4.0 COASTAL EROSION HAZARD ASSESSMENT

There has been considerable net coastal erosion at the southern end of Muriwai Beach over the last few decades (Cato, 1987). This chapter examines the trend for shoreline retreat and possible causes.

4.1 Analysis of Shoreline Surveys

Shoreline changes shown by analysis of historical surveys (Table 1 of Appendix A) are shown in Figure 10. This section discusses these shoreline changes in each of the management areas.

4.1.1 Shoreline Change: Southern Car Park

At the very southern end of the beach, the data in Figure 10 indicates:

- **Little to no net shoreline change in the period from 1924 to 1960.** The average erosion between these two surveys being only 8m, which is within the margin of error of the comparison.

- **Very significant erosion over the period since the 1970 survey,** with the mean high water mark having retreated by about 100m in front of the car park – an average of 2.4m per year.

The data suggests that the trend for serious coastal erosion probably commenced after 1960. Prior to this period, the shoreline appears to have been in dynamic equilibrium, probably fluctuating in position in response to periods of shore advance (e.g. during periods of low swell) and shore erosion (e.g. during storms), but with no net change in shoreline position over time.

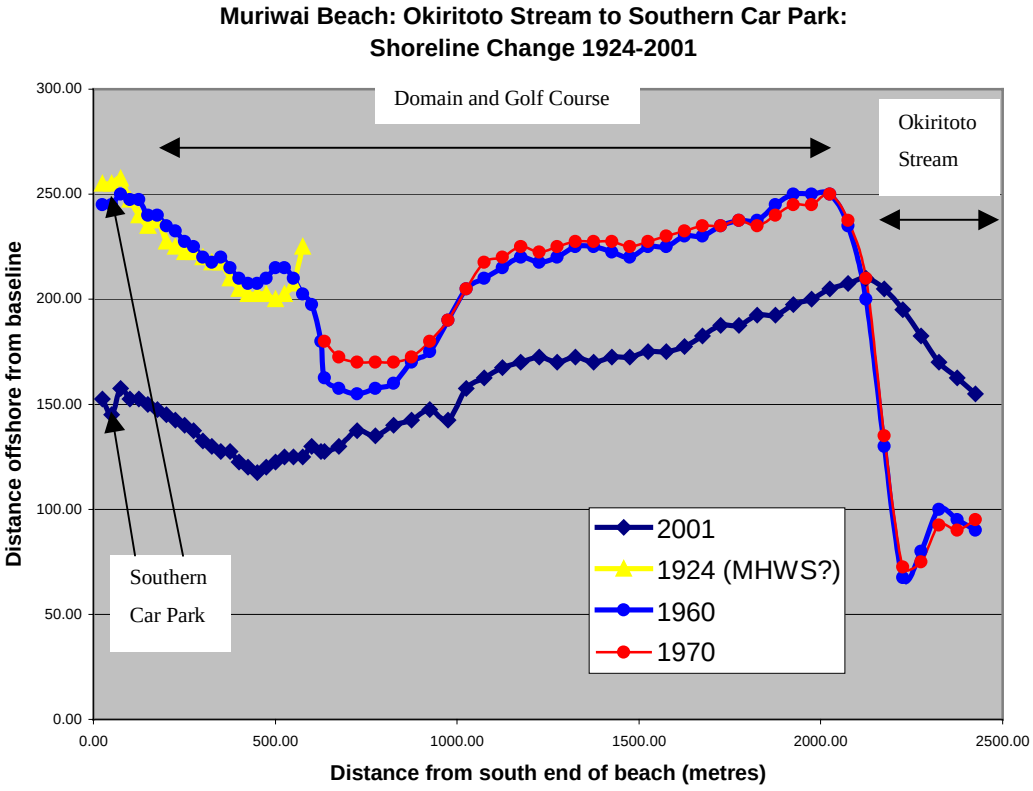

Figure 10: Shoreline changes at southern end of Muriwai beach as indicated by available historical surveys (see Appendix A).

4.1.2 Shoreline Change: Domain and Golf Course

The major features of the shoreline changes in this area (Figure 10) are:

Little net shoreline change in the period from 1960 to 1970, the average shoreline change over this area being within the margin of error of the comparison.

Significant erosion 1960 to 2001. The erosion has averaged 86m over the 600m shoreline fronting the Domain or 2.1m per year. Over most of the length of the Golf Course, the shoreline has retreated by 55-60m, an average of 1.8m per year. However, in a limited area towards the southern end of the Golf Course, the total erosion has only been in the order of 25-40m (Figure 10).

The relatively limited erosion in the period from 1960-1970 tends to suggest that the most serious erosion has occurred since 1970.

4.1.3 Shoreline Change: Okiritoto and the "five mile strip"

There is no historical data for the "five mile strip", but the area of the Okiritoto Stream entrance has advanced by 50-100m in the period since the 1960 and 1970 surveys (Figure 10). This advance represents shoreline recovery following earlier erosion by stream channel changes. Since then, the dunes have prograded seaward as a consequence of human plantings – but still lie well landward of the coast and are not subject to wave erosion. Further fluctuations in the position of the stream entrance are likely to occur in the future.

4.2 Beach Profiles

Beach profiles are shore perpendicular cross-sections that are repeatedly re-surveyed over time. There are beach profile sites located in the southern, central and northern areas of Muriwai Beach (Figure 1 of Appendix A). Therefore, the available data provides a useful indication of the general trends along the beach length over the period of the records.

4.2.1 Southern Car Park Area – Site P 4

This site (P4) is most representative of the Car Park area. The trends at this site are difficult to distinguish (Figure 11), but suggest ongoing net erosion. The difficulty in interpreting the data largely relates to collapse of the over-steepened dune profile after storms, which tends to mask the erosion trend. Dynamic variations also mask longer-term trends over the relatively short period of the record.

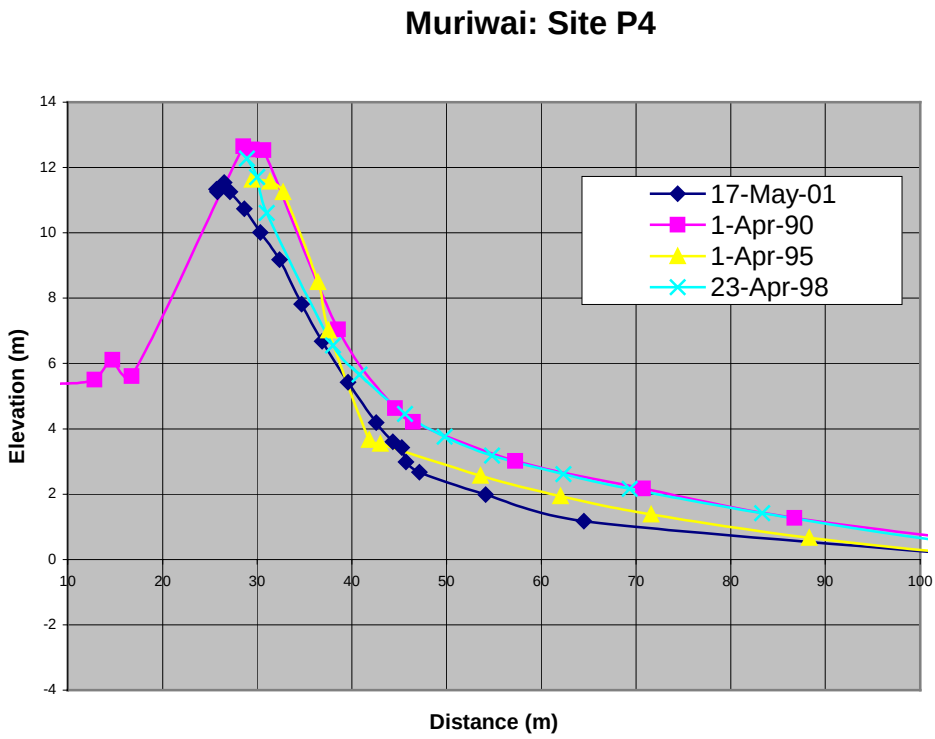

Figure 11: Beach profile data for site P4.

For instance, between the initial survey in April 1990 and the survey of April 1995, the toe of the dune retreated by about 9-11 metres, an average rate of 1.8-2.2 metres per year, a significant rate of erosion (Figure 11).

However, at the time of the April 1995 survey, the eroded dune face was markedly over-steepened (Figure 11) – suggesting that the severe erosion had occurred shortly before this survey. Subsequently, the over-steepened dune face collapsed. Together with short-term beach recovery, this resulted in some net accretion between April 1995 and April 1998 (Figure 11). Since April 1998, further erosion of the beach and dune has occurred, together with further retreat of the overall seaward dune face (Figure 11).

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Therefore, there does appear to be a trend for ongoing net duneline retreat in this area. This is also consistent with other lines of evidence (see section 4.3).

Overall, it appears that the toe of the dune retreated by about 9-11m between April 1990 and May 2001, suggesting an average rate of erosion of about 1 metre per year. The further erosion since that date (Section 4.3) suggests the trend for erosion is presently continuing.

While the average rate of erosion over the last decade is still very significant, it is considerably lower than the average rate of retreat observed over the period 1960-2001 (see section 4.1 above). Therefore, the average rate of erosion does appear to have slowed in this area.

4.2.2 Domain and Golf Course – Site P3

This site has shown a clear and consistent trend for beach and dune erosion over the 20-year period since monitoring commenced (Figure 12). For example, in May 2001 the toe of the dune (then at about RL 4m) lay 26m landward of the same elevation in the February 1981 survey, an average rate of retreat of about 1.3 metres per year.

