# Te Awanga – Haumoana
# Coastal Erosion

## Review & Recommendations

29 April 2009

*Prepared for*

THE HAWKE'S BAY REGIONAL COUNCIL
&
HASTINGS DISTRICT COUNCIL

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# 1. PURPOSE OF THE REPORT

The following is a report on the current situation, current state of knowledge, options and recommendations for moving forward on the issue of coastal erosion and storm inundation at Te Awanga – Haumoana in Hawke's Bay. This is a desk-top study based on a review of previous reports, supplemented with up-to-date cost estimates, and other incidental updates since previous investigations were completed in 2007.

The report is intended to assist the Hastings District and Hawke's Bay Regional Councils, and the people of Te Awanga – Haumoana, in making a decision on the way forward for dealing with the erosion issue, having regard to the risks and costs associated with alternative options.

# 2. THE EROSION ISSUE

The existing erosion of Te Awanga and Haumoana beach is the continuation of a long term erosion trend extending back to at least the 1930's. This is resulting in a gradual retreat of the shoreline and exposure of near-shore properties to increasing risk of wave damage during major storms. The same general trend can also be observed at East Clive and at Clifton. The historical record shows that the whole of the coastline from the mouth of the Ngaruroro southwards to the tip of Cape Kidnappers is generally in retreat. There are short term fluctuations within this trend, and localised discrepancies around river mouths and existing groyne structures, but the overall pattern shows a gradual retreat of the shore.

Evidence of a history of erosion can be observed by looking back on earlier aerial photographs of the coastline and records of transect surveys showing changes in the beach profile at various points along the southern coastline, mostly since the early 1970's, but in some cases with data as far back as 1914. Cadastral plans, overlaid on modern aerial photographs, also show how surveyors were once able to peg out legal boundaries in places that are now anywhere from 15m to 90m out to sea (at Haumoana and East Clive respectively)[1]. An early survey plan for the site of the houses at 1 – 41 Clifton Road shows that the beach at this point has retreated by about 40 metres since 1930[2].

In more recent times local residents will have also witnessed, directly, the damage or disappearance of near-shore buildings and mature trees. There is evidence that the coastal lagoons at East Clive are being progressively filled in by the retreat of the gravel beach. The Tukituki and Ngaruroro Rivers were

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[1] From *Quickmap* cadastral data and aerial photo overlays. Note that the figure of 90m is based on the point of greatest difference between existing and c.1890 shorelines. This is near the mouth of the Ngaruroro River and therefore could easily be affected by changes in the position of the river mouth over that period. The 'typical' difference between c.1890 and present day beach positions at East Clive is about -40 metres (according to this source).

[2] Reference: Survey Plan SO4308, sourced from Napier Public Library microfiche collection. The plan shows that the site of 1 – 41 Clifton Road was formerly part of a wide strip of reserve for Clifton Road extending from the landward side of the existing road all of the way down to the high water mark. The middle part of the road reserve was 'closed' in 1930, apparently to allow the subdivision of 1 – 41 Clifton Road. The road closure plan (SO4308) suggests that further subdivisions were also planned along this strip further to the south, although these further subdivisions evidently did not happen. The rest of the land was ultimately vested as recreation reserve and retains this status today.

once joined by this lagoon and exited to the sea by a common (but shifting) mouth. The connection between the two rivers ceased in about 1920 when, it appears, a dam was built across the lagoon at East Clive (probably for flood control purposes)[3]. It may be significant that the land in this area later dropped by about 0.76m during the 1931 earthquake. The roll-back of the bar on the seaward side of the lagoon (thereby filling in the lagoon) appears to have commenced around that time[4].

The cliffs along the shoreline between Clifton and Cape Kidnappers are also eroding but affecting only farm land. The retreat of the cliffs can be traced back on historical aerial photographs. Tonkin & Taylor (2005) have calculated, from aerial photo analysis, that the rate of retreat of the cliffs since the early 1950's has averaged about 0.16m per year (a total of 8.5m retreat over the 52 years of aerial photos). During this time there has been no corresponding enlargement of the beach at the base of the cliffs which indicates that when slips have fallen the material is generally carried away by the sea rather than remain to build up an ever-expanding beach.

Between 1972 and 1994 the shoreline at Clifton, Te Awanga and Haumoana has moved inland by about 25m, 10m and 15m respectively[5]. At East Clive the trend is more difficult to discern because of the influence of the various groynes and outfall structures in the area, the presence of the Ngaruroro/Tutaekuri and Tukituki Rivers, and the previous existence of a lagoon connection between the Tukituki and Ngaruroro. Historical transects at the site of the Hastings outfall between 1914 and 1978 show a total retreat of about 60 metres[6]. Later transects at the same site show a further retreat of 10 metres between 1979 and 1981[7]. The pattern thereafter appears to show a recovery of the beach soon after the installation of the second East Clive groyne in December 1993 but with renewed retreat from 1994 onwards[8]. A comparison between early survey plans and existing aerial photographs (with cadastral overlay) suggests, however, that the average amount of retreat along the whole of the beach at East Clive since 1931 may be closer to 40 metres[9].

Coastal inundation is also a problem in this area. The last major event was in August 1974 when storm waves over-topped and infiltrated the barrier beach and resulted in about 200 hectares of urban and rural land being inundated with seawater[10]. There have since been other smaller events but with comparatively minor damage as a result of improved (post-1974) protection works including enhanced pump drainage systems at Haumoana and coastal stop-banks at East Clive. The threat of future coastal inundation has not been

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[3] As evidenced from early maps, in the collection of Mr Maurice Bartlett, Napier.

[4] Based on historical maps in the collection of Mr Maurice Bartlett, Napier, and cross-sectional plans in HBRC publication *Beach Changes between Napier and Clifton* (June 1984), Fig 20, p.46.

[5] Based on transect data. Note that transects are samples only but assumed to be indicative of the overall trend along the beach. Transect data can be referred to in Appendix A & B of Tonkin & Taylor (2005).

[6] It may be significant that the transect plan (in Smith, 1984) shows retreat happening only after 1936. This would be post-earthquake.

[7] Smith (1984) *Beach Changes between Napier and Clifton*, p.46.

[8] Refer to Appendix A & B of Tonkin & Taylor (2005) for excursion plots. Those relating to the East Clive area are mostly to be found in Appendix B.

[9] Based on a comparison between survey plan SO1266 (sourced from the collection of Mr Maurice Bartlett) and digital aerial photos with cadastral overlay in *Quickmap* (computer mapping software).

[10] The 1974 event is recounted in Simons P.K. & Koutsos, P. (1985) *the East Clive Experience.*

eliminated by these improved protection schemes but is now considered to be at an acceptable level of design and risk[11].

The on-going retreat of the shoreline at Te Awanga – Haumoana is not expected to significantly increase the risk of future inundation beyond what it is at the present time. The profile of the beach (the angle of the seaward slope, the height of the beach crest and distance from the beach crest to the waters edge) should remain unchanged even as retreat occurs. The process involves a 'rolling back' of the gravel beach barrier whereby storm waves over-top the barrier and wash gravel over from the seaward to the landward side. This can be seen happening at Haumoana where the old tar-sealed access road at the Domain is being gradually overtaken by gravel as the beach rolls back over it. The result is a landward migration of the beach but maintenance of the same basic height and profile of the gravel barrier. The barrier will continue to be over-topped in future, as it is prone to being over-topped now, but as long as adequate back-up systems are in place and functioning, and as long as the beach barrier is not otherwise interfered with, the risk of wide-scale inundation should be no greater than now.

[11] Pers. comm G. Clode (HBRC Engineer).

# 3. EXPLANATIONS FOR THE EROSION

There is no commonly agreed explanation for the erosion and accretion trends occurring in this southern part of the bay – although there have been a number of possible and plausible theories put forward. These have been covered in earlier reports. The following is a brief summary:

## 3.1 1931 Earthquake

A possible or partial explanation for the erosion is that significant changes in ground level (also affecting the sea bed) occurred during the 1931 earthquake. The earthquake lifted up the land to the north of the Ngaruroro River (by about 1.5 to 1.8 metres) while causing the land to the south of the river to drop (by 0.5 to 0.76m between Ngaruroro and Haumoana)[12].

The changes in ground elevation will have resulted in corresponding changes in relative sea level along the shoreline. At Haumoana, where ground level dropped, mean water level will have effectively risen – leaving the foot of the barrier beach at Haumoana in 0.76m of deeper water. In theory this will have in turn exposed the beach to a greater severity of wave impact and caused the beach to be more easily driven back during storm events until eventually stabilising at a point where the beach profile, relative to mean sea level, is restored.

The effect could have been particularly significant in the East Clive area which was historically fronted by a lagoon and shingle bar. The Ngaruroro and Tukituki rivers were previously joined via this lagoon. The closure of the connection between the two rivers (probably around 1920), followed by the lowering of ground levels in the 1931 earthquake, may have caused the bar at the front of the lagoon to begin rolling back. This could have, in turn, triggered up-stream effects on the beach at Haumoana – Te Awanga.

It is hard to say how much shoreline retreat is likely to have been induced by the earthquake in the Te Awanga – Haumoana area. Calculations by Smith (1984) suggest that a 0.72m drop in ground level would have the potential to result in as much as a 320m retreat of the beach – although the model used in this case takes no account of the likely moderating effects of off-shore sedimentation and is therefore probably too high and certainly much more than the 70 – 100m predicted for this part of the coastline by Tonkin & Taylor through to the year 2100. It is also difficult to say whether the effects of the change in elevation that occurred in 1931 remain on-going.

## 3.2 Declining Gravel Supply

Another possible explanation for the erosion is that the supply of gravel to the beaches at Te Awanga, Haumoana and East Clive has been in decline. All of the beaches need a constant supply of gravel, usually carried in by long-shore transport, to balance out losses from out-going long-shore transport and from abrasion.

[12] The effect of the earthquake on ground levels at Te Awanga and Clifton is not clear because of the lack of reliable pre-earthquake ground level data – although Smith (1984) suggests that the amount of ground movement in this area was much less than at Haumoana and may have involved very little movement at all.

At Te Awanga and Haumoana the main sources of gravel are from the Maraetotara River and the erosion of cliffs at Cape Kidnappers. There are also some gravel deposits in deep water off the mouth of the Maraetotara River[13] – although their contribution to the beach, if any, is unknown and assumed to be negligible. The far northern end of Haumoana Beach can also, in some conditions, receive gravel from the Tukituki River.

East Clive in turn receives this same material as it continues along the coast (carried by long-shore transport), plus gravel washed out of the Tukituki. The erosion and nett 'loss' of gravel from the beach at Te Awanga – Haumoana and Clifton (estimated to be about 48,800m$^3$ per annum[14]) also becomes a 'gain' to East Clive and the rest of the coast as far as to the Port of Napier. A decline in the rate of erosion along the cliffs at Cape Kidnappers and/or reduction in output of gravel from the Maraetotara River would potentially lead to an imbalance in the sediment budget for this section of coastline.

There is, however, nothing to suggest that anything has materially changed at the Maraetotara River or along the coastal cliffs to reduce the supply of gravel at least since the earthquake in 1931. The earthquake itself should have, if anything, at least temporarily increased the supply of gravel as a result of the numerous slips that occurred along the cliff-faces at the time of the event. Yet this does not appear to have happened. There was reportedly a build-up of sediments between 1934 and 1943 around the mouth of the Ngaruroro, which some suggest originated from the Cape[15], but there is no record of a similar advance of the beach happening at Te Awanga – Haumoana[16]. In order for material to get from the Cape to the mouth of the Ngaruroro it would have to pass along Te Awanga – Haumoana beach.

Whether there has been any reduction in the amount of gravel coming down the Tukituki is also difficult to accurately determine – but seems unlikely. The output of gravel from the river on to the coast is highly variable and closely related to the incidence and duration of floods. The 'average' output is estimated to be about 28,000m$^3$ per annum but the amount can vary enormously (between 0 and 160,000m$^3$ in any given year) depending on how many floods have occurred and the size and duration of flood events. There is no evidence of any appreciable decline in the incidence of floods over the last 80 years.

Nor is there evidence that commercial extraction of gravel from the river is causing a decline in the supply of gravel to the sea – although further research may be wanted to check this out. Experimentation in the past by Hawke's Bay Regional Council river management staff has shown that where extra gravel is left in the channel there is no apparent increase in the rate of transport down-river but rather a tendency for the gravel to form up in to islands within the channel[17] (with the islands ultimately creating problems of their own as a potential threat to river flood protection works[18]). The limiting factor therefore

[13] Smith (1984), p.6, shows a map of seabed sediments.
[14] Komar (2007)., p.20.
[15] Tonkin & Taylor (2005), p.3, in reference to Single (1985).
[16] Likewise at Clifton. A notated aerial photograph (source: collection of Maurice Bartlett, Napier) suggests that there was significant erosion of the Clifton Domain immediately after the earthquake in 1931.
[17] Pers comm G. Edmondson, HBRC Design Engineer.
[18] The risks are associated with raising of the river-bed and deflection of river flows in such a way as to undermine banks and flood protection structures.

does not appear to be the 'availability' of gravel but rather the ability of the river to shift the gravel along. That is determined by the frequency, intensity and duration of floods.

## 3.3 Extraction at Awatoto

Another possible cause of erosion is the beach gravel extraction operation at Awatoto. In theory the removal of gravel from Awatoto results in a low-point or void in the shingle beach. Replacement gravel then flows in to the void (by long-shore transport) but thereby creates a new void at the place where the in-flowing gravel has come from. By this process a chain-reaction is caused that ripples back along the beach against the direction of long-shore transport.

It has been suggested that the effect could even extend all the way back to Te Awanga and Haumoana – although this remains unproven. There is a 5.5 kilometre separation distance between Awatoto and Haumoana with two major river outlets in between. It is also significant that the coastline to the north of the gravel works is predominantly stable[19].

The Awatoto gravel operation has historically removed, on average, about 47,800m$^3$ of gravel a year from the beach. The latest re-consenting for the quarry reduced that amount to a maximum allowable take of 30,000m$^3$ per annum.

