Shore protection options for Rapahoe Beach – revised report

For discussion by the Department of Conservation, Greymouth District Council and West Coast Regional Council

7 October, 1999

The Department's report dated 7 October 1996 has been revised following the assessment of new information provided by the OPUS International Consultants *Report on Rapahoe Bluffs Monitoring Programme*. This programme has provided a series of photos taken from set points in 1997, 1998 and 1999.

Coastal Erosion
It is important to realise that coastal erosion is not usually an isolated event, it is part of a larger continuous process. There are many factors which influence the natural movement of sediment along the coast including tides, winds, ocean currents and waves. When structures are introduced into this system they can change the natural processes in ways which are sometimes difficult to predict.

Beach erosion at Rapahoe has been occurring since at least the late 19th Century. It is thought that it is caused, or at least exacerbated, by the groyne effect of the Grey River tipheads (refer to figure 5 for an example of a typical groyne effect).

In this case, sediment is trapped on the southern (updrift) side at Blaketown as it is carried northwards by the prevailing southwesterly swell. The trapping of sediment at Blaketown has the effect of starving the downdrift (northern) beaches of sediment at Cobden and Rapahoe causing erosion. Commercial gravel extraction on Blaketown beach and the lower Grey River might also contribute to the beach erosion through the further starving of natural sediment.

Erosion Rates at Rapahoe
The photos provided in the OPUS monitoring report indicate that erosion still appears to be continuing at Rapahoe.

Figure 1 from Pfahlert (1984) indicates the erosion rates on Rapahoe beach over the period 1882-1984 are c.0.4m/yr at the north end of the town, and c. 0.8 m/yr at the south end. Put another way, this is 10m erosion every 12.5 years (north) to 25 years (south).

Pfahlert estimated that the Rapahoe beach is eroding at a rate of 3500 cu.m per year, though precisely what length of beachfront this refers to is unclear.

Observations by Pfahlert suggest that the beach is likely to be affected by a similar wave environment as is described in greater detail for Punakaiki by Kirk (1988) and Jones (1994). The influence of southwesterly waves is reduced towards the south of Rapahoe beach due to the protection provided by the reefs off Point Elizabeth.

Assets threatened by erosion
Listed below are all of the developed properties in Rapahoe (indicated in Figure 1) that, if the rate of erosion continues, are likely to be directly affected by wave inundation in the next 50 years. The approximate minimum distance of each building/asset to the top

of the beach is noted. Note that waves can reach up to about 10m inland of the beach scarp, depending on the height (and vegetation) of the foredune area:

- The Esplanade roadway (already inundated), 0m
- House at northern end of town, 10m
- The recreation reserve & campground facilities, 15m
- The pub, 40m

New Zealand Coastal Policy Statement considerations

The main provision from the NZCPS that is relevant to this issue is Policy 3.4.6 (though others also apply).

> ***NZCPS Policy 3.4.6:*** *Where existing subdivision, use or development is threatened by a coastal hazard, coastal protection works should be permitted only where they are the best practicable option for the future. The abandonment or relocation of existing structures should be considered among the options. Where coastal protection works are the best practicable option, they should be located and designed so as to avoid adverse environmental effects to the extent practicable.*

This report discusses the range of options available and recommends what I consider to be the best option.

Matters to Consider

Before any coastal erosion method is investigated it is necessary to identify the natural processes occurring at the site. Pfahlert (1984) identifies the following key processes:

1. *Wave direction and frequency* – figure 2 shows the wave direction and frequency for Rapahoe. Note that the predominant wave at the southern end of the town is from the north-west while and from the west/south-west at the northern end. This affects the flow of sediment within the bay and needs to be carefully considered, especially if groynes are to be used as protection.
2. *Localised sediment movement* – figure 3 shows beach profile changes through a year adjoining the township. This is where local sediment is simply moved from the beach to the seabed and is returned again, as a continuous process. Local sediment movement is approximately two metres at Rapahoe; that is, the height of the beach may fluctuate up to two metres within any one year. This fluctuation is further lowered by the loss of sediment each year as noted above. Any protection works, particularly sea walls would have to be set considerably deeper than two metres into the beach and set back as far as possible against the shore if under-cutting is to be avoided for any length of time. Where a protection structure is under-cut, its life will be minimal.
3. *Extent of coastal erosion* – as noted above, coastal erosion affects the beach adjoining the township and continues north under State Highway 6. If one particular area is protected, the unprotected areas will be likely to erode back, exposing the sides of the protection works. In order to protect against this inundation, ongoing maintenance of the protection structure will be required.

