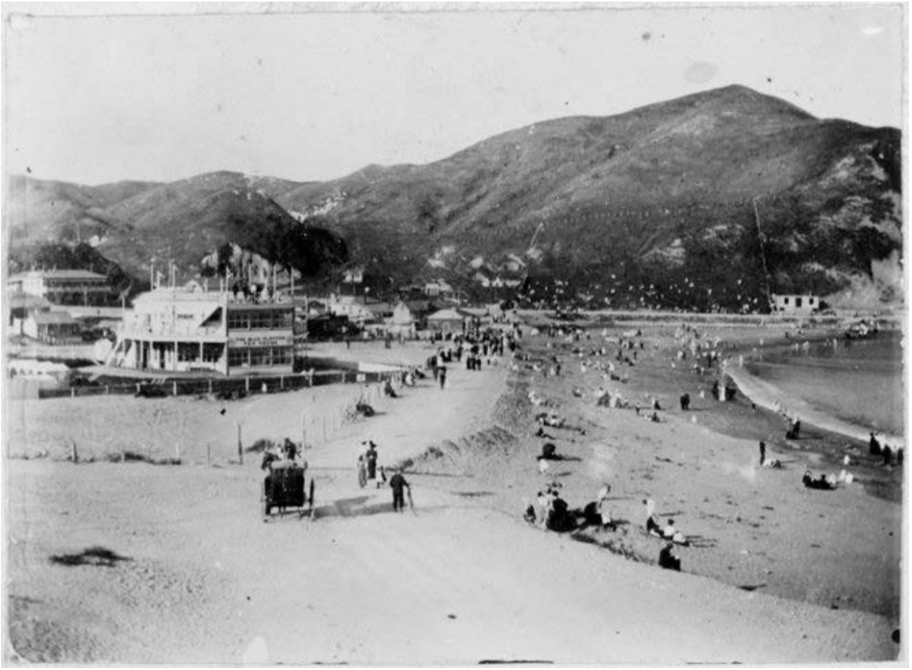


*Figure 4 Historic view of the Blue Platter Tea Rooms on The Esplanade, Island Bay. Photograph taken circa 1900, by an unidentified photographer Ref: 1/2-136056-F. Alexander Turnbull Library, Wellington, New Zealand.*

*Figure 5 Island Bay, Wellington, circa 1930, photographed by Robson & Boyer. PAColl-7081-06 Alexander Turnbull Library, Wellington, New Zealand.*

*Figure 6 Historic view of the Island Bay Seawall, circa 1930. Smith, Sydney Charles, 1888-1972: Photographs of New Zealand. Ref: 1/2-045879-G. Alexander Turnbull Library, Wellington, New Zealand.*

The road and seawall are constructed near the back of the active beach and so are not frequently exposed to coastal processes (wave impact, overtopping and erosion), however, the straight seawall alignment differs to the naturally crescentic beach (Photograpah A-1) and the central portion of wall is located further into the active beach (5 to 10 m behind the high water line) and more frequently affected by coastal processes (wave impact and erosion). A large storm event in June 2013 damaged the central portion of the seawall and requires repair (Photograph A-4). Wind blown sand accumulates against the wall at the eastern (Photograph A-2) and southwestern (Photograph A-6) sides of the bay.

A number of stormwater outfalls discharge into Island Bay, most notably the twin outlets at the western side the crescentic beach (Photograph A-5). These outlets have replaced the natural stream which likely historically outlet in the northern corner of the beach where the surf club is now located. The first outfall was in place by 1938 and the second constructed between 1989 and 2002. A grouted rock encased outfall discharges to the east of the crescentic beach (Photograph A-3) and a number of smaller outlets discharge along the backshore.

A former surf club building is located at the back of the crescentic beach. While no longer used as an active surf club, the building is used for other community activities (Spence et al., 2009). The lower parts of the building are occasionally inundated during storm conditions, though the wide beach width here indicates that erosion is not likely problematic.

## 2.3 Coastal processes

### 2.3.1 Historic development

Island Bay is sheltered by Taputeranga Island with small amounts of wave energy propagating up the west side of the island and more wave energy refracting into the bay to the north of the island from the east. The beach was likely initially formed as sea level stabilised at its present level some 6000-8000 years ago with material pushed along the coast entering the bay from the southwest between Taputeranga Island and the mainland. Dunes are higher at the western side of the bay against the hill reducing in height towards the centre of the bay where the local stream would have historically outlet and dunes would have been low and hummocky, possibly backed by wetlands and swamp (Figure 7). This wetland and dune systems have been replaced by development, with only remnants of the inland dune systems remaining today within Shorland Park (Photograph A-6). Lumsden (1996) suggests that the littoral cell in Island Bay is now effectively closed with little sediment exchange occurring along the coast or onshore-offshore.