## 3.4 'Natural' Retreat

A further possibility is that the retreat of the shoreline is just an extension of the on-going retreat of the cliffs at Cape Kidnappers. If the cliffs and shoreline are retreating between Clifton and the Cape then this must eventually have a knock-on effect on the continuation of the coastline to the north. The cliffs are estimated to have retreated about 8.5 metres between 1953 and 2005 as a result of continued attack by the sea. This is less than the amount of retreat experienced at Te Awanga – Haumoana but could still be a contributing factor.

The retreat also could be merely part of a long term erosion / accretion cycle affected by, for example, cyclic weather patterns (alternating predominance of La Niña / El Niño) or other longer term cyclic trends not yet known or properly understood.

[19] As illustrated by historical beach transect data. The stability of the beach is also illustrated by the relative positions of the existing shoreline and the line of old WWII machine-gun bunkers (c.1945) that extends from the mouth of the Ngaruroro / Tutaekuri to the south end of Napier. The modern shoreline is visibly no closer to the bunkers than would have been the case in 1945.

# 4. ALTERNATIVE OPTIONS

In this report we consider two possible alternative options for addressing the problem of coastal erosion at Te Awanga – Haumoana. These are to:

1. **Build coastal protection works**. The intention of these works would be to physically 'hold the line' or even advance the line against the prevailing trend of coastal retreat. For the purpose of this report it is assumed that the work would involve the construction of groynes. Other hard engineering options include the construction of sea walls or artificial reefs – although in practice these perform essentially the same function as groynes.

   Sea walls are discussed in the 2006 HBRC report[20]. They are dismissed on account of cost of construction (costing far more than groynes) and propensity to fail. Less is known of the likely effectiveness or durability of artificial reefs, although recent experience at Mount Maunganui (where a reef was completed in June 2008) has not been encouraging[21]. Reefs are also a higher-cost option than the construction of groynes.

   Another option is beach re-nourishment. This method involves physically trucking in gravel to the beach (typically on an annual basis) to replace what is washed away. Re-nourishment is discussed in the 2006 HBRC report and assumed for the purpose of the current report to be unsustainable in terms of sourcing of sufficient gravel, as well as cost.

   The construction of groynes would require regional council (and probably Minister of Conservation) consent under the Resource Management Act. Consent requirements for these types of structures are as set out in the Proposed and Operative Hawke's Bay Regional Coastal Plans. Further useful information (with background on policy context) in relation to the use of groynes and other coastal protection structures can also be found in the Ministry for the Environment 2008 document *Coastal Hazards Guidance Manual*.

2. **Conduct a staged retreat**. This would involve the relocation of houses, roads and other infrastructure further away from the coast and out of danger. The retreat would be assumed to involve a combination of on-site repositioning of houses (within their existing property) and full relocation of buildings to new sites. The re-positioning / relocation of houses would happen incrementally as individual circumstances demand. Further information is available in the MfE *Coastal Hazards Guidance Manual*.

   In terms of Resource Management Act requirements there would be no major consents needed for relocation of buildings but there may be zoning issues associated with the relocation of dwellings to sites not currently zoned for residential use.

Both of the options above have substantial costs attached as well as risks and uncertainties. These need to be considered and compared. The following sections of this report (Sections 5 & 6) look at each of these options in more detail – their advantages / disadvantages and comparative costs.

[20] HBRC (May 2006) *Haumoana – Te Awanga Coastal Hazards Management : Report on Management Options.*
[21] *Hawke's Bay Today / APN* (29/1/2009) 'Surf fails to rise at artificial reef'.

# 5. CONSTRUCTION OF GROYNES (OPTION 1)

## 5.1 How Groynes Work

Groynes work by trapping sediment as it is carried along the shore by long-shore transport and thereby holding the beach in place. If the length of the groynes is extended out to sea then the width of the artificially-held beach extends as well. If well designed, with built-in low points, then, in theory, once the groynes have filled with sediment the process of long-shore transport will continue carrying an over-spill of sediment past and/or over the groynes to supply the beaches beyond. Illustrations of typical groynes are as shown in Appendix 1.

## 5.2 Risk of Non-performance

There are risks associated with the use of groynes. The first of these risks is that the groynes may not actually work as intended in the chosen location or that the number and size of groynes estimated to be required (and budgeted for) may prove to be inadequate – meaning more are required.

In either case a considerable waste or extra expenditure of money would result. The costs involved are substantial. A typical 70 metre long groyne would be expected to cost in the order of $1,880,000 to install (inclusive of design costs and cost of initial filling) plus $8,500 per annum for on-going maintenance and provision for substantial re-builds (costing $370,000 per groyne) about once every 20 years. At least 13 of these groynes are expected to be required to hold the shoreline at Te Awanga – Haumoana in addition to the existing groyne at the mouth of the Tukituki River.

If a long term commitment was made to the construction and maintenance of groynes the cost of the project in 'today's dollars' (or nett present value (NPV) would be in the order of $18.5 million (NPV).

The risks of non-performance will not diminish over time. Rather, as sea level rise occurs (0.2m predicted by 2050 and 0.5m by 2100) the intensity of erosion and pressure on the groyne structures will increase. Groynes that are built for the existing beach dynamic will not necessarily still perform adequately in the changed coastal environment of 40 or 60 years time. To counter these changes it may be necessary to further increase the scale of protection works. This would in turn have implications in terms of cost and potential impacts on the coastline to the north.

## 5.3 Risk of Downstream Erosion

The other potential risk is that groynes installed at Te Awanga – Haumoana may result in increased erosion further north along the coast. The most vulnerable area is in the vicinity of East Clive but effects could theoretically extend along the whole of the bay as far as Napier. If the groynes were found to be having adverse effects on other parts of the coastline then legal action could be taken by affected landowners, or by owners of affected infrastructure, to have the groynes removed and/or compensation paid for the resulting damage. They could alternatively require the newly-created erosion to be put right by the installation of more groynes or by on-going beach renourishment. The liability for any such damage, if indeed damage is proven, would exist irrespective of whether there had been resource consents issued for the groynes under the RMA.

The risk of downstream erosion can be minimised by filling between the groynes with gravel immediately upon construction. Indeed, for any groynes built at Te Awanga – Haumoana it is assumed that this would be done as a matter of course. A failure to do so would result in complete obstruction of the long-shore transport of gravel past Te Awanga – Haumoana that goes on to supply the beaches to the north. There is a high risk that this would result in increased downstream erosion.

In theory, filling will enable the gravel that originates from Cape Kidnappers, and from the Maraetotara River, to continue past the groynes as the groynes would already be full. The gravel would therefore carry on to supply the rest of the bay to the north (minus that required to 'top up' the groynes in replacement of losses to abrasion or to replace gravel potentially swept out to sea).

There is, however, also the risk that merely stopping the erosion at Te Awanga - Haumoana would, in itself, have a significant effect on the sediment budget for the rest of the bay. At the present time it is estimated that about 48,800m$^3$ of gravel per annum is eroded from the beaches at Te Awanga, Haumoana and Clifton, with Te Awanga and Haumoana on their own representing about 37,200m$^3$/yr of this[22]. What is lost from Te Awanga and Haumoana is then carried north along the coast to supply and sustain the beaches to the north. Stopping the erosion in this area through the use of groynes, or any other method, would therefore mean 37,200m$^3$ less gravel per annum travelling northward. This would in turn, in theory, have an impact on the sediment budget along the rest of the bay and potentially put the northern beaches (especially around Clive / East Clive, but possibly all the way to Napier) in to deficit. Therefore, even if the transport of material along the coast from Cape Kidnappers and the Maraetotara River (and Clifton) continued as normal, the act of halting the existing erosion at Te Awanga and Haumoana could have significant adverse effects. The erosion problem would not be solved – it would just be transferred.

According to Komar (2007) the total longshore transport volume, inclusive of all inputs from Cape Kidnappers, the Tukituki and erosion of the southern beaches equates to about 90,000m$^3$ per annum. The erosion of 37,200m$^3$/yr from Te Awanga and Haumoana therefore represents about 40% of this. The implication is that if the gravel at Te Awanga – Haumoana beach was 'locked up' by the use of groynes then the amount of gravel continuing along the coastline would drop by 40%. If Komar's model is correct then the result would be substantially increased erosion at Clive / East Clive and the commencement of erosion along the Napier shoreline. Napier Beach is at the tail-end of the longshore transport chain and estimated to currently receive just enough gravel to sustain itself – amounting to 6,000m$^3$ a year. That small surplus would be expected to drop in to deficit if, as the model suggests, the supply of gravel to the longshore system was effectively reduced from about 90,000m$^3$ to 52,800m$^3$ by holding back 37,200m$^3$ of gravel per annum at Te Awanga and Haumoana.

[22] Source : Tonkin & Taylor (Sept 2005) *Southern Hawke Bay Shoreline Modelling Report* (refer to Table 4.2, p.16).

It is important to acknowledge that there are, nevertheless, a number of uncertainties in the Komar model. The same applies to the 2006 Tonkin & Taylor model which comes to similar conclusions as Komar and from which much of the original input data for Komar's model is derived. In reality the models provide only a simplified picture of the many complex processes and interactions giving rise to erosion and accretion in the bay and are constrained by the limitations of existing sediment budget data. But until proven otherwise, what they are saying is that there is at least a credible risk of significant adverse effects occurring (in the form of erosion of the northern beaches) if a groyne-field was to be constructed along the Te Awanga – Haumoana shoreline.

These concerns may yet be shown to be unfounded as our understanding of local coastal processes improves. But in the meantime, on account of what the existing models tell us, it would be imprudent to proceed with the construction of a groyne-field until these risks can be put aside. In these circumstances it is also highly unlikely that resource consents would be obtained. A hearing commissioner would be unlikely to grant consents for a project of this nature if such issues remained unresolved.

Other alternative models have been put forward. Among these is the model developed by South Island-based coastal analyst Mr Steve Moynihan for the southern Hawke's Bay coastline which predicts a trend toward a 'crenulate' (sickle-shaped) bay. According to this model the northern half of the bay is already in alignment with the crenulate form but from the Ngaruroro River southwards the beach becomes increasingly out of alignment and consequently prone to erosion – with erosion intensity steadily increasing from north to south. The model predicts that the beach at Te Awanga will be highly prone to erosion (indeed, more so than Haumoana) and that groynes will be ineffective in this area, but that the beachfront at Haumoana could be protected by the use of groynes. The model further predicts that the natural stability of the northern beaches would mean that they are largely unaffected by any such development.

The Moynihan model has its attractions but represents, in the end, just another theory on the nature of coastal processes in the bay. It does not disprove or displace, or provide any greater certainty than, the existing Komar and Tonkin & Taylor models. The existing models therefore remain and still indicate that the potential for downstream impacts, resulting from the construction of a groyne-field, needs to be seen as a credible risk.

The situation may change in future as our understanding of local coastal processes improves. For the time being we can only say that there *is* a risk and that more investigation and analysis would be required in order for there to be a sufficient level of confidence that the construction of a groyne-field would not result in significant downstream effects.

## 5.4 Number of Groynes Required

The current estimate for the minimum number of groynes required to hold the beach at Te Awanga – Haumoana is 13 x 70m long groynes at 280 metre spacing[23]. These would start from 280m south of the existing Haumoana groyne and end more or less opposite the community hall at Te Awanga. An illustration of this arrangement of groynes is as shown in Appendix 1.

As an economy measure the model allows for an 840 metre 'sacrificial area' (missing out three groynes) in the unoccupied strip between the two settlements. If this was unacceptable, due to possible effects on private land or public roads, reserves and other infrastructure, then another three groynes would be needed – bringing the total to 16. For the purpose of this report we will, however, assume a 13-groyne scenario.

A further option would be to build groynes only for the protection of Haumoana. In this case there would be 9 groynes at Haumoana and none at Te Awanga. The Te Awanga beachfront properties would instead plan for staged retreat. As will be explained later in this report, there are in fact some reasonable retreat options available for Te Awanga beach-front properties whereby complete off-site relocation may not actually be required. Because of this, and in consideration of the cost of being part of a groynes scheme, a lot of beach-front residents at Te Awanga may well prefer staged retreat.

If Te Awanga was not part of a groynes scheme it would, however, increase the overall cost of the scheme for residents of Haumoana. This would (as will be discussed later) have implications for the viability of the scheme as a whole.

Each 70m long groyne would hold about 37,800m$^3$ of gravel and provide a maximum extra high-tide beach width of 30 metres, tapering to 0 metres (i.e. the same as existing beach width) at the southern end of each cell – giving an average total 'gain' of approximately 15 metres of beach.

## 5.5 What the Groynes Would Achieve

If the groynes worked as intended they would prevent further nett erosion from Te Awanga – Haumoana beach. The design of the groynes would be planned to allow the longshore transport of gravel (originating from the Cape and Maraetotara River) to continue along the beach except for that which is trapped in replacement of gravel lost from the cells through abrasion or from being carried out to sea during storms.

Groynes built to 70m in length would be sufficient to hold the beach and provide sufficient advance to protect existing beach-front properties from the majority of storm events. The groynes, if successfully maintained, would also 'hold the line' against further retreat of the shoreline. Without protection works the retreat of the shoreline would be predicted to continue over the coming century – with consequences for other property within about 100 metres of the existing shoreline.

[23] As recommended by Richard Reinen-Hamill (Tonkin & Taylor Coastal Engineer). E-com (2/7/2008). Steve Moynihan agrees that this is a reasonable assumption in terms of spacing of groynes, at least at Haumoana, but that further detailed modelling would be required to determine numbers for the purpose of final design.

## 5.6 Effect on the Risk of Coastal Inundation

If the beach was left as it is (i.e. without groynes), the beach crest would continue to 'roll back'. As it rolled back it would maintain its existing profile, including existing height and width. Throughout this process, as long as the beach crest was not interfered with, the risk of inundation of inland areas, due to over-topping, infiltration or breaching during storm events, would remain essentially unchanged.

