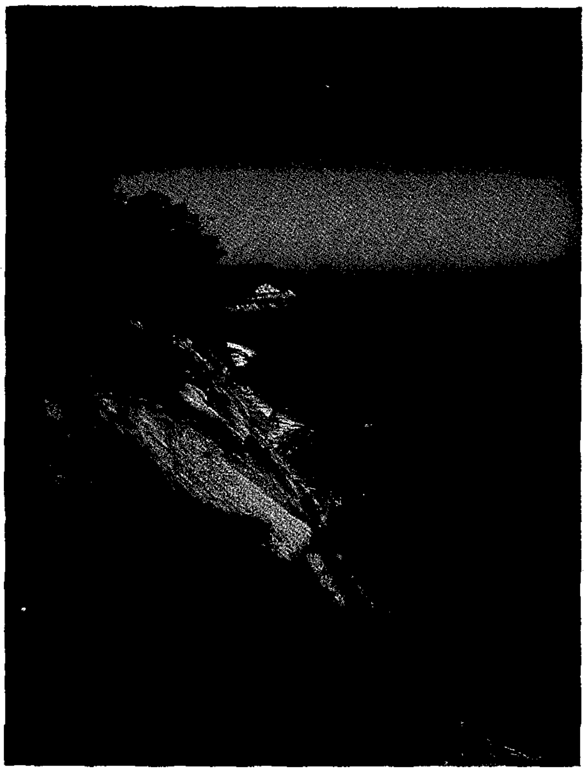
SHORE EROSION CONTROL GUIDELINES for Waterfront Property Owners



MARYLAND DEPARTMENT OF NATURAL RESOURCES
WATER RESOURCES ADMINISTRATION

SHORE EROSION CONTROL GUIDELINES for Waterfront Property Owners

MARYLAND DEPARTMENT OF NATURAL RESOURCES
WATER RESOURCES ADMINISTRATION

Production of this report was made possible by funding provided by the Coastal Resources Division, Tidewater Administration, Maryland Department of Natural Resources through a Coastal Zone Management Implementation Grant from the Office of Coastal Resources Management, National Oceanic and Atmospheric Administration.

EXECUTIVE SUMMARY

The Department of Natural Resources understands and respects waterfront property owners' rights to protect their property from erosion. It is in the best interest of waterfront property owners and the health of the Chesapeake Bay to select the most environmentally sensitive methods of combatting shore erosion.

Protection measures which best provide for the conservation of fish and wildlife habitat are encouraged by the Department of Natural Resources. Erosion control measures should be considered in the following order of preference:

- No action
- Relocation of threatened structures
- Non-structural stabilization including beach nourishment, slope grading and marsh creation
- Shoreline revetments
- Offshore breakwaters
- Groins
- Bulkheads

These recommendations are consistent with the objectives of the Chesapeake Bay Restoration Program and with Maryland's Critical Area Protection Program which encourages the use of non-structural shore protection measures in order to conserve and protect plant, fish and wildlife habitat.

PREFACE

This guidebook was developed by the Maryland Department of Natural Resources, Water Resources Administration, Tidal Wetlands Division, to assist waterfront property owners in understanding the various methods of shore erosion control and assist them in selecting the method most appropriate for their property. The appropriate shore erosion control method should be selected by considering the degree of erosion control needed, environmental impacts and cost.

TABLE OF CONTENTS

FIGURES

TABLE

INTRODUCTION

This book provides guidance to waterfront property owners on the Chesapeake Bay and Atlantic coastal waters (Atlantic shoreline and back bays) on how to protect their property from shore erosion. Each section builds on the previous section in a logical progression for the assessment and selection of the appropriate technique for protecting waterfront properties from shore erosion. Descriptions, site characteristics, construction materials, design considerations, maintenance requirements, advantages and disadvantages are discussed for each type of protection suggested.

The guidebook provides basic information for assessing erosion problems and selecting appropriate protection. However, the services of a qualified engineer should be employed for designing a specific shore erosion control project.

The appendix includes a glossary of terms commonly used in describing shore erosion problems and associated control measures.

The Maryland Department of Natural Resources (DNR), Water Resources Administration presents this guidebook as a public service. The methods of shore erosion protection discussed in this guidebook are not guaranteed to be successful for a specific site nor should regulatory approval from state or federal agencies be assumed. Further information may be obtained from: The Department of Natural Resources, Water Resources Administration, Tidal Wetlands Division, Tawes State Office Building D-2, Annapolis, Maryland 21401, Phone: (410) 974-3871.

Maryland Shoreline Statistics And Characteristics

The Chesapeake Bay, Atlantic coastal waters (coast and back bays), and their tidal tributaries include 4,360 miles of shoreline which are subject to erosion. Approximately 1,341 miles of that shoreline are eroding. Statistics compiled by the Department of Natural Resources show that 37 miles of shoreline are stabilized annually. The remaining shoreline that erodes each year is a serious economic and ecological problem because:

- Costs of shore erosion control and reclaiming lost property are beyond the means of some waterfront property owners.
- Valuable structures such as homes and businesses are at risk to storm damage.
- Sediments from the eroded shoreline smother important aquatic resources, contribute to the degradation of water quality, and fill navigation channels vital to commerce and recreation.

Understanding Shore Erosion

Erosion and sedimentation (the deposition of sediment) are natural processes, but often are in conflict with our use of the shoreline. The most noticeable problem created by erosion is the loss of waterfront property. Waterfront property values are high, so many owners spend considerable time and money protecting their shoreline from erosion.

Shore erosion is caused primarily by wind driven waves and to a minor extent by wakes from passing boats. Wind velocity, duration, and the expanse of open water (fetch) the wind blows over are the predominant factors generating waves that attack and erode the shoreline. Wave height and strength are generally greater in areas exposed to the main stem of the Chesapeake Bay than in rivers and creeks.

The basic progression of erosion resulting from wave action, diagrammed in Figure 1, includes: A) attack by waves, B) erosion of a bank and beach causing undercutting, C) slumping of the bank, and D) removal, transportation, and deposition of the bank sediments along the shoreline.

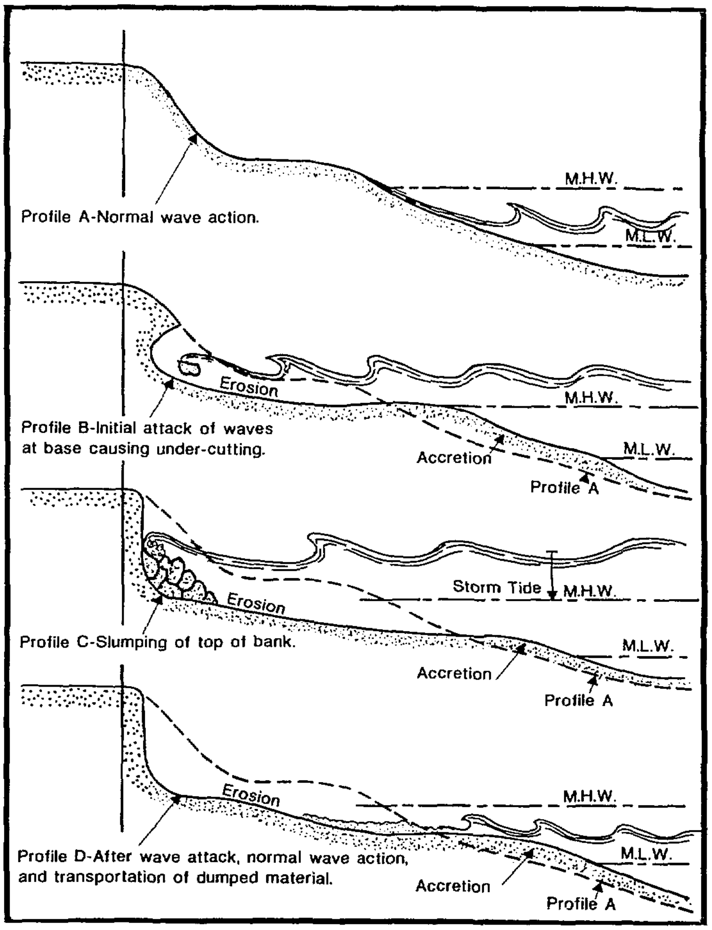


Figure 1. Wave erosion and transportation of sediments along a beach.

