Managing and adapting to coastal erosion on the West Coast: Rapahoe

2017 review and update

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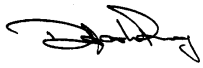
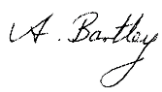
	Reviewed by:	Doug Ramsay
	Formatting checked by:	Alison Bartley
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Executive summary

Coastal erosion is an issue facing several communities on the West Coast. This report addresses coastal erosion at Rapahoe village which threatens property and infrastructure. The West Coast Regional Council (WCRC) has requested an update to a report titled "Managing and adapting to coastal erosion on the West Coast: Rapahoe" (NIWA, 2006). The advice is intended to benefit WCRC, the Rapahoe community and recreational users of the beach by assisting with informing a long term strategy for managing coastal hazard risk to development at Rapahoe.

There is nothing to suggest that since 2006 erosion in general is getting worse at Rapahoe. The same coastal processes that have been occurring over the last few decades since the seaward berm of the previous hāpua feature retreated landward and reconnected with the present shoreline are influencing the position of the beach. However, the awareness of the problem and the risk and vulnerability are increasing. At Rapahoe, the problem is not due to the ongoing changes in the coastline but rather that historical development, such as Beach Road, has been located too close to the sea to accommodate natural changes and trends in the coastline.

The most effective way to manage risk to private property at Rapahoe is to accommodate potential beach retreat by controlling any further development in the area between Beach Road and the shore-parallel line extension of Hawkens Road. There are only a few permanent properties (dwellings and hotel/pub) in this zone, and while the risk from erosion is not critical in the short-medium term, the erosion risk (along with increasing river and sea flood risks), suggests that opportunities should be explored (i) to relocate these buildings over the next one to two decades as they reach the end of their useful life, and (ii) to control any upgrade or future rebuilding in their present locations.

The existing rock protection suffers from ongoing wave attack causing undermining, abrasion and material losses. Without additional rock and maintenance works, this ongoing degradation of the existing defences may well cause erosion rates to increase, and consequently the remaining lifespan and protection will be short lived. The cost of a substantial upgrade to the rock protection works is unlikely to be economically viable for the community and is not justified given the value of assets at risk and that ultimately relocation of the most seaward buildings and associate development will be required.

The risk to the remaining section of Beach Road south of Statham Street remains high, as the narrow vegetated gravel barrier and poor quality rock/rubble berm are insufficient to withstand long-term beach retreat. The council and community should expect to relinquish Beach Road in the near future. Fortunately this section of Beach Road is not required for property access.

1 Introduction

Coastal erosion is an issue facing several communities on the West Coast. This report is one of several recent reports by NIWA addressing coastal issues for the West Coast Regional Council (WCRC) at several locations on the West Coast. This report addresses coastal erosion at Rapahoe village, situated approximately 10 km north of Greymouth (Figure 1-1) at the mouth of Seven Mile Creek.

Figure 1-1: Location of Rapahoe.

Coastal erosion at Rapahoe was reviewed in a previous report titled "Managing and adapting to coastal erosion on the West Coast: Rapahoe" completed by NIWA (NIWA, 2006) for the WCRC.

Erosion of the coastline in this area has continued and threatens property and infrastructure. WCRC requested an updated assessment to identify changes to the coastal environment in the 10 years since the report was released. The advice is intended to support WCRC, the Rapahoe community and recreational users of the beach through advice on a long term strategy for management of the beach and guidance on appropriate coastal protection options.

The investigation included a site visit to Rapahoe by Drs Michael Allis and Murray Hicks on the 21 of November, 2017, review of the NIWA (2006) report, and review of other literature since 2006 such as the West Coast Coastal Hazard Assessment (NIWA, 2012).

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2 Beach processes

The assessment of general geological controls and geomorphic processes and patterns at Rapahoe summarised in the previous assessment (NIWA, 2006) remains applicable. This includes:

- The evolution of a gravel barrier system, including the washover and overstepping processes during storm systems, and including possible responses of aggradation and retreat under sea-level rise scenarios.
- Gravel sediment supply and losses, characterised by long-term sediment starvation at Rapahoe by interception at Cobden/Pt Elizabeth along with ongoing abrasive and littoral transport losses on the beach face.
- Geological factors influencing shoreline evolution. Including the wave refraction around Pt. Elizabeth driving littoral transport, along with the northern and southern mudstone (Papa) outcrops constraining the beach but only supplying poor-quality (with respect to wave erosion resistance) sediment to the beach.
- Influence of existing protection works, including outflanking and edge effects alongside existing protection works, narrowing and lowering of the beach in front of rock revetment structures, and winnowing of smaller gravels through voids in the large rock.