Figure 1 – erosion History and Affected Properties

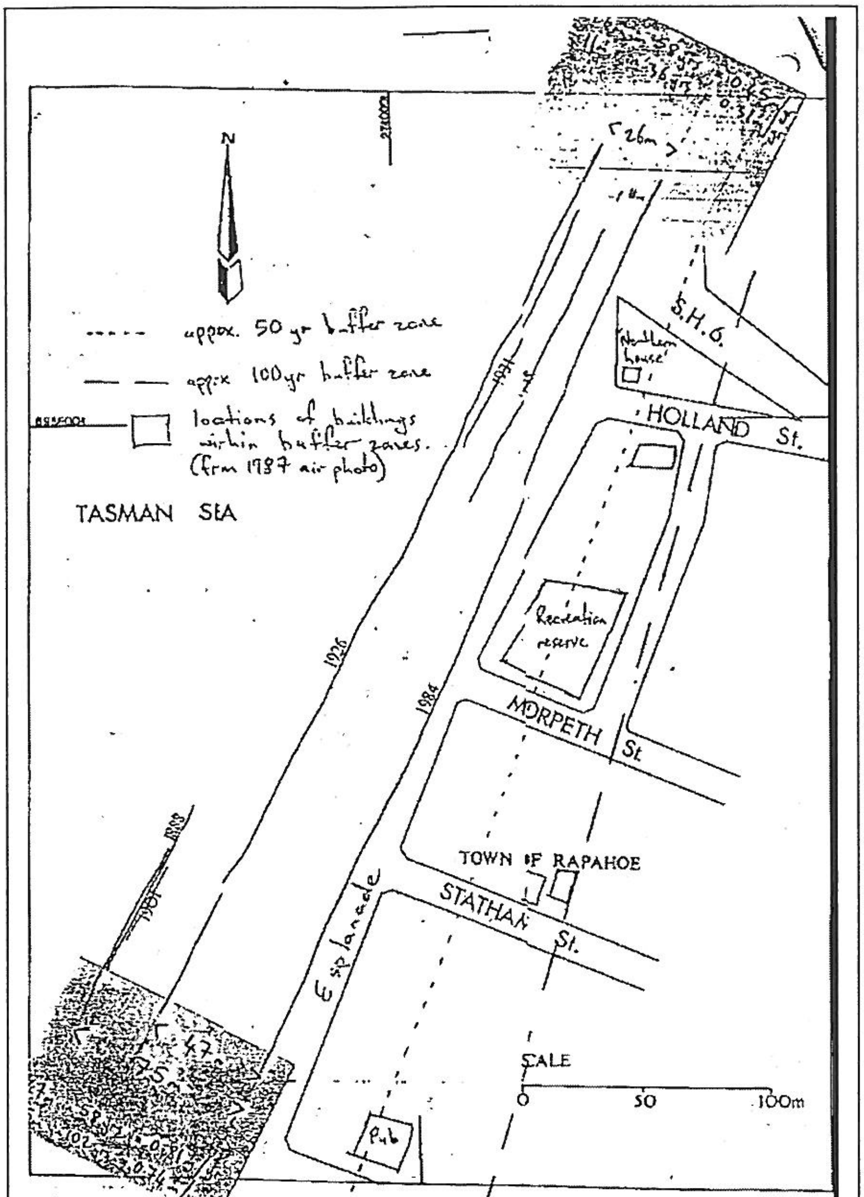


Figure 1

Map showing the historical positions of the Mean High Water Mark on Rapahoe Beach for the years 1882-1984.

Figure 1 has been copied over from the 1996 report. The figure illustrates those properties that are expected to be directly affected by erosion within the next 50 years. Figure 1 also shows the history of coastal erosion dating back to 1888.

The shaded areas at each end of the beach provide estimates of actual erosion rates.

Figure 2 – Wave direction and frequency (Pfahlert 1984).

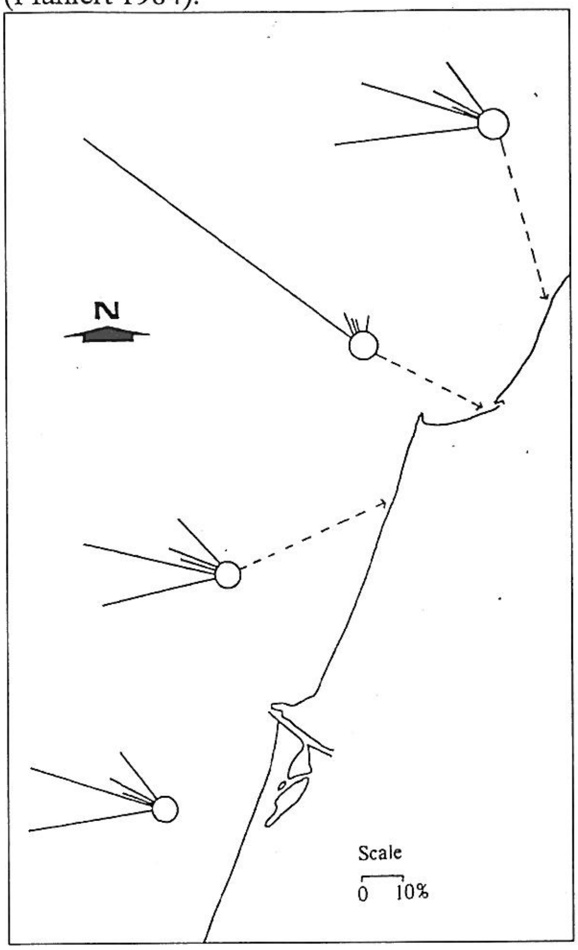
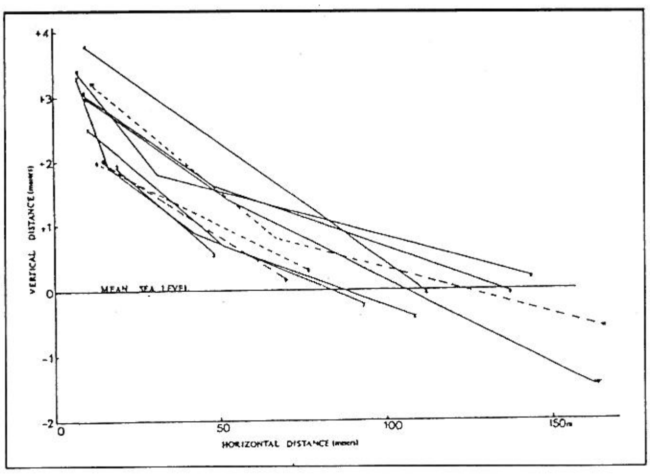


Figure 2 shows the direction of waves along the coastline. The length of the line indicates the percentage frequency of the waves.

The predominant wave direction at Rapahoe is north-west. This direction varies considerably from the predominant west to southwest direction along the coast and should be taken into account in the management of coastal erosion.

Figure 3 shows the beach profile over one year between May 1983 and May 1984. This profile was recorded on that area of the beach adjoining the township. A beach profile is an illustration of the beach as if one were looking along the beach. The vertical scale illustrates the changes in the height of the beach while the horizontal scale illustrates length of the profile in metres.