Shallow bottoms near the shore reduce wave action. Therefore, a shoreline is likely to receive fewer waves if there are shoals, tidal flats, offshore bars and/or a marsh near the shore. Also a wide beach can withstand more waves than a narrow beach, therefore reducing erosion of the shoreline.

Water level also affects the amount of erosion. Water levels are influenced by the seasons, tides, storms, seiches (sloshing action of water in a basin, similar to a wave set up in a bathtub), droughts, floods and the general rise of global sea level. New areas of the shoreline are exposed to erosion by these changes in water level.

Seasonal storms affect the level and movement of water, the intensity and direction of wind, and changes in the patterns of erosion and deposition (Figure 2).

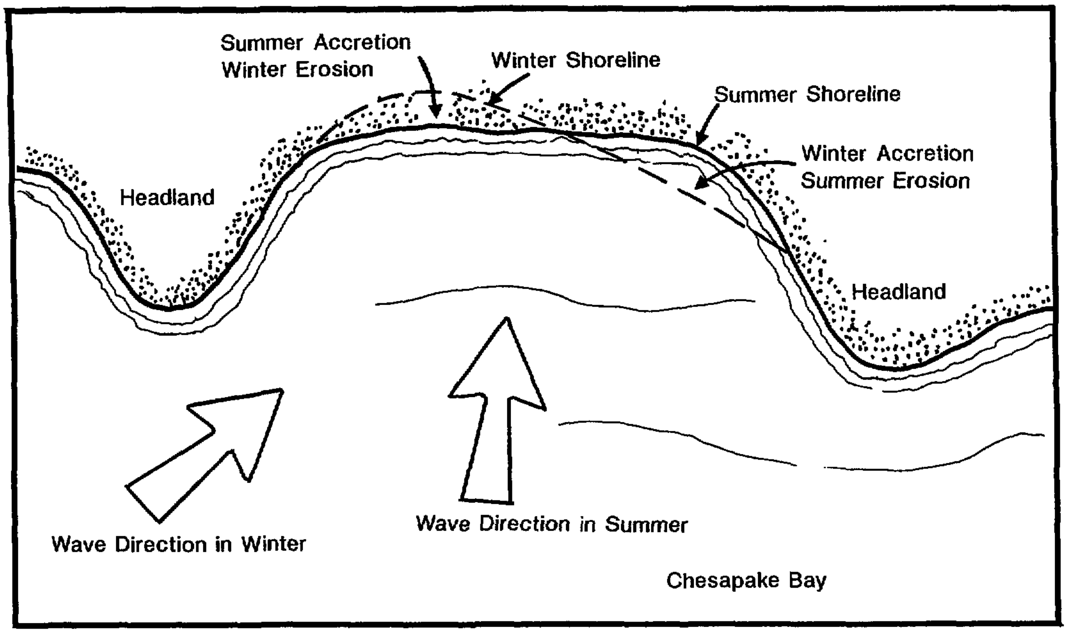


Figure 2. Seasonal changes in erosion and depositional patterns due to changing wave direction exposing new surfaces.

Often, changes in the pattern of a shoreline are mistakenly measured as an overall net gain or loss of sand when the changes are only seasonal.

Sand is carried onshore and offshore by the action of waves. Sand is also moved along the shore. Waves most often arrive at an angle with the shoreline creating a current along the shoreline. These currents move sand along the shoreline in a zigzag pattern as successive waves advance and retreat (Figure 3).

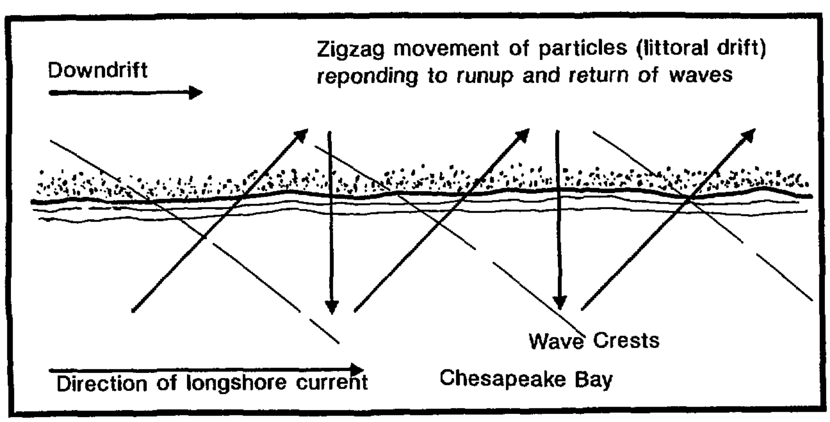


Figure 3. The zigzag pattern of sand movement along a shoreline.

A stabilized beach is dependent on the balance between sand supplied from the bank or transported along the shore, and sand lost to erosion. The movement of sand is essential to maintaining beaches and deterring erosion. The velocity (speed and direction) of water determines the amount of sand moved. Larger quantities and heavier sands can be transported by larger waves or fast moving currents along the shoreline. Fine grained sediments (silts and clays) are generally transported to the deeper sections offshore while larger grained sands are deposited along the shoreline.

Groundwater discharge through cracks (joints) in sediments as well as wave action contributes to shoreline erosion by causing the slumping of sediments from high banks (Figure 4).

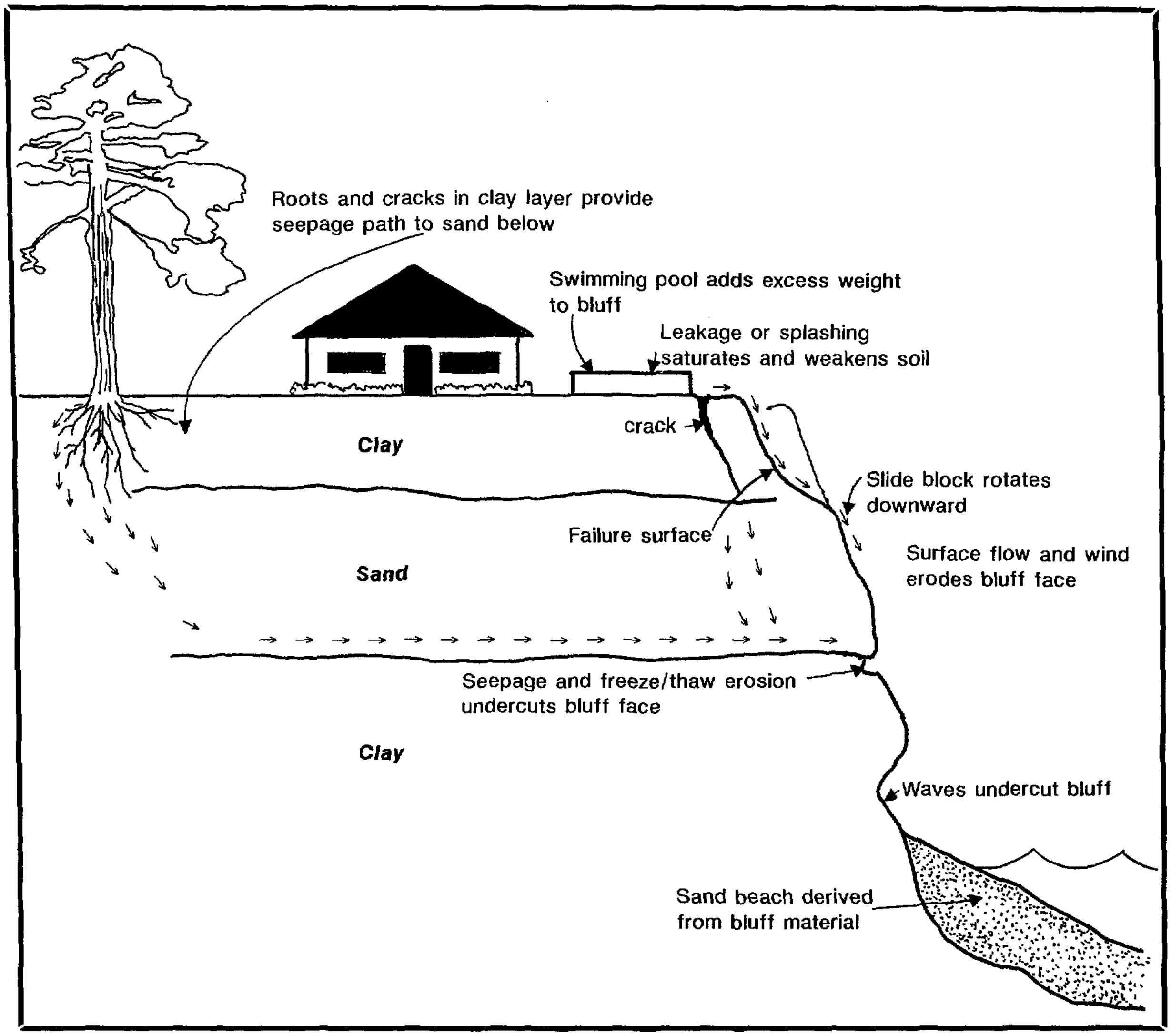


Figure 4. The combination of wave and groundwater erosion on a high bank.