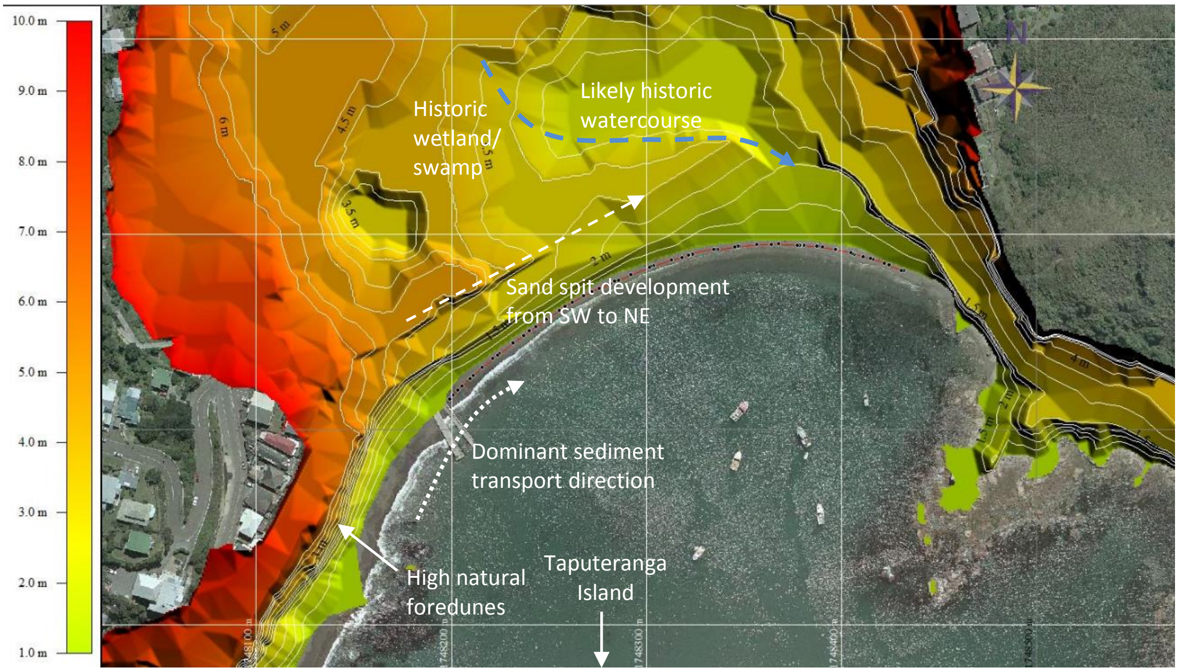



*Figure 7 Digital terrain model of the Island Bay coastline*

### 2.3.2 Beach planform

The beach within the northern part of Island Bay exhibits a crescentic planform typical of bound pocket beaches shaped by dominant wave refraction. The small headland to the east acts as a refraction point, with wave crests lengthening and bending as they spread into the bay behind Taputeranga Island.

The equilibrium curve for the present beach configuration was modelled using the software Mepbay (Klein et al., 2003) based on the parabolic bay model of Hsu and Evans (1989). Incoming wave angle is aligned between the eastern headland and Taputeranga Island and the southerly beach control point is assumed at the outfalls. Results (Figure 8) show that the existing beach planform (MHWS shown in red) is in very close agreement with the predicted equilibrium curve (shown in green) and is therefore expected to relatively stable.

To the southwest, the beach is generally linear along the base of the shoreline and is likely maintained in position by Taputeranga Island forming a salient in its lee. The high, well vegetated dune system here indicates a historic surplus of sediment available for dune formation.

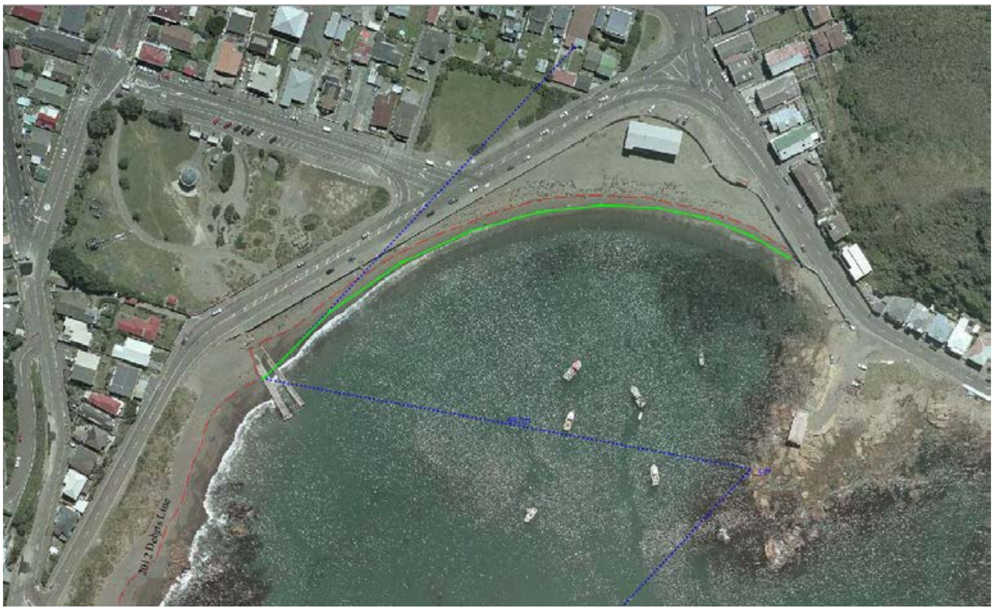


*Figure 8 Current MHWS line (- - -) compared to the predicted equilibrium planform (---)*