Figure 4 – Beach Profile (Pfahlert 1984)



Options for Rapahoe

Any solution to the coastal hazard problem at Rapahoe (both the township and the State highway to the north) needs to be co-ordinated so as to avoid possible adverse impacts on adjoining properties/assets. The following are a number of possible options for Rapahoe with a discussion of advantages and disadvantages:

1. "Hard" engineering solutions:

a. Rock seawall

A low rock seawall has been constructed by the GDC along about 200 metres of the Rapahoe beachfront. To be an effective barrier against coastal erosion, such a structure would have needed to have followed the guidelines in Attachment 1. At Rapahoe, it would need to withstand the effects of changes in beach height of up to two metres and elevated water levels of around ten vertical metres. Maintenance of the structure would also need to be ongoing to prevent inundation from the northern and southern ends.

The existing rock wall did not follow the attached guidelines and has not provided any lasting protection against erosion. A risk is that such a structure will have an opposite effect by increasing the reflection and scouring effect of waves and consequent loss of further beach gravel offshore. The photo monitoring undertaken by OPUS below State Highway 6 shows that even these very substantial rockworks are moved by storms and beach scour and require ongoing maintenance.

It is important to note that rockwalls do not prevent the natural processes that cause beach erosion, but merely aim to isolate the land behind from the effects of erosion. If the beach continues to erode (as has been occurring since the 19th century), the original beach material in front of the rock wall will disappear and the wall will come under increasing attack by waves. If a wall is to give lasting protection to the town, it will have to be constructed deep into the beach and continually maintained. The costs of such a wall are considerable and it is important that the Rapahoe community is informed of the initial and ongoing maintenance costs of such a structure.

b. Offshore breakwater

An example of an offshore breakwater is shown in figure 4. The structure would shelter the shore from the heavy wave action enabling sediment to build up in the sheltered area. The design and construction of an offshore breakwater would have to be carefully considered to ensure that it was correctly located to be most effective.

The costs of such a structure would be considerable, however, it could be considered in any potential design of the proposed Greymouth Coal jetty.

c. Groyne

Assuming a northward drift of sediment, the construction of a groyne at the northern (downdrift) end of the township would cause accretion (or at least reduce the erosion) of the beachfront (refer to figure 5). However, it would also cause an equivalent amount of erosion of the beach frontage of State Highway 6. Should SH6 be relocated inland (as Transit NZ are considering), and if it is acceptable to have an accelerated loss of the land where SH6 is presently located, then the groyne option should be investigated further. I suspect that a groyne here might not give effective protection to the south end of town. It might not be able to continue to maintain a stable shoreline in light of the significant erosion of this coastline but it is likely that it would be beneficial, even if only for the northern end of the town.

Because the northward drift of sediment is weaker at the southern end of the town, a groyne placement there would be more likely to cause an adverse effect on the town.