Runoff of surface water also causes erosion of high and low banks and beaches. The amount and velocity of the water, the height and slope of a bank, and the amount of vegetation determine the amount of material eroded and deposited along the shoreline.

There are natural defenses for shoreline protection. Gently sloping shorelines, beaches and marshes are a good defense against erosion. A beach prevents average high water from reaching upper areas of the shore. Marsh plants decrease the rate of erosion by breaking up waves and trapping sediment carried by currents along the shoreline. Where these features exist they must be managed wisely.

Erosion Rates

Erosion of the shoreline in Maryland varies from less than two to greater than eight feet per year. The rate is dependent upon the erosional forces, mentioned previously, attacking the shoreline and the soil composition of the bank, beach or marsh. The rate is also influenced by erosion control structures built along a shoreline. Often the protection of a single waterfront property has a negative effect (increased erosion) on adjoining properties. Therefore, coordinated protection of an entire segment of shoreline is highly recommended.

The Maryland Geological Survey (MGS) monitors shoreline changes both in the Bay and along the Atlantic Coast. MGS has compiled erosion data on a series of maps, "Atlas Of Historical Shoreline and Erosion Rates" (1975). The maps were produced at a scale of 1:24,000 and cover both the Chesapeake Bay and the Atlantic Coast. Individual maps can be obtained from the MGS, 2300 St. Paul Street, Baltimore, Maryland 21108-5210 for $1 each [(410) 554-5505].

PRELIMINARY CONSIDERATIONS FOR EROSION CONTROL OF YOUR WATERFRONT PROPERTY

Erosion problems are site specific. There are a variety of procedures and devices designed to protect against erosion. Selecting an appropriate erosion control measure for your property requires planning.

Planning Considerations

DETERMINING THE NEED FOR SHORE EROSION PROTECTION

The loss of property resulting from shore erosion is a serious problem for many waterfront property owners. It is important to determine the degree of erosion to your waterfront property before you or your community decide on a plan of action.

To determine if a shore erosion problem exists, you should consider the following questions.

- Has your shoreline noticeably receded during the last two years?
- If you have marsh along your shoreline, has it been disappearing?
- Do you have to step down to walk on your beach?
- Are trees along your shoreline falling into the water?
- Is your beach submerged at high tide?
- Have your neighbors installed shore erosion control measures?

If you answer yes to one or more of these questions you should contact the Shore Erosion Control Program in DNR, at (410) 974-3727, the Tidal Wetlands Division in DNR at (410) 974-3871, the local Soil Conservation District Office or consult the telephone directory for engineering or marine contracting firms in your area.

EROSION CONTROL DISTRICTS

Erosion crosses property lines, so a community approach is often the key to successful shore protection (Figure 5).

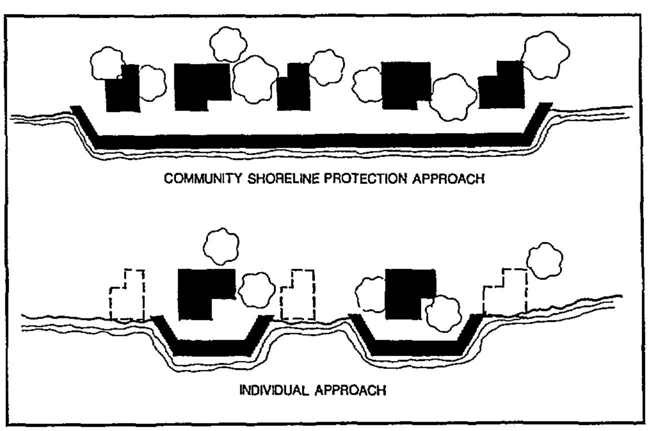


Figure 5. The single versus the community approach to shore protection.

STATE ASSISTANCE

Waterfront property owners suspecting an erosion problem on their shoreline should contact the Department of Natural Resources for assistance at (410) 974-3727 or (410) 974-3871. Shore Erosion Control personnel will inspect your property and suggest options available to prevent future erosion. These inspectors can provide a list of engineers and contractors in the area. Property owners who have serious erosion problems may also qualify for State financial assistance.

Individual landowners, municipalities and counties may apply for grants or interest-free loans for projects designed to control shore erosion. Financial assistance is awarded on the basis of available funds and a priority assessment established by DNR. Priority ratings are based on the rate of erosion, amount of sedimentation, public benefit, type of erosion and date of application for the loan. Community based approaches carry a higher priority for funding.

PERMIT REQUIREMENTS

Federal and State governments generally require that a permit be obtained prior to the construction of any erosion control project. The Department of Natural Resources and the U.S. Army Corps of Engineers should be contacted if there is any doubt as to the necessity of a permit. Local (county or municipal) governments should also be contacted because permit requirements vary widely.

Federal Permits

Federal permits for shore erosion control measures are issued by the U.S. Army Corps of Engineers. The Corps has responsibility for the administration of Federal laws for protection and preservation of the waters of the United States. Whether a permit is issued will depend upon the impact of the proposed work on:

- Navigation
- Fish and wildlife
- Water quality
- Economics
- Conservation
- Aesthetics
- Recreation
- Water supply
- Flood damage prevention
- Ecosystems
- Needs and welfare of the people

The Corps circulates permit applications for comment to the Environmental Protection Agency, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, and appropriate state and local agencies. Federal permits will not be issued until State Water Quality Certification and State Coastal Zone Consistency determinations have been provided to the Corps.

A pamphlet, "U.S. Army Corps of Engineer Permit Program, a Guide for Applicants", describing the procedures for applying for a federal permit, may be obtained free from the Baltimore Corps of Engineers' District Office.

For more information contact:

U.S. Army Corps of Engineers
Baltimore District - Permit Section
P.O. 1715
Baltimore, Maryland 21203
Phone: (410) 962-4500 eastern shore
(410) 962-4252 western shore

State Permits

Shoreline protection projects usually involve construction at or channelward of the mean high water line. Waterfront property owners must apply to the Department of Natural Resources for a permit or license to alter wetlands. Wetlands alteration includes:

- Filling
- Dredging
- Construction of bulkheads, revetments, boat ramps, piers, below-ground utilities, storm drain structures, groins, breakwaters, jetties, and similar structures or activities.
- Marsh creation.

Permit approvals are based on an evaluation of the impact of the proposed project on varying ecological, economic, developmental, recreational, and aesthetic values. The law recognizes the right of waterfront property owners to control erosion on their land, to gain access to navigable waters from their land and to reclaim land lost to erosion since January 1, 1972.

How To Apply For Federal Or State Permits

Only one application is necessary for a license, permit or approval from both the federal and state governments. This single application should be submitted to:

The Department of Natural Resources
Water Resources Administration
Permit Service Center
Tawes State Office Building, D-2
Annapolis, Maryland 21401
Phone: (410) 974-2755

The Permit Service Center distributes copies of the joint application to all federal and State wetland regulatory agencies for review and comment.