### 2.3.3 Storm response

The active beach spans from the dunes to the offshore area and is part of the natural system affected by coastal processes. During storms, sand is typically moved offshore from the beach face and dunes to the offshore, returning to the beach during calm periods and being blown into the dunes by aeolian (wind) processes. The seawall backing Island Bay has been partially constructed within the active beach. The portion of the seawall in front of Shorland Park prohibits sediment to be removed from the backshore dune during large storms events and so material is removed instead from the beach. This lowers beach elevation, causes the water line to move landward and enables larger waves to reach the backshore.

### 2.3.4 Long-term trends

Long-term trends have been assessed by analysis of historic, georeferenced aerial photographs dating between 1938 and 2009. These photographs (Appendix B) show that over this time the crescentic northern beach has been generally stable with slight rotation towards the east widening the western part of the beach and narrowing the northeast. This may have occurred due to changes in the stormwater regime (i.e. from a natural stream to outfalls), due to subtle changes in the offshore wave climate or to ongoing changes in sea level slightly altering the refraction patterns. This long-term stability supports the findings of the equilibrium planform modelling. The beach to the south appears to have narrowed slightly (5 – 10 m), particularly since 2002. However, changes have been small and trends are difficult to discern from the superimposed short-term changes.

## 2.4 Coastal hazards

Coastal hazards arise when coastal processes adversely affect human assets and infrastructure. Coastal hazards which may affect assets and Island Bay include:

- Wind-blown sand
- Coastal erosion and recession
- Coastal inundation.

### 2.4.1 Wind-blown sand

Wind-blown sand occurs when onshore winds are strong enough to entrain and move sediment particles. These particles remain mobile until the wind velocity reduces to allow deposition. This is the basic process of dune building where sand-binding vegetation such as spinifex and pingao reduce wind velocity and accumulate sediment. Hard structures such as walls often induce wind vortices and lowered areas in dunes such as walkaways may focus winds through flow constriction. Both of which may increase sediment entrainment and the potential for local scour.

Wind blown sand is typically an annoyance rather than a hazard of high consequence but regular maintenance is required to remove accumulated sediment. Solutions are generally to establish vegetated dunes or utilise permeable wind fencing which reduces velocities to allow sediment to be deposited rather than inducing scour. Mobile sediments may be accumulate against hard structures such as seawalls but if the sediment supply is sufficient, the sediment will gradually build until the structure is overtopped. This is evidenced at Island Bay (Photographs A-2, A-6).

### 2.4.2 Coastal erosion hazard

The extents of land threatened by erosion hazard is influenced by short-term storm erosion, the stability of slopes above any erosion scarp, long-term recession trends and additional recession due to future sea level rise. Figure 9 shows the current and future coastal erosion hazard zones.

There is little data on short-term fluctuations resulting from storm erosion at Island Bay. However, the sheltering provided by Taputeranga Island likely limits potential for significant erosion to 5 to 10 m. Long-term trends of recession or accretion were found to be minimal within the northern cescentic beach, although may be higher to the south.

As sea level rises the morphology of the beach profile is expected to respond. The most widely known model for this beach response is that of Bruun (1962). The Bruun model assumes that as sea level is raised, the equilibrium profile is moved upward and landward conserving mass and original shape. This profile translation effectively results in a recession of the coastline. Based on an average cross-shore slope of 0.08 and using the methods of Bruun (1962), this translates to potential recession of up to 6 m by 2065 and 12.5 m by 2100 for sea level rise of 0.5 and 1 m respectively.

Dunes become established at an elevation of around RL 2.5 m indicating this is the landward extent of typical swash excursion. With an average upper beach slope of 1(V):10(H), this translates to a distance some 17 m behind the current MHWS. It should be noted that this distance does not include allowance for dune processes which would require additional distance.

The resulting preliminary coastal erosion hazard zones from the existing MHWS position are shown in Table 2. Prudent values to adopt would be 25 m for 2014, 30 m for 2065 and 40 m for 2115. Note that these hazard zones contain a number of assumptions and distances would need to be reassessed before use in design or for planning purposes.