At present (and in future), if a one-in-100 year storm occurred, there is a reasonable chance that about 10 or 12 houses on the inland side of the beach crest at Haumoana would be flooded with sea water due to over-topping of the beach crest and the inability of the inland drainage system to keep up with the rate of over-topping and infiltration of seawater during such an event[24]. An event on this scale could also cause enough over-topping at Te Awanga to flood up to an estimated 115 houses[25].

The installation of 70 metre long groynes might reduce the amount of flooding that would occur at Haumoana in such an event. The groynes would effectively add another 15 metres to the average width of the beach (with 'actual' gains varying between 0 and 30 metres) and therefore increase the run-up distance for in-coming storm waves and slow down the rate of infiltration. It would not be enough to *prevent* flooding (a 100-year storm would still cause substantial over-topping), but could mean that the flooding was not as severe – i.e. fewer houses affected, or lower water levels where flooding does occur[26].

At Te Awanga the groynes would make little difference because the main 'weak point' for over-topping is around the river mouth / motorcamp area rather than the main beach. Storm surges would come in through the river mouth, flood over the motorcamp, in to the lagoon, and from there spread out in to other parts of the town. The installation of groynes along the beach-front would have no effect on this.

At Haumoana the situation would be more serious if a breach occurred. In a major storm (on the scale of a one-in-100 year event) it is possible that the beach could be scoured back to a point where waves eventually break through at one or more places along the beach crest and completely overwhelm the inland drainage system.

This would not be likely to happen at Te Awanga on account of the thickness of the existing natural beach crest, but is at least a possibility for Haumoana in places where the beach crest is not as wide.

The chances of a breach actually happening are uncertain – but if a breach did occur during a major storm it could result in an estimated 55 homes in the inland part of Haumoana township being flooded with between 10 cm and 1.0 metre of seawater (plus other more extensive but comparatively minor property

[24] Based on Hawke's Bay Regional Council coastal inundation modelling (March 2009). The figures given here are for flooding to a depth of 10cm or greater. Flooding of less than 10cm is assumed to be minor.
[25] Again, based on HBRC modelling and with reference only to flooding of 10cm depth or more.
[26] To completely eliminate the risk of flooding from over-topping it is estimated (Reinen-Hamill, pers comm) that the volume of the groynes would need to be more or less doubled. This would more than double the cost of construction and on-going maintenance of the groyne-field.

damage from floodwaters at 10 cm depth or less, or in areas not physically occupied by houses).[27]

In contrast, if the beach was 15 metres wider there would be practically no risk of a breach – even in a one-in-100 year storm. Flooding would still happen as a result of over-topping (as discussed above) but there would be a sufficient volume of material in the beach, as a result of the extra 15 metres, to allow a reasonable amount of scour to occur without any real risk of the beach crest actually giving way.

By adding an extra 15 metres to the average width of the beach, a groyne-field therefore could possibly have the additional benefit of protecting about 55 homes at Haumoana that otherwise *might* be at risk from flooding in the event of a breach occurring during an event on the scale of a one-in-100 year storm (although there would be no such benefit at Te Awanga).

Whether or not the owners of these Haumoana properties would see sufficient value in a scheme to build groynes along the water-front, in terms of extra protection that it would give them from coastal flooding, remains to be seen – particularly given the costs of the scheme (as will be discussed shortly); given the uncertain but probably low risk of inundation actually ever happening in their lifetimes, if at all; given that most households will already be covered by insurance; and given that there are likely to be more cost-effective ways of achieving better protection from inundation (such as improving the existing inland back-up drainage systems, or lifting house floor-levels) than resorting to the use of groynes. There is, furthermore, still no guarantee that groynes would actually prevent inundation. Nor will the construction of groynes make a difference to the risk of conventional flooding from the river or from high intensity rain events. This type of flooding would still occur and be undiminished by the existence of groynes.

## 5.7 Estimate of Costs

A single 70 metre long groyne, similar to the existing one at the mouth of the Tukituki River, along with in-filling, would presently cost about $1,880,000 to construct. About $340,000 of this relates to the construction of the groyne itself. A standard 9% of construction costs has also been allowed for engineering design ($30,600). The remainder ($756,000) is to cover the cost of in-filling.

An estimated 37,800m$^3$ of gravel would be required to fill each groyne. This would be sourced from local rivers at a cost of about $30 – $50 per cubic metre (transport costs only). For cost estimation purposes a rate of $40/m$^3$ has been assumed on the basis that, for the amount required, the majority of gravel would have to be sourced from rivers in Central Hawke's Bay.

We have also assumed that the groynes would be built either two at a time, with a two-year delay between each pair of groynes built, or at a rate of one groyne per year. Staggered construction, while lacking the efficiencies of a bulk construction programme, would allow time for the effects of each successive groyne or pair of groynes to be monitored and assessed before continuing on.

[27] The Proposed Hawke's Bay Regional Coastal Plan (Planning Maps) shows the full extent of potential coastal flooding, to all depths, including less than 10cm of standing water.

It would also reduce the pressure on local gravel supplies – a key logistical problem.

The cost of the groynes in the first 20 years (the initial 'design life' period) would be about $17.4 million if measured in today's dollars or nett present value (NPV). Over a period of 60 years the cost would be about $18.5 million (NPV). Conversion to NPV takes account of the discounting effect for costs that are incurred at some time in the future. An 8% baseline annual discount rate has been assumed and 3% annual rate of inflation.

Cost calculation spreadsheet are attached to this report as Appendix 2.

Note that no specific allowance has been made in the spreadsheets for the cost of resource consents – although these costs can also be significant. If groynes or any other type of structure are to be built in the coastal marine area and filled with gravel then (under the RMA) a resource consent would be required – with possible involvement of the Minister of Conservation[28]. This can be an expensive process. A budget of $500,000 or even $1,000,000 would not be unreasonable in anticipation of likely investigative costs (as well as legal and administrative costs) involved in obtaining these consents. Furthermore, there is no guarantee, at the end of this process, that consent would be granted.

Costs associated with consulting over, and determining, a final apportionment of cost have also not been specifically included (the cost would probably in the order of $100,000 - $150,000). Likewise the costs associated with pre-design and design for groyne construction, involving further modelling of the likely effects of the groynes and to determine their optimal size, spacing and method of construction. This would be a significant exercise on account of the considerable uncertainty that still remains in relation to the likely effect of the groynes along the coast. The estimated cost is between $500,000 and $1,000,000 (best guess being $750,000).

In the above estimate there has also been no contingency allowed for possible additional costs incurred if (a) experience proves that the groynes are indeed having an adverse downstream effect, whereupon action would be required to remedy the situation, or (b) the number of groynes is found to be inadequate and more need to be built than originally envisaged and budgeted for, or (c) the possibility that bigger, stronger, more expensive groynes will need to be built in future to counter the effects of rising sea levels, or (d) unexpectedly high future transport costs for the importation of gravel.

If all of these risk factors are taken in to account, the total value of the 'worst case' scenario is calculated to be in the order of $40 million (more or less double the estimated base-line NPV cost of $18.5M).

## 5.8 Availability of Gravel

37,800m$^3$ of gravel would be required to infill the space behind each groyne immediately upon construction. This is not an insignificant amount. As a comparison, the renourishment programme at Westshore beach in Napier (itself a major exercise) uses about 12,800 m$^3$ of gravel per annum. The filling of a

[28] Under the existing regional coastal plan the approval of the Minister of Consent is not required for groyne structures of less than 100 metres, but would be required for the deposition of gravel in excess of 50,000m$^3$ per year. That limit would be exceeded if more than one groyne was built per year.

single 70m long groyne would therefore require about three times the annual gravel take for re-nourishment at Westshore.

The sourcing of 37,800m$^3$ of gravel per annum (or 75,600m$^3$ every two years if groynes are built in pairs) would not be easy. The current annual allocation for the Lower Tukituki is 50 – 60,000m$^3$, of which only a small portion would be available for this specific project in any given year on top of existing consented extractions. The remainder, and indeed the majority, would need to be sourced from either the middle to upper Tukituki or Waipawa Rivers (where current allocation limits are 140,000m$^3$ and 200,000m$^3$ respectively). Current costs of transport from the middle to upper Tukituki are about \$40/m$^3$.

The option of building groynes *without* infilling would be unacceptable because of the risks of creating or intensifying erosion further along the beach. It is extremely unlikely that a resource consent would be granted without infilling being carried out.

## 5.9 Who Pays?

When works are carried out by a local authority to protect private property the costs of the works are generally recovered from the benefiting properties by way of a targeted rate. A contribution from the wider rate-paying community can also be made but only in circumstances where community assets are being protected or where some other community-wide benefit will result.

With inland flood protection schemes the convention (in Hawke's Bay and elsewhere) is that only those properties directly benefiting from a scheme will contribute to the cost of the works. A targeted rating formula is calculated whereby the level of contribution is in proportion to the degree of benefit received. Properties in low-lying areas, which would otherwise be prone to more frequent flooding, normally pay a proportionately greater share. Properties on slightly higher ground, where flooding is a less serious issue, pay proportionately less. The rating formula may also include a consideration of comparative land values.

Coastal protection schemes are rated in a similar way. A recent example is the proposed sea wall at Waihi Beach in the Western Bay of Plenty. Resource consents for the scheme were secured in 2008. The main beneficiaries of proposed sea wall are beach-front properties and this is reflected in the rating formula that was subsequently devised. Under this formula beach-front properties will be rated to cover 80% of the cost of the works with most of the remaining 20% of costs to be levied across the local Waihi community in reflection of a degree of public benefit from the work.

As an aside, and as a lesson for the situation in Hawke's Bay, it is useful to note that there has in fact been some adverse reaction to the Waihi scheme from a number of residents since the targeted rating was formally announced. The reason appears to be that many of the residents that the Council initially consulted with in its early stages of the scheme, and who indicated support in principle for a targeted rate, later sold up and moved on. They have in turn been replaced by a new crop of owners who were, at the time of purchase, unaware of the costs that they were now likely to face. They appear to have assumed that the work would be funded out of a general (district-wide) rate. Upon realising that this was not going to be the case, and that a significant rates increase would be the outcome, many have called for the outright rejection of the scheme. This has in turn led to some protracted legal battles between the opposing property-owners and the local district council.

The lesson that comes out of this experience is the need to ensure that the costs of a scheme of this kind are kept 'up front' at all times and that people are made aware throughout the process of what the work is likely to personally cost them if it proceeds. At Waihi it appears that cost issues fell in to the background after the initial discussions with residents were complete. This meant that new residents were not fully aware of what they were really buying in to. It also meant that even existing residents did not really know exactly what they were likely to be letting themselves in for, in terms of costs, until the project was well advanced.

## 5.10 Apportionment of Costs

A groyne field at Te Awanga – Haumoana beach would mostly benefit beach-front property owners. Properties further to the rear would also benefit in the long term (in 50+ years) if groynes were successful in halting the retreat. It is anticipated that these property owners, and in particular the owners of properties on the beach-front, would be required to meet the bulk of the costs associated with the construction and on-going maintenance of the groynes.

The fairest way to split the costs would probably be on the basis of 'immediacy of need'. This is similar, in principle, to the tiered rating system used for inland flood protection works where properties are rated according to their degree of exposure. At Te Awanga – Haumoana the difference is that the degree of exposure for individual properties is not constant but rather increases over time.

All properties that will eventually be under threat from erosion / wave attack become beneficiaries in effect. But it is reasonable to ask why a property owner whose house may not be affected for at least 50 or even 100 years should make an equal contribution to a scheme that he or she doesn't actually require right now or indeed may never personally benefit from within their own life-time. The solution is therefore to apply a rate of discount to the apportionment of costs depending on the time remaining before the relevant property would otherwise become exposed.

The logical rate of discount to assume for this exercise is the same rate as used in the calculation of nett present value (NPV) for determination of present day costs. This is as described in Section 5.7 (above). In this case the assumed baseline rate is 8% per annum with 3% per annum inflation adjustment.

With this approach, and by estimating the time remaining for each of the various affected properties before they are individually exposed to an imminent risk of erosion and/or wave-attack, it is possible to derive a formula for the individual apportionment of costs.

## 5.11 Provisional Cost Apportionment

Appendix 2 of this report sets out a spreadsheet showing how costs could be apportioned for the construction of a Te Awanga – Haumoana groynefield. The following is a brief summary of assumptions and provisional results:

1. **Front-line properties at 1 - 41 Clifton Road, Haumoana** (comprising 20 private properties of which about 18 properties are still occupied) are assumed to be in immediate need of protection. There is, therefore, no time-related discounting applied to these properties. Their benefit ratio[29] is 1.0. Their collective cost share equates to about 34% of the total cost of the project ($6.4 million out of a total NPV cost of $18.5 million for the project as a whole). Divided between 20 properties this equates to about $320,000 each. If paid up-front, that amount would cover the cost of the works for the life of the project[30].

   Alternatively, an up-front payment of around $293,000 could be made per property, followed by a $1,800 annual charge for on-going maintenance of the groynes over years 14 – 20. If re-construction was then required after year 20 (the assumed design life) the annual charge would need to increase again to about $7,000 per annum, but drop back to $1,800 per annum after that. This cycle of re-building, followed by basic annual maintenance, followed by further re-building would continue for the life of the project.

   A simpler alternative would be to pay a rate of $29,500 per annum per property for the first 13 years, followed by a $5,000 annual charge for on-going maintenance and to cover the cost of periodic re-builds. The $5,000 would be charged on an indefinite basis for as long as the groynes continued to be maintained and re-built every 20 years[31].

2. **The 40 front-line houses at Te Awanga** (221 – 299 Clifton Road) are assumed to be only slightly behind in terms of immediacy of need. Their 'benefit ratio' is 0.90. Their collective cost share is about 62%. The higher percentage (compared with the Haumoana beach-front properties) reflects the greater number of houses. The total NPV cost for this group is $11.5 million. This equates to an average of $288,000 per house. As a lump sum, paid up front, that amount would be sufficient to cover the life of the scheme.

   An alternative would be for each property to pay an initial lump sum of $264,000 (to cover initial construction) followed by a charge of $1,800 through years 14 – 20, then increasing to about $6,500 per annum for another 13 years as rebuilding occurs.