NIWA (2006) provides further explanation of these processes.

2.1 Recent studies

Since the NIWA (2006) assessment, two further studies have investigated coastal changes and hazards at Rapahoe Beach. Both confirm that the observations and assessment by NIWA (2006) remain applicable. The main addition to historic knowledge at Rapahoe is further information on shoreline evolution and retreat processes and rates over the last 70-80 years.

2.1.1 Ishikawa, 2008

Ishikawa's (2008) M.Sc. thesis on beach morphodynamics at Rapahoe investigated historical changes, wave processes and sediment transport, along with bay planform shape. Of interest are the historical features identified from aerial photographs during each decade from 1939-2005. Ishikawa digitised, rectified and analysed these photographs to establish the location of key geomorphic features and their movement over time.

Reprocessing the measurements of beach features (Ishikawa, 2008, Appendix 3.15) showed:

- A lagoon/hāpua feature was previously evident seaward of the present-day shoreline (Figure 2-1). The lagoon had an approximate surface area of 3 ha in 1939, reducing to 0.5 ha in 1945 and < 0.1 ha in 1970. No tidally-connected lagoon has been observed since 1970, although ponding in the former lagoon depressions is noted in the 1980s. The lagoon, as photographed in 1939, would have been classified as a hāpua-type lagoon (Kirk and Lauder, 2000) which are narrow, elongated and shallow, separated from the ocean by coarse clastic (gravel, cobble) barrier beaches formed by strong longshore sediment transport (Hume et al. 2016).

- The seaward gravel barrier berm, which separated the lagoon from the ocean, has retreated over 60 m (1939-2005) landward and merged with the shoreline along the landward edge of the lagoon (forming the present-day shoreline). This is seen in Figure 2-1 as the landward extent of the lagoon (located beneath the present day Beach Road) remains nearly stationary as the outer berm retreats landward, with the hāpua body and depression narrowing due to barrier washover and rollover processes. Evidence of washover lobes and water-filled depressions is also seen in historic figures reproduced by NIWA (2006, Figure 4-top). This process was particularly evident during the 1939 to 1948 period, when the hāpua dramatically reduced in size and was cut off from Seven Mile Creek (Figure 2-1).
- The outer berm retreated at an average rate of 0.95 m/year from 1939-2005, to infill the lagoon depression and merge with the inner berm forming the present-day shoreline. Peak localised retreat rates were 3 m/year during 1948-1959 and 2.7 m/year from 1980-1988. The rate of retreat slowed from 1.56 m/year for 1980-1988 to 0.63 m/year for 1988-1997 and further to 0.13 m/year for 1997-2005 as the berms merged into the present-day shoreline berm.
- The vegetation line, representing the top of the gravel barrier on the seaward side of Beach Road, retreated a total of 8.8 m from 1939-2005 at an average rate of 0.13 m/year. This movement is much less compared to the seaward berm due to the protection provided by the seaward berm before they merged. Minor phases of seaward advance occurred in 1939-1959 (+5 m advance over 20 years) as the outer berm merged with the vegetated berm. However, since 1959 the vegetation line has steadily retreated at 0.3 m/year (1959-2005), with a total of 13 m retreat. This phase of retreat has continued since Ishikawa's study and is causing the heightened risk to property by reducing the buffer between the sea and development.
- Ishikawa concludes that the shoreline may further retreat due to geological controls (soft mudstones), ongoing potential sediment transport (wave refraction and hinge point) and the transgressive nature of the composite beaches (evidenced by loss of lagoon). The coast is expected to evolve in a manner consistent with past changes, i.e., with barrier rollover and overwash advancing into the hinterland.

This information shows that the present-day erosion issue has a longer recorded timeline than previously summarised in the 2006 report. The former hāpua acted as a buffer between the sea and the village. The retreat of the vegetation line (inferred to be the landward berm beneath Beach Road and the present-day shoreline) has been slower but steady at 0.3 m/year since 1959. It is this ongoing retreat which is causing the heightened risk to property by reducing the buffer between the sea and development.