**Table 2 Coastal Erosion Hazard Zones**

| Coastal erosion hazard zone | Short-term fluctuation (ST) | Dune stability allowance (DS) | Long-term trend LT | Recession due to SLR (m) | Distance from MHWS (m) |
|---|---|---|---|---|---|
| 2014 | 5-10 m | 17 m | 0 m | - | ***22-27 m*** |
| 2065 | 5-10 m | 17 m | 0 m | 6 m | ***28-33 m*** |
| 2115 | 5-10 m | 17 m | 0 m | 12.5 m | ***35-40 m*** |

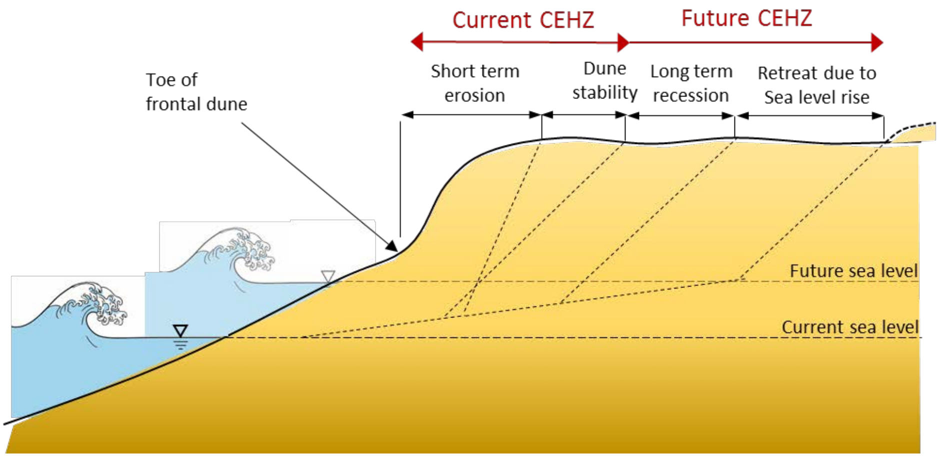



*Figure 9 Definition sketch for open coast coastal erosion hazard zones*

### 2.4.3 Coastal inundation hazard

Coastal inundation occurs due to the occurrence or combination of several components which may combine to elevate sea levels sufficiently to overtop the backshore. Key components that determine water level at the beach face are:

- Astronomical tides
- Barometric and wind effects, generally referred to as storm surge
- Medium term fluctuations, including ENSO and IPO effects
- Long-term changes in sea level
- Wave setup and run-up due to wave breaking

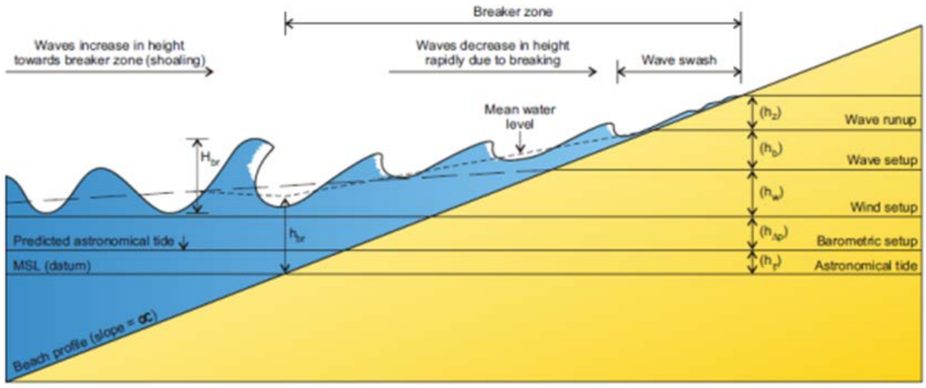



*Figure 10 Components of elevated sea levels (adapted from Frisby and Goldberg, 1981)*

The water levels at Queens Wharf during the June 2013 storm event was approximately RL 1.3 m, or 0.6 m above the predicted tide height. The seawall backing the beach at Island Bay has a recurve wall and a crest elevation of at RL 3.5 m. This wall appeared to generally limit overtopping until a section failed allowing waves to run onto the road, damaging the pavement (Figure 2). A post-storm survey by T&T indicates that the road backing the beach in this location is approximately RL 2.5 m indicating that the total runup and setup level were in excess of RL 2.5 m and probably closer to RL 3m.

While a seawall crest level of 3.5 m is likely sufficient to restrict overtopping flows at the present time if adequately constructed to withstand wave forces, it will likely become insufficient in the future as sea levels increase and larger waves are able to propagate to the wall. Any seawall crest would likely need to be at least RL 4 m by 2065 and RL 4.5 m by 2115.

# 3 Potential coastal management options

## 3.1 Introduction

A large storm event on 22-23 June 2013 caused widespread damage along Wellington's South Coast, which included the seawall at Island Bay. The damaged caused to the wall included a 35m section of wall rotating and a further 50m section completely failed.

While repairs to this section of seawall are presently underway, a range of longer-term management options are being assessed for the Island Bay Beach to improve resilience.

