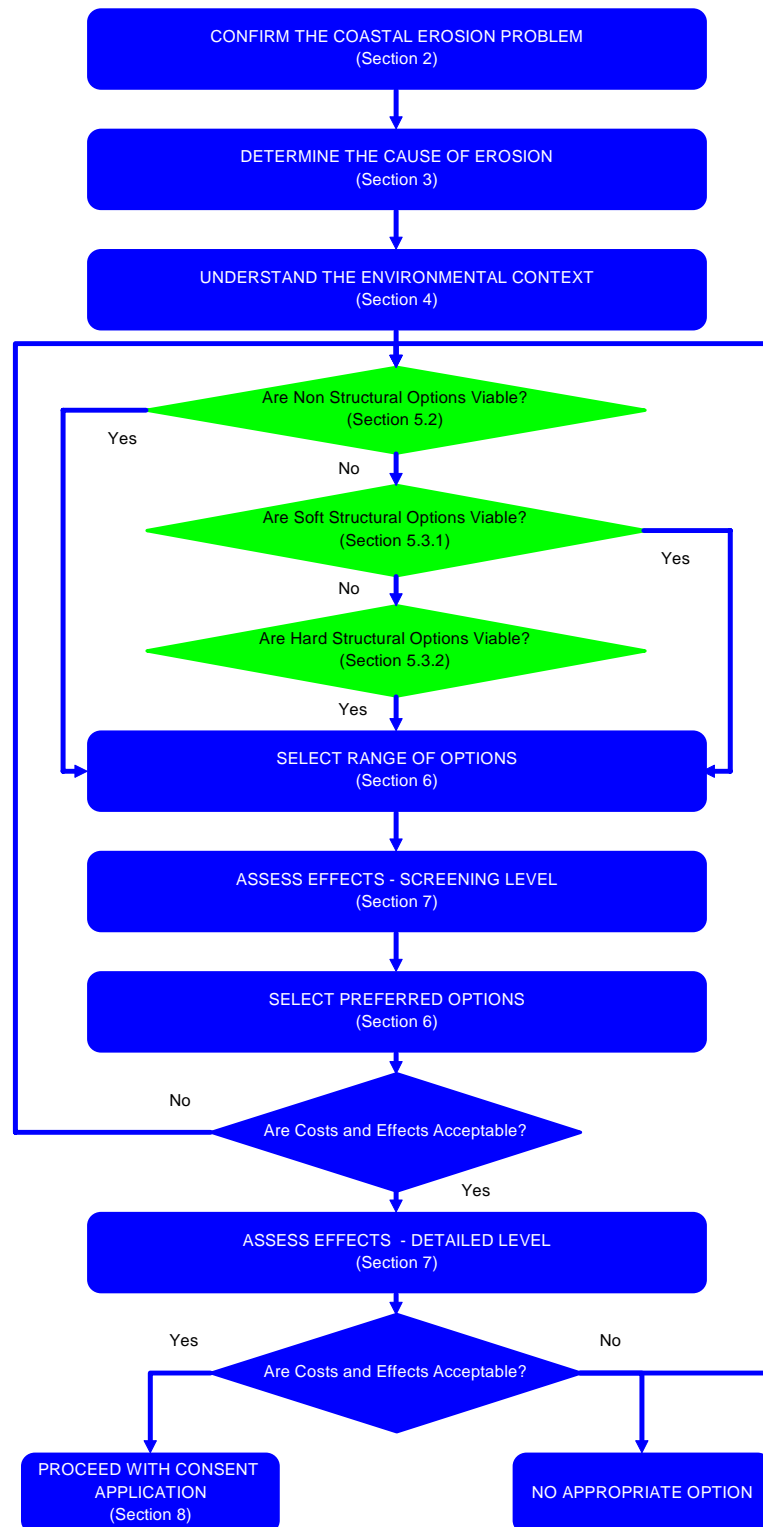


COASTAL EROSION MANAGEMENT MANUAL



SECTION 5 - YOUR RESPONSE TO THE PROBLEM

EXPECTED OUTCOME OF THIS SECTION:

To be aware of the range of coastal erosion management options available.

COASTAL EROSION MANAGEMENT MANUAL

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5. YOUR RESPONSE TO THE PROBLEM

5.1 COASTAL EROSION MANAGEMENT OPTIONS

There are many coastal erosion management solutions which have been developed, successfully tested and evaluated in the scientific and management literature. These solutions are generally portable for specific coastal landforms. This is particularly important in the Auckland and New Zealand context as the high variability of the coast, the short history of formal coastal management, and the deficiencies of the knowledge base all place a high premium on the lessons of comparative experience.

Coastal erosion management options include the do nothing option, non-structural activities (e.g. the application of land use planning techniques), structural works (e.g. beach nourishment, construction of a seawall), and a combination of these activities. The range of options discussed in this manual are identified in Table 5.1.

In generic terms there are two types of coastal erosion management solutions:

- **Non-structural Options** - which aim to manage the activities in the coastal environment so as to avoid the creation of a coastal erosion hazard. They are more likely to be implemented on a district level and relate to the management of land-uses above MHWS.
- **Structural Options** - which aim to protect coastal development and activities by managing the physical processes causing coastal erosion. These options require physical works and a relatively high level of investigation and design to be successfully implemented.