Figure 4 – Possible Offshore Breakwater

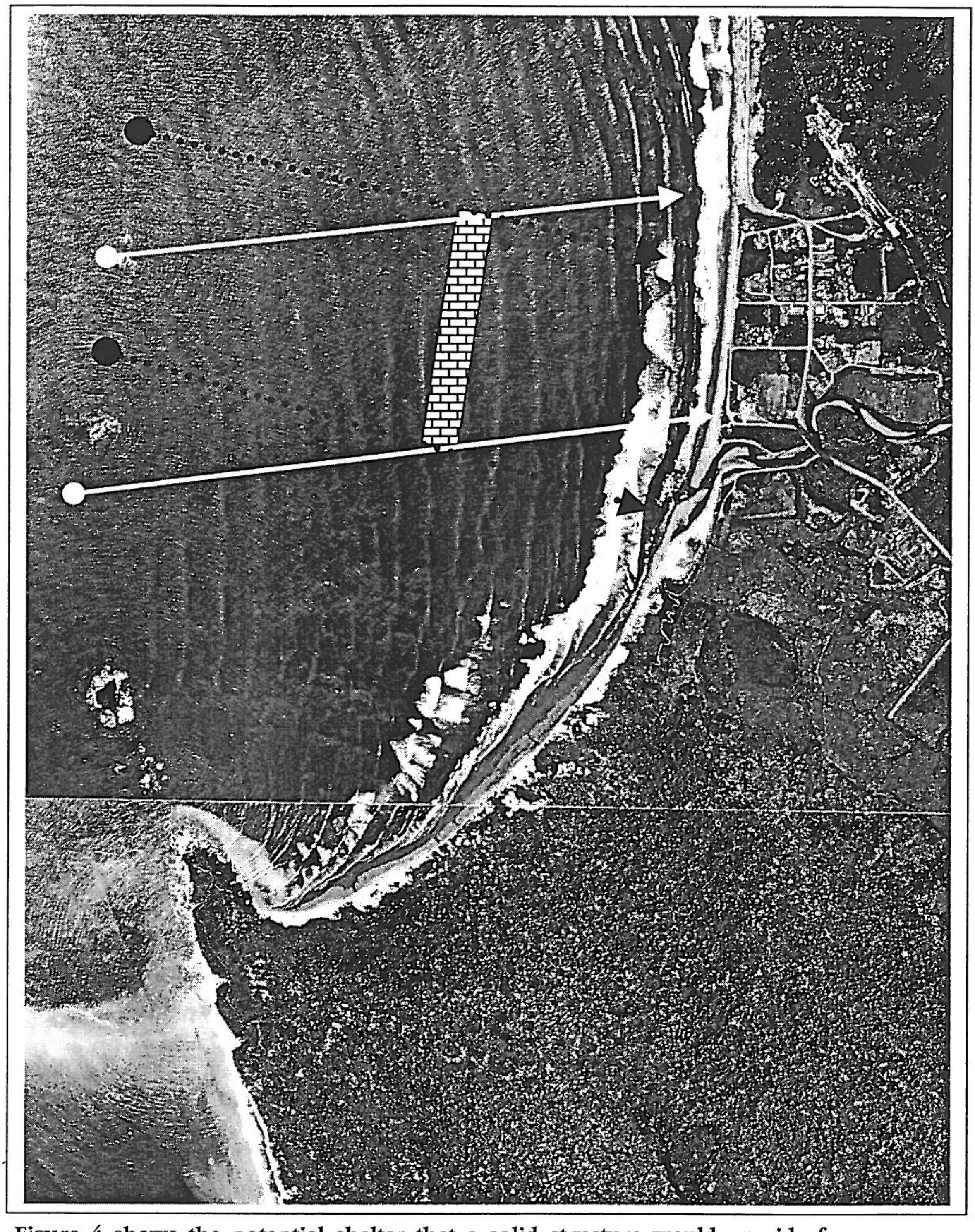
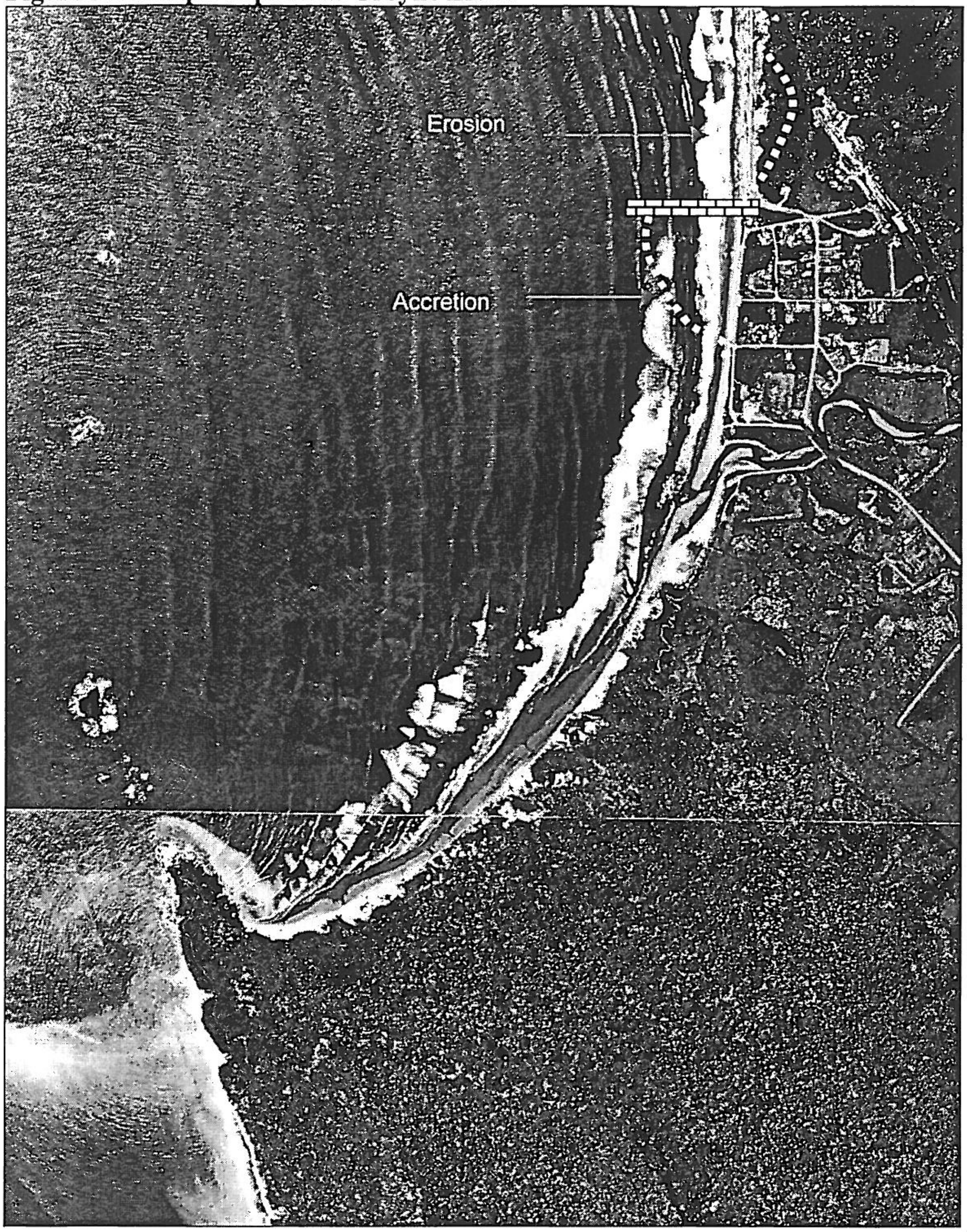


Figure 4 shows the potential shelter that a solid structure would provide from a north-west and a southwest swell.

Figure 5: Example of possible Groyne Effect



2. **"Soft" engineering solutions**

a. *Gravel stopbank*

A gravel stopbank similar to those constructed at Granity School and Pororari beach would provide temporary relief against wave inundation into properties. However, ongoing erosion of the beach would erode such a structure. To provide protection for the longest time possible, such a stopbank should be positioned as far back from the beach as practicable.

b. *Plantings*

The planting of broad-based plants such as flax (and retention of existing vegetation) will add to the protection against wave inundation. It is significant that the problems of wave inundation appear to have occurred only in areas that are not fronted by flax (i.e. the northern house, the Esplanade, an access track to the recreation reserve, and the street ends).

c. *Beach renourishment*

While a gravel stopbank will provide some relief from beach erosion, the benefits are likely to be short-lived due to the natural loss of material caused by the offshore and along-shore movements of gravel by waves. To counter the natural loss of gravel from the beach, large volumes of gravel would need to be imported in order for any renourishment to be effective. Using Pfahlert's estimate, this would amount to about 3500 cu m/yr, though this figure needs to be verified by further study. To be an effective long-term solution, this option would require ongoing resources.

Possible sources of gravel for renourishment could be Blaketown or the Grey River, though both of these sites are probably natural gravel sources for the eroding beaches at both Cobden and Rapahoe. Use of these gravel sources might therefore be merely a transfer of sediment from one part of the system to another, rather than a positive gain in the quantity of gravel in the system. It might also increase the erosion threat at Cobden or the banks of the Grey River, by reducing the natural gravel supply to these sites. Nevertheless, further investigation of this option might be worthwhile.