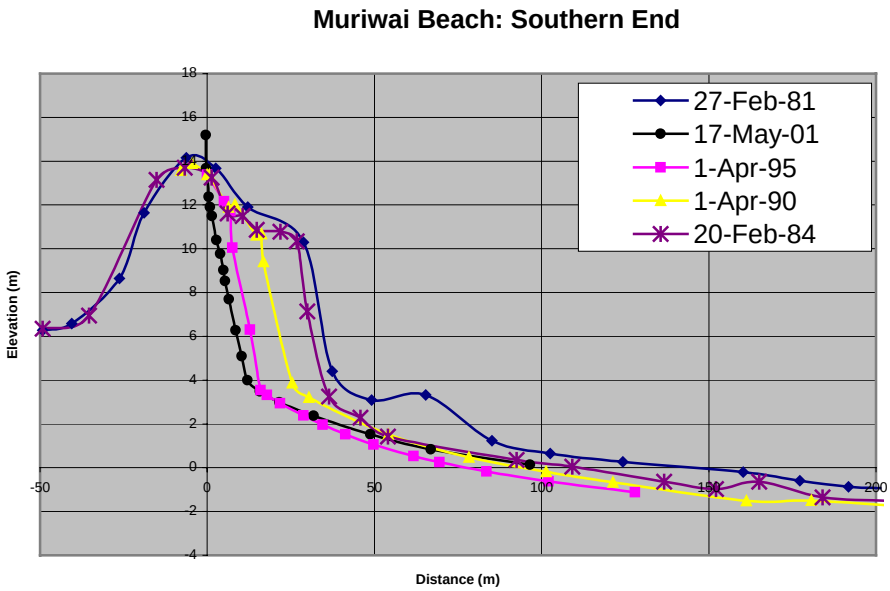

Figure 12: Beach profile data for site P3

This is slightly lower than the average rate of erosion in this area derived from comparison of the 1970 and 2001 surveys (1.5 metres per year). The average rate of erosion in the 1980's (February 1981 and April 1990) at 1.4 metres per year was also slightly higher than the average rate of 1.2 metres per year in the subsequent period (April 1990 to May 2001). Collectively, these figures could suggest that the rate of erosion is slowing over time. However, in the 11 years between the surveys of February 1984 and April 1995, the average rate of erosion was 1.8 metres per year. Therefore, the differences could equally represent dynamic variations over time, rather than a trend for the rate of erosion to decrease with time.

Tonkin and Taylor (1998) note a trend for accretion between 1995 and 1998. However, with the advantage of further data, this accretion appears simply to have been a period of short-term beach recovery. Further erosion has occurred since 1998 and the overall trend between April 1995 and May 2001 was for net duneline retreat of about 4-5 metres. Short-term variations of this nature are to be expected in the beach profile record.

Therefore, at this point in time, it appears that erosion is continuing at the average rate observed over the last 2-4 decades (i.e. 1.3-1.5 metres per year), higher in some periods and lower in others.

It is difficult to draw any firm conclusions in respect of net trends in beach level due to dynamic variations in profile shape. However, plotting the two surveys that are most similar in profile shape (February 1982 and April 1995) does suggest a trend for beach lowering (Figure 13). The average lowering of the upper beach (adjacent to the dune) is about 2m and the average beach gradient in this area is about 1:13. Therefore, the apparent beach lowering is of the scale that would be expected to give rise to the observed dune retreat (25m) between these two surveys.

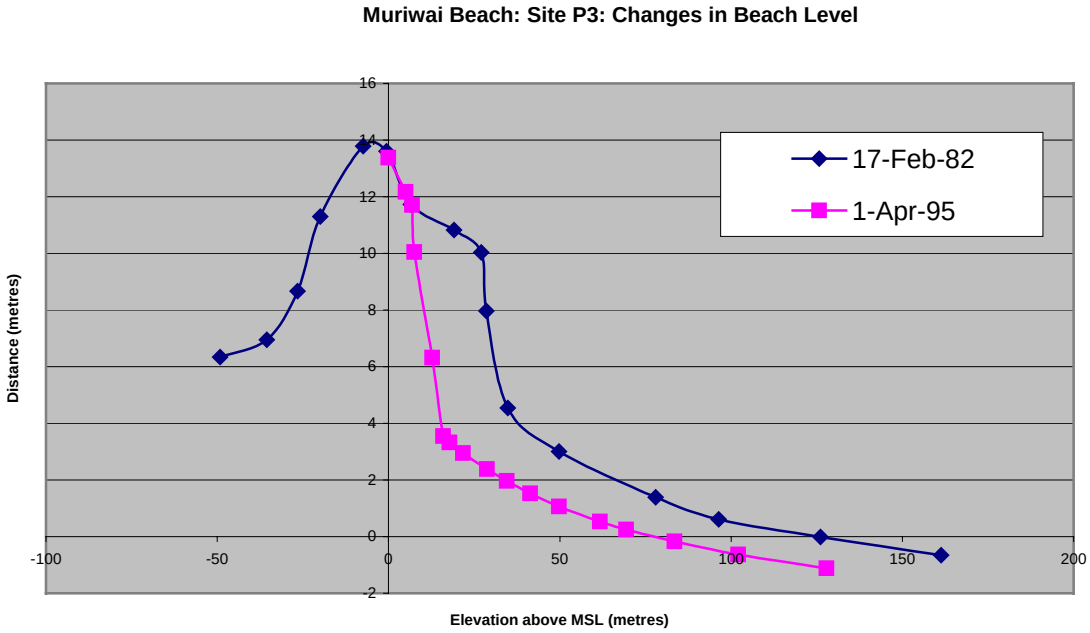

Figure 13: Changes in beach levels between 1982 and 1995.

This evidence tends to suggest that the ongoing trend for severe dune erosion relates to an ongoing trend for net loss of sediment from the beach system fronting the dune.

4.2.3 Okiritoto Stream and the "five mile strip" - Sites P 1 and P2

Site P2: Centre of Muriwai Beach:

The data suggests the shoreline is slowly prograding at this site (Figure 14).

In May 2001, the toe of the main frontal dune (approximately RL 4.5m) lay about 5m seaward of the equivalent elevation in April 1990 (Figure 14), suggesting slow net seaward advance of about 0.45m per year.

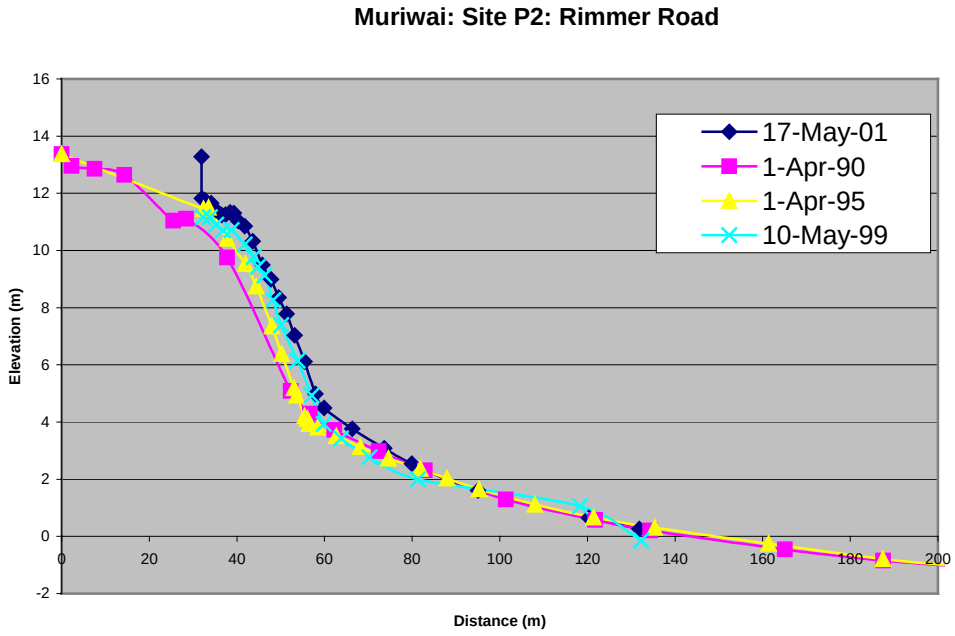

Figure 14: Beach profile data -site P2

The prograding dune face is very steep and appears to have become slightly steeper over the 10 years of monitoring (Figure14). For instance, the main part of the dune face, between RL 4 and RL10m, increased in slope from 1V: 3.2H in 1990 to 1V: 2.8H in May 2001. This is likely to give rise to increasing instability problems as the dune grows in height. The steep seaward face is almost certainly a function of the marram vegetation that dominates the frontal dune.

Site P1: Northern Area of Muriwai Beach

This site shows a clear trend for seaward dune advance over the 11-year record (Figure 15). The dune toe in May 2001 (about RL 4m) was located 14m seaward of the equivalent elevation in April 1990, indicating an average rate of dune advance of about 1.3 metres per year.

Detailed examination of the full data set (11 surveys between 1990 and May 2001) indicates that the trend for dune advance has been consistent throughout the period, though occasional storm erosion is also evident (e.g. April 1995 survey).