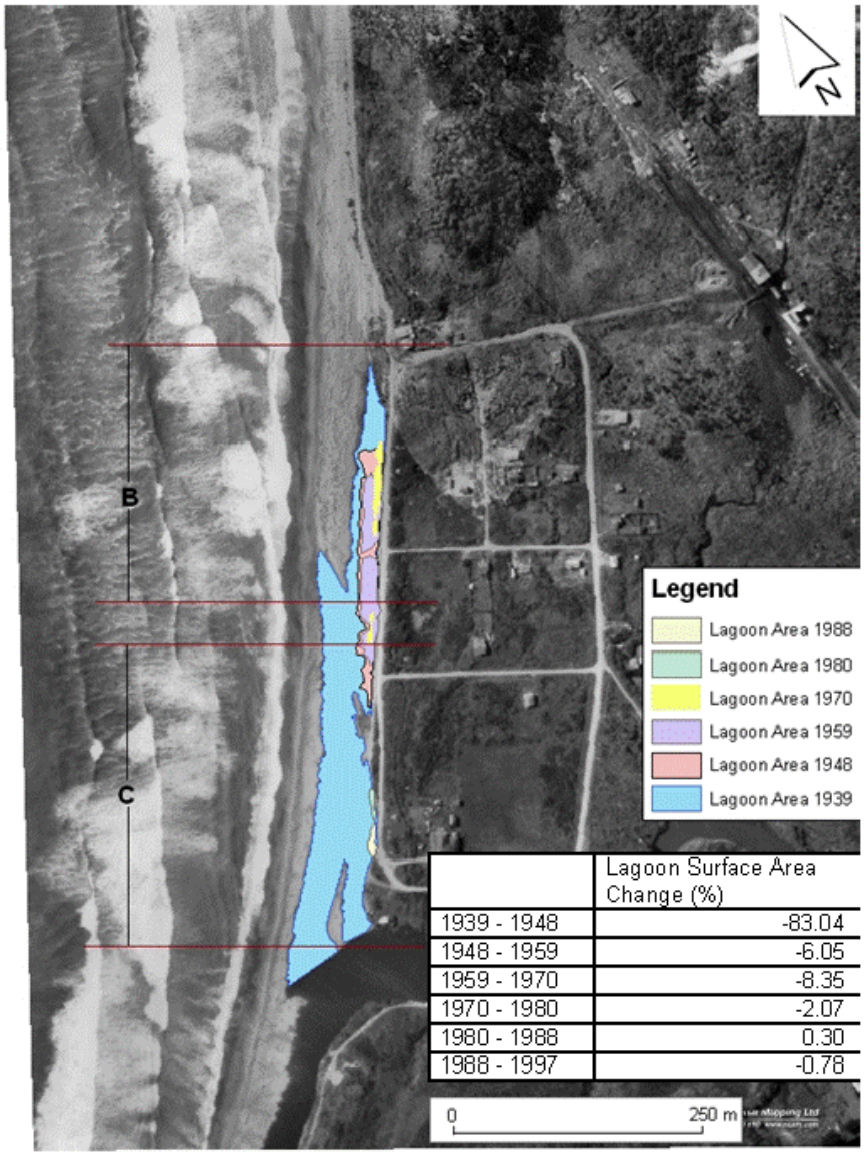

Figure 2-1: Historic hāpua extents and historic aerial photograph (1939). [*Credit*: NZ Aerial Mapping Ltd, Ishikawa (2008, Figure 3.9)].

2.1.2 Regional coastal hazard assessment (2012)

The latest Coastal Hazard Assessment (CHA) at Rapahoe (NIWA, 2012) prioritises the Rapahoe coastal area as *'High: ongoing processes threaten to erode several properties as well as SH6. Sea flooding will become an increasing problem as more erosion occurs'*. The CHA identifies the variability in erosion rates along the beach predominantly due to the varying exposure to wave energy and direction. The CHA recommends development of hazard zones to allow assessment of risk to property, along with management plans for present and future usage.

Note that historically, the development at Rapahoe (since 1939) is characterised by infilling between houses, and generally inland from the shore-parallel line of Hawkens St (compare Figure 2-1 and Figure 3-1 below). There are a few exceptions to this, namely the campground, pub and Holland St areas. The CHA recommendation about developing hazard zones to accommodate coastal retreat is largely about managing housing development in the area seaward of the shore-parallel line of Hawkens St to reduce increasing exposure risk, **not** trying to control the shoreline.

3 Updated observations

The investigation included a site visit by Drs Michael Allis and Murray Hicks on the 21st November 2016. At the time of inspection (1 pm to 4:30 pm), low tide was predicted for about 11:09 am for the Grey River mouth (6 km south), offshore significant wave height was approximately 1.5 m from the west, and winds were light (< 10km/h) and from the west.

Figure 3-1: Rapahoe location diagram. Imagery 2013. [*Credit*: gis.westcoast.govt.nz].