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[29] "Benefit ratio" is, in effect, a multiplier based on the rate of discount at the time of 'immediacy of need'. Properties with an immediate need of protection have a higher benefit ratio / multiplication rate. Properties further away from the beach and unlikely to be affected for many years have a lower benefit ratio / multiplication rate. The highest multiplication rate is 1.0. All other rates are fractions of 1.0.

[30] In this case the project life is assumed to be 90 years. If a 60-year project life is assumed the cost is about $5,000 less.

[31] An assumed 20-year design life is consistent with recommendations from the Ministry for the Environment 2008 Guidance Manual. It also concurs with experience at the existing Ngaruroro groynes (pers. comm G. Clode).

The other simpler option is to charge an annual rate of $26,600 per household per year for the first 13 years, followed by a standard $5,000 per annum charge for on-going maintenance and periodic rebuilds.

This, of course, assumes that the Te Awanga beach-front properties participate in the scheme. Note that all of the 40 front-line houses at Te Awanga are on reasonably large (50m long) sections and that most houses have been erected right on the coastal edge. There is, therefore, a possible alternative option of retreat for many of the houses while staying within their existing property. This strategy could potentially gain the owners another 50 years, or more, before full relocation is required (assuming that predicted rates of coastal retreat are correct). The cost of on-site relocation is relatively cheap (about $20,000 per house)[32]. If the 'immediacy of need' in relation to the construction of groynes was able to be deferred for 50 years then this would significantly affect the cost share for these properties. The 'benefit ratio' reduces from 0.90 to about 0.005 and the total 'actual' contribution drops to 0.025% or $4,100 (lump sum NPV) per property – although by reducing the cost share for the Te Awanga properties the costs for all other parties, and in particular the beach-front properties at Haumoana, correspondingly increase. For the 20 front-line Haumoana properties this would raise their contribution to about $770,000 each. They are unlikely to find this affordable. If so the scheme simply would not go ahead.

This would probably also be the outcome if Te Awanga residents chose to opt out of the scheme altogether – relying instead on on-site relocation of buildings and the possibility of off-site relocation after 50 or more years. Under this scenario there would be no groynes built at Te Awanga (only at Haumoana).

If so the total cost of the groynes scheme would be reduced by having to build 4 fewer groynes but all of the cost of the remaining 9 groynes would then all be put on the community at Haumoana. The cost per Haumoana beach-front property would be in the order of $668,000 (if paid as an up-front lump sum).

For the purpose of the current exercise we are therefore working on the assumption that the 40 beach-front Te Awanga properties are fully committed to the construction of groynes and that staged relocation (first on-site, then off-site) is not an option. The alternative would mean making the scheme so expensive for other participants and beneficiaries as to be completely unaffordable.

3. **Council assets** are also predicted to eventually be impacted by the retreat of the beach. This includes portions of Beach Road and Clifton Road (affected within 50 years). In the shorter term the Te Awanga Community Hall and beach reserves at both Haumoana and Te Awanga will be affected. Underground services, both Council-owned and corporate-owned), will also be affected where these are located in the road reserve.

[32] Sewage fields (for household septic tanks) may also need to be relocated during this process. The need or otherwise for new sewage fields will depend on whether Te Awanga has a reticulated sewerage system operating at the time and/or whether other disposal alternatives are available. The cost of creating new sewage fields has not been included in this estimate.

Council would have the choice of either protecting, demolishing or relocating the hall. The affected roads could also be relocated if necessary by realignment of the existing road formations and/or utilisation of unformed 'paper' roads. The reserves can not easily be relocated although replacement land could potentially be secured. In practice the activities that take place on the beach reserves (walking, swimming, fishing) are unlikely to be greatly affected by a retreating shoreline except to the extent that parts of the beach will become, in effect, located on private land. Theoretically the owners of the land could therefore exercise rights of trespass. If so, the public would have to move further along the beach to other areas remaining in Council ownership. Despite the erosion there will at all times continue to be a reasonable amount of publicly accessible beach.

As far as the Council's assets and interests are concerned it is not therefore imperative that the retreat of the beach is halted. Other options exist. But for the purpose of the current exercise it is assumed that coastal protection, rather than relocation, is the long term option preferred. In that case the benefit ratio for Te Awanga Hall would be about 0.35 (equating to a cost contribution toward the construction of groynes of $112,000, NPV) and for Beach Road / Clifton Road 0.015 ($5,000, NPV). As owner of these assets, the total contribution from Hastings District Council would therefore be in the order of $117,000 (NPV). A further contribution could be made in respect of Council beach reserves although, as noted above, the actual use of the beaches will not be overly compromised by the retreat of the shoreline. The value of preventing further retreat of the beach, in terms of general public recreational benefit, is therefore marginal and has not been included in these calculations.

4. **The remaining properties** that would contribute to the scheme are the other houses within the 2100 coastal hazard line. Some of these (21 Gaskin Place, 113 Beach Road) are predicted to be directly affected within a relatively short time-frame. The contribution from these properties to the construction of the groyne field would therefore be quite high – about $260,000 and $125,000 respectively (lump sum NPV). Another property affected in the medium term is 8 Collison Place. The contribution from this property would be in the order of $14,000.

   All other properties are relatively far removed and unlikely to be affected by the retreat for at least another 50 years. Their contribution would typically be in the order of $1,500 to $4,000 (NPV).

   It is assumed that there would be no contribution from properties in the wider coastal inundation hazard (CHZ3) zone because of the relatively small benefit that these properties would receive from the scheme. If increased protection from coastal inundation was the primary objective there would be better and more cost-effective ways to do it than by the construction of groynes.

   If, however, a contribution *was* to be made by these properties (on the basis of increased protection from inundation) about 55 inland properties at Haumoana would be involved. These are the houses that would potentially suffer significant flood damage in the event of a failure of the beach crest during a major storm and that the construction of groynes would otherwise possibly prevent.

If other less affected houses were also taken in to account the total number of contributors could potentially get up to 200, but unlikely to be substantially more. If all of these 200 houses were required to contribute to the scheme their contributions would be in the order of $2,500 per property (paid as a lump sum). This is based on an assumed $100,000 worth of damage per house in a major inundation event, on the scale of a 100-year storm or breach, and with this event occurring in about 50 years time. It is also assumed that the same inundation would not occur if a groyne-field was in place. If so, the present-day cost of the damage (occurring in 50 years time) would be about $500,000. That amounts to about $2,500 per affected house. If this is assumed to be the 'value' of the groyne-field to inundation-prone inland properties then a $2,500 lump sum contribution per property could be made.

This would still leave about $18 million (NPV) to be covered mainly by beachfront property owners. It would not make a significant difference to the overall cost of the scheme for beachfront properties. It would, in fact, be likely to barely cover the cost of the pre-consenting investigation process, which has not actually been included in the overall estimated cost for the work.

An alternative funding method would be for inland properties (those potentially exposed to inundation) to cover, say, 20% of the overall cost of the scheme. This would be similar to the formula used for the construction of the Waihi sea wall in the Bay of Plenty. If worked out on this basis, the cost to inland properties would be about $3.7 million. Divided between an assumed 200 potentially inundation-prone properties that would equate to a lump-sum payment of about $18,500 each. The lump sum cost to beach-front properties would then drop to about $264,000 (at Te Awanga) and $293,000 (at Haumoana) – thereby saving beachfront properties about $25,000 to $30,000 each.

Yet another option would be to spread the 20% of cost around *all* inland properties at Te Awanga and Haumoana, irrespective of whether houses are at risk of inundation or not. That would mean spreading the $3.7 million between about 700 houses. If so, the cost per house would be about $5,300 each. Again, the effect of this would be to save beachfront property-owners about $25,000 to $30,000 each in terms of their overall contribution to the scheme. Whether non-affected property owners would agree to support the project to this extent would, however, remain to be seen.

Note that there is likely to be some flexibility around the above figures. If a groyne-field construction scheme was to proceed at Te Awanga – Haumoana then a further refinement of both costs and their individual apportionments would be required. The presented figures are, however, considered to be a reasonable guide to the relative magnitude of individual costs.

# 6. STAGED RETREAT (OPTION 2)

Staged or 'managed' retreat would mean, in effect, foregoing any major efforts to stop the erosion at Te Awanga / Haumoana and concentrating resources instead on preparing for the short and long term relocation of homes and other assets out of the hazard zone.

## 6.1 Relationship to Groynes Option

The staged retreat option can be regarded as either an alternative to the construction of groynes or as merely a fall-back option in the event that the groynes do not work or create problems that later require them to be removed.

The advantage of the 'fall-back' strategy is that groynes are given a chance to work. Only if they do not work does it become necessary to resign to the prospect of gradual abandonment of existing sites and relocation further inland.

The *dis*advantage of this strategy is that if indeed the groynes do not work then a considerable amount of money will already have been spent – leaving little in reserve for relocation. It will be local residents (especially those on the beach-front) who are meeting the bulk of these costs. The groynes would use up about $18.5 million (NPV). Relocation would then cost about another $7.4 million if the groynes did not work. Either option is costly enough on its own. It is unlikely that many property-owners and contributors to the scheme could afford to do both.

The alternative is to focus exclusively on staged retreat. This option has at least the advantage of certainty in terms of cost and outcome. Once houses have been relocated out of the hazard zone they will be safe. The disadvantage is that by taking this approach it will never be known whether groynes really would have worked as a long term solution. Residents would in this case have to eventually accept the necessity of moving – if indeed the predictions of ongoing erosion are realised.

## 6.2 Assumed Scenario for Staged Retreat

If a staged retreat was to occur then this would most likely be an incremental process with home-owners moving out of the hazard zone only when they are unable to safely remain any longer and have a pre-arranged place to shift to. The reality is that the majority of affected property owners are very unlikely to voluntarily move until forced to do so by physical circumstance[33]. It is therefore assumed that relocation would happen only when people are individually ready and willing to move.

On this basis the first people to move would be the occupants of the 18 to 19 remaining houses at numbers 1 – 41 Clifton Road, Haumoana. The houses at the northern end of this row are under immediate threat but those at the southern end probably have a few more years remaining.

[33] As noted in HBRC (May 2006) *Haumoana – Te Awanga Coastal Hazards Management : Report on Management Options* and Ministry for the Environment (2008) *Coastal Hazards & Climate Change : Guidance Manual*.

Thereafter the next most exposed would be the 40 properties on the seaward side of Clifton Road (numbers 221 – 299) at the northern end of Te Awanga – although (as mentioned earlier) these properties could have an interim solution of moving houses back on their existing sites – possibly even utilising the rear service lane – to gain some time before full scale relocation is needed. The sections are all about 50m long and the houses have mainly been built at the extreme seaward end. Most of them could probably be moved back closer to the road (and preferably put on elevated piles as protection against wave run-out over top of the beach crest) as the seaward end of the properties gets further eroded. The up-front cost of on-site relocation would be in the order of $20,000 per house and potentially give a breathing space of 50 years. This would also allow time to see how erosion and sea level rise predictions unfold and to make preparations for longer term relocation as may be necessary. If the hazard lines prove to be accurate, and if the service lane can be utilised, then for at least half of these properties on-site relocation could in fact provide a solution that is effective for the next 90 years.

Another house likely to be affected in the short term but which also has the option of on-site retreat is 21 Gaskin Place. The section that this house is located on is about 130 metres in length. If the house was moved back to the western end of the section it would be outside the 2100 coastal hazard zone (CHZ2). On-site relocation also appears to be an option for 8 Collison Tce.

The motorcamp at Te Awanga will be affected in the short term but appears to have space for relocation of affected permanent camping sites within the existing property. The affected areas appear to be former accretion gains around the mouth of the Maraetotara River[34].

The house at 113 Beach Road is on a relatively small site and would have few other options than to relocate as the beach moves inland. It is estimated and assumed that this relocation would be required by about 2040.

By about 2050 it will be necessary to consider on-site relocation of a number of houses on the landward side of Beach Road, in the block between Van Asch Road and East Road, along with the re-alignment of the street. The alternative would be to provide a service lane to allow access to these houses from the rear. In the latter scenario it is assumed that 2 properties would need to be purchased as part of the creation of the service lane. Another 2 to 5 properties in this area might have to be abandoned due to a combination of access constraints and coastal retreat.

At the same time it will be necessary to realign portions of Clifton Road and re-organise access to properties at the intersection of Clifton Road and East Road (either as part of the re-alignment of Clifton Road or by the creation of service lanes). The assumed scenario (for costing purposes) is that land would be purchased for the creation of a service lane for the corner properties and that there would be minor landward realignments of Clifton Road between Haumoana and Te Awanga.

From about 2060 onwards, depending on how the erosion has progressed, there may be a need to permanently relocate the houses at 221 – 299 Clifton Road. Another 15 houses on the seaward side of Collison Terrace and Beach

[34] As evident from cadastral plans.

Road may also need to be permanently relocated around this time. Neither of these outcomes are certain, and indeed the current hazard lines suggest that these properties will still be viable by 2100, but their relocation has nevertheless been included as part of the costing for the staged retreat scenario.

## 6.3 Costs of Staged Retreat

On the basis of the scenario described above, the total estimated cost of the staged retreat option over the entire 90-year planning period would be in the order of $7.4 million in 'today's dollars' (NPV). The non-discounted cost is approximately $25.8 million. This compares with $18.5 million NPV (or $52M non-discounted) for the construction and maintenance of groynes over the same period.