Table 5.1 Erosion Management Options

NON-STRUCTURAL	STRUCTURAL
Land Use Strategy	Soft
	<ul style="list-style-type: none"> • Beach Nourishment
Buffer Mechanisms	<ul style="list-style-type: none"> • Revegetation
<ul style="list-style-type: none"> • Restrictive Zoning 	<ul style="list-style-type: none"> • Dune Reconstruction
<ul style="list-style-type: none"> • Setbacks 	Hard
<ul style="list-style-type: none"> • Reserves 	<ul style="list-style-type: none"> • Seawalls
Remedial Planning Techniques	<ul style="list-style-type: none"> • Groynes
<ul style="list-style-type: none"> • Planned Retreat 	<ul style="list-style-type: none"> • Artificial Headlands
<ul style="list-style-type: none"> • Transferable Development Rights 	<ul style="list-style-type: none"> • Offshore Breakwaters
	<ul style="list-style-type: none"> • Artificial Reefs
Good Practices	<ul style="list-style-type: none"> • Geotextiles

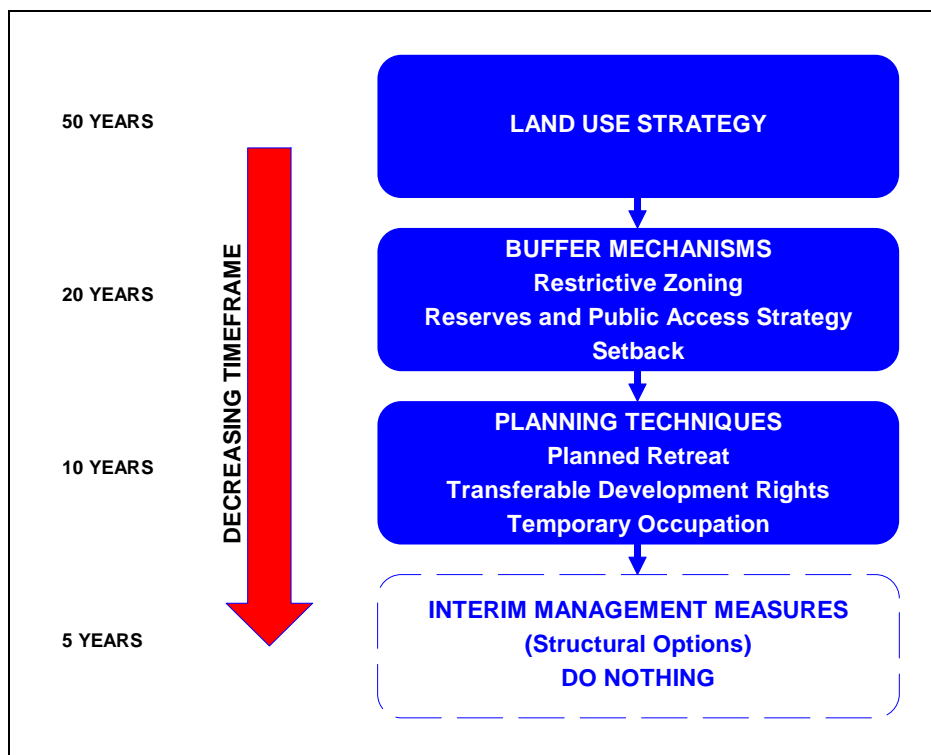
Non-structural options are considered preferable to structural options. In addition, options which include the removal of existing, ineffective works or the extension of existing effective works are preferred to new types of works in an area.

5.2 NON-STRUCTURAL OPTIONS

The underlying principle with non-structural coastal erosion management options is to recognise the environmental processes operating on the coast and 'design with nature', thereby ensuring development is sited in such a position to avoid the creation of a coastal erosion problem. Alternatively, where this is difficult to achieve because of existing development constraints, the principle involves managing human activities to ensure development is carefully designed in or withdrawn, in an equitable manner, from sites so that the problem is minimised or avoided. Non-structural options are applicable to all coastline types, as long as the associated costs and affects are acceptable.

Non-structural options are most readily categorised by the timeframes over which they are implemented, as indicated in Figure 5.1. Long term planning or land use strategies require the longest period for implementation, with proactive planning options or buffer mechanisms and the reactive planning options or remedial measures requiring less time. The suitability of each option will depend on the planning timeframe and the level of existing development at the site.

*Figure 5.1
Hierarchy of Non-structural Options*



The timeframes given in Figure 5.1 are indicative only and are based on the timeframes for implementation of regional and district planning documents. Structural options are included only as interim measures. Structural options may be included in a planning option, to manage an erosion problem until planning techniques have relocated development at risk. Interim measures may involve temporary works (e.g. sandbag seawalls), or works designed to last until planning techniques are fully implemented.