At Rapahoe, several observations were made in order to review and update the NIWA (2006) assessment. These are:

- Ongoing wave overwash of gravel is evident at all locations along the Rapahoe beach front (Figure 3-2). Wave overtopping, saltwater spray and gravel movement are affecting beach-crest vegetation and roadways (Beach Road and the seaward ends of

Statham, Morpeth and Holland Streets, see Figure 3-2), with evidence of periodic council sweeping and clean-up on Beach Road. Nearer to high tide (within 90 minutes) at the end of the inspection, the relatively benign waves and uprush regularly submerged and covered much of the rock protection on the beach face, but waves were not able to reach the beach crest. Evidence of storm overwash into the coastal fringe of inland private properties was also observed.

- Beach Road remains closed between Stantham St and Holland Rd, with no additional lengths closed since 2006. This is probably due to the protection provided by a small rock/rubble berm placed alongside Beach Rd, extending approximately 100 m south from Statham St (Figure 3-1, Figure 3-3 (right), Figure 3-4). The berm is composed of small mudstone cobbles and boulders (<0.5 m diameter) mixed with sands and gravels. The rock berm appears to have been placed on the beach crest without any geotextile underlayer or toe embedment, and is only 1-1.5 m wide and reaches 1 m above ground level. The council appear to maintain this after erosion and overwash occurrences (Figure 3-2, right). This berm is a poor quality, short-term coastal defence which is much smaller than protection works at the northern end of Rapahoe. The berm has already suffered erosion/undermining from wave attack and is not expected to survive large storm erosion or to protect against wave overtopping.

- Continued beach retreat along the entire foreshore. Although there have been no additional closures of Beach Rd, the entire beach is narrowing and the beach crest continues to retreat landward. This is evidenced in the exposed and eroding former road base (Beach Road between Morpeth St and Holland St, Figure 3-3, left) and the lowering and retreat of the upper beach increasing the space between the top of the rock armour and beach crest (Figure 3-4, right; Figure 3-5).

- Retreat of the beach along the Rapahoe frontage north of Statham Street (Figure 3-1) is now undermining the existing rock protection, causing it to subside. The crest of the rock protection is now >1 m below, and 3-5 m from, the beach crest (Figure 3-4, right; Figure 3-5). The amount of recent erosion and subsidence reduces at the north end of Rapahoe, with <1 m retreat over the last 10 years at the low mudstone bluffs (Figure 3-1, Figure 3-5 and Forbes house). Despite the ongoing erosion, the relatively low retreat rate since 1997 (< 0.5 m/year) compared to the 1939-1988 retreat rate (1.5 m/year) is due to the protection provided by the merged gravel barriers and to some extent the rock revetment.

- Erosion of the bluff is due to both the gradual loss of protection provided by the beach material fronting the bluff and the undermining and slumping of the larger rocks in the revetment which decreases the level of protection to the bluff behind.

- The Forbes house and garage at the far northern end of Rapahoe beach front (un-numbered, on Holland Street, see Figure 3-1) have been relocated 20-25 m inland on the same section in response to the ongoing erosion threat. The former foundations and driveway have since been partially lost to erosion. Large (>1m diameter) boulders have been placed along the beach front linking to the NZTA protection of the northern Rapahoe bluffs (Figure 3-6).

Figure 3-2: Continued overwash deposits onto Morpeth St (left) and Beach Rd near Statham St (right). [*Credit*: M. Hicks].

Figure 3-3: Continued erosion behind the rock revetment along the former Beach Rd between Morpeth St and Holland St (left) and recent protection works alongside Beach Rd south from Statham St (Right). Left: note former Beach Rd tar seal and basecourse layers at right of image. [*Credit*: M. Allis].

Figure 3-4: Continued beach retreat against rock berm (left) and along the entire foreshore (right). [*Credit*: M. Hicks].

Figure 3-5: Current condition (21 November 2016) of the northern end of the rock revetment. [*Credit*: M. M. Allis].

Figure 3-6: Relocated Forbes house, Holland St. Former foundations and driveway are just visible 20-25 m seaward (left) from house [*Credit*: M. Hicks].

4 Updated assessment

4.1 Erosion rates

There is nothing to suggest that since 2006 erosion in general is getting worse at Rapahoe. The same coastal processes that have been occurring over the last few decades since the seaward berm of the previous hāpua feature has retreated landward and reconnected with the present shoreline are influencing the position of the beach. However, the awareness of the problem and the risk and vulnerability are increasing. At Rapahoe, the problem is not due to the ongoing changes in the coastline but rather that historical development, such as Beach Road, has been located too close to the sea to accommodate natural changes and trends in the coastline.