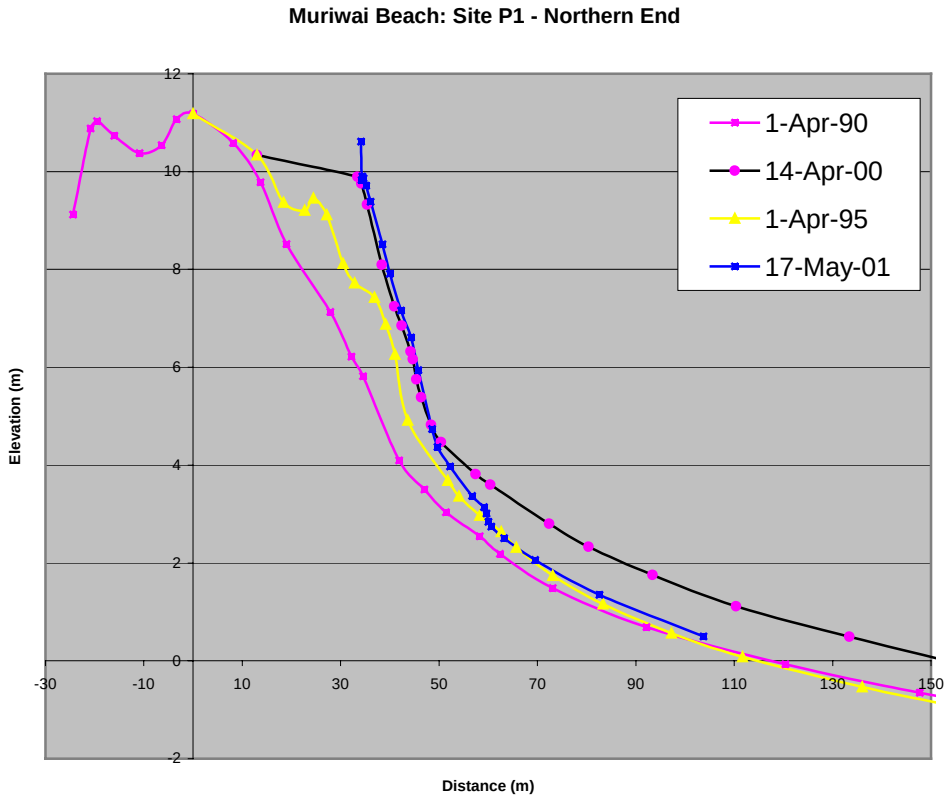

Figure 15: Beach profile data for site P1

The advancing dune has also steepened over time (Figure 15). In the period between the surveys of April 1990 and May 2001, the average gradient of the seaward dune face (between RL 4m and RL 10m) increased from 1V: 5.5H to 1V: 2.7H.

The average slope on the marram-dominated dune faces contrasts markedly with the smooth aerodynamic profile (1V: 5H) noted on the spinifex dunes at the entrance to Okiritoto Stream (see Chapter 2). These differences and ongoing problems related to instability of steep, high marram dunes are a key reason why the use of marram should be avoided on frontal dunes.

4.3 Field Inspections and Historical Information

This section briefly reviews other information on coastal erosion, including historical files and photographs, field observations and information from locals and agency staff.

No evidence of wave erosion at the southern end of Muriwai Beach was found prior to the 1960's. The earliest reference to wave erosion noted during this study was that of Brothers (1954) (cited in Cato, 1987, p34). However, examination of Whites Aviation oblique aerial photographs flown in 1951, 1953 and 1957 indicate a consistently well-vegetated dune face south of Okiritoto Stream, with no evidence of erosion. It appears that Brothers was either not discussing the southern end of the beach or was simply describing short-term storm erosion.

The duneline in these photos also demonstrated an irregular wavy pattern, reflecting the severe wind erosion of earlier decades. The persistence of this wavy pattern further indicates that there had been no significant duneline recession (i.e. net erosion) in preceding decades. In contrast, aerial photos taken in the late 1960's and 1970's, after severe ongoing erosion had commenced, show a straight sharp edge to the duneline.

Therefore, there is little evidence of long-term erosion at the southern end of the beach prior to 1960, consistent with the survey data (section 4.1).

The earliest definitive reference to wave erosion at the southern end of the beach was a letter dated 21 May 1962 discussing the Motutara Domain:

> …heavy storms .. experienced earlier this year .. caused considerable erosion at Muriwai Beach. (Lands and Survey Auckland, File 8/3/94, held at Archives NZ, Auckland).

In 1963, a letter from the MoW discussing the Domain notes

> Apparently for some time, the sea has been lowering the beach level and causing heavy seas to pound against the high sand dune on the right of the valley outfall.". (Resident Engineer, Central Residency, MoW to District Commissioner of Works, Auckland, dated 7 October 1963, PWD File 26/4/2, held Archives NZ, Auckland).

This tends to suggest that a trend for ongoing shoreline retreat was becoming evident. In 1965 a, NZFS report noted in respect of the Muriwai Golf Course:

> ... erosion of the foredune is particularly bad … and the toe of the foredune is being continually pushed back thereby forming a steep bare sand face on the foredune (note dated 14 May 1965, NZFS Woodhill File 6/179/6 , Archives NZ, Auckland)

An oblique aerial photograph dating from May 1968 (Whites Aviation Photo 67730) indicates that, by this time, the frontal dune was scarped along most the length of the golf course to Okiritoto Stream. The wavy duneline noted in earlier photos was no longer evident.

In the late 1970's and early 1980's, attempts were made to protect the dune at the southern end of the beach by means of a timber wall. The first part of the sea wall was built by the ARA in 1978 (Cato, 1987) and by the early 1980's an extensive wall, constructed by various parties, extended over several hundred metres at the southern end of the beach. The wall was extensively damaged by a stormy period in July 1986, which undermined and destroyed about 250m of the most northern portion and left remaining areas intact but "undermined and robbed of backfill" (Cato, 1987, p68). Attempts to repair the remaining wall area were unsuccessful and the wall appears to have been largely ineffective or removed by 1987 (Cato, 1987).

Locals report that the erosion has continued to the present time. For instance, a piled, pedestrian accessway fronting the southern car park was recently removed due to an increase in the frequency and severity of wave damage. The first accessway placed in the mid 1980's only suffered occasional minor erosion damage. In recent years however, very severe damage by wave action has been sustained on a number of occasions and the ARC insurer declined to provide further cover (Mr J Dent, ARC, pers. comm., January 2001).

Field inspections during this study indicate that severe dune erosion extends beyond the northern limit of the regional park. However, ARC rangers note that the erosion does

appear to become increasingly less severe with distance north, consistent with the beach profile data (section 4.2).

4.4 Potential Impact of Climate Change

There is now a scientific consensus that changes likely to accompany predicted global warming may impact on coastal erosion and flooding over the next century and beyond (IPCC, 2001; NIWA, 2001).

It is difficult to predict the impact of these changes on coastal erosion at Muriwai. The Brunn Rule (Brunn, 1962; 1983) argues that as sea level rises against shore-normal profile in equilibrium, beach erosion takes place to provide sediments to the near shore, so that the seabed is elevated in direct proportion to the rate of sea level rise. Using this rule and present best estimates of sea level rise over the next century (0.3-0.5m, IPCC, 2001) suggests additional erosion of up to 20-30m could occur.

However, it is questionable whether the assumptions underlying the Bruun Rule apply to the West Coast sites such as Muriwai. These sites form part of an interconnected littoral drift system (Chapter 2). Therefore, sediment supply for profile adjustment to sea level rise may be derived from net littoral inputs rather than erosion of the upper beach profile and erosion in response to sea level rise may be minimal at Muriwai.

4.5 Erosion Hazard Assessment

This section uses the preceding analysis to estimate future vulnerability to coastal erosion.

4.5.1 Coastal Erosion Trends

The analysis of available information suggests that the trend for erosion at the southern end of Muriwai Beach probably commenced in the early to mid 1960's and was in a state of dynamic equilibrium prior to that.

Since 1960, the beach fronting the Domain and Southern Car Park has retreated by an average of about 80-100m, though the average rate of erosion appears to have decreased to about 1m per year over the last decade.

The foreshore area fronting the Muriwai Golf Course has typically lost 55-60m since the erosion commenced, apart from a short length at the southern end. Over the last 2 decades, the rate of erosion has averaged about 1.3 metres per year.

The erosion extends well north of the study area. However, beach profile data and field observations suggest that the erosion decreases with distance north, with a slow trend for shoreline advance evident at beach profile site P2, about 15.5km north from the southern end of the beach.

The trend for shoreline advance then appears to increase with further distance north, averaging about 1.3 metres per year at the northernmost beach profile site (P1), 26.4 km north from the southern end of the beach.

As net sediment transport along the West Coasts is to the north, it appears that sand is being eroded from the southernmost 12-14km of the beach and deposited in areas further north.

4.5.2 Possible Causes of the Erosion

In order to predict future erosion trends, it is important to try and understand the causes of the present erosion.

Earlier work suggested that the erosion trend could be linked to the dune stabilisation works (Cato, 1987). However, this is unlikely and fails to explain why the northern end of the beach, also subject to dune stabilisation, is accreting.

Rather, the fact that the southern end of the beach is eroding suggests that net longshore sediment supply from the south is not presently balancing the net sediment losses to the north. The reasons for this are unclear, but we believe that it may relate to macro-scale influences on sediment transport, particularly the influence of the Manukau Harbour entrance. The following paragraphs elaborate this hypothesis.