The following table gives a summary of the various assumed costs. Some of these costs are due to be incurred about now. Others are not due to be incurred for another 10, 20, 50 or 60 years.

| Action Required as part of Staged Retreat | Estimated Cost |
|---|---|
| Land purchase and relocation costs for relocation of 19 immediately-affected houses at Haumoana. Includes cost of subdivision and servicing. (yr 2010) | $5.9M |
| Land purchase and relocation costs for future relocation of 40 beach-front houses at Te Awanga. Includes cost of subdivision and servicing. (yr 2060) | $8.8M |
| Land purchase and relocation costs for future relocation of 15 houses on Collison Terrace, Haumoana. Includes cost of subdivision and servicing. | $4.5M |
| Land purchase and relocation costs for 5 houses on corner of Beach / East Road, Haumoana. Includes cost of subdivision and servicing. (yr 2060) | $1.5M |
| Land purchase and relocation costs for No.113 Beach Road, Haumoana. (yr 2020) | $280K |
| Form new rear access to Beach Road properties. (yr 2050) | $2M |
| Interim on-site relocation of 40 Te Awanga beach-front houses plus other houses at Te Awanga & Haumoana. (yr 2010) | $800K<br>@ $20K ea. |
| Other on-site relocations (within existing section) | $20K per site. |
| Relocate Te Awanga Hall. (yr 2020) | $200K |
| Form new alignment of Beach Road / Clifton Road. (yr 2050) | $1.5M |
| Relocate in-road services. (yr 2050) | $300K |

The costings assume, for several of the affected properties (including the 40 beach-front properties at 221 – 299 Clifton Road), that there will be an initial relocation of houses within their existing sections so that full relocation will not be required for 40, 50 or more years. Several of the Te Awanga beach-front properties (perhaps two-thirds of them) could even still be viable by 2100 if allowed to retreat back on to the service lane alongside Clifton Road.

This has significant implications for the cost of the staged retreat option for the various affected properties at Te Awanga. The longer that a cost can be delayed, the lower the effective cost becomes in the present day. If relocation was required immediately then the cost in 'today's dollars' would be in the order of $280,000 per house (based on removal of the existing house and relocation of that house to a new section). If the same cost was able to be delayed for 40 years then the effective cost in 'today's dollars' (expressed as nett present value or NPV) reduces to $14,000. If delayed for 60 years the effective cost reduces to $3,000 NPV.

The discounting method used here is the same as used in determining costs for the groyne option (refer to Section 5.7). In both cases an 8% annual baseline discount rate and 3% annual rate of inflation have been assumed.

For the Haumoana beachfront properties at 1 – 41 Clifton Road there may also be an interim relocation option of moving houses further along the beach to the south. The land to the south is Council-owned (used as an over-nighting area for camper-vans) and held as recreation reserve. It is still within the hazard zone but further back from the shore. If houses were relocated in to this area they would potentially gain about another 50 years of occupation and use. This option would be likely to encounter problems in terms of procedures under the Reserves Act and may not be acceptable to the wider community. There would also be issues in regard to the appropriateness or otherwise of relocating houses to a place where they are still within an identified coastal hazard zone – notwithstanding that they would be further removed from the sea. The more usual convention would be to ensure that houses (at least in a 'greenfield' situation) are placed where they are likely to be safe for at least the next 200 years. The option of interim relocation is nevertheless an option for these houses, and should be identified as such.

## 6.4 Inclusion of Effects on Land Value

In the costings above there is no specific allowance made for loss of land value for land that is abandoned during the process of staged retreat. This is difficult to factor in because of fluidity of the value of land. Values only reflect the perceptions of the market – including the market's perception of coastal hazard risk. If existing land values are an accurate reflection of the risk then there has already been, in effect, an accounting made of the potential future loss and write-off of the value of the land. If, on the other hand, existing values *do not* adequately take account of the risk then it may be argued that values are currently artificially high.

For simplicity we will, however, assume that existing land values are accurate and that the future loss of these land values can be added (in the spreadsheet) as a further 'cost' to the staged retreat option. In this case the loss of value is assumed to occur at the time that erosion reaches a point where the property is no longer viable and becomes abandoned. 'Land value' is taken to be the same as the rateable value of the land.

The loss of value is in this case treated like any other future cost and discounted over time. This does not affect the assumed present value of the beach-front houses at 1 – 41 Clifton Road in Haumoana but does affect the assumed present value of the 40 houses at 221- 299 Clifton Road at Te Awanga. If, as assumed, the latter group does not need to be fully relocated for at least another 50 years then the 'cost' of the loss of land value for these properties is discounted over time. They are assumed to get, in effect, at least another 50 years value from continued use, occupation and on-sale of these sites.

With the addition of these values as a 'cost' to the staged retreat scenario the total cost of staged retreat increases from $7.4 million to $11 million NPV. This is closer to, but still less than, the estimated $18.5 million (NPV) required for construction and maintenance of groynes.

Note also that the figure of $11 million is a 'total' cost and that individual costs will vary from property to property depending on when they are assumed to be required to move, and the current value of their property.

Also, although the cost of the staged retreat option remains cheaper overall, the comparative cost will be more expensive for some properties (specifically the 20 private properties at 1 – 41 Clifton Road, Haumoana) than would be the construction of groynes. That is as based on the cost allocation model outlined in this report. For the 20 beachfront Haumoana properties, if loss of existing land value is included, the relocation option would average about $431,000 per property. That is approximately $110,000 more expensive than the groyne-construction option, on average, per site, if the allocation model set out in this report is followed. If the groyne-field was successful then it could be the cheaper solution for these specific properties (unless interim relocation on to reserve land to the south of the existing house-sites, as discussed in section 6.3, is feasible.

For all other properties, including the 40 beach-front properties at 221 – 299 Clifton Road in Te Awanga, staged relocation remains the cheaper option. For these properties, if loss of existing land value is taken in to account, the overall average cost of staged retreat is about $30,000 NPV (up from $23,700 NPV if existing property value is excluded). This compares with a cost of about 288,000 (NPV) per house, on average, for construction and maintenance of groynes.

Note that caution is still required in the comparison of these costs (inclusive of property values) with costings for the construction and maintenance of groynes. The groynes option is, itself, likely to have an impact on land values by virtue of the substantial annual charge that would be levied on all beach-front properties. The cost of the levy would probably be carried through in to the re-sale value of affected properties. This has not been explicitly included in the costings for the groyne option but could, in theory, result in a drop in values equivalent to the value of the levy itself ($271,000 to $300,000 per property if calculated over the first 20 years). This compares with an average existing beach-front land value of about $260,000. The perceived benefits of a groyne-field would need to result in at least a doubling of land values in order to compensate for the loss of value that the levy has the potential to incur.

## 6.5 Uncertainty over Predictions

A further consideration for residents of Te Awanga – Haumoana who are within the coastal hazard zones when weighing up the risks and costs of the different options will be their own assessment of the long term risk of erosion eventually retreating all the way back to where their own properties are located. The existing hazard zones are based on current understanding of coastal processes in the area and are the best estimate available to date of where coastal hazard will be active in the next 100 years. But it should also be acknowledged that there is an inherent uncertainty in these predictions. The predicted rate and extent of erosion may not come to pass – or could turn out to be much faster and further than currently expected. Residents will need to consider and balance these risks and costs.

## 6.6 Direct Costs to Councils

### Hastings District Council

The staged retreat option, based on the scenario described above, anticipates that there will be an eventual cost to the Hastings District associated with the re-alignment of sections of Beach Road and Clifton Road. This is expected to cost approximately $1.5 million in about the year 2050. In today's dollars, assuming an 8% rate of interest and 3% annual inflation, that equates to $75,000 (NPV).

The District Council would also be faced with the future relocation or demolition of the Te Awanga Community Hall ($95,000 NPV) and the formation of new front access to properties along the landward side of Beach Road ($80,000 NPV).

It is assumed that there would be no costs associated with the repair or relocation of Council beach reserves. These areas would be allowed to be taken over by the sea.

### Hawke's Bay Regional Council

No allowance has been made for Regional Council assets. The only HBRC assets in the area are the pump drainage scheme at Haumoana and existing Haumoana groyne. It is assumed that these would be subject to normal budgeted maintenance.

## 6.7 Other Possible Council Roles

Aside from looking after their own respective assets the two councils could choose to assist in making preparations for the future relocation of affected residential properties. This would be on a voluntary basis. There is no mandatory requirement on the councils for assistance to be offered.

There may be a role, for example, for the councils to assist in negotiations for the purchase and re-zoning of land that is suitable for re-settlement and holding this as a land bank reserved specifically for home-owners that will in future be driven from their existing properties by the advance of the sea. It is not anticipated that the land would be provided freely but rather, when needed, made available at cost. There are sizable blocks of land, currently zoned Rural, not far from either of the main erosion hazard areas in Haumoana and Te Awanga that could potentially be acquired and re-zoned for this purpose (subject to availability, price, and satisfying of RMA tests for re-zoning).

It would be easier for Hastings District Council to facilitate this process than for individual property owners along the beach-front to try and do so in coordination with their neighbours.

The District Council could also begin making preparations for the designation of new alignments for Beach Road, Clifton Road, and new accessways for affected properties along the landward side of Beach Road (southern end) and Clifton Road (northern end) at Haumoana. If predictions are accurate for the retreat of the shoreline over the next 100 years then there should be at least some contingency planning begun for how these new accessways would specifically look and how they might be secured.

Another area where the District Council could possibly assist would be to gift, sell or exchange the land comprising the service lane to the landward side of the 40 Te Awanga beach-front properties as a further area available to these properties for interim retreat. This would involve formal road-stopping procedures.

The District Council could also possibly facilitate some form of land exchange for the Haumoana beachfront properties at 1 – 41 Clifton Road if the option of exchange for reserve land further to the south of these properties is shown to be feasible. A process would need to be initiated under the Reserves Act to have part of the reserve status uplifted. A land re-zoning would also be required in order to allow residential occupation and to recognise the interim nature of occupation at this site. Relocation on to this area could potentially gain affected home-owners about another 50 years of occupation and use. There are some significant issues here (as identified in Section 6.3) but interim relocation is at least an option.

Assistance from the Regional Council could be provided by way of advice on avoidance of flood risk, further enhancement of back-up protections against coastal inundation and allowance of some greater flexibility around the approval of consents for the modification of on-site wastewater systems.

# 7. SUMMARY & CONCLUSIONS

From the preceding analysis we conclude:

1. The construction of a groyne-field between the Tukituki River and Te Awanga would be one possible response to the erosion problem and could possibly provide a solution for beach-front residents of Te Awanga and Haumoana. However, the disadvantages are:

   (a) Their high cost. Each individual groyne would cost about $1.8 million to construct, with $8,500 per annum basic maintenance costs, and with reconstruction (costing $370,000) required about every 20 years. The total cost for 13 groynes, over the lifetime of the project, would be about $18.5 million (NPV).

   (b) Uncertainty in relation to costs. The figure of $18.5 million (NPV) is a current best estimate of likely costs for construction of a groyne-field but final costs, in a 'worst case' scenario, could be more than double that amount.

   (c) The uncertainty of the outcome. Existing models are uncertain but suggest a credible risk of downstream erosion resulting from the construction of groynes at Te Awanga – Haumoana. It would be imprudent to proceed with the construction of groynes until more is known about the likely effects. In the meantime it is also unlikely that resource consents would be granted for such a project.

2. The cost of building and maintaining groynes would be largely recovered from the residents of Te Awanga – Haumoana (on the same basis as cost-recovery methods for river flood protection schemes). Beach-front properties would be the principal beneficiaries of the scheme and would be responsible for about 90% of overall costs, to be recovered through a targeted rate. There are a number of possible formulae for how a targeted rate would be divided but if paid as an up-front lump sum the cost to individual beach-front properties would be in the order of $288,000 to $320,000 to cover the lifetime of the scheme. The 'worst case' scenario is for costs in the order of $636,000 - $700,000 (NPV) per beach-front property.

3. If paid as an annual targeted rate (rather than lump sum), the cost to individual beach-front property owners would be between $26,600 and $29,500 per annum for the first thirteen years of the project, followed by an annual $5,000 charge for on-going maintenance of the groynes.

4. If the wider Te Awanga – Haumoana community contributed to the scheme, in recognition of reduced risk of coastal inundation, the 200 or so inundation-prone properties would be expected to pay in the order of $2,500 per household (lump sum). This would not have a significant effect on reducing the overall cost of the project for beach-front properties.

5. An alternative contribution scheme would be for *all* inland (i.e. non-beachfront) properties, irrespective of flood-risk, to collectively cover 20% of the overall cost. That would amount to $5,300 per household, paid as a lump sum. The effect of this contribution would be to reduce the overall

cost to beach-front properties down to about $264,000 – $293,000 each (thereby saving each beachfront property owner about $25,000 - $30,000.

6. The alternative to building groynes is to adopt a strategy of 'staged retreat' whereby houses are progressively moved out of the hazard zone as the shoreline retreats. Houses would be moved either within their existing properties or by relocating off-site. The timing for relocation would vary from house to house.

7. The total cost of the staged retreat option would be about $7.4 million (NPV). This compares with $18.5 million as the cost of building and maintaining groynes.

8. The cost of the staged retreat option increases to $11 million (NPV) if loss of private property value is included – although caution is required in the comparison of this figure with the cost of the groynes option because the groynes option would itself impact on property values as a result of the flow-on effect of the per-household annual charge. An annual charge for groyne construction and maintenance could potentially reduce beach-front property values by somewhere in the order $271,000 - $300,000 per property. This is more than the average existing land value.

9. A policy of staged retreat would almost certainly mean the progressive removal and off-site relocation of the remaining 18 or 19 beach-front houses on Clifton Road at Haumoana – with this process needing to start quite soon. But for the majority of other houses (including the 40 beach-front houses at Te Awanga) complete off-site relocation may not actually be required for at least another 50 years. On-site relocation of the 40 Te Awanga properties to the rear of their existing sections, including possible occupation of the rear service lane, could in fact mean that these properties are still viable for another 90 years.

10. For the Haumoana beachfront properties at 1 – 41 Clifton Road there is a possible option of interim relocation of houses on to reserve land further to the south along the beach. This would require uplifting of reserve status over part of the reserve. It would probably also involve a land-swap for the existing properties. A relocation to this area would potentially provide about another 50 years of occupation and use but would require several issues to be resolved in terms of process under the Reserves Act and relocation of buildings to what is in effect another identified coastal hazard zone.

# 8. RECOMMENDATIONS

It is recommended that the question of the future direction for management of coastal erosion should be, in the first instance, put back to the Te Awanga – Haumoana community – particularly to those who would ultimately cover the bulk of the costs. Either option (whether groynes or staged retreat) is ‘possible’ but both options have costs and risks attached. All parties need to be made aware of these costs and risks and understand that it will be the Te Awanga – Haumoana community (and in particular the beach-front properties) that the costs will come back to. If groynes are to be constructed then the cost would be met through a local targeted rate rather than through the general rates fund. If staged retreat is chosen then the costs are likely to mainly lie where they fall. There would be no central government assistance in either scenario.