In addition to federal and State wetland permits, a sediment and erosion control plan, approved by the Soil Conservation District, may be required before any work begins. You should consult the local Soil Conservation District for technical advice on how to address sediment control during construction of erosion control projects.

Projects must also be in compliance with the Chesapeake Bay Critical Area Protection Program. Under that Program's requirement, first preference is given to non-structural shore erosion control measures. For more information on these requirements contact your city or county planning and zoning office.

ENVIRONMENTAL IMPACT

Shore erosion control measures can be harmful to aquatic plants, invertebrates, fish, and wildlife. Therefore, the impact on the environment by these measures must be minimized. Installation of shore erosion control measures should be placed landward of all marshes.

The area most impacted by shore erosion control measures is the intertidal zone, located between high and low tide. This zone includes nearshore shallow waters, associated marine soils, and marshes. Habitat, food and cover for many species of fish and wildlife are the products of the intertidal zone, especially salt marshes. Marshes also improve water quality by filtering upland runoff, absorbing excess nutrients and trapping sediments.

Selecting non-structural shore erosion control methods, such as beach nourishment or marsh creation provide greater environmental benefits than structural control methods. In particular, marsh creation projects not only reduce erosion but also enhance the fisheries value of the area and reduce pollutants entering the Bay.

Structural shore erosion control such as a bulkhead may cause erosion in front of the structure, endangering the shallow intertidal zone and contributing to water quality problems. These adverse impacts can be minimized by placing stone in front of the structure to break-up waves. Also bulkheads are chemically treated to retard the growth of many marine organisms. These chemicals may contribute to water quality degradation.

Stone or riprap revetments breakup waves allowing the marsh to survive channelward of the structure. They provide habitat and cover for small fish. The use of stone or riprap revetments is environmentally preferable to bulkheads.

Groins interrupt the natural flow of sand along a shoreline and may adversely change the characteristics of the intertidal zone by accumulating sand in one area of shoreline while starving another.

COST ASSESSMENT

Costs vary for different types of erosion control and from contractor to contractor. The costs of protection, both structural and non-structural, depend upon construction details, longevity of the type of protection considered, the risk and consequence of failure, availability of construction materials and degree of maintenance required.

Contracts for shore protection projects should clearly identify the responsibilities of both parties, the owner and contractor. The contract should be based on plans and specifications and include prices for the work. It is important that both parties understand the scope of work. The property owner is encouraged to get estimates, or bids from several contractors to insure quality work at the lowest price.

Waterfront property owners should be aware that any method of shore protection, if properly implemented, is expensive. Cost must be considered with respect to the amount of erosion currently experienced and the amount of protection that will be needed to control future erosion.

DESIGN CRITERIA

The contractor or property owner will be required to develop a final plan for an erosion control project that includes a layout drawing, construction details, and material specifications. Design considerations will vary for each method of shore erosion control and are discussed in the next section.

TYPES OF EROSION CONTROL

This section presents typical shore protection measures with a discussion of site characteristics, construction materials, design considerations, maintenance requirements, advantages, and disadvantages. A careful analysis of the erosion control measures will reveal several that may be adequate to solve the specific problems on your property. Costs should be assessed early in the planning effort, because they will vary greatly among the methods of erosion control and the level of protection provided.

Protection measures which best provide for the conservation of fish and plant habitat are encouraged by the Department of Natural Resources. Erosion control measures should be considered in the following order of preference:

- No action
- Relocation of threatened structures
- Non-structural stabilization including beach nourishment, slope grading and marsh creation
- Shoreline revetments
- Offshore breakwaters
- Groins
- Bulkheads

These recommendations are consistent with the objectives of the Chesapeake Bay Restoration Program and with provisions of Maryland's Critical Area Protection Program which encourages the use of non-structural shore protection measures in order to conserve and protect plant, fish and wildlife habitat.

NON-STRUCTURAL

The first three protection measures mentioned above fall into this category. The consideration of any of these methods requires careful planning and design considerations to withstand the erosive forces that may be encountered on your property.

NO ACTION AND RELOCATION

Description

A property owner should first consider taking no action. Often, a property owner's reaction to shore erosion is to act immediately. The property owner is advised to estimate the losses if no action is taken, especially if the land is undeveloped or relatively inexpensive structures are at risk. In some circumstances, the property will have only a very low erosion rate or experience erosion only during major storms. It may be desirable under these site characteristics to leave the shoreline in its natural condition. If the encroachment of the water on the property threatens valuable structures, then relocation should be the next alternative considered.

Site characteristics

The shoreline is usually flat. The exposure to the forces of erosion must be minimal and the erosion rate low to nonexistent. Sufficient land should also be present between the water and any structures to withstand the erosion rate during the lifetime of the structures.

Advantages

The advantages of this option are saving money and avoiding accelerating erosion on adjacent properties. The relocation of any structures could cost less than erosion control measures.

Disadvantages

The loss of any waterfront property may be costly and this option provides no protection from erosion. Relocation of structures takes special equipment and technical expertise and could cost as much or more than an erosion control structure. The introduction of sediment from uncontrolled erosion into the water may also be harmful to fish and aquatic plants.

BEACH NOURISHMENT

Description

Beach nourishment is the replacement of sand along the shoreline of an eroding beach. This method of control takes advantage of the natural protection that a beach provides against wave attack. Beach nourishment may also be used in combination with other methods of shore erosion control such as groin fields and breakwaters.

Site Characteristics

Beach nourishment is appropriate where a gently sloping shoreline is present. It is also appropriate where the erosion rate is low.

Construction Materials

The sand applied in a beach nourishment project should be identical to the original beach. A coarser sand may erode more slowly than a finer sand. The sand may be dredged and pumped from offshore or transported from upland sites by trucks and dumped.

Design Considerations

The erosion rate of the property is probably the most important element in designing a beach nourishment project. If the rate is high then beach nourishment may not be appropriate.

The direction and rate of movement of sand along the shoreline should be determined. Sand may be placed directly along the eroded shoreline or at a point updrift, allowing natural currents to move sand downdrift. The resulting shoreline protects the area in back of it by sacrificing the newly deposited sand. If the added materials are eroded their eventual fate should be considered, to avoid shoaling and filling of adjacent properties and waterways.

Maintenance requirements

Periodic replenishment of the beach using appropriate size sand will help maintain the beach. The need to replenish the beach depends upon the rate of erosion at the particular site. Although the original cost of the addition of sand may be low, the cost of periodic replenishment may rival a more permanent solution.

Advantages

Beach nourishment provides effective protection without altering the recreational values or natural integrity of a shoreline. In providing protection, beach nourishment benefits rather than deprives adjacent areas. This option maintains access along the beach for activities such as swimming and fishing.

Disadvantages

Along shorelines where no beach exists or removal of the sand is rapid it may be difficult or impracticable to maintain a beach of sufficient dimensions to protect your property. Even well developed beaches do not provide total protection during major storms.

The addition of sand may also result in shoaling of adjacent properties and waterways and increase turbidity during the placement of the sand. This can cause temporary damage to fish and submerged aquatic vegetation.

SLOPE GRADING AND TERRACING

Description

A shoreline bank may be unstable due to the steepness of the slope. Slope grading and terracing (Figure 6) will reduce the steepness, and therefore, decrease erosion caused by waves striking a steep slope.