Sand moving northwards along the West Coast has to bypass some significant obstacles, such as major river and estuary entrances and headlands. We are aware of evidence that suggests that sand may bypass these obstacles in clumps or slugs, rather than as a steady stream. For instance, Dahm (1999) reports periods of erosion and accretion on the northern side of the Mokau River entrance. These appear to be associated with sediment bypassing. The beach on the northern side of the Mokau River entrance undergoes rapid accretion when a slug of sediment bypasses the entrance – over 55m of beach accretion noted over only two months in 2001. The slug of sediment then appears to be moved north over time, with the beach (and eventually the dune) being slowly eroded until the next slug of sediment arrives from the south. At the Mokau River entrance, there have been 3 periods of erosion and accretion associated with such processes in the period from 1955 to 2001 (Dahm, 1999).

Similar processes appear to operate at larger entrances such as Manukau Harbour, though the slugs of sediment and the time required for by-passing appear to be much larger. For instance, Whatipu Spit on the northern side of the harbour entrance underwent significant seaward advance (about 1km) from the mid 1800's until at least the 1970's (Williams, 1977). This suggests the arrival of a major "slug" of sediment. There is also evidence that the progradation at Whatipu was preceded by erosion of a significant coastal plain on the southern side of the harbour (Smith, 1878). If correct, this could account for the "slug" of sediment that subsequently arrived at Whatipu.

Therefore, while this hypothesis requires further testing, it does appear that the Harbour entrance acts as an obstacle to net northwards sediment transport, with sediment bypassing the entrance in substantial "slugs". Northward movement of these slugs could be expected to give rise to alternating periods of accretion and erosion, each lasting several decades. In other words, a beach would accrete as a "slug" of sediment arrives and then erode as the "slugs" continues to move north. In simple terms, the "slug" can be viewed as a wave of sediment moving slowly northwards along the coast.

Piha, the beach to the immediate north of Whatipu also appears to have been accreting seaward over the past 50-100 years (NIWA, 1999), adding strength to this hypothesis.

Therefore, while the cause of the erosion at Muriwai is unknown, it could be associated with the northward movement of a previous 'slug" or longshore wave of sediment. This hypothesis explains why the erosion at Muriwai had a distinct beginning point (early 1960s) and suggests that the erosion will not continue indefinitely and will probably slow over time. It also suggests that a period of accretion will probably be experienced when the next wave of sediment arrives from the south.

We believe this hypothesis provides the best explanation of the present erosion being experienced at the southern end of Muriwai Beach. However, more detailed work, well beyond the scope of this report, would be required to validate or test this hypothesis.

4.5.3 Future Erosion Trends

If the preceding hypothesis is correct, then it implies that the present erosion trend will cease at some future date and will probably be followed by a period of accretion. However, even if this is so, it is not possible on the basis of available information to predict when the erosion may cease. Therefore, for management purposes, it is prudent to assume that the existing erosion trend will continue for the foreseeable future.

4.7 Summary

The analysis of available on formation suggests that the trend for erosion at the southern end of Muriwai Beach probably commenced in the early to mid 1960's and is ongoing.

The available data suggests that erosion has averaged 1-1.5m per year over last decade and it is recommended that these rates be adopted for management purposes.

However, given the uncertainty in regard to continuation of existing trend, it is also recommended that these rates be periodically reviewed on the basis of ongoing beach monitoring,

The causes of this erosion are uncertain, but appear to relate macro-scale sediment transport processes operating along the West Coast.

5.0 HAZARD MANAGEMENT: SOUTHERN CAR PARK

5.1 Community Uses and Values

This is a high use area catering for a wide range of activities, including:

- **Boat launching.** The access road from the car park to the beach is a highly valued launching facility (Figure 6), providing one of the easiest and safest opportunities for launching on the open west coast of the Auckland Region.
- **Gannet watching.** Many visitors to the gannet colony at Otakamiro Point choose to use the coastal walking track from the southern car park.
- **Fishing**. The southern end of Muriwai Beach is very popular for both rock fishing and surfcasting.
- **Beach users.** The termination of the main road and the location of the surf club tower results in many users accessing the beach from the southern car park.
- **Surfing.** The area adjacent to Flat Rock is popular for surfing.
- **Vehicle access**. Until recently, the road onto the beach from the southern car park was the primary vehicle access point onto Muriwai Beach.

5.2 Hazard Management Issues

This investigation and consultation has identified the following coastal hazard management issues in this area:

Erosion threat to the car park

In recent years, the seaward face of the car park has experienced a steady increase in the frequency and severity of wave attack and erosion damage.

This problem results from a combination of:

- the gradual seaward extension of the car park by infilling and culverting of the former stream gully (see Chapter 2), and
- the trend for coastal erosion at the southern end of the beach, (see Chapter 4).

Collectively, these changes have gradually increased wave attack on the seaward face of the car park. The bank is now on nearly the same alignment as the adjacent shoreline and can be expected to retreat at similar rates. Erosion may even be more severe, due to the added influence of the stormwater discharges. Wave attack and erosion is also locally aggravated by lowering of the beach associated with stream/stormwater discharges, though this effect cannot be quantified with available data.

Consequently, the shoreline armouring works along the base of the bank and adjacent to the stormwater outlet have been increasingly damaged and are now in a state of serious disrepair (Figure 5b). The pedestrian access steps in this area have also had to be removed (see section 4.4). If no action is taken, the remaining armouring works around the outlet will probably be destroyed in the relatively near future and the bank fronting the car park will continue to erode.

The erosion damage to coastal structures and the clay fill composing the seaward face of the car park is also degrading the natural character of this high use and high profile area (Figure 6b). These adverse effects on natural character will be exacerbated by ongoing coastal erosion.

Access difficulties

The erosion is resulting in access difficulties for both pedestrians and vehicles.

For instance, despite the removal of the pedestrian access steps from the front of the car park, many users still access the beach down the steep bank in this area, rather than via the access road (Figure 5b). This is not only difficult but also raises safety concerns.

The ongoing trend for beach lowering (see section 4.3) also impacts on vehicle access to the beach from the southern car park. While vehicle access is still adequate on most

occasions, it is often difficult or impossible after storms when there can be a significant drop from the seaward edge of Flat Rock (Figure 5a) onto the beach. Any potential difficulties with emergency vehicle access are undesirable. The existing problems have already interfered with significant recreation events (e.g. a major fishing contest) and represent a source of uncertainty and inconvenience that the users would like to see addressed. These difficulties will be aggravated over time with continued beach lowering associated with shoreline retreat (e.g. Figures 11 and 13).

5.3 Hazard Management Options

This section examines hazard management options for each of the above issues:

5.3.1 Erosion hazard to car park

Essentially, there are two options to manage the increased erosion along the seaward face of the car park:

Hold the existing shoreline using armouring

This would require the design and placement of shoreline armouring works capable of folding the existing shoreline against the increasing frequency and severity of wave attack. The wave energy in this area has increased over time, severely damaging previous armouring works. Therefore, a well designed and extremely robust structure would be required – probably a riprap revetment. These works would be expensive, probably of the order of $2000 per linear metre.

This option would avoid any need to reduce the size of the existing car park and to disrupt other existing infrastructure. However, a massive structure of this nature would be a significant visual feature and would reduce the natural character of the area. In addition, continued beach erosion in front of the wall would gradually eliminate any high tide beach in this area, impacting on public access and recreational values.

Landward relocation of the seaward face of the car park

This option involves the removal of the seaward portion of the car park, partially reinstating the stream gully (Figure 9). This landward relocation will reduce the frequency and severity of wave attack on the seaward face of the car park.

This option avoids the need for a massive armouring structure, though less significant shoreline armouring works will still be required to protect the stormwater outlet and the access road onto Flat Rock.

However, this option will result in the loss of the seaward portion of the car park, including existing roading and other infrastructure in this area. The extent of the landward relocation needs to balance various factors including hazard exposure, design life of the works, costs and minimising loss of infrastructure. This will require detailed design. However, a landward excavation of about 30m should appropriately reduce erosion damage and ensure a reasonable design life (e.g. 15-20 years), while minimising loss of existing infrastructure. A relatively limited excavation of this nature is also appropriate, given the uncertainty in regard to duration of the existing erosion trends.

Consultation during this study indicates general community support for this option.

5.3.2 Access Difficulties

Pedestrian Access

If the pedestrian accessway were reinstated on the existing seaward face of the car park, it would suffer frequent and severe wave damage – possibly having to be substantially rebuilt or replaced annually or even more frequently. Moreover, the frequency and severity of wave damage would continue to increase as the present erosion trend continues.

The pedestrian access steps would suffer considerably less frequent damage if combined with landward relocation discussed above. However, even with this option, damage would still be experienced during storms and will steadily increase with ongoing shoreline retreat.

A further alternative is not to replace the pedestrian accessway. However, so long as beach users continue to be drawn to this area by the access road and the location of the surf club, there will be a continued demand for direct beach access from this car park. Therefore, if the accessway is not replaced, it would have to be part of a strategy to redirect beach users further north, reserving the southern car park for those activities for which it provides the only, or the most suitable access. Encouraging beach users to park in areas further north would also be appropriate if the area available for parking was reduced by landward relocation of the seaward face.

Vehicle Access

The options to address the increasing difficulties with vehicle access are either to redirect vehicles further north or to improve access from Flat Rock onto the beach.

The option of moving vehicle access further to Okiritoto Stream is presently being trialled, with all vehicle activities except boat launching and emergency (e.g. Surf Club) now required to access the beach via the Okiritoto Stream track. This very effectively eliminates the serious user conflicts and safety issues which were previously experienced at the high use southern end of the beach.