It would be useful to have some further debate around these issues and for a consensus to be reached, if possible, within the affected community in relation to the different options, their affordability, and acceptability of risk.

On the face of it, staged retreat would appear to be the most attractive option. The retreat option has much better certainty. It is also the cheaper option overall (based on current costings) and one that, to some extent, allows home-owners to work out their own unique solutions according to their circumstances, personal resources and needs. A significant number of properties, for example, appear to have the option of simply moving their house back within their existing section and thereby deferring the costs of relocation for perhaps another 50 or more years. A possible option for the houses at 1 – 41 Clifton Road would be to relocate to Council reserve land immediately to the south. This could also gain about 50 years. By deferral, the cost of relocation (in ‘today’s dollars’) is effectively reduced.

The groynes option is not recommended because of the uncertainty of success with this option; the potential for causing increased erosion to the north (according to existing coastal process models); the low probability of securing necessary resource consents; and extremely high cost.

If a strategy of staged retreat is chosen then it is recommended that the councils (particularly HDC) look at ways of preparing for this and assisting property owners who will both now and in future be facing the prospect of relocation from their existing site. Possible options include (a) helping with the establishment of an appropriately-zoned land-bank of sites reserved for future re-locations, (b) gifting, selling or swapping land that currently forms a service-lane at the rear of beach-front Te Awanga properties as extra space for on-site retreat of buildings, and (c) commencing planning for future re-alignment of parts of Beach Road / Clifton Road. Planning will also be required for the future of the Te Awanga Community Hall.

If a strategy of constructing groynes is chosen then it is recommended that this be undertaken as a staged / staggered project – with a maximum average of one groyne built per year. This would improve the logistics of gravel supply (for in-filling the groynes) and allow time for the effect of each successive groyne to be monitored. The project would be funded by a targeted rate with the majority of costs recovered from beach-front properties as primary beneficiaries of the work.

# Appendix 1

## Groyne Diagrams

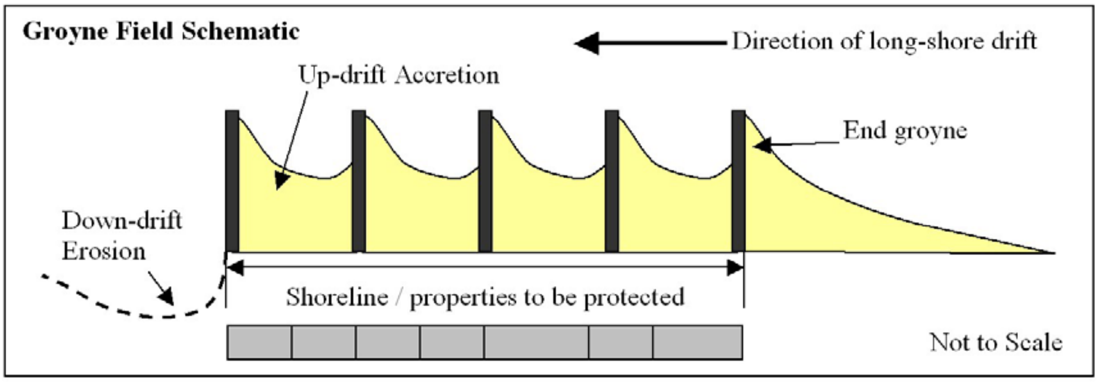


Figure 1 : A typical groyne-field

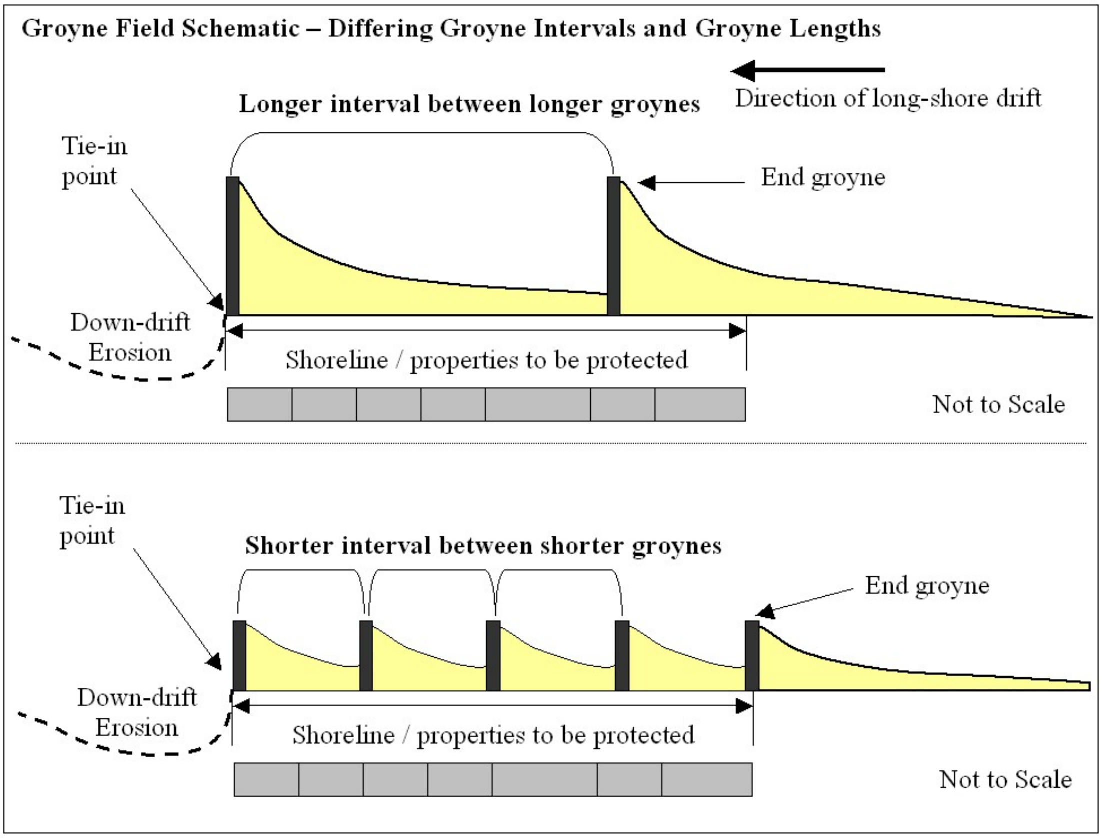


Figure 2 : Relationship between groyne length and
Groyne spacings

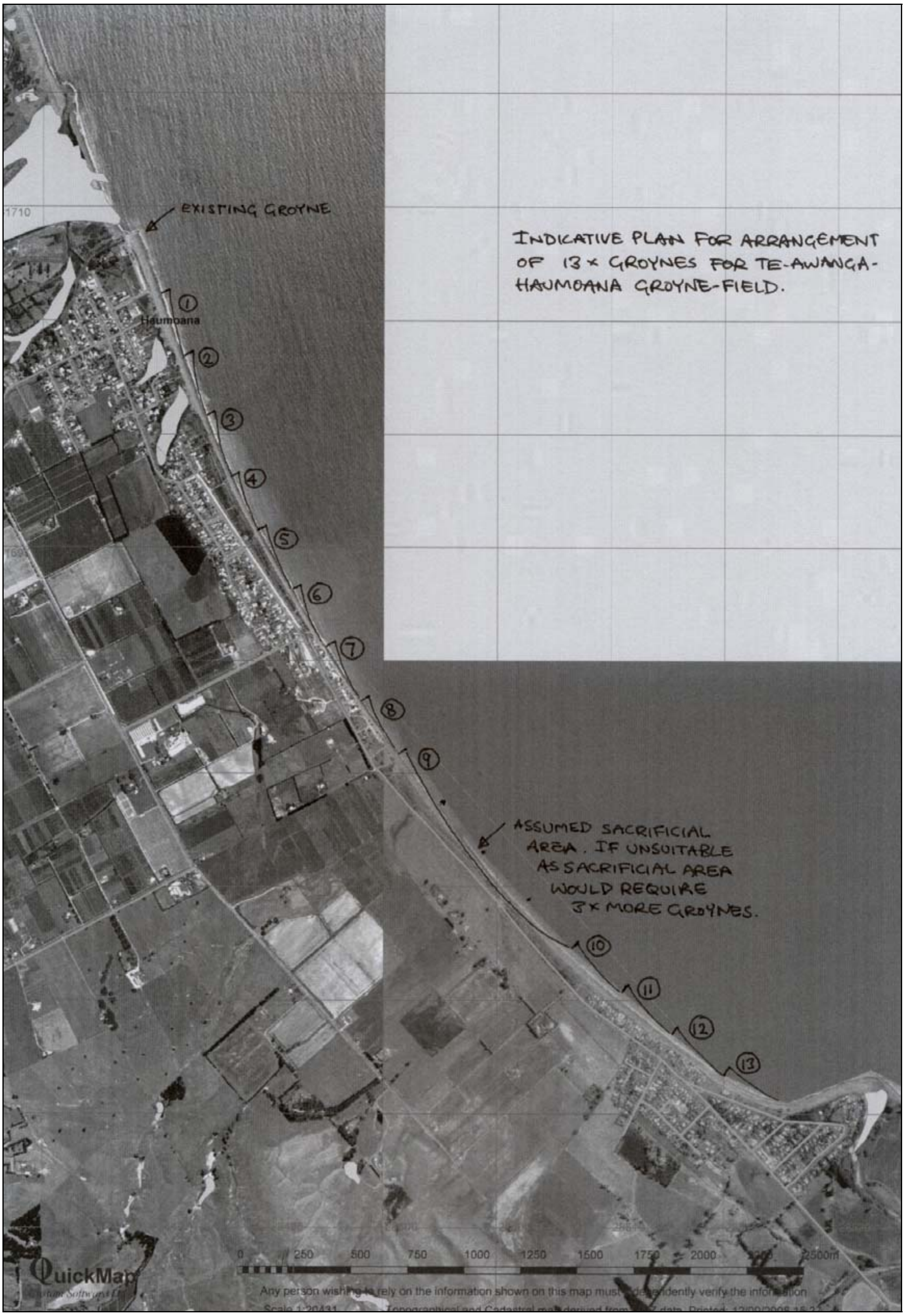


Figure 3 : Indicative plan showing assumed layout of groynes for the groyne-field option

# Appendix 2

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## Cost Calculation Spreadsheets

## Cost Assumptions for Groyne Construction

| | | |
|---|---|---|
| **Cost per groyne** | Based on $340K construction cost + investigation & design @9% construction costs + $756K filling cost (@ $40/m3 * 3 | $ 1,882,600 |
| | Maintenance cost per groyne (being approx average annual cost for existing Haumoana groyne = | $ 8,500 |
| | Number of groynes required : Assumes 13 x 70m-long groynes at 280m spacings.<br>Assumes 13 groynes needed to protect the whole of the beach from Haumoana to Maraetotara River (inclusive of sacrificial area between Haum & Te Awanga).<br>If no sacrifical area, number of groynes increases to 16. | |
| | Groynes are assumed to have a design life of 20 years with re-building required thereafter. Re-filling is assumed to be | $ 370,600 |

## Cost Assumptions for Staged Retreat

| | | | | |
|---|---|---|---|---|
| Haumoana | | | Per house cost | |
| | Relocate Haumoana 20 to new sites (eg. across the road) | $5,900,000 | $280,952 | (assumes $2m land purchase, $3.5m land development costs @$150k per site & $400,000 building relocation costs) |
| | Relocate 1 other house at Haumoana to completely new site | $280,952 | $280,952 | (assumes same cost per house as above) |
| | Move back (on-site) 1 house at Haumoana | | $20,000 | (based on upper figure from phone enquiry with house relocation company) |
| Te Awanga | | | Per house cost | |
| | Move back on site for 40 houses at Te Awanga | $ 800,000 | $ 20,000 | |
| | Move back on site for 2 houses at Haumoana | $ 40,000 | $ 20,000 | |
| | Relocate Te Awanga 40 to new sites (e.g. across the road) | $ 8,800,000 | $220,000 | (assumes $2m land purchase, $150k land development costs per site & $20k house relocation costs) |