5.2.1 LAND USE STRATEGY

A land use strategy involves predetermining what kind of development, if any, can proceed and where. The intention is to ensure that the type of development and potential damage is consistent with the hazard, i.e. avoid creating a coastal erosion problem. A land use strategy is generally undertaken by regional and territorial authorities, but maybe applied by individual property owners. An example is Rodney District Council's *Coastal Management Strategy*, which identifies resource issues in the coastal environment, including erosion problems, and directs land use activities within the coastal environment.

A Land Use Strategy recognises that land use is constrained by the coastal environment, including future changes to it. It recognises that in the long term, land use and development must be managed with full cognisance of its potential effect on the coastal environment. The strategic management approach should encourage development in appropriate areas and identify areas where development is inappropriate, for example no development should be undertaken in areas of high potential erosion, rather conservation practices should be employed there. Managing activities to avoid coastal erosion should be one component of an integrated land use strategy for the coast.

5.2.2 BUFFER MECHANISMS

Buffer mechanisms involve identifying the probable landward extent of coastal erosion over a given time frame and limiting use of the area seaward of this extent. See Figure 5.2. These mechanisms are based on the philosophy that management of coastal erosion should accommodate changes resulting from natural coastal processes, rather than prevent or alter them. Accordingly these options manage activities rather than processes, providing a buffer that reduces the risk of erosion so that the hazard is avoided or minimised.

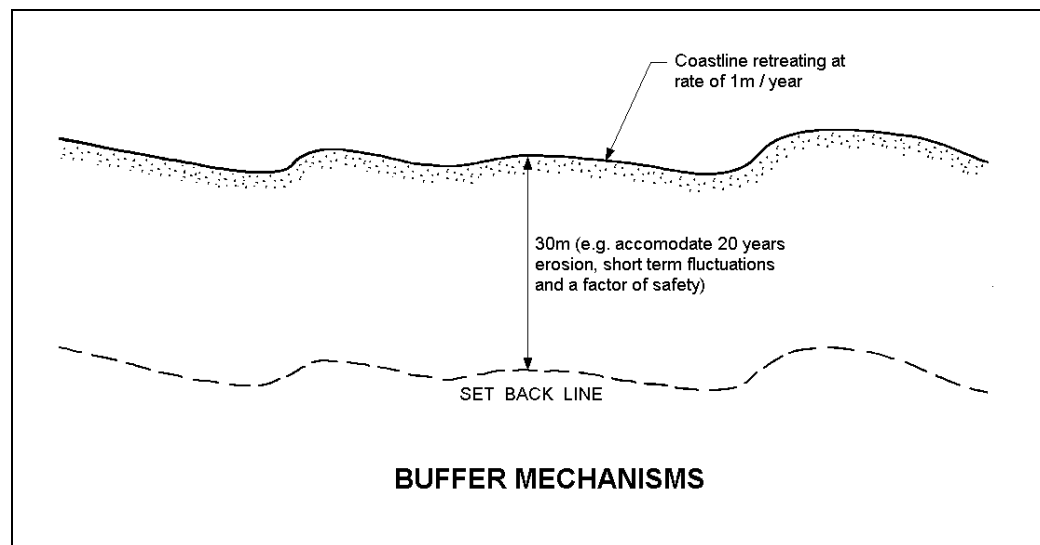
Implementation of a buffer mechanism requires determination of an appropriate width (i.e. coastal management (hazard) zone). This width should be sufficient to provide for:

- implementation of positive erosion management techniques to slow or reverse erosion;
- ongoing coastal erosion over the selected 'design' period;
- short term fluctuations in coastline;
- extreme storm events; and
- factor of safety (safety margin).

In some cases, it may be appropriate to consider other coastal hazards (e.g. inundation) in conjunction with coastal erosion. *Coastal Hazard Strategy for the Auckland Region* (ARC, 2000) provides guidance on this issue including appropriate techniques for determining a coastal hazard zone.

Buffer mechanisms are a proactive technique for coastal erosion management, that is they preempt the occurrence of a coastal erosion hazard. They are generally more applicable to undeveloped sites but they can also be successfully implemented on developed sites using remedial planning techniques.

Figure 5.2
Buffer Mechanisms



There are a number of buffer mechanisms which can be employed, depending on the severity of risk and the level of control sought. This section briefly outlines some of the main buffer mechanisms.

5.2.2.1 *RESTRICTIVE ZONING*

Restrictive Zoning controls activities that can occur within an identified area, through zoning in District Plans. Broad categories of restrictive zones are:

- **special uses:** these zones ensure particular protection for areas, for example environmental or coastal protection. Special use zones may define the coastal hazard zone;
- **open space:** this zone is generally applied to areas of reserve, owned by the Crown, local authorities, or other agencies (e.g. by the Royal Forest & Bird Protection Society); and
- **rural:** this zone may be appropriate in areas where low intensity activity will avoid the need for erosion management.

In addition, urban land use zones may be imposed with restrictions on the intensity of residential development. For example the Auckland City Council (ACC) employs restrictive zoning through its 'Coastal Management Area' zone, which applies additional restrictions on buildings, structures and earthworks to protect the coastal area.