3. **No action, and loss bearing**

Taking no action would require landowners to bear the losses caused by coastal erosion and inundation. Since the erosion appears to be ongoing, the losses and threats to properties would be expected to continue. Properties would have to be abandoned as the sea overcomes them. Loss bearing can be acceptable for a period of time when little permanent damage occurs, but one or more of the other solutions listed here are often required when the situation starts to directly affect built property. It may, however, be a realistic option for undeveloped properties.

It is important that the Rapahoe community have this as an option as an alternative to continually funding protection works.

4. **Relocation or abandonment of assets**

At present, only the esplanade, the recreation reserve and the northernmost house are threatened by coastal hazards. Other developed properties are unlikely to be under threat within the next 30-40 years (if they do eventually come under threat, a rockwall or similar option along the present shoreline would not have given any benefit to them in any case). Relocation or abandonment of assets that are under immediate threat is an option.

Abandonment of the esplanade would be possible because it is not required for access. All of the developed properties in Rapahoe can be accessed from the State highway or from the roads running east west (Holland, Morpeth and Statham Streets).

Abandonment or relocation of the recreation reserve (& camping ground facilities) is probably feasible, as all assets appear to be movable (though this should be examined in detail). Any consideration of abandoning the reserve should include the views of the community, lessee, GDC and the Department. If relocation is the best option, other sites to the eastern side of Rapahoe might be available for purchase.

The best relocation/abandonment options for the northern house and the pub are largely up to the owners of those properties to decide.

5. **District planning, buffer zones**

Such measures can serve to direct new developments away from the area under threat, and thereby reduce the hazard in the future. Based on historic erosion rates, a buffer zone of about 50 metres at the northern end increasing to 90 metres at the southern end, would be necessary to provide protection for the next 100 years (see Figure 1). This zone should be used in any case to ensure that future properties are not developed in the areas under threat.

Conclusions

Coastal erosion at Rapahoe appears to be a long-term threat which makes the likely effectiveness of engineering solutions uncertain. Chronic long-term erosion of an exposed coastline is seldom possible to arrest. It is essential that if engineering works are used, that any designs address the issues of wave direction, beach height fluctuation and sediment loss. It is also important that the ongoing, as well as the initial maintenance costs are identified.

It is consider that the best practicable solution to control erosion at Rapahoe is similar to that described for Punakaiki by Kirk 1988:

- A short-term solution to the problem of wave inundation is the construction of a gravel stopbank at strategic sites, and the planting of dense vegetation.
- A long-term solution lies in the relocation or abandonment of assets and the siting of any new developments away from the zone under threat.
- If the resources are available, other longer-term solutions might include a groyne and/or beach renourishment, although a more thorough assessment of these options are required to ensure that resources are best invested.

A comprehensive mix of planning and engineering controls would help to ensure that the management of the area and its coastal environment would constitute the best practicable option for the future.

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CO (Coastal/Marine)
for Conservator

References

Benn JL; Neale DM (1988) A report on coastal hazards in the West Coast region. The West Coast Regional Council.

Jones, CL (1994) Pororari beach wave analysis report. Unpublished report for the Dept of Conservation, Hokitika.

Kirk RM (1988) Coastal erosion and inundation at Punakaiki village (Pororari beach) Westland, 1983-86. Unpublished report for the Department of Conservation, Hokitika.

Pfahlert J (1984) Coastal dynamics and sedimentation at Point Elizabeth, West Coast, South Island, New Zealand. Unpublished Msc thesis, University of Canterbury.

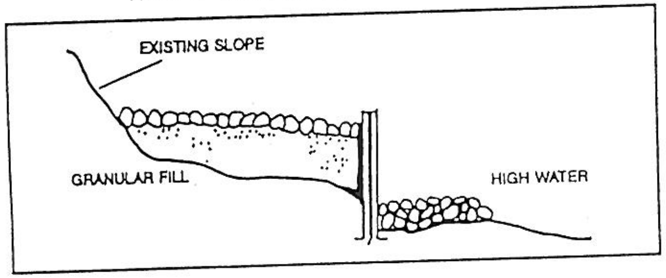
US Army Coastal Engineering Research Centre (1984) Shore Protection Manual, Vol I and II.

CONSTRUCTION AND MAINTENANCE GUIDELINES FOR SHORE PROTECTION WORKS

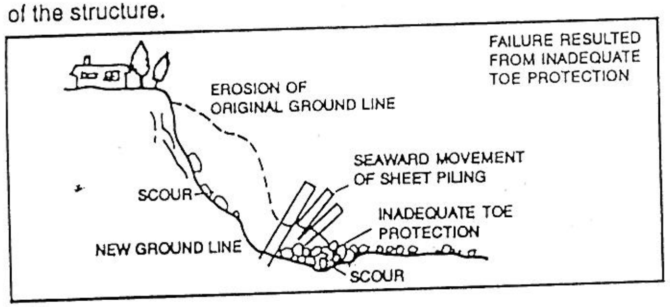
The foll..ing guidelines should be followed for any shore protect works built in New Zealand. If they are not followed, the structure will inevitably fail after construction. Shore protection devices require varying degrees of maintenance depending on the type of structure and exposure to severe wave action. Establish familiarity with the symptoms of failure and the action that should be taken to maintain the structure. Construction rules and maintenance requirements are described below. Constant vigilance of all structures is necessary. Inspect your structure after every storm. Repair it immediately if it shows any sign of damage. Except for the alter ive of relocation, the various structures shown below all are subject to failure if not built in accordance with construction guidelines. Once built, they must be maintained in accordance with maintenance guidelines. Note that beach renourishment and dune construction using sand and/or gravel are alternative methods of shore protection to which these guidlines do not apply.

These guidelines are largely reproduced from guidelines for the American Great Lakes, developed by the US Army Coastal Engineering Research Centre. This reproduction is by Don Neale, Department of Conservation, Hokitika with graphics and layout by Andy McLaren, August 1994.