However, the Okiritoto Stream access is considerably less suitable for boat launching and emergency vehicle access. The extra time and difficulty required for emergency vehicles to access the high use southern end of the beach via this area eliminates this option. There are also significant problems with the Okiritoto site for boat launching, including the lengthy distance of soft sand that has to be crossed to reach the sea and potential issues with security of vehicles left parked on the beach in this more isolated area. Boat owners who get into trouble in the surf are also a lot less likely to be readily noticed and helped at Okiritoto.

Therefore, vehicle access for boat launching and emergency vehicles will have to be maintained at the southern end of the beach. This will require improved access from Flat Rock onto the beach, either with careful reshaping of the rock edge or by a ramp

structure. The means by which the access improvement is effected will require detailed and sensitive design and consultation.

5.4 Recommended Hazard Management Action

Erosion threat to the car park

It is clear from the above discussion that there is no simple or cheap answer to this issue.

However, given the importance of maintaining and enhancing the natural character of this area, it is very unlikely that any major structure will be consented as long-term solution – even though lesser protection works will continue to be required to maintain the existing vehicle access road and to provide scour protection around the storm water outlet. Therefore, if the erosion trend continues, the seaward face of the car park will almost certainly have to be relocated landward.

This action will involve considerable expense and the disruption of existing infrastructure. Therefore, given uncertainty in regard to the ongoing erosion, it may be appropriate to adopt a "wait and see" approach. This would involve closely monitoring the situation for the next 1-3 years in the (probably slim) hope that the erosion may slow or cease, allowing major works to be avoided. The grassed zone at the top of the bank provides a useful buffer that will help mitigate damage to the adjacent roundabout in the near future. However, it must be appreciated that such a "wait and see" approach may result in significant and unsightly erosion damage to the clay fill composing the seaward face of the car park. Access to and from the beach may also need to be more rigorously controlled to avoid safety concerns that would be aggravated by such erosion.

Pedestrian and Vehicle Access

It is not likely to be appropriate to re-establish pedestrian access steps along the seaward face of the car park, even if this area is relocated landward. Rather, in the broader context of coastal management at Muriwai, the most effective long term solution is

probably to redirect beach users further north, reserving the southern car park for those activities for which it provides the only, or the most suitable access. This would almost certainly require roading changes, so that incoming road access terminates in car parks further north rather than the southern car park.

The beach south of Okiritoto Stream should continue to remain closed to vehicles to avoid serious user conflicts and accompanying issues at the high use southern end of the beach. However, it is important to maintain the present boat launching and emergency vehicle access at the southern end of the beach. Therefore, access from Flat Rock to the beach will need to be improved to provide for these activities.

HAZARD MANAGEMENT: DOMAIN AND GOLF COURSE

6.1 Community Uses and Values

Domain/Beach

This area, from the southern car park to the golf course, is predominantly utilised by beach users, with a large number of activities ranging from swimming, surfing, walking and sightseeing through to organised sports events such as touch rugby tournaments (ARC, 1995; NRB, 1996; Henderson, 1997). Extremely high numbers of people access the beach from the car parks during summer. The present accessways are fenced and effectively minimise damage to stabilising vegetation.

The heavy surf characteristic of the beach can be treacherous and Muriwai had the third highest number of drownings in New Zealand in the period between 1 January 1980 and 31 October 1999 (Muir, 1999). Therefore the surf club tower is an extremely important facility, with the present location tending to draw beach users towards the southern end.

The erosion trend has narrowed the high tide dry beach and tends to push beach users onto the frontal dune, particularly at higher stages of the tide. This can pose a human safety issue on those occasions when the dune face is over-steepened after periods of serious wave erosion.

ARC Parks staff indicate that the well-developed parklands and motor camp landward of the car parks are not as well utilised as they could be, given the number of visitors. The location of the car parking tends to separate beach users from these areas further landward and may contribute to the under-utilisation.

Golf Course

The Muriwai Golf Course, established in 1956, occupies the back beach area between south Muriwai Beach and the Okiritoto Stream. The golf course is a public facility and a popular local and regional recreational asset, with approximately 55,000 rounds of golf per year (Mr Lee Joffe, pers. comm., November, 2001).

6.2 Hazard Management Issues

The following hazard management issues are identified in this area:

Coastal erosion hazard to nearshore areas

Over the next century, the ongoing trend for coastal erosion potentially poses a threat to any assets located within 100-150m inland of the present shoreline. However, there is also considerable uncertainty as to how much longer the present erosion trend will continue.

This potential hazard area is heavily used and recreational demands will continue to increase. Therefore, while it is desirable to avoid hazard risk to significant assets, it is also important to maximise the potential for human use and recreation.

In the short term, there are several public assets likely to be affected by coastal erosion. These include the present surf club tower, now only 3m from the top edge of the eroding dune scarp, the car parks and the northern end of the golf course.

Wind erosion hazard to nearshore areas

Historical experience clearly indicates that human use of the frontal dunes at Muriwai has the potential to give rise to serious wind erosion. Therefore, there needs to be an ongoing emphasis on the careful management of human activities. The current trend for coastal erosion, resulting in a bare sand face on the frontal foredune, further aggravates the potential for wind erosion.

However, management of the coastal margin also has to maximise opportunities for public use and enjoyment, ensure the provision of safe and easy beach access, and preserve the wilderness character of the area.

Beach Safety

The ongoing coastal erosion at Muriwai has implications for beach safety.

For instance, the present surf club tower is currently under threat from coastal erosion and will need to relocate in the near future if the erosion continues. Given the high wave energy at Muriwai and the large number of drownings that have occurred (see Chapter 2), the provision and location of surf life saving facilities is extremely important. The relocation of this facility will need to be carefully integrated with other activities.

In addition, coastal erosion occasionally leads to the formation of over-steepened and unstable dune face slopes. The collapse of these slopes could potentially pose a threat, particularly to children who frequently like to clamber up such areas. At times the narrow high tide beach also forces beach users onto the lower dune face.

6.3 Hazard Management Options

The question of whether to hold the present shoreline or to live with coastal erosion is fundamental to hazard management along this 2km length of shoreline. This section reviews these alternatives.

6.3.1 Option 1: Holding the shoreline

This section reviews and evaluates the various options that might be used to hold the present shoreline position.

Beach nourishment

This option involves the placement of large volumes of sand to balance the present losses to erosion. Attempting to hold the Muriwai shoreline using beach nourishment would be expensive and require significant ongoing maintenance.

For instance, an initial placement in excess of 100,000 cubic metres would be required to protect the southernmost 600m of shoreline and significant ongoing maintenance would be required (probably averaging 10,000 cubic metres per year). Even if the sand was able to be sourced locally, the initial placement would cost in excess of $1 million and annual maintenance costs would average at least $100,000.

Shoreline armouring

This option would involve the placement of a shore parallel structure, sufficiently rigorous enough to hold the shoreline in its present position. However, any such structure would be extremely expensive because of the serious erosion trend at this beach and the very high wave energy. Costs would probably exceed $1500-2000 per lineal metre. Previous attempts to armour the shoreline using a timber wall failed (see Chapter 4).

In addition, the continued beach erosion in front of the wall would result in serious beach loss, impacting on public access and recreational values and degrading the natural character of the beach. These adverse impacts are not consistent with sustainable coastal management or with community uses and values at this site.

Offshore reefs or artificial surfing reefs

These options essentially involve the placement of offshore structures to decrease and otherwise modify the wave energy reaching the coast.

Traditional offshore breakwaters and reefs have been exposed above water level at certain stages of the tide. These structures would be extremely expensive in this high-energy wave environment and would also have serious adverse environmental effects that are not appropriate at this site.

Offshore surfing reefs, relatively new technology, appear to have considerable potential in the management of coastal erosion. However, at this site, protection of the length of shoreline affected by erosion (several kilometres) would require very large-scale works.

It is possible that an artificial surfing reef could be designed to provide more localised protection (e.g. at the southern end adjacent to the Domain and car park). The structure could also be used to enhance local surfing and provide a more sheltered beach area for activities such as swimming and boat launching. The reef would also provide localised fish habitat. However, the costs of such a structure would still be high – probably several million dollars, depending on design details. The measure could also impact on longshore sediment transfers and have adverse effects on areas further north.

Groynes

These are structures built at an angle to the shoreline (usually shore-perpendicular) and designed to trap longshore sediment transfers, thereby building or maintaining a protective beach in front of up drift shoreline areas. They can also be designed (e.g. T groynes) to reduce onshore-offshore transfers.

These measures would be very expensive to construct and maintain in the high-energy wave environment at Muriwai – each groyne probably costing of the order of $2-4 million (depending on design details) and several such features are likely to be required along this length of shoreline. The structures would have a significant adverse effect on the natural character of the coast and would also impact on longshore transfers, unless accompanied by extensive beach nourishment. These effects are not compatible with sustainable coastal management or community values at this site.

Beach dewatering systems

Proponents of these systems argue that they can be effective in mitigating coastal erosion by reducing backwash. However, the technology is at best experimental and is extremely unlikely to be effective at mitigating the serious erosion presently being experienced at Muriwai.

Overall, the option of holding the existing shoreline is unlikely to be either economically practical or environmentally appropriate.

6.3.2 Option 2: Accommodating Coastal Erosion

This management approach involves managing the coastal margin in a way that accommodates coastal erosion while also achieving desired management objectives.

This approach is well suited to Muriwai where it is desirable to preserve natural character and where there is generally adequate open space to allow natural erosion to occur and no private property that is immediately threatened.