Advantages of restrictive zoning include:

- retaining private ownership;
- identification in District Plans so clearly identifies appropriate activities;
- allowing for activities compatible with the local environment while maintaining a minimum standard for control (i.e. may allow buildings or structures, but will require resource consent approval);
- can be specific to particular concerns (e.g. vegetation removal only); and
- can be used to identify a coastal hazard zone.

Disadvantages of restrictive zoning include:

- control of private use rights;
- generally controls activities rather than avoiding them;
- may only apply to future development; and
- inflexibility, in that a District Plan is generally operative for 10 years which may mean that either the erosion could extend beyond the buffer zone OR the restrictions for protection may unnecessarily limit development in the short term.

5.2.2.2 *SETBACKS*

Setbacks are a mechanism to control specific activities within a defined area, usually characterised as a width from Mean High Water Springs (MHWS). The extent of a setback will alter with changes in the coastline (i.e. it will shift with MHWS). In contrast to restrictive zoning, a setback specifies a distance that buildings or other identified structures must be from the coast.

Generally setbacks are identified under a District Plan. For example, the Auckland City Council's Proposed District Plan identifies the Coastal Protection Yard, which restricts buildings and structures up to 20m landward of Mean High Water Spring.

Advantages of setbacks include:

- can be activity specific. For example may include all structures or only specific buildings/structures. An example of this is rule 7.3.7 of the Franklin District Plan which excludes buildings which provide living or sleeping areas in a particular area.
- can move with the coast; and
- retains private ownership of the coastal land affected.

The establishment of a setback is generally defined for broad areas of the coast and may not provide for localised erosion. The setback distance is therefore general rather than locally determined and applied. If the coast continues to recede building setback lines may encroach on existing developed areas. Accordingly, it is important to consider the rates of erosion and other mechanisms that may be required (for example, planned retreat or temporary occupation licenses). One draw back of this option is that it cannot readily be applied to existing properties without addressing major public interest concerns and the potential need to address compensation issues.

5.2.2.3 *RESERVES*

*Refer Section D,
Statutory
Framework*

Reserves are generally publicly owned lands managed by the Crown, Regional Council or Territorial Authorities. There are numerous types of reserve lands, and these are defined under the Reserves Act (1977), the Local Government Act (1974), the Conservation Act (1987), and the Resource Management Act (1991). Examples include esplanade, recreation, local purposes, road or conservation reserves. In areas prone to erosion a reserve provides a buffer between private land and the hazard. The type of reserve determines activities permitted within it.

Under the RMA, Esplanade Reserves and Esplanade Strips provide the two main planning mechanisms for creating reserves adjacent to the coast. An Esplanade Reserve is a public reserve that is (generally) 20m from MHWS and is fixed by a surveyed reference. It may therefore be lost over time on an eroding coast. In contrast an Esplanade Strip is a covenant on private land stipulating an interest held by the territorial authority and controlling the use and development of this land. Generally this strip is also at least 20m wide from MHWS and moves with the coast.

Figure 5.3
Reserve at St.
Anne's Crescent,
Wattledowns



Reserves, including esplanade reserves and strips, are generally created during the subdivision or development of land. However, there are a number of alternatives to the acquisition of reserves including: gifting, private reserves and covenants (e.g. Queen Elizabeth II Trust and conservation covenants under the Conservation Act), exchange of public lands, and leasing of land from private owners.

Advantages of reserves include:

- establishes public ownership and control; facilitating an integrated approach to any further erosion management required (e.g. land in public ownership can be managed in a way private land cannot);
- promotes public access;
- provides for an area of no development; and
- allows for re-establishment of native coastal vegetation and enhancement of natural character.

However, reserves do not move with the coast (with the exception of esplanade strips) and therefore, may be lost due to erosion. In addition, the costs of acquiring and maintaining reserves needs to be weighed against their benefits.

5.2.3 REMEDIAL PLANNING TECHNIQUES

Remedial Planning Techniques are reactive measures (i.e. they deal with coastal erosion after it has become apparent that it is a problem) to retract the extent of development and establish a buffer area. The following briefly outlines the main planning options for remedial techniques.

5.2.3.1 PLANNED RETREAT

Planned Retreat provides a timeframe for the retraction of activities and establishment of a buffer area by allowing for temporary activities or providing for their staged removal. There are a number of mechanisms for Planned Retreat, including:

- relocation of structures within a property;
- purchase by a public authority (establishing reserves);
- swapping land in coastal environment for land elsewhere;
- lease-back (leasing land back to the landowner for a limited period following acquisition, providing some financial relief);
- temporary occupation licenses (limiting the duration of occupation); and
- compensated benefits.

5.2.3.2 TRANSFERABLE DEVELOPMENT RIGHTS

Transferable development rights provide a measure to support setbacks or restrictive zoning, compensating for the loss of development rights within the protected buffer area. For example, they may allow more intensive development elsewhere on site, as compensation for restricting development within the coastal buffer.

5.2.3.3 OTHER PLANNING TECHNIQUES

Other remedial planning techniques include: Buyer beware/no public liability (e.g. encumbrance, covenant or caveat on the title) which means that a TLA is not obligated to offer protection to the development in the future; and the do nothing option which allows the current situation to continue.