RULE 1
PROVIDE ADEQUATE TOE PROTECTION FOR THE TOE OF THE STRUCTURE SO THAT IT WILL NOT BE UNDERMINED

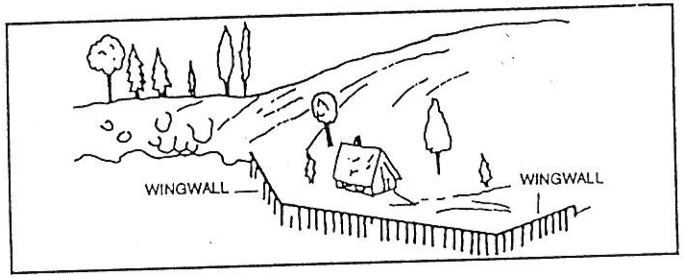


CHECK FOR SIGNS OF FAILURE
Most failures of shore protection works result from "toe failure", or erosion under the lowest part of the structure. Failure of the bulkhead can be prevented with adequate toe protection. Toe protection must be substantial enough to prevent the original ground under it from washing through the toe protection blanket, and extend far enough seaward of the structure to prevent undermining. Check for signs of failure such as seaward movement of the wall, erosion behind or at the toe, or at the end of the structure.

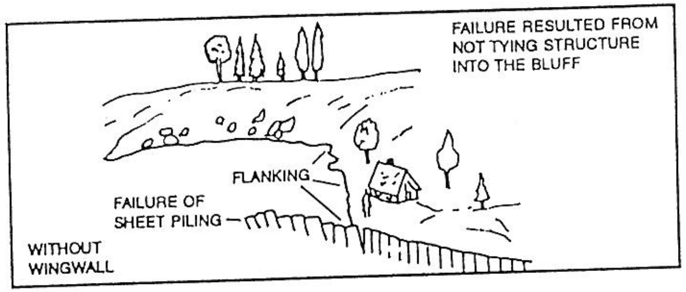


MAINTENANCE OR REPAIR PROCEDURE
Re-establish support by underpinning, tie-backs, systems of anchor piling, walers and tie rods. Place larger stone or rock-filled mattress at toe of structure to prevent scour. Backfill where necessary.

RULE 2
SECURE BOTH ENDS OF THE SHORE PROTECTION WORKS AGAINST FLANKING

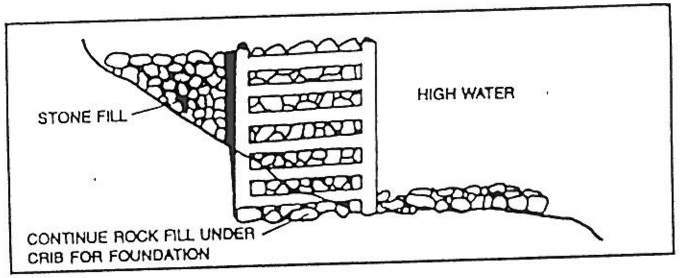


CHECK FOR SIGNS OF FAILURE
Erosion will continue adjacent to your works. If an existing structure has been flanked such as the one shown below, correct it by placing additional material at the ends and tying your works directly into the bluff. Check for signs of failure such as seaward movement of the ends and erosion at the ends of the structure. The illustration below shows the result of not constructing wingwalls and not tying the ends of the structure into the bluff.

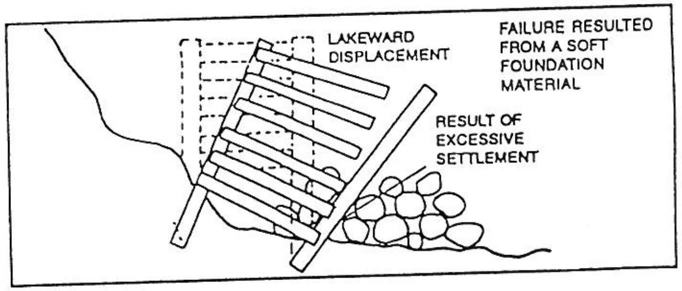


MAINTENANCE OR REPAIR PROCEDURE
Place additional material at the ends and tie structure directly back into the bluff.

RULE 3
CHECK FOUNDATION CONDITIONS



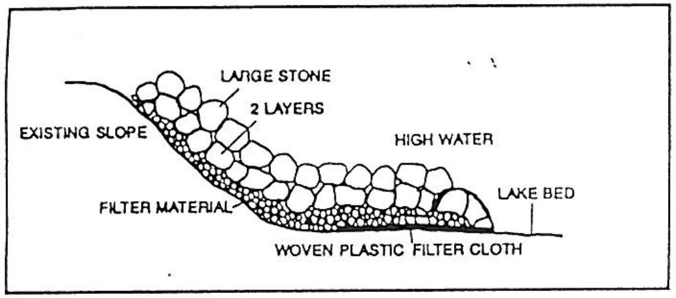
CHECK FOR SIGNS OF FAILURE
Soft foundation material may result in excessive settlement of the structure. Soft underlayers may allow all or part of the structure to slide. Check for settlement and excessive displacement. Hydrostatic pressure due to groundwater seepage may cause seaward movement of some types of impermeable walls.



MAINTENANCE OR REPAIR PROCEDURE
Re-establish support by construction underpinning, foundation protection and backfilling. If the structure was impermeable such as a steel wall, add or reopen weep holes.

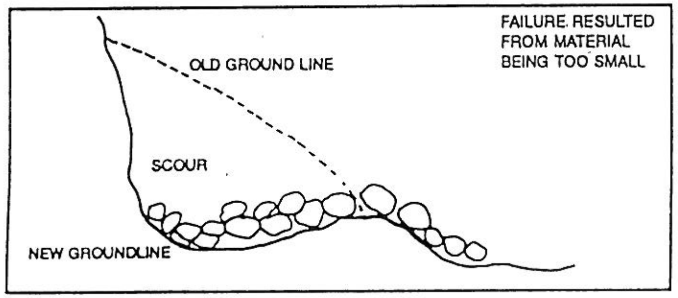
RULE 4

USE MATERIAL THAT IS HEAVY AND DENSE ENOUGH ~~TH~~AT WAVES WILL NOT MOVE INDIVIDUAL PIECES OF THE PROTECTION



CHECK FOR SIGNS OF FAILURE

A cause of common failure is to use undersized material; waves have tremendous power and can move a lot of material in a short time. Small stones, or pieces of concrete will be moved around and carried away by small waves. Larger waves will do it even faster. The bank revetment below was constructed of undersized stone and was carried down the slope by large waves. Excessive settlement, increase in voids, loss of filter material, erosion behind or at the ends of the structure can result due to the use of small stone. A layer or two of filter material may be inserted between the underlying ground and the protective material.