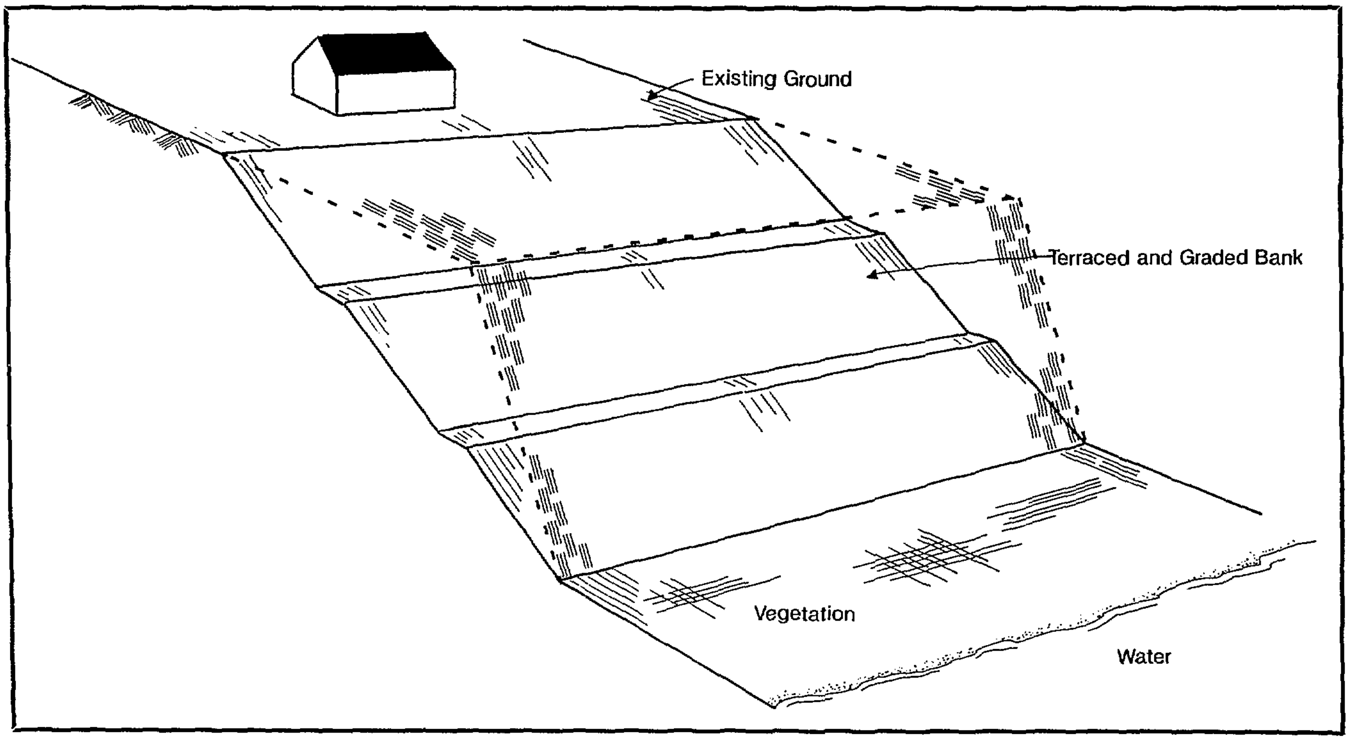


Figure 6. Grading and terracing.

Site Characteristics

The shoreline must have a steep slope where erosion is present.

Construction Materials

No additional materials are required for this type of shoreline protection other than top soil, vegetation and materials for surface/subsurface water management such as ditches or drains.

Design Considerations

If wave energies are high, the use of slope reduction and terracing may not be enough to stop erosion. The slope of the existing shoreline and the desired one must be determined. A recommended design is 5:1 (average for terracing), although a slope of 3:1 is often satisfactory - especially if combined with other methods of shore protection. It is recommended that regraded banks be stabilized with plants.

The control of surface and sub-surface runoff is necessary to maintain slope stability and to prevent the destruction of any grading that is performed on the site. Generally, the cost for this procedure is low but varies. The cost rises dramatically if materials need to be removed from the site.

Maintenance Requirements

Periodic regrading and replanting may be necessary depending upon the erosion rate. The use of additional material may also be necessary to maintain the proper slope.

Advantages

Slope grading and terracing can result in land that is more useful to the property owner and provides access to the waterfront. The process can also be combined with erosion control structures for increased effectiveness at low additional cost.

Disadvantages

Grading and terracing alone is generally not effective against intensive wave action by itself. It cannot be done where bulkheads or revetments are adjacent to or in the proximity of your property.

MARSH CREATION

Description

Tidal marshes form the transition zone between open water and upland. They are recognized as vital links in the food chain of the Chesapeake Bay. Tidal action in marsh areas provides nutrients that are converted to plant material. The plant material is grazed upon directly by wildlife and waterfowl, or is transported by the tide to open water to nourish fish and other aquatic organisms.

Tidal marshes provide habitat for thousands of species of plants and animals. Many of these species, particularly fish, shellfish, and furbearing animals are of direct commercial and recreational importance. Marshes also provide natural shore erosion control, better water quality, and recreation and education opportunities.

Planting a marsh along an eroding shoreline, therefore, provides shore protection and many environmental benefits.

Site characteristics

The basic procedure for preparing and planting a marsh site is shown in Figure 7. The vegetation planted in this procedure has the potential of trapping sediment lost from the eroding banks as well as from sand moving along the shoreline. Over time, the band of trapped sediments may increase, resulting in the widening of the marsh. This will cause the mean high tide line to move away from the front of the eroding bank and the dense buffer of vegetation will protect the shoreline against waves.

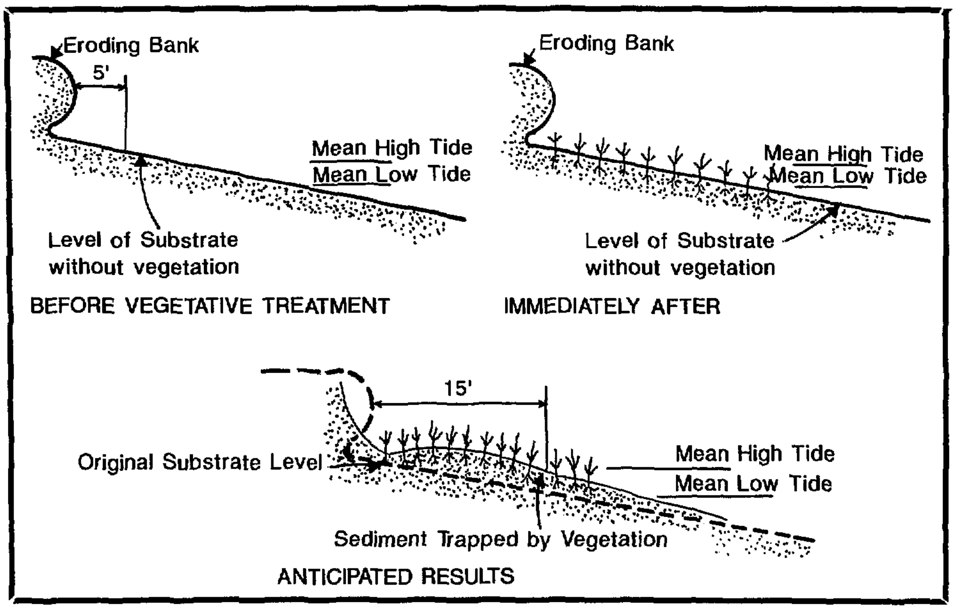


Figure 7. Potential role of vegetation in tidal shoreline stabilization.

Environmental factors affecting the success of the vegetative plantings on tidal beaches include the width of the existing beach, depth and type of beach soil, shoreline geometry, and shoreline orientation.

Before choosing this type of shoreline protection you should decide if the site meets certain requirements. Table 1, developed by the Soil Conservation Service, evaluates the potential for a particular site for successful marsh creation.

DIRECTION FOR USE

1. Evaluate each of the first four shoreline variables and match the site characteristics of the variable to the appropriate descriptive category.
2. Place the Vegetative Treatment Potential (VTP) assigned for each of the four variables in the right hand column.
3. Obtain the Cumulative Vegetative Treatment Potential for variables 1, 2, 3 & 4 by adding the VTP for each.
4. If it is 23 or more, the potential for the site to be stabilized with vegetation is very good and the rest of the table need not be used. If it is below 23, go to step 5.
5. Determine the VTP for shoreline variables 5 through 9 and obtain the cumulative VTP for variables 1-9.
6. Compare the cumulative VTP score with the Vegetative Treatment Potential Scale at the bottom of this page.