## 3.2 Option A: Retain wall in present alignment

**Description**

The seawall would be maintained in its present alignment with the damaged section repaired and maintained as required in the future.

**Technical feasibility**

Ongoing sea level rise is likely to mean that the high tide beach width (part dry at high tide) is reduced to a few metres by 2065 and will disappear by 2115 with the beach only exposed at low tide along the central ~50 to 100 m beach length (Figure 11). This will eventually restrict public access and cause more frequent wave interaction with the seawall. This may increase scour due to wave reflection further lowering beach levels.

This option is technically feasible at the current time. Higher future sea levels and retreating shoreline will mean the wall becomes more frequently exposed to larger waves increasing the potential for damage and flooding by wave overtopping.

Along a 200 m section, the wall is likely to require more frequent maintenance and repair in the future. This may include raising of wall crest levels, potentially by 0.5 m before 2065 and by 1 m before 2115 and/or works to improve the walls foundations.

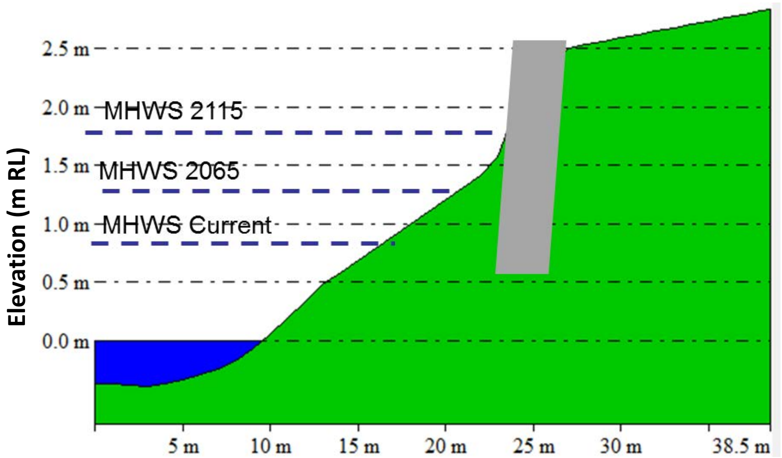



*Figure 11 Future mean high water spring positions*

**Likely capital cost**

Likely costs associated with this option include:

| Component | | Cost estimate ($ ,000) |
|---|---|---|
| 1. | Initial repair of wall | $250 |
| 1. | Ongoing maintenance and repair of 200 m section of wall | $200 - 600K |
| 2. | Raise crest levels of 100 m section of wall in the future | $100 - 300K |
| | ***Total*** | ***$550 - 1,150*** |

Costs do not include detailed design, consenting, construction supervision costs or contingency.

## 3.3 Option B: Beach replenishment to protect wall

**Description**

The seawall would be maintained in its present alignment with the damaged section repaired. Additional sand would be added to the beach to build a 5 m wide, RL 2.5m high berm along a 300 m beach length between the stormwater outfalls to the south and headland to the east. This would require the addition of some 12,500 $m^3$ of sand.

**Technical feasibility**

While additional sediment is required only along 80-100 m section in the middle of the beach, the curved alignment of the beach will require the entire beach to be extended, thus making the replenishment a relatively high cost option, although there may be increased amenity benefits due to the wider dry beach.

The incidence of waves reaching the seawall will be reduced at the present time reducing maintenance requirements. Over time, the beach will continue to recede with ongoing sea level rise without further ongoing replenishment. By 2065 the beach will be similar to present and by 2115 the MHWS position will likely have reached the wall.

The stormwater outfalls to the southwest of the beach may need to be extended by a similar distance to ensure outlets flows are not reduced.

An increased dry beach width may increase the incidence of wind-blown sand and the sand level against the seawall. Placement of large sand volumes may have adverse effects on the ecology within the Taputeranga Marine Reserve.

**Likely capital cost**

Likely costs associated with this option include:

| Component | | Cost estimate ($ ,000) |
|---|---|---|
| 1. | Supply and place 12,500$m^3$ sand | $1,000 – 1,500 |
| 2. | Stormwater outfall extensions if required | $200-400 |
| | ***Total*** | ***$1,200-1,900*** |
| *Provisional* | | |
| *3.* | *Future replenishment as required, or* | *$200 - 300* |
| *4.* | *Ongoing maintenance and repair of the wall if nourishment ceases or is insufficient to protect wall* | *$200 - 400* |
| *5.* | *Raise wall crest levels in the future if nourishment ceases or is insufficient to protect wall* | *$100 - 300* |
| | ***Total inc. provisional*** | ***$1,700 - 2,900*** |

Costs do not include detailed design, consenting, construction supervision costs or contingency.

## 3.4 Option C: Relocate wall to stable beach planform

**Description**

The straight seawall between the outfalls and surf club would be realigned to the natural beach planform and the road and pavement realigned fully or partially behind the wall.