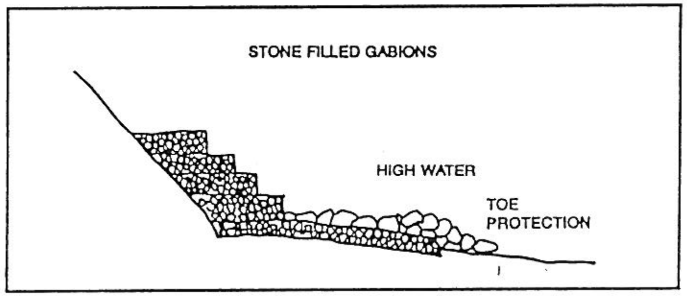


MAINTENANCE OR REPAIR PROCEDURE

Place additional stone at toe, restore to original elevation, section and thickness, reduce excessive void ratio, backfill behind structure; extensive upgrading in size of material may be required.

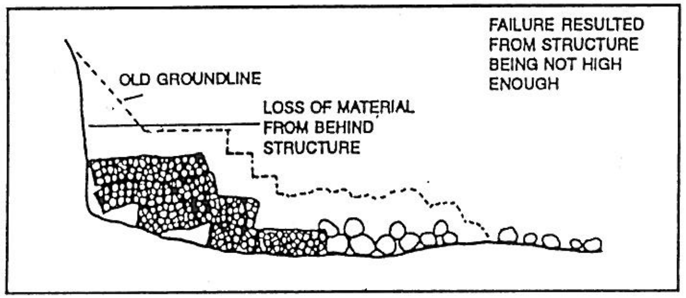
RULE 5

BUILD REVETMENT HIGH ENOUGH THAT WAVES CANNOT OVERTOP IT (SPRAY OVERTOPPING IS ALRIGHT, BUT NOT 'GREEN' WATER)



CHECK FOR SIGNS OF FAILURE

Many failures have happened because the structure was not built high enough and erosion could then continue behind the structure as if it were not there. Check for broken wire, excessive movement, and erosion behind or at the ends of the structure.

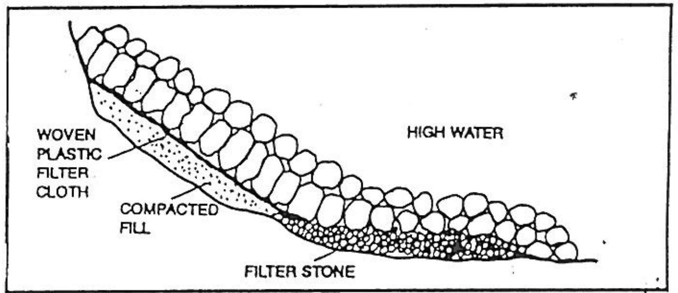


MAINTENANCE OR REPAIR PROCEDURE

Restore to higher elevation, backfill behind structure, add filter cloth and splash apron.

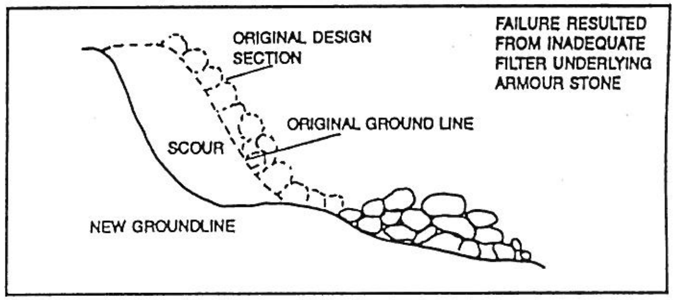
RULE 6

MAKE SURE THAT VOIDS BETWEEN INDIVIDUAL PIECES OF PROTECTION MATERIAL ARE SMALL ENOUGH THAT UNDERLYING MATERIAL IS NOT WASHED OUT BY WAVES



CHECK FOR SIGNS OF FAILURE

A filter material such as woven plastic filter cloth must be placed on a highly erodible embankment to prevent the fine material from washing through the voids in the structure. The protection material must be thick enough to make a long passage for dissipation of wave energy prior to reaching the underlying materials. In the case below, woven plastic filter cloth was not included. As a result, fine bluff material was washed out by waves.

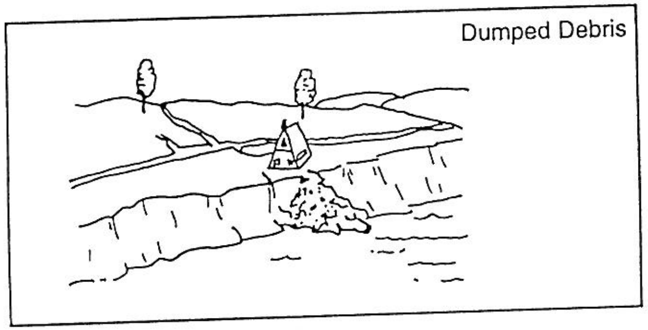


MAINTENANCE OR REPAIR PROCEDURE

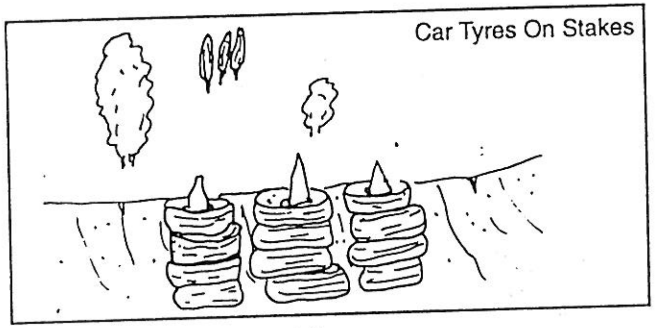
Rebuild to original elevation, use at least two layers of stone, use a stone filter or woven plastic filter cloth, fill behind structure.