A policy of living with coastal erosion, either relocating or abandoning threatened assets or locating them well landward, is also consistent with the approach generally adopted at Muriwai over the last few years. For instance, the golf club abandoned a tee in the early 1970s which was threatened by a combination of encroaching sand and wave erosion and have subsequently relocated the southern portion of their course about 200-250m inland (Mr Ray Barnett, Muriwai Golf Club, pers. comm., October 2001). The Muriwai Surf Club tower has also moved in response to coastal erosion and in 1980 the clubhouse was also relocated behind a more stable section of foredune (Cato, 1987; Mr Jim Dent, ARC, pers. comm., January 2001). The ARC has also either removed or abandoned assets and facilities (e.g. parking areas, a toilet block, accessways) threatened by erosion (Mr Jim Dent, ARC, pers. comm., January 2001).

In view of the impracticality of artificially holding the present shoreline, accommodating the erosion appears to be the most prudent overall policy to adopt at Muriwai.

6.4 Recommended Hazard Management Actions

The management goals for this area relate to maximising opportunities for human use and enjoyment, while avoiding wind and coastal erosion problems and accounting for the uncertainty in regard to the extent of future erosion.

It is recommended that this can best be achieved by adopting a pattern of use consisting of the following broad management zones:

- Eroding dune face
- Wind erosion buffer
- Recreation and amenity zone

These zones, particularly the two most seaward, would roll landward with erosion (or extend seaward in response to accretion), thereby providing the required management flexibility. The various zones are discussed below.

Eroding dune face

The present bare, seaward face of the frontal dune is likely to persist until the trend for shoreline retreat ceases.

It has been suggested that the large man-made frontal dune that characterises this area could be reshaped and planted with native sand grasses – in an attempt to re-establish a more naturally functioning dune system. However, there is little point in such action while the present erosion trend continues – since any reshaping and planting works would simply be lost within a few years. However, reshaping of the dune face and restoration of native sand grasses would be a useful activity once the erosion trend has ceased and would assist in the formation of a more natural and self-sustaining frontal dune.

In the interim, there is no point in any works on the seaward face of the dune. However, immediately after severe storm erosion, the over-steepened dune face could potentially be a safety hazard and consideration should be given to printing simple warning signs that can be erected on such occasions.

Vegetated wind erosion buffer

It is important to maintain a vegetated zone immediately behind the eroding dune face to avoid the serious wind erosion problems experienced in the past. However, there is no point in planting for ecological purposes in this area until the erosion ceases, since the planting will simply be lost over time. Rather, a pragmatic approach can be adopted, using whatever plants are easiest and cheapest to establish and maintain. The existing rough vegetation characterising this area is adequate. The key issue is to protect it from damage by human activities.

The width of the zone required will vary according to frontal dune characteristics and the uses along the landward margin. However, as a general rule, a minimum width of 20-30m should be maintained – extending the zone landward as necessary to retain such width. Any damage to the zone, particularly along the seaward margin, should be quickly repaired.

The key to protection of the area is to maintain adequate accessways to provide simple and easy access to and from the beach. The present beach accessway design is perfectly adequate in this respect. However, it is important to ensure that beach accessways are quickly repaired after storm damage and are sufficiently close to discourage “short-cutting”. However, the steep eroding dune face does tend to provide a significant discouragement to short-cutting. The accessways should remain fenced, as at present to protect the vegetated areas on the back of the frontal dune. However, fences and other works that are abandoned should be totally removed from the dunes. Remnants of old fences (e.g. posts, wire), car parks (e.g. fill) and other works that are not removed will ultimately become exposed on the seaward face of the eroding dune and detract considerably from the natural character of the beach. Strong concerns were frequently expressed in regard to these remnants during public consultation.

With the exception of the surf club tower, important structures or development should be avoided in this zone.

Recreation and amenity zone

The aim of this zone is to provide a pleasant back-dune environment reasonably close to the beach, to improve the link between the beach and the wide back dune areas and enhance amenity. This area should include the provision of shade and wind shelter in addition to open space.

Toilets and other facilities should be kept a reasonable distance back from the seaward margin of this zone to ensure a reasonable design life if the present erosion trends continue. Parking areas should be located towards the landward margin, so that the amenity area lies between the parking and the beach, rather than the present situation where parking areas act to separate the beach from back-dune amenity areas. Car parks should also be well landscaped to avoid major visual intrusion on the landscape.

The width of this zone will vary but in high use areas will probably extend up to at least 100m inland, including the parking areas.

At present, there are large clumps of trees and shrubs in areas 80-150m landward of the shoreline. These areas are largely remnants from previous stabilisation and forestry plantings, though there are also large numbers of native trees and shrubs which have either established naturally or been planted.

These trees and shrubs offer the potential to form a useful vegetated buffer along the landward margin of the zone. They also offer the opportunity to enhance amenity through the provision of walking tracks and sheltered areas. Under-planting with suitable native coastal species could also be undertaken to incorporate ecological restoration objectives. The area is at very low risk from coastal erosion and will not be affected for several decades, if ever. The limited resources available for ecological restoration are probably better focused in such areas until the erosion has ceased.

Ideally, any future road access along the landward edge of the Domain should be located as far landward as reasonably practical. This will provide the maximum opportunity for the various zones noted above to “roll landward” in response to erosion. It will also ensure the longest possible design life for the access road.

Other considerations

The nature and dimensions of the various zones of the rolling easement will obviously vary in space and time. For instance, the use and recreation zones will probably be quite significant in southern, high use areas compared to areas further north.

The northern end of the golf course lies immediately adjacent to the eroding foreshore. In the medium term (probably the next 10-15 years), this area will increasingly be affected by coastal erosion with continuation of present trends. Serious consideration should be given to landward relocation of this part of the course, consistent with the approach undertaken at the southern end. This action would have the additional benefit of freeing up more of the coastal margin for public use and amenity to meet increasing user pressure and provide a greater range of recreational opportunities.

7.0 HAZARD MANAGEMENT: OKIRITOTO STREAM AND THE "FIVE MILE STRIP"

7.1 Community Uses and Values

This area is popular for the peaceful and remote experience it offers and is extensively and increasingly used for many different recreational activities, including horse trekking, dog walking and mountain biking.

Muriwai Beach has a long established pattern of vehicle use dating from about 1918, including motor races held on the beach from the 1920's through to the 1960's (ARC, 1995). In recent decades, this use has expanded considerably with the increase in ownership of trail bikes and four-wheel drive vehicles. This use is now focused on the area north of Okiritoto Stream, since most vehicles are no longer permitted on the beach south of the Stream.

7.2 Management Issues

The potential for serious wind erosion as a consequence of the disruption of stabilising dune vegetation by human activities is the main coastal hazard management issue in this area. Active coastal erosion does not pose any significant threat to human uses and values, such as the adjacent forestry and various sites of significance to tangata, because there is a very wide buffer zone (several hundred metres) between these values and the shoreline.

The wind erosion concerns primarily relate to off-road vehicles on the dunes, though horse trekking and other uses that may impact on dune vegetation are also increasing. Concerns have been expressed from at least the 1960's in regard to the impact of off-

road vehicles on dunes. ARC Parks and Carter Holt Harvey Forests both indicate that this user pressure is increasing with the large numbers of vehicles that now use the beach north of Okiritoto Stream.

There are also other issues that, while outside the scope of this study, are also relevant to the management of vehicles on Muriwai Beach. These include:

- **Concerns related to user conflicts and safety issues** associated with the passage of vehicles through the high-use, southern end of the beach. This issue has now been addressed through bylaw changes and the establishment of gated control on the road access at the southern end of the beach. These changes appear to have quite successful even though some vehicles still head south from the Okiritoto access.

- **Cultural concerns.** Representatives of a local Iwi (Ngati Whatua) expressed concern regarding vehicles from the beach impacting on Urupa in back-dune areas north of Okiritoto Stream. They also note potential impacts on the toheroa populations of the main beach, an issue that has also been raised by others (Jeffs, 1997).

7.3 Hazard Management Options

The most appropriate management option to address wind erosion concerns is probably to identify those activities that are placing pressure on the dunes and to work with these user groups to effect appropriate changes in culture. Given the large numbers of users, such an approach will need to be well targeted and sustained.

Ideally, the approach would emphasize user participation in concert with approaches such as signage, educational pamphlets, media articles and other information. Over time, participatory approaches are generally more successful in developing user/community ownership of issues and in promoting appropriate changes in beach

user awareness and behaviour. The community peer pressure generated by participatory approaches can be an extremely effective change agent.

Other options, such as attempts to ban specific activities, are unlikely to be appropriate. For instance, various parties have suggested closure of the Okiritoto access road and banning vehicles from the beach. However, this is an extremely blunt instrument that would adversely impact on the use and enjoyment of a very large number of people, the majority of whom probably cause no damage to the dunes. Given the long history of this highly valued use, banning of vehicles would meet strong community opposition. It would also require active enforcement, with associated costs and difficulties, and may simply transfer vehicle problems further north (e.g. Rimmers Road and forestry roads).

The banning of vehicles from driving on the beach cannot be justified on the basis of concerns about wind erosion. It is vehicles on dunes, not vehicles on the beach, which are the concern. However, restrictions on vehicle use on the beach may be appropriate if research establishes that this use seriously affects toheroa beds.

7.4 Recommended Hazard Management Actions

The most appropriate approach to address concerns in respect of vehicles and other human activities on dunes is a well-targeted and designed participatory process that focuses on effecting appropriate changes in user behaviour.