SHORELINE VARIABLES	**DIRECTION FOR USE** The Vegetative Treatment Potential (VTP) is Located in Upper Left Hand of Each Category Box					**VTP**
1. Fetch: Average distance in miles of open water measured perpendicular to the shore and 45° either side of perpendicular to shore.	8 Less than 0.5 miles	7 0.5 thru 1 mile	0 Greater than 1 mile[1]			
2. General shape of shore line for distance of 200 yards on each side of the planting site.	8 Coves	3 Irregular shoreline	0 Headland or straight shoreline			
3. Shoreline orientation: General geographic direction the shoreline faces.	5 Any orientation less than one-half mile fetch	3 West to North	2 South to West	1 South to East	0 North to East	
4. Boat traffic: Proximity of site to recreational and commercial boat traffic.	5 None	3 1-10 per week within ½ mi. of shore	2 More than 10 per week within ½ mi. of shore	1 1-10 per week within 100 yds. of shore	0 More than 10 per week within 100 yds. of shore	

Cumulative Vegetative Treatment Potential for Variables 1, 2, 3 & 4 ________

If this score is 23 or above, the potential for the site is very good and the rest of the table need not be used. *If it is below 23, go to step 5 below.*

5. Width of Beach Above Mean High Tide in Feet	3 Greater than 10′	2 10′ thru 7′	1 6′ thru 3′	0 Less than 3′	
6. Potential width of Planting Area in Feet[2]	3 More than 20′	2 20′ thru 15′	1 14′ thru 10′	0 Less than 10′ Do Not Plant	
7. On Shore Gradiant: % slope from MLW to toe of bank	6 Below 8%	3 8 thru 14%	1 15 thru 20%	0 over 20%	
8. Beach Vegetation	3 Vegetation below toe of slope	0 No vegetation below toe of slope			
9. Depth of sand at Mean High Tide in inches[3]	3 More than 10″	2 10″ thru 3″	0 Less than 3″		

Table 1. Vegetative Treatment Potential for Eroding Tidal Shorelines in the Mid-Atlantic States. (from U.S.D.A., Soil Conservation Service)

Cumulative Vegetative Treatment Potential for Variables 1 - 9:

VEGETATIVE TREATMENT POTENTIAL (VTP) SCALE

If the VTP is: Between	And	Potential of site to be Stabilized with Vegetation
40	33	Good
32	24	Good
23	16	Good
below 16		**Do Not Plant**

[1] Do not plant.
[2] If tidal fluctuation is 2.5 feet or less, measure from Mean Low Water to toe of bank. If greater than 2.5 feet, measure from the Mean Tide Level to toe of bank.
[3] Refers to the depth of sand deposited over the substrate.

Construction Materials

Adding sediments similar to the existing beach may be necessary before marsh creation can be performed.

The following marsh and beach grasses may be appropriate for protecting your waterfront property and are commercially available in Maryland:

Marsh Plants;

Smooth Cordgrass (Spartina alterniflora). This plant is the dominant marsh grass from Newfoundland to central Florida. This species ranges from 1.5-8 feet tall with soft and spongy stems often more than 0.5 inch thick. Smooth Cordgrass can be planted with a better chance of success than any other coastal marsh species native to the United States. This species will grow well in brackish or salt water(salinities of 10-35 parts per thousand).

Saltmeadow Cordgrass (Spartina patens). This species is common in the irregularly flooded high marsh areas along the Atlantic coast. It is able to withstand extended periods of both flooding and drought, growing in spots where the surface drainage is poor and water ponds during rainy periods. It cannot, however, tolerate the daily flooding of the intertidal zone. Saltmeadow Cordgrass is a valuable stabilizer in the zone between Smooth Cordgrass and upland grass species.

Smooth and Saltmeadow Cordgrass are strong sod formers, but relatively poor seed producers. The Smooth Cordgrass usually grows in the area between high and low tides along brackish streams. Saltmeadow Cordgrass is usually found between Mean High Tide and the area above any tidal influence. Both cordgrasses tolerate a wide range of salinity and substrate textures, from coarse sands to silty-clay sediments. Both are well adapted to the very wet, low oxygen soil conditions characteristic of most salt marshes.

Beach Grass (Ammophila breviliguata)

American Beachgrass is native to the mid-Atlantic coastal sand dunes from Maine to North Carolina. It may be planted above the area commonly planted with Saltmeadow Cordgrass to provide additional stabilization.

Further information on planting these and other species can be obtained from county offices of the Soil Conservation Service.

Design Considerations

Marsh creation projects are particularly sensitive and adversely impacted by human traffic. Marsh plants should be protected, where possible, from waterfowl grazing.

Careful selection of the varieties of plants with regard to local soil, water (salinity), and wind conditions, is necessary to achieve successful erosion control. Native plants are more likely to thrive than imported vegetation. Experience has shown that *Spartina alterniflora* and *Spartina patens* will grow well along most of the shoreline in Maryland.

The width of a marsh creation project is based on characteristics of the site including fetch, shoreline orientation and the water depth of the nearshore area to be planted. At a minimum a marsh creation project should be 10 feet wide. Typical marsh creation projects have widths of 20-25 feet.

When the water depths within the proposed planting area are too deep for creating a marsh, the addition of sand and grading may be necessary.

The effect of shade from overhanging trees on marsh creation projects must be considered. All sites chosen for marsh creation must receive at least six hours of direct sunlight daily throughout the growing season (April-October). Trees must be pruned or removed to allow for the daily minimum amount of direct sunlight.

The State of Maryland considers the use of vegetation for shore erosion control to be an important part of its Chesapeake Bay Restoration Program. The Shoreline Erosion Control Program (SEC), was created within the Maryland Department of Natural Resources to encourage property owners who have shore erosion problems to use non-structural techniques for which the state can provide a (50%) matching grant.

In general, property owners whose shorelines meet the following site characteristics are eligible to participate in the State SEC Grant program:

- Presence of intertidal marsh grass growing on the shore within 500 feet of where the project will be located,
  and
- Less than a one mile fetch.

Waterfront property owners may call or write the SEC Program staff or their local Soil Conservation District office to obtain further information.

State of Maryland
Department of Natural Resources
Shore Erosion Control
Tawes State Office Building D-4
Annapolis, Maryland 2140
Phone: (410) 974-3727

Professional guidance in selecting plants for marsh creation projects is recommended to increase the likelihood of success.

Maintenance Requirements

Plants that are removed or die during the early stages of growth must be replaced immediately to insure the undisturbed growth of the remaining plants. The removal of debris and selective pruning of trees is also a good maintenance practice. After significant growth has occurred only periodic inspections may be necessary. Protection measures, such as fencing, must be taken to keep waterfowl from eating the young plants.

Advantages

For a minimum investment, marsh creation will help bind the soil against erosion and extend the life of erosion control structures (revetments, bulkheads etc.). Where no structure exists it will slow down erosion. The cost for this type of protection is much less than most other types of shore erosion control.

A created marsh along the shoreline not only reduces erosion but also enhances the fisheries value of the area. It also provides an attractive natural shoreline. In many cases the newly created marsh will also serve as a buffer strip. This strip can reduce the amount of sediments and nutrients entering tidal waters by filtering upland runoff.

Disadvantages

This method of erosion control may only be used along shorelines with low erosion rates.

STRUCTURAL

Structural erosion control devices are divided into two broad groups according to their purpose; 1) those designed to stabilize a bank or fastland, and 2) those designed to stabilize a beach or promote accretion.

Two basic types of structures are designed to stabilize a bank: filter structures and wall structures. Filter structures reduce the level of the wave's strength while keeping soil from passing through to the water. Wall structures are impervious vertical walls that separate the natural shoreline from water and wave action. The success of both types depends upon adequate design and construction.

FILTER TYPE STRUCTURES (Stone Revetments and similar structures)

Description

Filter type structures are designed to reduce the energy of the incoming waves as they strike the surface of the structure, while at the same time, hold the soil beneath it in place. Reduction of the energy of incoming waves is accomplished by the sloping shape of the structure and by its rough surface. Filtering qualities result from the use of layers of varying sized stone and other materials. In construction, the bank is first graded to achieve the shape required for the structure being installed. A filter cloth is placed on and attached to the graded bank. This cloth is similar in weave and texture to tightly woven burlap but is made of a non-deteriorating plastic. On top of the layer of filter cloth is placed a six to eight inch layer of stone. This layer of stone holds the filter cloth in place and becomes the bottom layer of the actual structure. A variety of outer layers are then placed on top of the stone. This type of structure is preferred to bulkheads where groundwater is part of the erosion process.