IMPROPER SOLUTIONS

Each of these IMPROPER SOLUTIONS violates two or more construction guidelines. Can you tell which construction guidelines each of these examples violates and how the structure will fail?
Answers are provided under each illustration.



Violates Rules 1, 2, 4, 5 & 6



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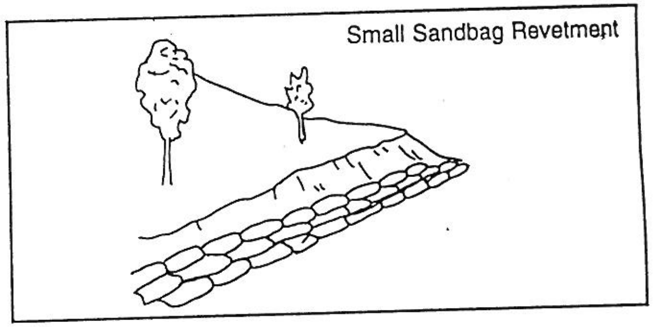

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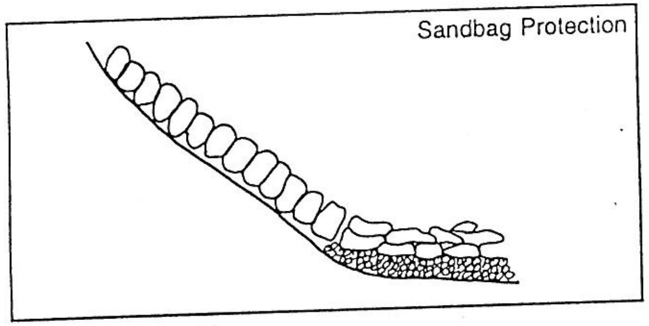

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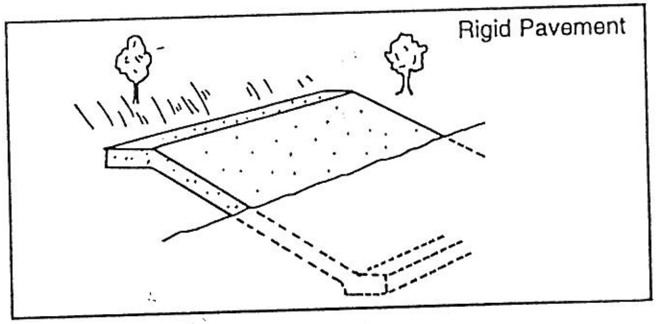
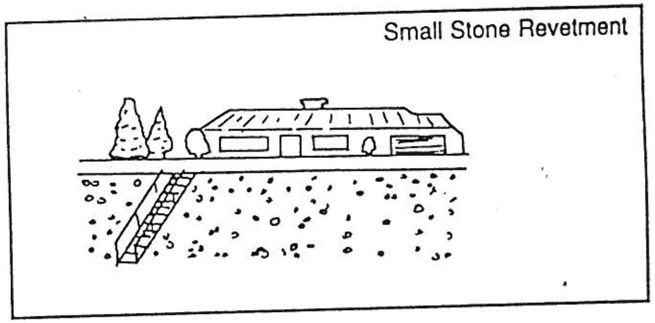


Violates Rules 1 & 2



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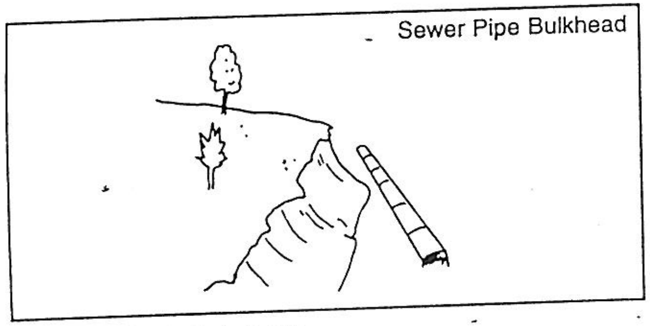

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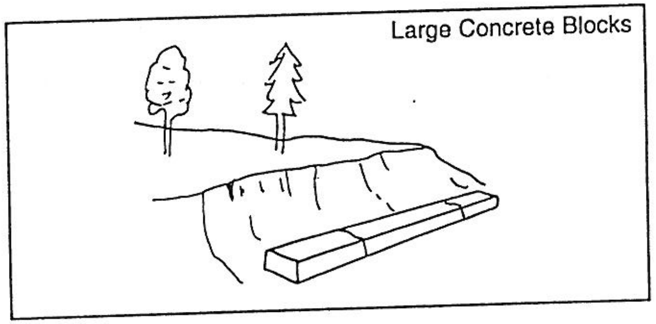
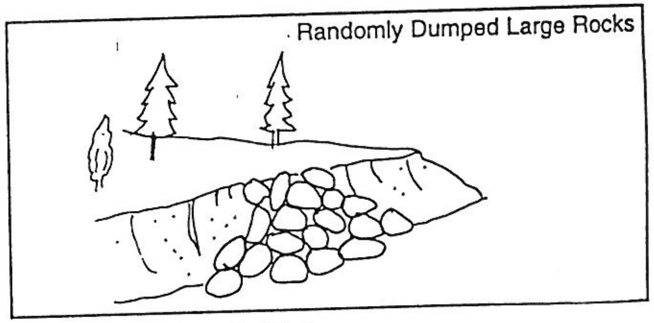


Violates Rules 1, 2, & 5



Violates Rules 1, 2, 3, 5 & 6