The survey data from Ishikawa (2008) has quantified shoreline changes and showed a slowing of the retreat rates in latter decades of the 20th Century. A decline in retreat rates are visible during the periods of 1980-1988 (1.56 m/year), 1988-1997 (0.63 m/year) and 1997-2005 (0.13 m/year)[1]. This slowing in the rate of retreat is probably due the retreat of the seaward berm of the previous hāpua as it reconnects with the present shoreline berm and the influence of the geologic bedrock controls of the northern Kaiata mudstone bluffs. Some short-term slowing of the retreat rate from 1997 onwards could also be due to the rock protection works by NZTA below the northern mudstone bluffs and rock protection works along the Rapahoe beach frontage, although the longer-term effects and longevity of the rock protection works cannot be predicted at this stage.

In contrast, the 2006-2016 retreat rate of the barrier crest is estimated to be 0.3-0.5 m/year (estimated from site photographs). This recent increase in the rate of retreat suggests the gravel barrier material is winnowed from between the rock protection causing undermining of the protection works and subsequent slight acceleration of landward retreat.

With the exception of a significant earthquake event there is unlikely to be any significant change in the inputs of cobbles and gravel to the Rapahoe beach system. Long-term retreat is expected to be an ongoing feature of this section of coast. The placement of the rock armour has slowed the rate of retreat but given the ad hoc and poorly constructed nature of the defence it will not prevent ongoing retreat of the shoreline or significantly reduce wave overwashing and potential flooding during high tide and large wave conditions.

4.2 Risk and vulnerability

The Forbes property (far northern end, previously at critical risk) provides an effective example of managing development risk from coast erosion and flooding at Rapahoe (Figure 3.5). The relocation of the property has substantially reduced the risk of damage to the property and increased the future timeframe over which the property can be effectively used.

The most effective way to manage risk to private property in the future is accommodating the potential beach retreat through controlling any further development in the area between Beach Road and the shore-parallel line of Hawkens Road - see red shaded area in Figure 3-1. This low-lying area is also being increasingly exposed to storm-related flooding due to wave overtopping, potential breaching of the shoreline berm, or from high river levels, and will increasingly experience drainage and more frequent flooding during storm events as sea-levels rise.

[1] Reprocessed from Ishikawa (2008, Appendix 3.15).

There are only a few permanent properties (dwellings and hotel/pub) along this seaward section at Rapahoe. These are typically at least 30-40 m from the present-day beach crest, and while not a critical risk from erosion in the short-medium term, this along with increased flood risks suggest that opportunities should be explored to relocate these buildings over the next one to two decades as they reach the end of their useful life and to control any upgrade or future rebuilding in their present locations. The existing camp and caravan sites (see Figure 3-1) are relatively straightforward assets to relocate should impacts from erosion or flooding on the site become more likely or significant, assuming there is a suitable site to relocate to. The most cost-effective long-term strategy to reduce risk will be to relocate rather than continue to maintain and extend the rock protection.

The existing rock protection suffers from ongoing wave attack causing undermining, abrasion and material losses. Without additional rock and maintenance works, this ongoing degradation of the existing defences may well cause erosion rates to increase - and consequently the remaining lifespan of the protection will be shortened. The cost of a substantial upgrade to the rock protection works is unlikely to be economically viable for the community, given the development at risk. Thus medium to long-term relocation of the most seaward buildings and associated development will be required.

The risk to the remaining section of Beach Road south of Statham Street remains high, as the narrow vegetated gravel barrier and poor quality (size, position, material strength, and material composition) rock/rubble berm are insufficient to withstand long-term beach retreat. The council and community should expect to relinquish Beach Road in the near future. Fortunately, this section of Beach Road is not required for property access.

5 Future management options

Overall, with only small changes to the Rapahoe beach system over the past decade, the management options proposed by NIWA (2006, Chapter 3) remain applicable:

- The most cost-effective medium to long-term risk reduction strategy will be to relocate the most seaward buildings and development rather than continue to maintain, upgrade, or extend the rock protection.
- Controls to restrict future development seaward of Hawkens Street will reduce the risk to development from the long-term beach retreat at Rapahoe. This may include restrictions on new properties, on rebuilding once dwellings reach their end of life, or relocating before the risk becomes critical.
- There is little economic justification for adopting a continued upgrade/extension of the hard defence seawall along the majority of this coastal frontage for the protection of Beach Road, given that Beach Road is not required for property access and the adjacent properties are either undeveloped or their developments relocatable (e.g., campground).

6 References

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