5.3 STRUCTURAL OPTIONS

Structural options involve the introduction of physical works into the coastal environment. They reduce the risk of erosion either by accommodating or altering coastal processes (soft and hard structural options respectively).

*Refer Section E,
Design Information*

For structural options to provide effective coastal erosion protection they must be well designed, constructed and maintained. If this is not achieved, they may fail, either by not managing the erosion to the desired extent or by losing their structural integrity.

5.3.1 SOFT STRUCTURAL OPTIONS

*Refer Section E.3,
Soft Structural
Options*

The objective of soft structural options is to re-establish or maintain the natural form of the coastal environment. They do not modify the coastal processes causing erosion. These options tend to use naturally occurring materials such as sand and vegetation, and are more in keeping with natural characteristics of the environment compared with hard structural options.

5.3.1.1 BEACH NOURISHMENT

Refer Section E.3.1,
Beach Nourishment

Beach Nourishment is generally used to create a wider beach berm (i.e. the dry area of a beach) by increasing the volume of sediment on the beach or redistributing sediment within an area. The wider beach manages coastal erosion by providing an increased buffer, accommodating both erosion and short term fluctuations in beach profile. Beach nourishment is only applicable to soft coasts.

Beach nourishment is generally thought of as 'environmentally friendly' because it emulates nature, improves amenity and recreational value, and has minimal undesirable effects on the coastal environment. Beach nourishment does not halt the erosion process and once the initial design life is exceeded, further nourishment (i.e. renourishment) is likely to be required. Like any other part of the coast nourished beaches are subject to short term fluctuations, particularly during storms. This is often perceived by the public as a failure because the sand is 'lost'. Accurate public information during the design and construction phase can address this misconception.

Figure 5.4
Beach Nourishment
at Mission Bay



Before:
Note rock at base of wall and low beach profile.



After:
Note wide beach berm.

In the Auckland Region beach nourishment has considerable potential in managing coastal erosion of the many pocket beaches which exist. This can be achieved relatively easily by transporting sediment from the accretion zone (usually at the downdrift end of the beach) to the erosion zone. This form of coastal erosion management has effectively been carried out at Eastern and Orewa Beaches.

5.3.1.2 REVEGETATION

Refer Section E.3.2,
Revegetation and
Section C.9,
Vegetation

Revegetation is the re-planting of coastal areas where existing vegetation has been removed or degraded. Vegetation assists in reducing coastal erosion of hard and semi-hard coasts by assisting slope stability, and on soft coasts, by trapping and binding sediment.

Where there is existing vegetation, protection of it (e.g. by fencing, pest and weed control), and under-planting to re-establish a proper vegetation composition and structure will allow regeneration to provide long-term viability.

Revegetation is applicable to all types of coasts. A wide range of coastal shrub and tree species can be planted along cliffs, above the mean high water level along the coasts of estuaries, and in the dunes of beaches. Within the tidal zone of estuaries mangroves and a number of indigenous rush species can be established to reduce erosion. Sand binding grasses and sedges can be planted on foredunes, whilst scramblers and woody ground cover plants are suitable for providing stability in hinddune areas. Major indigenous plant species that can be used in revegetation in the Auckland Region are given in Table 5.2. An indication of appropriate plant species can be obtained by looking at what grows at the site naturally, and what is present in remnants.

Coastline type	Zone	Species
Soft-coast	Foredune	Sand binding grasses & sedges, e.g., pingao, spinifex, sand fescue
	Mid-zone	Woody ground covers, e.g., pohuehue, sand coprosma
	Backdune	Shrubs & trees, e.g., karo, taupata, houpara, pohutukawa, toetoe, ngaio
Semi-hard coast (estuaries)	Intertidal	Mangroves & rush spp., e.g., <i>Juncus</i> spp., <i>Leptocarpus</i> spp.
	Clayey banks/ high ground	Shrubs, e.g., manuka, marsh ribbonwood, flax, cabbage tree, ngaio, ake ake
Hard coast	Cliff tops	Shrubs and trees, e.g., karo, houpara, taupata, kohuhu, pohutukawa, ngaio, ake ake, puriri

Generally, it is desirable to use indigenous species in revegetation of coastlines to recreate or enhance the local indigenous plant and animal communities. Revegetation using indigenous plants species enhances the natural character of the coastal environment, including traditional, cultural and historical values. Whilst there is scope for using exotic species for stability in some coastal environments, use of indigenous species is a practical option for revegetation along much of the Auckland coastline where conservation or biodiversity are important considerations alongside erosion management.

With indigenous species, plant material that has been sourced locally should be used if possible. Using locally sourced material protects the genetic integrity of populations of the same species. In addition, local material is likely to be more tolerant of local conditions than plants sourced from other areas.

The aim of revegetation is to establish a self sustaining cover and to slow and even reverse coastal erosion. Techniques for successful revegetation vary according to the coastal type, local climatic and site conditions, type of vegetation to be used and the objectives of revegetation. There may need to be several stages in revegetation of some sites where early successional species are planted first followed by later planting of more sensitive later successional species in sheltered areas.