**Technical feasibility**

Realignment of the seawall to the natural beach planform would restore natural swash processes along the beach and reduce the incidence of wave impact on the wall for the next 50 to 100 years until long-term recession reaches the new wall position.

Dunes appear to become established at an elevation of around RL 2.5 m indicating this is the landward extent of typical swash excursion. A stable alignment to remove the wall from the majority of wave activity is estimated at 20 m behind the current MHWS line. This is likely to increase to around 26 m by 2065 and 33 m by 2115. These curves are shown in Figure 12. The hazard zone extent remains landward of this point due to dune instabilities and the realigned wall would therefore function as a backstop wall, used to control erosion and wave impact during extreme watar level and erosion events.

Based on the width of the existing footpaths, road and seawall of around 20 m, the road could be relocated inland of the 2065 alignment without intruding on private property but relocation to the 2115 alignment would impact some private property if a full width road and footpath is to be maintained. Therefore realignment to 2065 is seen as a less intrusive option, but may require further works in the future including beach nourishment and/or wall repair and upgrade.

It is unlikely that the *existing wall* could be relocated, although parts of it could potentially be reused.

Around 2200 m$^3$ of Council reserve including parts of Shorland Park would be required for the road relocation. An increased dry beach width may increase the incidence of wind-blown sand and the sand level against the seawall, and sand on the road reserve.

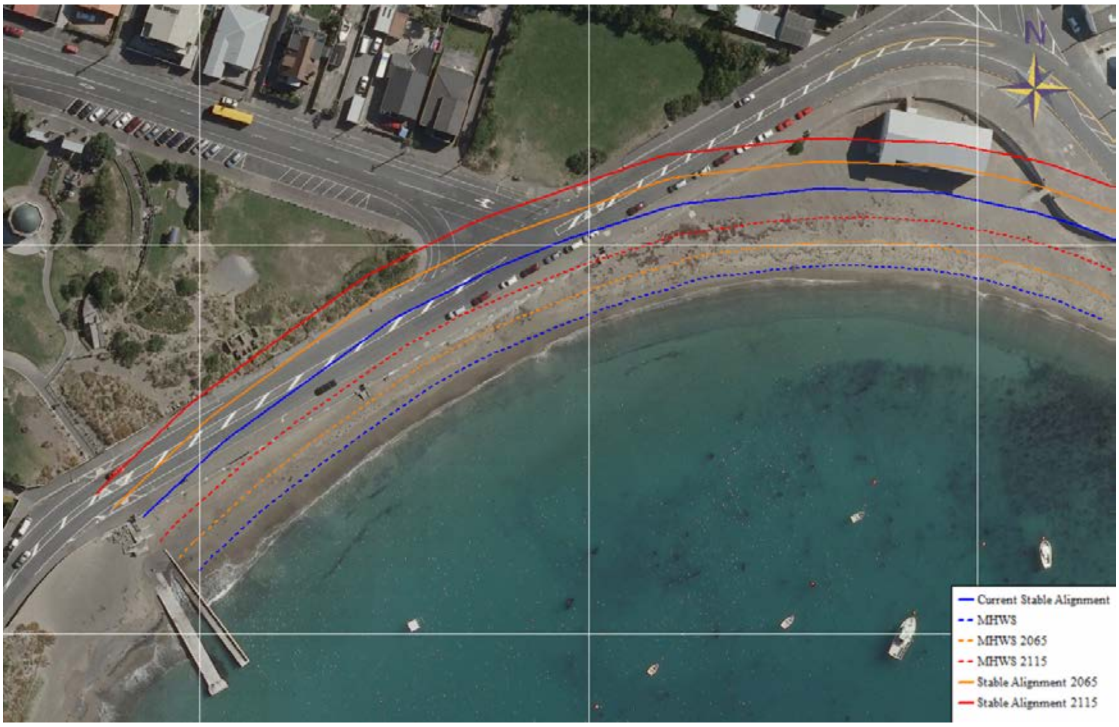



*Figure 12 Current and future MHWS and stable backshore alignment*

**Likely capital cost**

Likely costs associated with realignment to the 2065 stable beach planform include:

| Component | | Cost estimate ($ ,000) |
|---|---|---|
| 1. | Removal of 200 m of existing wall, roadway, footpath and utilities | $100 |
| 2. | Clearance of 2200 $m^2$ of Council reserve inland of the road | $80 |
| 3. | Construction of a 206 m long seawall, likely of similar construction to the existing wall. Ensure crest levels and foundation sufficient to future-proof. | $700 – 1,200 |
| 4. | Construction of road on realignment | $300 - 800 |
| 4. | Addition of minor sand nourishment as required to build the backshore up to ~RL 2.5m | $200 - 300 |
| | ***Total*** | ***1.9 – 2.2 M*** |

Costs do not include detailed design, consenting, construction supervision costs or contingency.

It should be noted that the length required for realignment to the 2065 stable planform is only around 30% longer than required to realign to the current stable planform. It is therefore economical to relocate as far inland as possible to reduce future maintenance requirements or further physical works.