Blunt instruments, such as a ban of vehicles on the beach north of Okiritoto Stream are unlikely to be appropriate.

8.0 SUMMARY AND CONCLUSIONS

8.1 Human Modification and Natural Changes of Muriwai Beach

Muriwai Beach and dunes have a long history of human occupation and use. This study concludes that, over time, human activities have significantly modified the natural environment. In particular, there has been extensive disruption of stabilising dune vegetation, resulting in periods of widespread dune destabilisation and wind erosion. In the last 100 years, particularly since the 1930's, there has also been significant human modification of the dune system associated with artificial dune stabilisation works.

In addition, since the early 1960's there has been a period of significant shoreline retreat at the southern end of the beach. The retreat, typically of the order of 40-80m south of Okiritoto Stream, appears to be continuing at an average rate of 1-1.5m per year. The causes of this erosion are unknown but appear to relate to natural processes, particularly macro-scale sediment transport processes. It is not presently possible to predict when this erosion phase will cease, but it is very unlikely to continue indefinitely.

These human and natural changes are summarised in Table 1.

DATE	Human Modification of Muriwai Environment
Pre Human Settlement	Muriwai dunes were probably forested
Approximately 1300AD	Initial Maori settlement
1700's	Widespread instability of Muriwai dunes
Mid 1800's	Reduced human occupation and pressure, dune vegetation recovery evident by 1880
Early 1900s	Increased human pressure, widespread dune destabilisation
1909	Motutara Domain established
1910-1931	Initial sporadic stabilisation works attempted
1930's	PWD commenced dune stabilisation works in Muriwai area in 1931/2. Standard approach using marram planting and fencing to build high frontal dune (see Section 3.4)
1940's	Ongoing stabilisation reduced by WWII, with up to 50% of earlier marram stabilisation works lost
1951	NZFS commences major dune stabilisation programme
Late 1950's to 1969	Increased recreational pressure leads to new wind erosion problems at southern end of beach. Stabilisation works unsuccessful due to poor management of human use
1960's	Significant infilling and culverting of natural stream gully to extend southern car park seaward
Early 1960s	Shoreline retreat begins at southern end of beach
1960's onwards	Increasing issues with vehicles, including user conflicts at south end and dune vegetation damage
1969	Domain vested in Auckland Regional Authority. Active management of human use, dunes stabilised
Mid 1970's to early 1980's	Timber sea walls constructed along southern end of beach – works largely destroyed by late 1980's.
2001	Shoreline retreat of 60-80m south of Okiritoto Stream since 1960's. Variety of human uses affected. Natural erosion continuing at 1-1.5m per year

Table 1: Summary of natural and human changes of Muriwai Beach and dunes

8.2 Recommended Hazard Management Strategy

A strategy has been developed to manage coastal hazards in a manner that is consistent with the requirements of sustainable coastal management and that also best meets community expectations. In particular, the strategy ensures the coastal margin is managed to:

- Avoid or mitigate coastal erosion hazard, while recognising the uncertainty of future erosion trends
- Maximise opportunity for public use and enjoyment
- Avoid wind erosion problems
- Preserve the natural and wilderness character of the coastal margin
- Enhance degraded ecological values, as far as practicable
- Provide for safe and easy public access to and along the coastal margin

The details of the recommended strategy are outlined below.

8.2.1 Southern Car Park

If the erosion trend continues, there are no simple or cheap solutions to the hazard issues in this area.

Erosion threat to the car park

- Relatively minor protection works will be required to maintain the existing vehicle access road and to provide scour protection around the storm water outlet.
- If the erosion continues the seaward face of the car park will have to be relocated landward, as it is unlikely that a major erosion protection structure would be appropriate or consented given the natural values of the coast in this area.
- In view of the considerable expense and disruption of existing infrastructure, consideration could be given to monitoring the erosion until it is clear that major works are necessary.

Pedestrian and Vehicle Access

- It is unlikely to be cost-effective to re-establish and maintain pedestrian access steps off the front of the car park. In the medium term, the most appropriate solution is to redirect beach users further north, reserving the southern car park for those activities for which it provides the only, or the most suitable access.
- However, more work is required to decide on an appropriate short-term solution to the issues currently being experienced in this area.
- The beach south of Okiritoto Stream should continue to remain closed to vehicles to avoid serious user conflicts and accompanying issues at the high use southern end of the beach. However, it is important to maintain the present boat launching and emergency vehicle access at the southern end of the beach and access from Flat Rock to the beach will need to be improved for these activities.

8.2.2 Domain and Golf Course

It is recommended that the following management zones be established for this area:

Eroding dune face zone

- After major storms the over-steepened dune face could be a safety hazard and consideration should be given to erecting warning signs on such occasions.
- Reshaping of the dune face and restoration of native sand grasses should be undertaken once the erosion trend has ceased to assist the formation of a more natural and self-sustaining frontal dune.

Vegetated wind erosion buffer zone

- Maintain a vegetated zone of at least 30m width on the rear of the frontal dune to avoid the serious wind erosion problems, using whatever plants are easiest and cheapest to establish and maintain.
- An adequate number of fenced accessways should be maintained to provide simple and easy access to and from the beach.
- Abandoned works should be totally removed from the dunes.
- With the exception of the surf club tower, important structures or development should be avoided in this zone.

Recreation and amenity zone

- Improve the link between the beach and the wide back dune areas by providing a pleasant environment immediately landward of the frontal dune, including the provision of shade and wind shelter.
- Toilets and other facilities should be some distance back from the seaward margin of this zone to ensure a reasonable design life if the present erosion trends continue.
- Parking areas should be located so they do not separate this zone from the beach.
- The large clumps of trees and shrubs in areas 80-150m landward of the shoreline could be extended by plantings to form a screen along the landward margin of this zone. Under-planting with suitable native coastal species could also be undertaken to incorporate ecological restoration objectives.
- Any future road access along the landward edge of the Domain should be located as far landward as reasonably practical – preferably at least 100m from the present shoreline.

In addition to the establishment of the above zone, serious consideration should be given in the medium term to landward relocation of the northern part of the golf course, consistent with the approach undertaken at the southern end.

8.2.3 Okiritoto Stream and "five mile strip:

- To minimise the potential for serious wind erosion problems in this area, a well-designed and targeted participatory process should be initiated to effect appropriate changes in user behaviour.
- A ban of vehicles on the beach north of Okiritoto Stream is unlikely to be appropriate, or necessary to manage the wind erosion threat.

8.2.4 Integrated Management

- A well-planned and collaborative approach between the various management agencies will be critical to the success of future coastal hazard management

- Local and regional community involvement and participation should also be given a central role in the implementation of the recommended strategy and ongoing management of the park – as envisaged in the draft Regional Park Management Strategy (ARC, 2001).

Many hazard management issues highlighted in this report arise from the way people use the Muriwai Regional Park and coast. Therefore, effective coastal hazard management requires appropriate changes in human awareness and behaviour

It is now widely recognised that to effect any significant and long lasting changes in user culture it is necessary to emphasise the participation of beach users and stake holders in coastal and parks management (RAC, 1993; NSW National Parks and Wildlife Service, 2001; Rademacher, S. and Kent, F. 1997). The management of use and impacts and the achievement of reasonable goals must involve the people whose use and activities relate to the area (Great Barrier Reef Marine Park Authority, 2002).

In addition, many staff in management agencies now recognise that they have as much to learn from the user communities and iwi as these groups have to learn from them. Processes that utilise community knowledge and experience, while also incorporating the technical and political knowledge of management agencies enhance society's ability to manage natural hazards (Renn, Webler and Johnson, 2001).

8.2.5 Monitoring

An ongoing programme is required to:

Monitor erosion trends

- Ongoing shoreline monitoring is critical given the uncertainty with regard to continuation of the present erosion.
- The present beach profile monitoring programme should be continued, with at least annual surveying of all four profile sites with trends reviewed every 3-5 years.
- If monitoring reveals firm and consistent evidence of a significant change in erosion rates, the strategy should be revised accordingly.

- Monitor the threat posed by erosion to infrastructure, particularly the Southern Car Park, to enable appropriate responses to be planned and implemented.

Monitor strategy effectiveness

- A record should be kept of dune management expenditure related to the management of human activities.
- Regular inspection of the dunes should be conducted and records kept of damage related to human activities.
- The monitoring programme should be reviewed annually in collaboration with beach users and local iwi, through the participatory process set up for ongoing park and hazard management.

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APPENDIX A: DETAILED METHODOLOGY

Assessment of Coastal Hazards

The assessment of coastal erosion, including wind and wave erosion, was based on information from a variety of sources, including:

Shoreline Surveys. Available historical surveys for the area south of Okiritoto Stream were collated and a further survey of the shoreline in this area was undertaken on October 30 2001 with ARC staff. This data, compiled onto a single 1:5000 plan by ARC, was then analysed to assess the nature and rate of shoreline change. Cross-sections were also surveyed at selected points along the southern end of the beach to define the present frontal dune morphology.

Date	Source	Longshore Extent
1924	SO 22939	Southernmost 600m only
1960	DCDB Plan 2001	Okiritoto Stream to south end inclusive
1970	SO 46753	Golf Club foreshore and Okiritoto Stream area only
2001	ARC Survey	Okiritoto Stream to south end inclusive

Table 1: Survey data used in shoreline change analysis

The October 2001 survey fixed the position of the toe of dune along the eroding foreshore. The earlier surveys are presumed to have fixed either the mean high water mark (MHWM) or mean high water spring (MHWS). The 1924 survey also fixed a line further landward, a wavy irregular line that may have represented the toe of the dune at that time.