On sand dunes it is important that the revegetated area is of sufficient landward depth for the establishment of a sequence of different vegetation types from foredune to backdune and that the appropriate species are planted within each zone. Artificial shelter fences on hard and semi-hard coasts and on backdunes of soft coasts may be used to ameliorate exposed sites for revegetation purposes. Sand trapping fences in foredunes in combination with planting can assist in plant establishment and trapping wind blown sand.

When designing a revegetation scheme, consideration should be given to:

- appropriate species;
- preparation of the area (e.g. removal of undesirable exotics);
- collection of seed or sourcing of seedlings and the lead in time required to obtain them;
- need for layout of planting;
- fertilising and mulching;
- need for artificial shelter on exposed sites during the establishment period;
- weed control and pest management; and
- ongoing maintenance.

Any revegetation programme should consider the provision of access ways, signage and fencing to protect the new vegetation. Continued maintenance of these structures will be required, as well as maintenance of the plants themselves. As with other non-structural options fluctuations in the position of the coastline need to be provided for.

Community involvement in revegetation programmes (e.g. Coastcare groups) is a practical method of implementation and is becoming more common. Community involvement increases public awareness of the importance of vegetation in terms of coastal erosion management and gives a sense of 'owning' the beach and its vegetation, resulting in reduced human impact on vegetation (e.g. enforcement of access restrictions). Coastcare programmes are ideally an integrated approach to tackling coastal erosion problems involving not only the local community but other beach users, interest groups (e.g. polytechnics, Department of Conservation (DoC), forest owners, nurseries and iwi), local authorities and appropriate technical experts.

5.3.1.3 *DUNE RECONSTRUCTION*

*Refer Section E.3.3,
Dune
Reconstruction*

Dune reconstruction involves reshaping dune formations to fill in blowouts thereby encouraging a uniform wind field and reducing the chance of wind channeling and further blowouts. Dune reconstruction may also involve the complete reconstruction of a dune formation or reshaping the dune cross section to give a more aerodynamic and stable state.

Dune reconstruction can be undertaken by reshaping existing dunes or placing additional sand. Where sand is imported for the purpose of dune reconstruction, additional protection is provided by the increase in sediment in the system. Sources of sediment need to be considered in a similar manner as for beach nourishment.

Figure 5.5
*Revegetation of
Sand Dunes at Piha
Beach*



The physical movement of sand by earthmoving equipment may not be necessary in all cases of dune reconstruction. In some cases, the installation of dune forming fences or planting vegetation to trap sand may be sufficient.

Dune reconstruction may also require revegetation using appropriate species on foredunes and backdunes and the provision of access ways, fences and signage so as to reduce further damage to the dunes. Maintenance of these items and the dunes themselves will be required.

5.3.1.4 OTHER SOFT STRUCTURAL OPTIONS

Other soft structural options for coastal erosion management include:

- **Configuration Dredging:** dredging to a pattern so as to reduce wave focusing and energy at particular locations on the coast.
- **Beach Dewatering:** providing subsurface drainage on the beach so as to lower the water table, improve percolation and sediment frictional resistance in the swash zone and potentially reduce the loss of sediment. This involves the drainage of tidal and ground water flow to a pumping station for controlled discharge.
- **Unloading of Slopes:** either by cutting back slopes to a more stable profile or by installing a drainage system and lowering the water table.

It may be appropriate to consider these options in some instances. However the design techniques associated with the initial two options are not yet well developed and the effectiveness of the options in managing coastal erosion is not well established.

5.3.2 HARD STRUCTURAL OPTIONS

Refer Section E.4, Hard Structural Options, and Section F, Assessment of the Effects on the Environment

Hard structural options often alter the physical processes which cause coastal erosion in order to reduce the erosion rate. They are typically constructed of materials such as rock, concrete or timber and often modify the character of the area in which they are constructed. These options will impact on coastal processes and these effects need to be carefully considered in the overall assessment of environmental effects.

5.3.2.1 SEAWALLS

Refer Section E.4.1, Seawalls

Seawalls are walls constructed parallel to the coastline. The primary purpose of a seawall is to protect the land behind them from wave and current action. Seawalls can be likened to retaining walls in that they physically retain land. They are used to maintain the coastline in a fixed position.

Seawalls can be used on any coastline type, although their application will vary slightly.

- **Hard or semi-hard coasts** - seawalls located at the toe of the cliff can be designed to absorb or reflect wave energy, reducing the effects of wave attack. They can also be designed to improve slope stability.
- **Soft Coasts** - seawalls are better located high up the beach profile as the lower beach section can then act as a wave energy dissipater and maintain its amenity value, and to allow the beach to continue to fluctuate within its natural dynamic envelope.

Seawalls can be located at any position on a coastline, but are best used to protect continuous lengths of coastline rather than isolated properties. Where seawalls are used to protect individual properties on an eroding coastline the adjacent sections of coastline will continue to erode (if they remain unprotected) and this will ultimately result in a discontinuity in the coastline (i.e. the protected area will eventually become a headland) and possibly outflanking of the wall (i.e. loss of material from behind the end of the wall).