## 3.5 Option D: Remove wall and restore coastal dunes

**Description**

The straight seawall between the outfalls and surf club and the backing road and footpath would be removed. Once the seawall, backing road and park are removed and cleared, sand would be imported and shaped into a dune system, stabilised using wind-fencing and planted. Where the existing seawalls are truncated, the wall ends should be turned inland to ensure they are not outflanked.

**Technical feasibility**

This option would return the beach to a natural system capable of adapting to storm events and long-term climate change.

High dunes as exist further to the south are not likely to form (based on historical imagery and topographic relief) but rather low, hummocky dunes RL 3.5 to 5.5 m in height. There remains potential for significant wind-blown sand unless dunes are fully stabilised by planting and protected from damage by fencing. A dune width of 30 to 50 m would therefore be expected to be required to efficiently trap wind-blown sand and allow for storm erosion and future climate change. While at least 30 m would be available from the 'current' dune toe, this may decrease to less than 15 m adjacent to No. 12 Reef St by 2115. Sand inundation may become problematic as the dune system attempts to 'roll back' over backing land.

Significant areas of Council Reserve including Shorland Park would need to be returned to natural dune system for this option, although it is noted that southern parts of Shorland Park are already dune.

Immediate modification to the stormwater outfalls are not envisioned and have not been costed into the present project but modifications may be required during future upgrades to the stormwater system.

While a waterway did historically outlet in Island Bay, the backshore appears to have been low, wetlands with capacity to store significant volumes of water before flushing of the entrance and drainage would have occurred. Reinstatement of a natural waterway and outlet may potentially be feasible with earthworks but ongoing blockage of the entrance is likely, increasing risk of flooding in low lying parts of Island Bay.

There is some risk of future erosion impacting assets and infrastructure by complete removal of the seawall. However, given the general stability of the beach system and the distance between the projected future MHWS position and the nearest asset, this risk is low.

**Likely capital cost**

Likely costs associated with removal of the wall and road between Shorland Park and the Surf Club include:

| Component | | Cost estimate ($ ,000)[1] |
|---|---|---|
| 1. | Removal of 250 m of existing wall, roadway, fill material, footpath and utilities | $150 |
| 2. | Modification to the remaining walls ends to ensure they are not outflanked in the future | $150 – 300 |
| 3. | Clearance of 3000 $m^2$ of Council reserve inland of the road | $90 - 200 |
| 4. | Importing sand as necessary to build dune system | $300 - 500 |
| 5. | installation of wind fencing and planting suitable native sand-binding vegetation (pingao, spinifex) over 5000 $m^2$ area | $100 – 300 |
| 6. | Construction of additional walkways behind and through the dune system as required | $50 – 100K |
| 7. | Rediversion of roadway and utilities inland, likely up Trent St and The Parade | $ TBA |
| | ***Total*** | ***850 – 1,500***[2] |

[1]Costs do not include detailed design, consenting, construction supervision costs or contingency.

[2]Does not include costs associated with diversion of roadway and utilities inland, likely up Trent St and The Parade

# 4 Applicability

This report has been prepared for the benefit of Wellington City Council with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Tonkin & Taylor LTD

Environmental and Engineering Consultants

| Report prepared by: | Authorised for Tonkin & Taylor Ltd by: |
|---|---|
| ......................................................... | ...................................................... |
| Dr Tom Shand | Richard Reinen-Hamill |
| Senior Coastal Engineer | Project Director |

TDS

P:\29595\WorkingMaterial\R20140521.CoastalProcessAssessment_V3.docx

# References


Bruun, P. (1962). Sea level rise as a cause of shore erosion. Proceedings of the American Society of Civil Engineers (ASCE), Journal of Waterways & Harbours Division, Vol. 88 (WW1), 117-130.

Klein, A.H.F., Vargas, A., Raabe, A.L.A., and Hsu, J.R.C, (2003) Visual assessment of bayed beach stability using computer software, Computer and Geosciences, 29, 1249-1257, 2003.

LINZ (2013) http://www.linz.govt.nz/geodetic/datums-projections-heights/vertical-datums/tidal-level-information-for-surveyors

Ministry for the Environment (2008) Coastal Hazards and Climate Change. A Guidance Manual for Local Government in New Zealand. 2nd edition. Revised by Ramsay, D, and Bell, R. (NIWA). Prepared for Ministry for the Environment.

Stephens, S.; Reeve, G.; Bell, R. (2009). Modelling of the 2 February 1936 storm tide in Wellington Harbour. NIWA Client Report HAM2009-014 prepared for Greater Wellington Regional Council. 33p.