**Cost Estimates for Staged Retreat Option**

| | | | | | | | Discount rate = | 11.00 | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | **Costs for Reteat Options (Discounted & Not-Discounted)** | Cost | Inflation @ 3% | Inflated cost | Discount multiplier | Discounted value | 10-yearly sub-totals (Discounted values) |
| | | 2008 | | | | | | | |
| | | 2009 | | | | | | | |
| Year 0 | 0 | 2010 | Relocate the 20 beachfront houses at Clifton Road, Haumoana | $ 5,900,000 | 1.00 | $ 5,900,000.00 | 1.000000000 | $ 5,900,000 | |
| Year 1 | 1 | 2011 | Move 40 beachfront houses at Te Awanga to back of existing house sites | $ 800,000 | 1.03 | $ 824,000.00 | 0.900900901 | $ 742,342 | |
| Year 2 | 2 | 2012 | Move house at 21 Gaskin Place (Haum) to back of existing site | $ 20,000 | 1.06 | $ 21,218.00 | 0.811622433 | $ 17,221 | |
| Year 3 | 3 | 2013 | | | 1.09 | $ - | 0.731191381 | $ - | |
| Year 4 | 4 | 2014 | | | 1.13 | $ - | 0.658730974 | $ - | |
| Year 5 | 5 | 2015 | | | 1.16 | $ - | 0.593451328 | $ - | |
| Year 6 | 6 | 2016 | | | 1.19 | $ - | 0.534640836 | $ - | |
| Year 7 | 7 | 2017 | | | 1.23 | $ - | 0.481658411 | $ - | |
| Year 8 | 8 | 2018 | | | 1.27 | $ - | 0.433926496 | $ - | |
| Year 9 | 9 | 2019 | Relocate 113 Beach Road (Haum to a new site | $ 280,000 | 1.30 | $ 365,336.49 | 0.390924771 | $ 142,819 | |
| Year 10 | 10 | 2020 | Relocate Te Awanga Community Hall | $ 200,000 | 1.34 | $ 268,783.28 | 0.352184479 | $ 94,661 | $ 6,897,044 |
| Year 11 | 11 | 2021 | | | 1.38 | $ - | 0.317283314 | $ - | |
| Year 12 | 12 | 2022 | | | 1.43 | $ - | 0.285840824 | $ - | |
| Year 13 | 13 | 2023 | | | 1.47 | $ - | 0.257514256 | $ - | |
| Year 14 | 14 | 2024 | | | 1.51 | $ - | 0.231994825 | $ - | |
| Year 15 | 15 | 2025 | | | 1.56 | $ - | 0.209004347 | $ - | |
| Year 16 | 16 | 2026 | | | 1.60 | $ - | 0.188292204 | $ - | |
| Year 17 | 17 | 2027 | | | 1.65 | $ - | 0.169632616 | $ - | |
| Year 18 | 18 | 2028 | | | 1.70 | $ - | 0.152822177 | $ - | |
| Year 19 | 19 | 2029 | | | 1.75 | $ - | 0.137677637 | $ - | |
| Year 20 | 20 | 2030 | | | 1.81 | $ - | 0.124033907 | $ - | $ 6,897,044 |
| Year 21 | 21 | 2031 | | | 1.86 | $ - | 0.111742259 | $ - | |
| Year 22 | 22 | 2032 | | | 1.92 | $ - | 0.100668701 | $ - | |
| Year 23 | 23 | 2033 | | | 1.97 | $ - | 0.090692524 | $ - | |
| Year 24 | 24 | 2034 | | | 2.03 | $ - | 0.081704976 | $ - | |
| Year 25 | 25 | 2035 | | | 2.09 | $ - | 0.073608087 | $ - | |
| Year 26 | 26 | 2036 | | | 2.16 | $ - | 0.066313592 | $ - | |
| Year 27 | 27 | 2037 | | | 2.22 | $ - | 0.059741975 | $ - | |
| Year 28 | 28 | 2038 | | | 2.29 | $ - | 0.053821599 | $ - | |
| Year 29 | 29 | 2039 | | | 2.36 | $ - | 0.048487927 | $ - | |
| Year 30 | 30 | 2040 | Move house at 8 Collison Tce to back of existing site | $ 20,000 | 2.43 | $ 48,545.25 | 0.043682817 | $ 2,121 | $ 6,899,164 |
| Year 31 | 31 | 2041 | | | 2.50 | $ - | 0.039353889 | $ - | |
| Year 32 | 32 | 2042 | | | 2.58 | $ - | 0.035453954 | $ - | |
| Year 33 | 33 | 2043 | | | 2.65 | $ - | 0.031940499 | $ - | |
| Year 34 | 34 | 2044 | | | 2.73 | $ - | 0.028775225 | $ - | |
| Year 35 | 35 | 2045 | | | 2.81 | $ - | 0.025923626 | $ - | |
| Year 36 | 36 | 2046 | | | 2.90 | $ - | 0.023354618 | $ - | |
| Year 37 | 37 | 2047 | | | 2.99 | $ - | 0.021040196 | $ - | |
| Year 38 | 38 | 2048 | | | 3.07 | $ - | 0.018955132 | $ - | |
| Year 39 | 39 | 2049 | | | 3.17 | $ - | 0.017076695 | $ - | |
| Year 40 | 40 | 2050 | Form new alignment for Clifton Road | $ 1,500,000 | 3.26 | $ 4,893,056.69 | 0.015384410 | $ 75,277 | $ 6,974,441 |
| Year 41 | 41 | 2051 | Relocate in-road services | $ 300,000 | 3.36 | $ 1,007,969.68 | 0.013859829 | $ 13,970 | |
| Year 42 | 42 | 2052 | | | 3.46 | $ - | 0.012486332 | $ - | |
| Year 43 | 43 | 2053 | Form new rear access for houses landward of Beach Rd | $ 2,000,000 | 3.56 | $ 7,129,033.54 | 0.011248948 | $ 80,194 | |
| Year 44 | 44 | 2054 | | | 3.67 | $ - | 0.010134187 | $ - | |
| Year 45 | 45 | 2055 | | | 3.78 | $ - | 0.009129899 | $ - | |
| Year 46 | 46 | 2056 | | | 3.90 | $ - | 0.008225134 | $ - | |
| Year 47 | 47 | 2057 | | | 4.01 | $ - | 0.007410031 | $ - | |
| Year 48 | 48 | 2058 | | | 4.13 | $ - | 0.006675703 | $ - | |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Year 49 | 49 | 2059 | | | | | | | | | 4.26 | $ - | 0.006014147 | $ - | |
| Year 50 | 50 | 2060 | | Relocate the 40 beach-front houses at Te Awanga to new site | | | | | | $ 8,800,000 | 4.38 | $ 38,578,372.96 | 0.005418150 | $ 209,023 | $ 7,277,629 |
| Year 51 | 51 | 2061 | | Relocate 5 houses at corner of Beach & East Roads | | | | | | $ 1,500,000 | 4.52 | $ 6,773,134.80 | 0.004881217 | $ 33,061 | |
| Year 52 | 52 | 2062 | | Relocate 15 houses on seaward side of Collison & Beach Rd's | | | | | | $ 4,500,000 | 4.65 | $ 20,928,986.53 | 0.004397492 | $ 92,035 | |
| Year 53 | 53 | 2063 | | | | | | | | | 4.79 | $ - | 0.003961705 | $ - | |
| Year 54 | 54 | 2064 | | | | | | | | | 4.93 | $ - | 0.003569104 | $ - | |
| Year 55 | 55 | 2065 | | | | | | | | | 5.08 | $ - | 0.003215409 | $ - | |
| Year 56 | 56 | 2066 | | | | | | | | | 5.23 | $ - | 0.002896764 | $ - | |
| Year 57 | 57 | 2067 | | | | | | | | | 5.39 | $ - | 0.002609698 | $ - | |
| Year 58 | 58 | 2068 | | | | | | | | | 5.55 | $ - | 0.002351079 | $ - | |
| Year 59 | 59 | 2069 | | | | | | | | | 5.72 | $ - | 0.002118089 | $ - | |
| Year 60 | 60 | 2070 | | | | | | | | | 5.89 | $ - | 0.001908188 | $ - | $ 7,402,725 |
| Year 61 | 61 | 2071 | | | | | | | | | 6.07 | $ - | 0.001719089 | $ - | |
| Year 62 | 62 | 2072 | | | | | | | | | 6.25 | $ - | 0.001548729 | $ - | |
| Year 63 | 63 | 2073 | | | | | | | | | 6.44 | $ - | 0.001395251 | $ - | |
| Year 64 | 64 | 2074 | | | | | | | | | 6.63 | $ - | 0.001256983 | $ - | |
| Year 65 | 65 | 2075 | | | | | | | | | 6.83 | $ - | 0.001132417 | $ - | |
| Year 66 | 66 | 2076 | | | | | | | | | 7.03 | $ - | 0.001020195 | $ - | |
| Year 67 | 67 | 2077 | | | | | | | | | 7.25 | $ - | 0.000919095 | $ - | |
| Year 68 | 68 | 2078 | | | | | | | | | 7.46 | $ - | 0.000828014 | $ - | |
| Year 69 | 69 | 2079 | | | | | | | | | 7.69 | $ - | 0.000745958 | $ - | |
| Year 70 | 70 | 2080 | | | | | | | | | 7.92 | $ - | 0.000672034 | $ - | $ 7,402,725 |
| Year 71 | 71 | 2081 | | | | | | | | | 8.16 | $ - | 0.000605436 | $ - | |
| Year 72 | 72 | 2082 | | | | | | | | | 8.40 | $ - | 0.000545438 | $ - | |
| Year 73 | 73 | 2083 | | | | | | | | | 8.65 | $ - | 0.000491386 | $ - | |
| Year 74 | 74 | 2084 | | | | | | | | | 8.91 | $ - | 0.000442690 | $ - | |
| Year 75 | 75 | 2085 | | | | | | | | | 9.18 | $ - | 0.000398820 | $ - | |
| Year 76 | 76 | 2086 | | | | | | | | | 9.45 | $ - | 0.000359297 | $ - | |
| Year 77 | 77 | 2087 | | | | | | | | | 9.74 | $ - | 0.000323691 | $ - | |
| Year 78 | 78 | 2088 | | | | | | | | | 10.03 | $ - | 0.000291614 | $ - | |
| Year 79 | 79 | 2089 | | | | | | | | | 10.33 | $ - | 0.000262715 | $ - | |
| Year 80 | 80 | 2090 | | Move 23 Gaskin Tce back on existing site | | | | | | $ 20,000 | 10.64 | $ 212,817.81 | 0.000236680 | $ 50 | $ 7,402,776 |
| Year 81 | 81 | 2091 | | | | | | | | | 10.96 | $ - | 0.000213225 | $ - | |
| Year 82 | 82 | 2092 | | | | | | | | | 11.29 | $ - | 0.000192095 | $ - | |
| Year 83 | 83 | 2093 | | | | | | | | | 11.63 | $ - | 0.000173058 | $ - | |
| Year 84 | 84 | 2094 | | | | | | | | | 11.98 | $ - | 0.000155908 | $ - | |
| Year 85 | 85 | 2095 | | | | | | | | | 12.34 | $ - | 0.000140458 | $ - | |
| Year 86 | 86 | 2096 | | | | | | | | | 12.71 | $ - | 0.000126539 | $ - | |
| Year 87 | 87 | 2097 | | | | | | | | | 13.09 | $ - | 0.000113999 | $ - | |
| Year 88 | 88 | 2098 | | | | | | | | | 13.48 | $ - | 0.000102702 | $ - | |
| Year 89 | 89 | 2099 | | | | | | | | | 13.88 | $ - | 0.000092524 | $ - | |
| Year 90 | 90 | 2100 | | | | | | | | | 14.30 | $ - | 0.000083355 | $ - | |
| | | | | | | | | | | | | | | | |
| | | | | | | | | | **Totals** | **$ 25,840,000** | | | | **$ 7,402,776** | |
| | | | | | | | | | | Non-discounted | | | | Discounted | |