A stone revetment (Figure 8) is constructed by placing progressively larger blocks or pieces of stone on filter cloth or fine gravel.

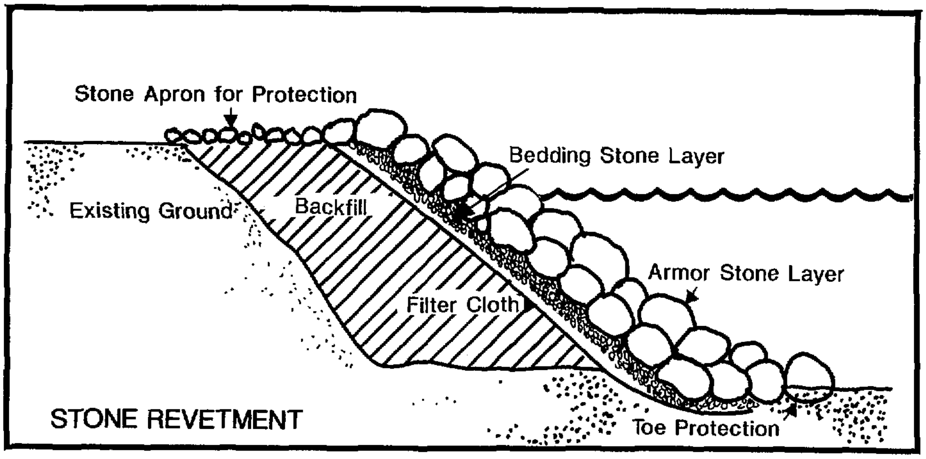


Figure 8. Profile of a stone revetment.

The armor layer must be stable against movement by waves. The armor layer is typically made of rough angular rock. The underlying filter layer supports the armor layer against settlement. It allows groundwater drainage through the structure and prevents the soil beneath from being washed though the armor layer by waves or groundwater seepage. Toe protection prevents settlement and protects the edge of the revetment from washing away. In areas where large waves are expected, an overtopping (or splash) apron is sometimes added. Generally, the apron is a layer of 10 to 12 inch stone about 10 feet wide that extends landward from the top of the revetment.

Site Characteristics

Revetments, to remain stable, must be built on gentle slopes (2:1 or better slopes).

Prior to construction, the ground should be graded to a gentle slope and fill material should be added only as needed to achieve a uniform grade. The fill should be free of large stones and firmly compacted before revetment construction proceeds.

Construction materials

Heavy armor stones with an interlocking design are needed for a revetment to withstand storm waves. There are many types of materials that are used for the construction of revetments, however, quarry stone is the most reliable type of revetment material.

Design considerations

Important design considerations include the proper height and width of the revetment, protection from erosion in front of the revetment, and analysis of the supporting soil characteristics. Revetments should be high enough to prevent overtopping by waves. To deter erosion along the sides, additional stone should be placed perpendicular to the revetment. Erosion in front of the revetment can be prevented by the placement of additional stone. The soils comprising the area under the revetment must be analyzed to determine if they can support the structure.

If a beach is present in front of the revetment, access should be considered for recreational activities. When access to boats in front of a revetment is desired, a pier constructed over the revetment may need to be designed.

Maintenance Requirements

Periodic maintenance may be necessary to fill holes and restore the height and width of the revetment. These maintenance activities are required because the individual stones comprising the revetment may be subject to movement and settling.

Toe protection should be monitored on a regular basis. The steeper a revetment the more frequently it should be inspected because the toe is likely to erode more quickly. Other types of erosion control should be considered in areas where movement of the structure may occur because of unstable slopes.

Advantages

Where the shoreline requires structural measures to control erosion, a sloping stone revetment is strongly recommended for the following reasons:

- Stone used in this type of structure does not degrade over time.
- Waves reflecting from sloping revetments usually cause only minor disturbance and scour of the sediment offshore and at the toe of the structure.
- This type of protection is unlikely to fail completely during a storm. There is a possibility that stones may be dislodged if waves wash over the revetment during a storm. However, the stones may be recovered and replaced afterwards.
- Stone generally provides a better habitat for aquatic organisms than the materials that are used in most other types of structural shoreline protection.
- No preservatives are used in revetments such as those found in bulkheads which discourage the growth of aquatic plants and animals.

Disadvantages

A large amount of stone is needed to properly build a revetment. Costs for buying and transporting the stone may be considerable. It may be difficult to transport construction materials to the shoreline on properties where access is limited by bridges or roads with low load limits, high banks, or shallow nearshore areas. Under these circumstances another type of structure may be necessary.

STRUCTURAL — WALL TYPE STRUCTURES

Wall type erosion control structures generally form a wall to retain material on the upland side and separate erodible land from damaging wave action. Two such structures, gabions and bulkheads, are described below.

GABIONS

Description

Gabions are rectangular wire baskets filled with stone. Gabions are very versatile. They may be used as revetments, groins and offshore breakwaters. Figure 9 shows gabions being utilized as a wall type erosion control structure.

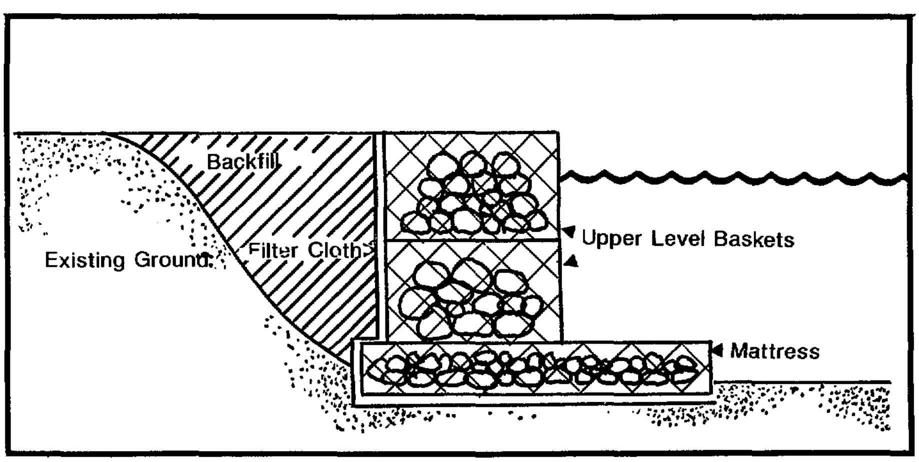


Figure 9. Gabion (used as a wall).

There are two types of gabions: mattresses and upper level baskets. Mattresses are baskets which are usually 9 to 12 inches thick and provide a foundation for the upper level baskets. Upper level baskets are available in 6, 9, and 12 foot lengths and 1, 1.5, and 3 feet heights.

At the construction site, gabion baskets are unfolded and assembled by lacing the basket edges together with wire. Individual baskets are then laced together, stretched, and filled with stone. The lids are closed and then wired to other baskets. The result is a large heavy mass that is not as easily moved by waves as single stones might be.

Site Characteristics

Generally, gabions are suitable on sites where bulkheads or revetments are acceptable.

Construction Materials

The baskets are made of galvanized and polyvinyl chloride (PVC) coated steel wire in a hexagonal mesh. The stones used to fill the baskets are usually in the range of 4 to 8 inches.

Design Considerations

Gabions are suggested for use in brackish and freshwater environments, where corrosion of the wire will be minimal.

The baskets should be staggered and joined, much like the courses of a brick wall, in order to form a stronger structure. It is also recommended that the seaward end of the mattresses be anchored with large stones or anchor screws.

Maintenance Requirements

Damage to the baskets should be repaired immediately. Missing stones should also be replaced from time to time to maintain a tightly packed basket. This will minimize stone movement which can cause abrasion damage to the basket wires.

Advantages

The construction of gabions may be accomplished without heavy equipment. The structure is flexible and continues to function properly even if the foundation settles. Adding stones to the baskets is an easy maintenance procedure. The cost of using gabions may be low compared to other protection methods depending on the distance of the stone from the job site.

Disadvantages

Gabion baskets may open under heavy wave action releasing the stones and scattering them. Water borne debris, cobbles, ice, and foot-traffic can damage the baskets. Corrosion of baskets placed in salt water begins with the smallest defect in the protective coatings.