Tonkin & Taylor (2013). KiwiRail Remedial Works Development of Design Environmental Conditions. Report for Kiwirail. Job number 29405.000

Hsu, J.R.C. And Evans, C. (1989) Parabolic bay shapes and applications, Proc. of the Institute of Civil Engineers, Part 2, 87, 557-570, 1989

# Appendix A: Site photos

*A-1 Island Bay overview showing crescentic beach planfrom backed by straight seawall*

*A-2 Wind-blown sand accumulating against the existing seawall on eastern side of bay*

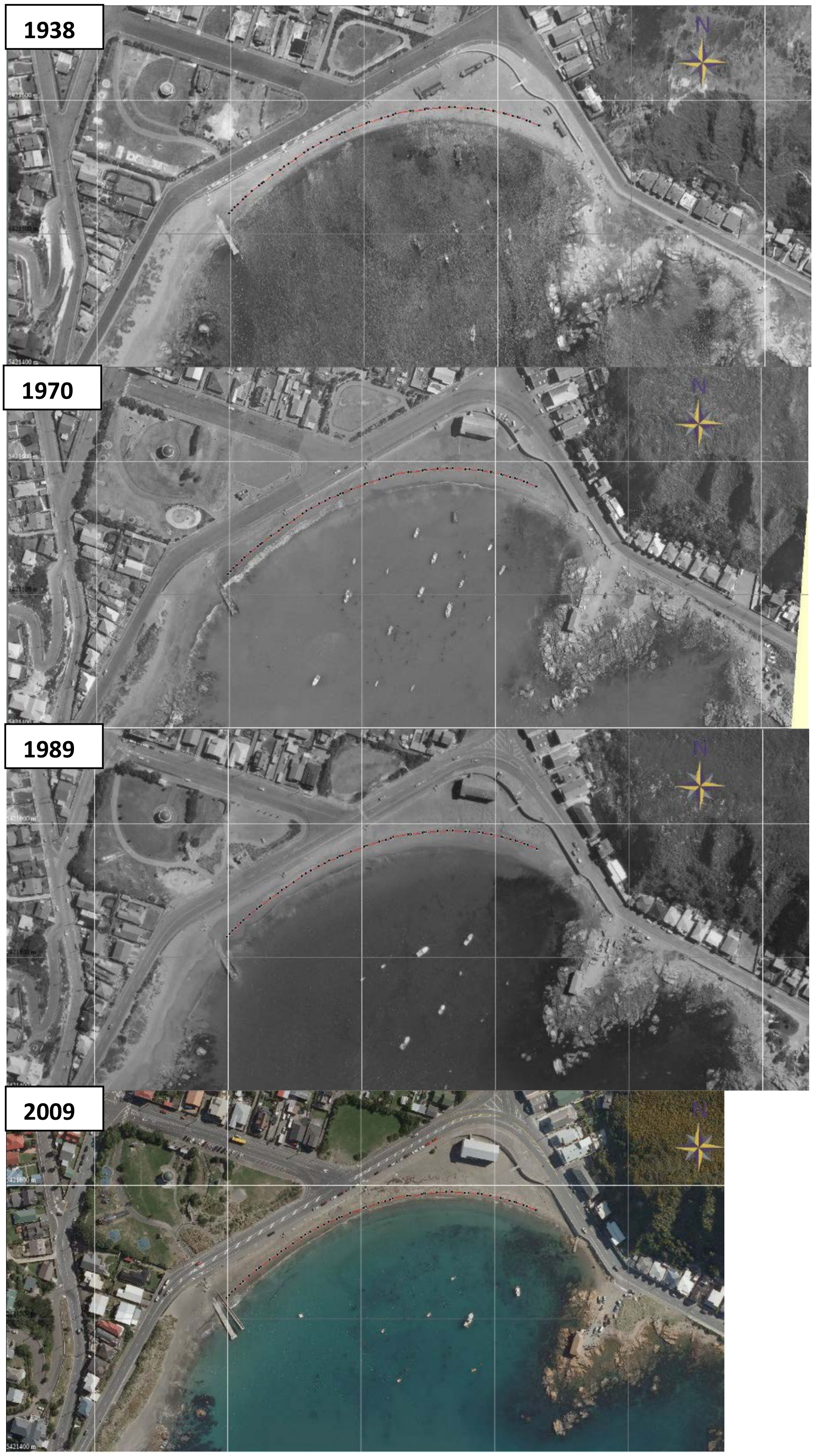
*A-3 Grouted rock and concrete outfall on eastern side of bay*

*A-4 Failed section of seawall with temporary rock repair*

*A-5 Stormwater outfalls at southwesten end of bay*

*A-6 Wind-blown sand accumulating against seawall and detached dune system evident across road in Shorlanad Park*

# Appendix B: Historic aerial photographs




*2013 MHWS line (- - -) superimposed on georeferenced historic aerial photographs*

## Appendix C: Indicative management option figures

- **Option 1: Retain wall in present alignment**
- **Option 2: Beach nourishment to provide buffer**
- **Option 3: Realign wall to natural beach planform**
- **Option 4: Remove wall and re-establish dune system**

www.tonkin.co.nz

ENVIRONMENTAL AND ENGINEERING CONSULTANTS