Seawalls can be rigid (e.g. timber or concrete cantilever structures), semi rigid (e.g. gabion structures) or flexible (e.g. rock rubble structures) and the selection of one of these types will be dependent on site specific characteristics such as adjacent site conditions, available material and environmental effects. Flexible structures are generally more suitable where the extent of long term (passive) erosion is difficult to estimate (i.e. the structures can accommodate movement, or can be relocated and materials reused). There are also a variety of face profiles for seawalls that allow their use in a range of wave climates.

While seawalls serve to protect land behind them they do not protect the beach in front of them. If the cause of erosion is a deficiency in the supply of sediment the imposition of a seawall will stop the landward translation of the coastline, however that is likely to be at the expense of the beach, i.e. the beach will continue to erode to such a time it disappears or all that remains of it is a much smaller beach. The seawall may contribute to this process through the interaction of coastal processes with the wall. The construction of a seawall may also contribute to erosion by sealing the landward source of sediment, effectively removing it from the beach system. Whether this is the case or not, the effects of seawalls on the amenity and natural character values of the site will need to be assessed and weighed against the value of the property being protected.

Figure 5.6
*Typical Seawalls of
the Auckland
Region*



a) Stepped Seawall - Bucklands Beach



b) Vertical Faced, Gabion Seawall - Tamaki Estuary



c) Sloping, Riprap Seawall - Kohimarama



d) Sloping Seawall - Cheltenham Beach

5.3.2.2 GROYNES

Refer Section E.4.2,
Groynes

Groynes are narrow structures constructed perpendicular to the coastline. They are designed to trap longshore drift and thus create a wider beach. They are not an effective means of coastal erosion management where the primary cause of erosion is onshore-offshore transport or the longshore drift is small. Groynes are generally used on soft coasts with a negative sediment budget and are designed to interrupt longshore drift.

Groynes will continue trapping sediment until the area updrift of the groyne (known as the fillet) is full. At this stage sediment bypassing will occur, either around the end of the groyne (end-passing) or over the top (overpassing). Until this time, the supply of sediment to the downdrift areas of the coast will be interrupted, potentially resulting in erosion of those areas. This is typically the most significant physical effect of groyne construction.

The change in beach alignment resulting from the construction of a groyne causes a discontinuity in the coastline. The construction of a series of groynes (known as a groyne field and illustrated in Figure 5.7) of varying lengths will reduce this discontinuity. However, this approach will segment the beach visually and impact on natural character and amenity.

Figure 5.7
Groyne Field,
Omaha Beach.



The construction of a groyne field can be staged so as to minimise downdrift erosion. This involves constructing downdrift groynes once the preceding fillet has formed. An alternative approach is to artificially fill the fillets, i.e. by beach nourishment. The use of permeable groynes may also reduce the discontinuity in the coastline and downdrift erosion by allowing some of the longshore drift to continue unimpeded.

The permeability of groynes is dependent on the material it is made from. Groynes can be constructed from a variety of materials, with rock rubble or timber most commonly used in the Auckland Region.

Artificial Headlands are a specific type of groyne. Artificial headlands are more common in low wave energy environments as they are difficult to construct on the open coast. The design process and considerations for artificial headlands are similar to those for groynes.

5.3.2.3 *OFFSHORE BREAKWATERS*

*Refer Section E.4.3,
Offshore
Breakwaters*

Offshore Breakwaters are structures built parallel (normally) and offshore to the coast. Wave energy is either dissipated at the structure (by waves breaking due to reduced water depth or the structure) or reflected, resulting in a reduced wave energy environment in the lee of the breakwater. Offshore breakwaters can be used to provide protection to beach systems and cliffs. Offshore breakwaters have yet to be used for coastal erosion management in the Auckland Region.

Artificial Reefs are a specific type of offshore breakwater. They are generally submerged and encourage waves to break over them. This reduces the wave energy transmitted to the coast within the shadow of this structure. Artificial reefs are appropriate for all coastline types. As yet they are not common in the Auckland region. A successful example can be seen along the Wattle Downs coastline in the Manukau Harbour.

On hard coasts, artificial reefs can protect cliffs where the shore platform continues offshore from the base of the cliff, as opposed to a steep offshore slope.

5.3.2.4 *GEOTEXTILES*

*Refer Section
E.5.1.1, Typical
Materials*

Geotextiles can be considered as a form of hard structural coastal erosion management. They can be used to retain land (comparable to gabion type seawalls), provide toe protection, or in establishing vegetation. Generally, geotextile products do not survive well in the harsh coastal environment (where wave impact and UV exposure are high) although there are some products available which specifically address these issues (e.g. UV resistant products). As a result, geotextile products are more likely to be suitable for soft, low wave environment areas or in combination with other options.

5.4 COMBINATION OF OPTIONS

In many cases it will be important to consider a combination of the coastal erosion management options to provide an environmentally and economically acceptable erosion management solution. The main reasons for this are:

- as a means to improve the efficiency of the works; or
- as a mitigative measure.