Dynamic variability of shoreline markers is less significant at Muriwai than east coast beaches, because of the modally dissipative nature of the beach system (Cato, 1987). It is considered that the various survey lines fix the time-averaged beach position at the date of the survey to within $\pm$ 5m, when averaged over a sufficient length of beach (e.g. > 200m). Therefore, shoreline change estimates derived from comparison of any two of the surveys may have an error of up to $\pm$ 10m.

Shoreline change between the various surveys was determined by measuring distances from a shore-parallel baseline plotted landward of the surveys. Distances were measured along shore-perpendicular transects, spaced at 25m over the southern 600m of the beach and at 50m spacings over the remainder.

Beach profiles.
Beach profiles are shore perpendicular transects which can be used to quantify beach and duneline changes. If the beach profiles are well located, the changes at the profile sites can be reasonably assumed to be broadly representative of adjacent shoreline areas, though they may be markedly unrepresentative in terms of beach response to individual storm events.

There are beach profile sites located in the southern, central and northern areas of Muriwai Beach (Figure 1). Existing data for Muriwai Beach was obtained from ARC and analysed.

Profiles 3 and 4 at the southern end of Muriwai Beach have been surveyed since 1981, but the data for Profile 4 is only usable from 1990 because of datum problems (Tonkin and Taylor, 1998). Profile 3 is located near the centre of the golf course. Profile 4 is located at the high use southern end of the beach.

The central (Profile 2) and northern (Profile 1) sites were established in 1990. Profile 2 is located about 15.5 km north from the southern end of the beach, near Rimmer Road, and Profile 1 about 27.4 km.

All levels at the sites are relative to mean sea level and all distances are offsets from permanent benchmarks at the sites.

In interpreting the trends from the beach profile data, emphasis has been placed on the position of the dune toe, rather than changes further seaward.

The position of the dune toe is the most easily identified and accurate measure of beach and dune trends, because of the very low beach gradients at Muriwai. For instance, as a consequence of the low beach gradients (commonly 1V: 13H in upper beach areas and less than 1V: 20H in mid and lower beach areas), an average lowering of beach level by 1m could give rise to a net duneline retreat of 13m or more. The large duneline change could be quantified with a reasonable degree of precision (probably $\pm$ 2m). However, the much smaller net change in beach level (occurring over periods of several years) would be very difficult to quantify, particularly given the added complication of shorter-term dynamic changes (i.e. occurring over days, weeks or months).

Historical files and information. Relevant ARC and RDC files were located and examined. In addition, extensive searches were made of historical files held by Archives NZ, including the records of the Motutara Domain Board, Public Works Department, Lands and Survey Department and the New Zealand Forest Service, the various agencies that have been involved with coastal hazard issues at Muriwai since the early 1900s.

Information held by the Helensville Museum, Auckland Museum and the National Library in Wellington was also examined, together with various local history books (e.g. Sheffield, 1963; Muriwai the Beautiful) and newspaper reports on past erosion and other hazard issues were obtained.

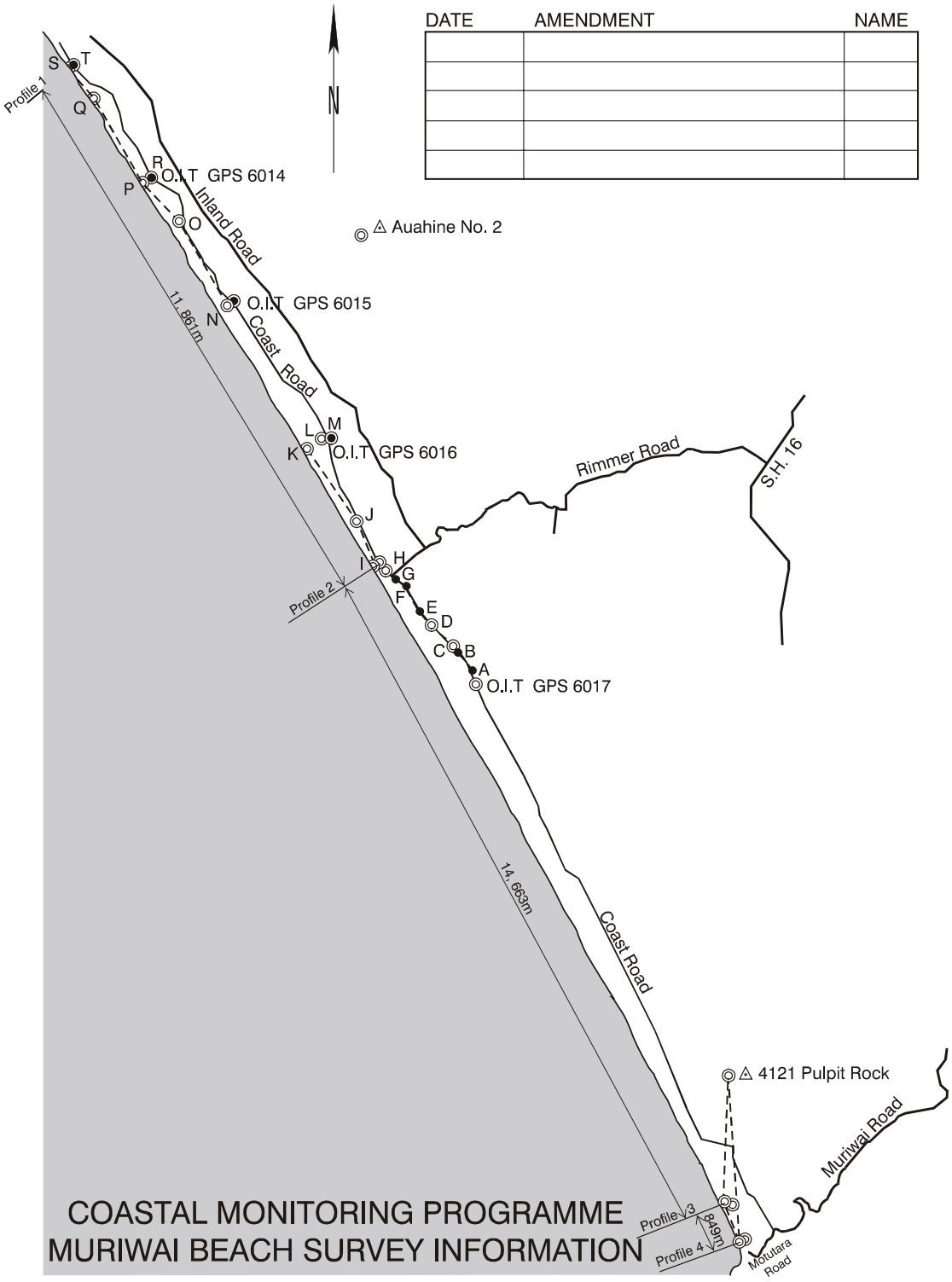

Figure 1: ARC location diagram showing Beach profile monitoring sites

Historical photography. Photos from various sources and dating from the 1920s was examined, including those held by the Auckland Museum, members of the community, various publications (e.g. Muriwai the Beautiful), university theses (particularly Cato, 1987), oblique photographs held by Whites Aviation, vertical aerial photography held by ARC and RDC, photos on relevant historical files and other sources.

Consultation with Community Members, Iwi and Agency Staff. Information on past shoreline changes, dune instability and other hazard issues was obtained through the consultation process.

Field inspections. Extensive field inspections were conducted during the course of the study, with 10 site visits between mid 2001 and February 2002.

Previous reports. University theses, scientific papers and other relevant reports were examined.

The information from the various sources was integrated to develop an understanding of the coastal processes and to quantify the nature and scale of coastal hazards at Muriwai Beach.

Once the magnitude of existing and potential coastal hazards had been identified (chapters 3&4), the risk posed to community assets and values was assessed (chapter 5) and an appropriate coastal hazard management strategy developed (chapter 6).

Community Uses and Values

Information on community uses, values and concerns were obtained from a number of sources during the course of the study, including:

Public meetings. Six public meetings were attended including a facilitated public meeting held to specifically discuss the project.

Targeted Meetings. Meetings were sought with representatives of various beach user groups including the Muriwai Progressive Association, Muriwai Golf Course, a local iwi group (Ngati Whatua), and Muriwai Surf Club.

Informal communication. Meetings with individuals and telephone discussions were held with a wide range of beach user interests including rock fishers, boat club, Maori Bay Board riders, Telecom, Carter Holt Harvey Forestry, and long-standing locals.

Summaries of public submissions. Submissions on the 1994/95 *Muriwai Regional Park Management Plan* process and on the more recent *Draft Regional Parks Management Plan* were reviewed. A wide variety of community uses and concerns were also identified in historical files and other information.

Several meetings and discussions were also held with staff from management agencies, including RDC, ARC Parks, ARC Coastal and ARC Heritage.

Strategy Development

On the basis of the above work and relevant statutory documents, the various hazard management issues relevant at the site were identified.

Alternative management options were considered and a recommended management strategy was then developed. The strategy identifies both the management actions required in the immediate future and the medium-long term actions that may not need to be implemented for several years.

The recommended strategy was developed in consultation with various management agency staff, the RDC consultant coordinating preparation of the Structure Plan and key users. Elements of the draft strategy were also discussed at a Structure Plan community meeting held on 13 February 2002, though the full strategy has yet to be presented and discussed.