| Costings for Construction & Mainteance of Groynes | | | | | | |
|---|---|---|---|---|---|---|
| | | Assumes 20-year design life. | | | | |
| | | $ 1,882,600 | is cost of construction per groyne | | | |
| | | Assumed discount & inflation rates same as for staged retreat option | | | | 10-yearly |
| | | 13 groynes + annual Maint | Subtotals | 13 groynes + annual maint | | Subtotals |
| | 2008 | | Non-discounted | | | (discounted) |
| | 2009 | | | | | |
| Year 0 | 2010 | $ 3,765,200 | | $ 3,765,200 | | |
| Year 1 | 2011 | $ 17,000 | | $ 15,775 | | |
| Year 2 | 2012 | $ 3,765,200 | | $ 3,242,026 | | |
| Year 3 | 2013 | $ 34,000 | | $ 27,166 | | |
| Year 4 | 2014 | $ 3,765,200 | | $ 2,791,548 | | |
| Year 5 | 2015 | $ 51,000 | | $ 35,087 | | |
| Year 6 | 2016 | $ 3,765,200 | | $ 2,403,663 | | |
| Year 7 | 2017 | $ 68,000 | | $ 40,282 | | |
| Year 8 | 2018 | $ 3,765,200 | | $ 2,069,674 | | |
| Year 9 | 2019 | $ 85,000 | | $ 43,356 | | |
| Year 10 | 2020 | $ 3,765,200 | 22,846,200 | $ 1,782,094 | | $ 16,215,869 |
| Year 11 | 2021 | $ 102,000 | | $ 44,798 | | |
| Year 12 | 2022 | $ 1,882,600 | | $ 767,236 | | |
| Year 13 | 2023 | $ 110,500 | | $ 41,788 | | |
| Year 14 | 2024 | $ 110,500 | | $ 38,776 | | |
| Year 15 | 2025 | $ 110,500 | | $ 35,981 | | |
| Year 16 | 2026 | $ 110,500 | | $ 33,388 | | |
| Year 17 | 2027 | $ 110,500 | | $ 30,982 | | |
| Year 18 | 2028 | $ 110,500 | | $ 28,749 | | |
| Year 19 | 2029 | $ 110,500 | | $ 26,677 | | |
| Year 20 | 2030 | $ 851,700 | 26,456,000 | $ 190,797 | | $ 17,455,040 |
| Year 21 | 2031 | $ 110,500 | | $ 22,970 | | |
| Year 22 | 2032 | $ 851,700 | | $ 164,286 | | |
| Year 23 | 2033 | $ 110,500 | | $ 19,778 | | |
| Year 24 | 2034 | $ 851,700 | | $ 141,458 | | |
| Year 25 | 2035 | $ 110,500 | | $ 17,030 | | |
| Year 26 | 2036 | $ 851,700 | | $ 121,803 | | |
| Year 27 | 2037 | $ 110,500 | | $ 14,664 | | |
| Year 28 | 2038 | $ 851,700 | | $ 104,878 | | |
| Year 29 | 2039 | $ 110,500 | | $ 12,626 | | |
| Year 30 | 2040 | $ 851,700 | 31,267,000 | $ 90,305 | | $ 18,164,839 |
| Year 31 | 2041 | $ 110,500 | | $ 10,872 | | |
| Year 32 | 2042 | $ 425,850 | | $ 38,879 | | |
| Year 33 | 2043 | $ 110,500 | | $ 9,361 | | |
| Year 34 | 2044 | $ 110,500 | | $ 8,687 | | |
| Year 35 | 2045 | $ 110,500 | | $ 8,060 | | |
| Year 36 | 2046 | $ 110,500 | | $ 7,480 | | |
| Year 37 | 2047 | $ 110,500 | | $ 6,940 | | |
| Year 38 | 2048 | $ 110,500 | | $ 6,440 | | |
| Year 39 | 2049 | $ 110,500 | | $ 5,976 | | |
| Year 40 | 2050 | $ 851,700 | 33,428,550 | $ 42,742 | | $ 18,310,277 |
| Year 41 | 2051 | $ 110,500 | | $ 5,146 | | |
| Year 42 | 2052 | $ 851,700 | | $ 36,803 | | |
| Year 43 | 2053 | $ 110,500 | | $ 4,431 | | |
| Year 44 | 2054 | $ 851,700 | | $ 31,689 | | |
| Year 45 | 2055 | $ 110,500 | | $ 3,815 | | |
| Year 46 | 2056 | $ 851,700 | | $ 27,286 | | |
| Year 47 | 2057 | $ 110,500 | | $ 3,285 | | |
| Year 48 | 2058 | $ 851,700 | | $ 23,495 | | |
| Year 49 | 2059 | $ 110,500 | | $ 2,829 | | |
| Year 50 | 2060 | $ 851,700 | 38,239,550 | $ 20,230 | | $ 18,469,285 |
| Year 51 | 2061 | $ 110,500 | | $ 2,436 | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Year 52 | 2062 | $ 425,850 | | $ 8,710 | | |
| Year 53 | 2063 | $ 110,500 | | $ 2,097 | | |
| Year 54 | 2064 | $ 110,500 | | $ 1,946 | | |
| Year 55 | 2065 | $ 110,500 | | $ 1,806 | | |
| Year 56 | 2066 | $ 110,500 | | $ 1,676 | | |
| Year 57 | 2067 | $ 110,500 | | $ 1,555 | | |
| Year 58 | 2068 | $ 110,500 | | $ 1,443 | | |
| Year 59 | 2069 | $ 110,500 | | $ 1,339 | | |
| Year 60 | 2070 | $ 851,700 | 40,401,100 | $ 9,575 | | $ 18,501,866 |
| Year 61 | 2071 | $ 110,500 | | $ 1,153 | | |
| Year 62 | 2072 | $ 851,700 | | $ 8,245 | | |
| Year 63 | 2073 | $ 110,500 | | $ 993 | | |
| Year 64 | 2074 | $ 851,700 | | $ 7,099 | | |
| Year 65 | 2075 | $ 110,500 | | $ 855 | | |
| Year 66 | 2076 | $ 851,700 | | $ 6,113 | | |
| Year 67 | 2077 | $ 110,500 | | $ 736 | | |
| Year 68 | 2078 | $ 851,700 | | $ 5,263 | | |
| Year 69 | 2079 | $ 110,500 | | $ 634 | | |
| Year 70 | 2080 | $ 851,700 | 45,212,100 | $ 4,532 | | $ 18,537,487 |
| Year 71 | 2081 | $ 110,500 | | $ 546 | | |
| Year 72 | 2082 | $ 425,850 | | $ 1,951 | | |
| Year 73 | 2083 | $ 110,500 | | $ 470 | | |
| Year 74 | 2084 | $ 110,500 | | $ 436 | | |
| Year 75 | 2085 | $ 110,500 | | $ 405 | | |
| Year 76 | 2086 | $ 110,500 | | $ 375 | | |
| Year 77 | 2087 | $ 110,500 | | $ 348 | | |
| Year 78 | 2088 | $ 110,500 | | $ 323 | | |
| Year 79 | 2089 | $ 110,500 | | $ 300 | | |
| Year 80 | 2090 | $ 851,700 | 47,373,650 | $ 2,145 | | $ 18,544,786 |
| Year 81 | 2091 | $ 110,500 | | $ 258 | | |
| Year 82 | 2092 | $ 851,700 | | $ 1,847 | | |
| Year 83 | 2093 | $ 110,500 | | $ 222 | | |
| Year 84 | 2094 | $ 851,700 | | $ 1,590 | | |
| Year 85 | 2095 | $ 110,500 | | $ 191 | | |
| Year 86 | 2096 | $ 851,700 | | $ 1,369 | | |
| Year 87 | 2097 | $ 110,500 | | $ 165 | | |
| Year 88 | 2098 | $ 851,700 | | $ 1,179 | | |
| Year 89 | 2099 | $ 110,500 | | $ 142 | | |
| Year 90 | 2100 | $ 851,700 | | $ 1,015 | | |
| | | | | | | |
| | | $ 52,184,650 | | **$ 18,552,765** | | |
| | | Non-discounted | | Discounted | | |

**Rating Scenario for Construction of Groynes**

Benefit ratio = measure of immediacy of need for protection of property. Figure is based on discount rate applying at time when house is predicted to be at imminent risk from coastal erosion.

| | | | | | | Average Discounted Cost per Property | |
|---|---|---|---|---|---|---|---|
| **Front-line properties** | **No. of properties** | **Benefit Ratio** | **Total Shares** | **Percentage Ber** | **Cost Share per Property** | 13 groynes | Group subtotals |
| | | | | | | | |
| Haumoana Beachfront Properties on Clifton Road (x20) | 20 | 1.000 | 20.00 | 34.53% | 1.726% | $ 320,295 | $ 6,405,903 |
| Te Awanga Beachfront Properties on Clifton Road (x40) | 40 | 0.901 | 36.04 | 62.21% | 1.555% | $ 288,554 | $ 11,542,167 |
| 21 Gaskin Place, Haum (x1) | 1 | 0.812 | 0.81 | 1.40% | 1.401% | $ 259,959 | $ 259,959 |
| 113 Beach Road, Haum (x1) | 1 | 0.391 | 0.39 | 0.67% | 0.675% | $ 125,211 | $ 125,211 |
| | | | | | | $ - | $ - |
| | | | | | | $ - | $ - |
| **Second-line properties** | | | | | | $ - | $ - |
| Te Awanga Hall | 1 | 0.352 | 0.35 | 0.61% | 0.608% | $ 112,803 | $ 112,803 |
| 8 Collison Tce | 1 | 0.044 | 0.04 | 0.08% | 0.075% | $ 13,991 | $ 13,991 |
| | | | | | | $ - | $ - |
| | | | | | | $ - | $ - |
| **Third-line properties** | | | | | | $ - | $ - |
| Clifton Road (HDC) | 1 | 0.015 | 0.02 | 0.03% | 0.027% | $ 4,928 | $ 4,928 |
| Landward properties on Beach Road (x20) | 20 | 0.012 | 0.25 | 0.43% | 0.022% | $ 3,999 | $ 79,986 |
| Houses at corner of Beach & East Road (x5) | 5 | 0.005 | 0.02 | 0.04% | 0.008% | $ 1,563 | $ 7,817 |
| | | | | | | $ - | $ - |
| | | | | | | $ - | $ - |
| | | | | | | $ - | $ - |
| | | | | | | | |
| **Totals** | 90 | 3.532 | 57.92 | 100% | | | $ 18,552,765 |

| | | |
|---|---|---|
| **Cost Scenarios (Beach-front Properties only)** | | |
| **Cost as Lump Sum then On-going Maint** | | |
| Assuming equal maintenance costs for Haum & Te Aw | | |
| (Only applies to first 20 years). | | |
| | Haum Beachfront | Te Aw Beachfront |
| | | |
| Lump sum | $ 293,970 | 264,838 |
| | | |
| Year 14 - Yr 20 | $ 1,782 | $ 1,782 |
| | | |
| | | |
| | | |
| | | |
| **Cost as single Lump Sum (Groynes)** | | |
| **Over 90 years** | | |
| | | |
| | Haum Beachfront | Te Aw Beachfront |
| | | |
| Lump Sum | $ 320,295 | $ 288,554 |
| | | |
| | | |
| | | |
| | | |
| | | |
| **Cost as single Lump Sum (Groynes)** | | |
| **Over 60 years** | | |
| | | |
| | Haum Beachfront | Te Aw Beachfront |
| | | |
| Lump Sum | $ 319,416 | $ 287,763 |
| | | |
| | | |
| | | |
| | | |
| **Annual on-going charge after year 14 (if averaged)** | | |
| | | |
| | Haum beachfront | Te Aw Beachfront |
| 60 years | $ 5,062 | $ 4,704 |
| 90 years | $ 5,439 | $ 4,987 |
| | | |

| Cost of Groynes as an Average Annual Rate for Beachfront Properties | | | | | |
|---|---|---|---|---|---|
| Av cost share per Haum beach | | 1.726% | | | |
| Av cost share per Te Aw beach | | 1.555% | Haumoana beach front | | Te Aw beach front |
| | Non-discounted f | Haum beachfront | Average annual charge | Te Aw beachfront | Average annual charge |
| 2008 | $ - | $ - | | $ - | |
| 2009 | $ - | $ - | | $ - | |
| 2010 | $ 3,765,200 | $ 65,002 | $ 32,648 | $ 58,561 | $ 29,413 |
| 2011 | $ 17,000 | $ 293 | $ 32,648 | $ 264 | $ 29,413 |
| 2012 | $ 3,765,200 | $ 65,002 | $ 32,795 | $ 58,561 | $ 29,545 |
| 2013 | $ 34,000 | $ 587 | $ 32,795 | $ 529 | $ 29,545 |
| 2014 | $ 3,765,200 | $ 65,002 | $ 32,941 | $ 58,561 | $ 29,677 |
| 2015 | $ 51,000 | $ 880 | $ 32,941 | $ 793 | $ 29,677 |
| 2016 | $ 3,765,200 | $ 65,002 | $ 33,088 | $ 58,561 | $ 29,809 |
| 2017 | $ 68,000 | $ 1,174 | $ 33,088 | $ 1,058 | $ 29,809 |
| 2018 | $ 3,765,200 | $ 65,002 | $ 33,235 | $ 58,561 | $ 29,941 |
| 2019 | $ 85,000 | $ 1,467 | $ 33,235 | $ 1,322 | $ 29,941 |
| 2020 | $ 3,765,200 | $ 65,002 | $ 33,382 | $ 58,561 | $ 30,074 |
| 2021 | $ 102,000 | $ 1,761 | $ 17,131 | $ 1,586 | $ 15,433 |
| 2022 | $ 1,882,600 | $ 32,501 | $ 17,204 | $ 29,280 | $ 15,500 |
| 2023 | $ 110,500 | $ 1,908 | $ 17,204 | $ 1,719 | $ 15,500 |
| 2024 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |
| 2025 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |
| 2026 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |
| 2027 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |
| 2028 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |
| 2029 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |
| 2030 | $ 851,700 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2031 | $ 110,500 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2032 | $ 851,700 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2033 | $ 110,500 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2034 | $ 851,700 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2035 | $ 110,500 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2036 | $ 851,700 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2037 | $ 110,500 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2038 | $ 851,700 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2039 | $ 110,500 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2040 | $ 851,700 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2041 | $ 110,500 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2042 | $ 425,850 | $ 3,676 | $ 3,676 | $ 6,623 | $ 6,623 |
| 2043 | $ 110,500 | $ 3,676 | $ 3,676 | $ 6,623 | $ 6,623 |
| 2044 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |
| 2045 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |
| 2046 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |
| 2047 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |
| 2048 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |
| 2049 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |
| 2050 | $ 851,700 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2051 | $ 110,500 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2052 | $ 851,700 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2053 | $ 110,500 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2054 | $ 851,700 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2055 | $ 110,500 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2056 | $ 851,700 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2057 | $ 110,500 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2058 | $ 851,700 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2059 | $ 110,500 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2060 | $ 851,700 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2061 | $ 110,500 | $ 7,352 | $ 7,352 | $ 6,623 | $ 6,623 |
| 2062 | $ 425,850 | $ 3,676 | $ 3,676 | $ 3,312 | $ 3,312 |
| 2063 | $ 110,500 | $ 3,676 | $ 3,676 | $ 3,312 | $ 3,312 |
| 2064 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |
| 2065 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |
| 2066 | $ 110,500 | $ 1,908 | $ 1,908 | $ 1,719 | $ 1,719 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| 2067 | $ | 110,500 | $ | 1,908 | $ | 1,908 | $ | 1,719 | $ | 1,719 |
| 2068 | $ | 110,500 | $ | 1,908 | $ | 1,908 | $ | 1,719 | $ | 1,719 |
| 2069 | $ | 110,500 | $ | 1,908 | $ | 1,908 | $ | 1,719 | $ | 1,719 |
| 2070 | $ | 851,700 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2071 | $ | 110,500 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2072 | $ | 851,700 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2073 | $ | 110,500 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2074 | $ | 851,700 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2075 | $ | 110,500 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2076 | $ | 851,700 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2077 | $ | 110,500 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2078 | $ | 851,700 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2079 | $ | 110,500 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2080 | $ | 851,700 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2081 | $ | 110,500 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2082 | $ | 425,850 | $ | 3,676 | $ | 3,676 | $ | 3,312 | $ | 3,312 |
| 2083 | $ | 110,500 | $ | 3,676 | $ | 3,676 | $ | 3,312 | $ | 3,312 |
| 2084 | $ | 110,500 | $ | 1,908 | $ | 1,908 | $ | 1,719 | $ | 1,719 |
| 2085 | $ | 110,500 | $ | 1,908 | $ | 1,908 | $ | 1,719 | $ | 1,719 |
| 2086 | $ | 110,500 | $ | 1,908 | $ | 1,908 | $ | 1,719 | $ | 1,719 |
| 2087 | $ | 110,500 | $ | 1,908 | $ | 1,908 | $ | 1,719 | $ | 1,719 |
| 2088 | $ | 110,500 | $ | 1,908 | $ | 1,908 | $ | 1,719 | $ | 1,719 |
| 2089 | $ | 110,500 | $ | 1,908 | $ | 1,908 | $ | 1,719 | $ | 1,719 |
| 2090 | $ | 851,700 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2091 | $ | 110,500 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2092 | $ | 851,700 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2093 | $ | 110,500 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2094 | $ | 851,700 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2095 | $ | 110,500 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2096 | $ | 851,700 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2097 | $ | 110,500 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2098 | $ | 851,700 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2099 | $ | 110,500 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| 2100 | $ | 851,700 | $ | 7,352 | $ | 7,352 | $ | 6,623 | $ | 6,623 |
| | | | | | | | | | | |
| **Totals** | **$** | **52,184,650** | **$** | **843,965** | **$** | **827,714** | **$** | **766,952** | **$** | **752,312** |