The following are some examples of the more common combinations.

5.4.1 BUFFER MECHANISMS AND REMEDIAL PLANNING TECHNIQUES

In cases where development has already occurred the establishment of a buffer will

require remedial planning techniques, such as planned retreat, to remove existing buildings and activities from the coastal hazard zone.

5.4.2 REMEDIAL PLANNING TECHNIQUES AND STRUCTURAL OPTIONS

Refer Section E.3, Soft Structural Options and E.4, Hard Structural Options

Many remedial planning techniques, aimed at establishing a buffer, may need to be implemented over a relatively long time frame, with protection of land and development required as an interim measure. This interim protection can be provided by any appropriate structural option (e.g. beach nourishment, seawall, groyne).

5.4.3 DUNE RECONSTRUCTION AND REVEGETATION

Refer Section E.3.3, Dune Reconstruction and E.3.2 Revegetation

The establishment of an appropriate dune shape is preferable before undertaking the revegetation of dunes, otherwise wind channelisation may damage the new vegetation. Reconstructed dunes should be revegetated to provide stability to the new formation by retaining the sand.

5.4.4 BEACH NOURISHMENT AND GROYNES/ARTIFICIAL HEADLANDS

Refer Section E.3.1, Beach Nourishment and E.4.2, Groynes

Groynes/Artificial Headlands are often used in association with beach nourishment schemes to trap the newly placed sediment, to reduce the frequency of subsequent renourishment, and to reduce downdrift erosion.

5.4.5 BEACH NOURISHMENT AND REVEGETATION

Refer Section E.3.1, Beach Nourishment and E.3.2 Revegetation

Establishing a cover of appropriate vegetation on the foredune on newly nourished beaches is desirable. This will reduce the loss or redistribution of the additional sediment, particularly at exposed sites.

5.4.6 REVEGETATION OF SLOPES AND INTERIM HARD STRUCTURAL WORKS

Refer Section E.3.2, Revegetation and E.4, Hard Structural Options

Revegetation of cliff and clayey bank faces maybe appropriate if they can first be stabilised by means of interim works. Once the plants have established, the interim works may be able to be removed. Suitable interim works may be offshore reefs, or temporary seawalls/ revetments.

5.4.7 GOOD PRACTICES

Refer Section C.3.4, Sediment Budget and Section C.2.3.3, Mass Movement.

There are many human influences in the coastal environment which directly cause or accelerate coastal erosion. Most of these are associated with changing sediment transport regimes and consequently the balance of a sediment budget, or reducing the stability of a landform.

All development within the coastal environment should involve case specific design and planning so as to minimise the effects of these influences. This planning and design, can be considered 'good practice' and involves considering the impact that any work may have on coastal erosion. Good practices should also be employed during the construction period to minimise both the potential hazard to the work being undertaken and the potential the work has to cause risk to other structures, activities or values within the coastal environment.

Examples of the impacts to consider when employing good practices are given in the following sections.

5.4.7.1 *SEDIMENT TRANSPORT*

*Refer Section C.3.4,
Sediment Budget*

a) Depletion Of Sediment Sources

Depletion of sediment sources will result in a negative sediment budget. Depletion can occur by physically removing sediment from the site or by retaining it in such a manner that it is no longer available to the sediment budget (e.g. behind a seawall).

Sand mining and dredging, depending on the location of the extraction site, may result in depletion of a sediment source by removing it from the site. The construction of structures, particularly seawalls, will result in sediment being retained. Damming of rivers may result in the direct retention of sediment and attenuation of flows which would otherwise have flushed sediment from the river bed. Quantification of these activities is required to assess their overall effects.

b) Interruption Of Sediment Transport

*Refer Section C.3.,
Sediment Transport*

Interruption to sediment transport may result in a negative sediment budget. Direct interruption to longshore drift can be caused by the construction of structures not specifically intended for coastal erosion management such as reclamations, boat ramps and, depending on their construction, wharves. Construction of breakwaters for ports and marinas may interrupt onshore-offshore sediment transport, depending on their location. In addition, the construction of structures may interrupt windborne sediment transport.

Less obvious causes of interruption to sediment transport are the diversion of stormwater discharges (which will alter the location of the deposition area for the associated sediment) and the altering of wave directions by offshore dredging.

5.4.7.2 *LANDFORM STABILITY*

*Refer Section
C.2.3.3, Mass
Movement.*

a) Cliffs and Clayey Banks

Irrigation at the tops of cliffs and clayey banks will increase groundwater levels, reducing slope stability and increasing the risk of mass movement. Discharge of stormwater will have a similar effect but will also cause gradual erosion by abrasion and weathering. Additional loading to the tops of cliffs due to development may also cause a reduction in slope stability.

*Refer Section C.2.6,
Dunes*

b) Dunes

Damage to dunes and dune vegetation may result in blowouts and the irretrievable loss of sand to backdune areas. Damage of this type can result from development near dunes (particularly during construction phases), pedestrian and vehicle access over the dunes, bush clearing, stock grazing and recreational activities (such as use of 4WD vehicles).