BULKHEADS

These structures are walls designed to protect the shoreline by providing a barrier to waves. They are most appropriate where fishing and boating are the primary uses of the shore, and for deep water commercial, port applications.

Description

There are two basic types of bulkheads: sheet pile and post-supported. Sheet pile bulkheads (Figure 10) consist of interconnecting very tightly-spaced sheets of material driven vertically into the ground with special pile driving equipment.

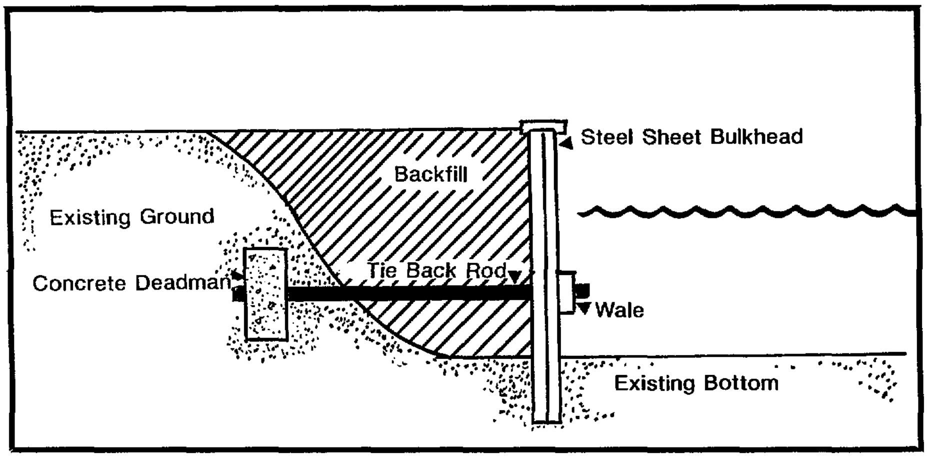


Figure 10. Basic design of a sheet pile bulkhead.

The sheet pile bulkhead may be cantilevered or anchored (Figure 11). A cantilevered bulkhead is a sheet pile wall supported solely by the depth to which it is buried in the ground. The anchored bulkhead is supported by embedded anchors or tilted structural bracing on the water side.

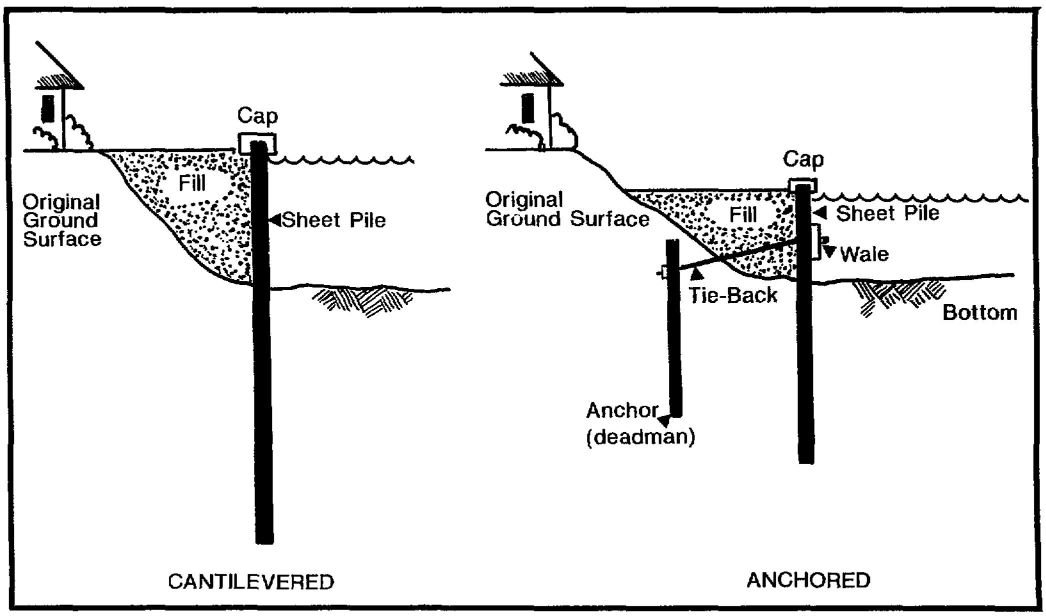
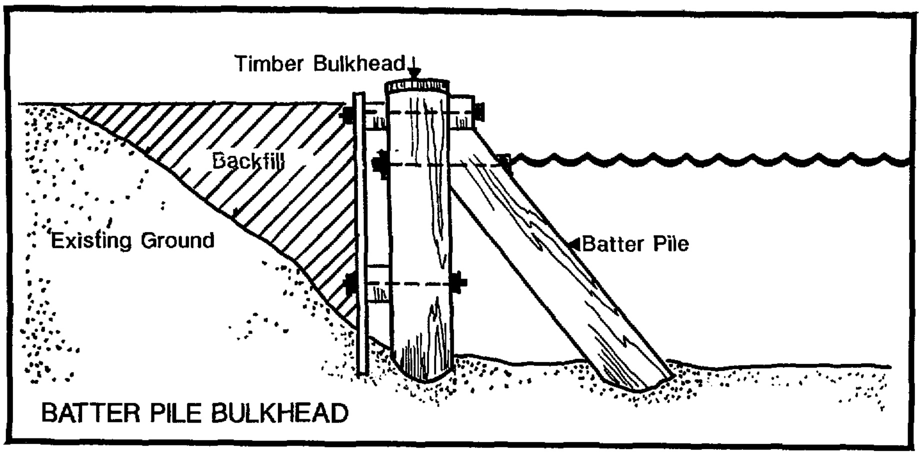


Figure 11. Cantilevered and anchored sheet pile bulkheads.

There are two types of post-supported bulkhead: batter pile and tie back (Figure 12). They both consist of evenly spaced piles (usually timber) driven into the ground with an attached facing material that forms a retaining wall. The posts support the bulkhead and may be of the cantilevered or anchored type.



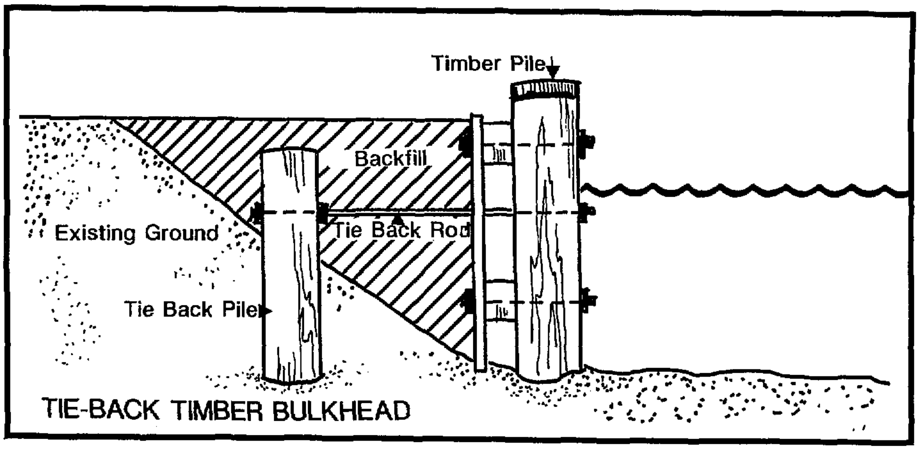


Figure 12. Profile view of the two types of post-supported bulkheads.

Bulkheads are not generally needed along shorelines with low fetch where large waves are not common.

Site characteristics

In general bulkheads should be limited to sites where the use of marsh creation or stone revetments to provide shore erosion control is inappropriate. Bulkheads may be the preferred shore erosion control option under the following circumstances:

- High energy shoreline
- Inaccessible shoreline
- Adjacent bulkheaded shoreline
- Commercial vessel berthing (Deep water application).

Construction Materials

Sheet-pile bulkheads may be constructed of steel or timber. The type of soil at a site determines the type of sheet-piling that can be used. Steel sheet piles can be driven into hard sediments and some soft rock. Timber sheet piles can be driven into softer sediments. Steel bulkheads are constructed of a marine alloy to resist corrosion by salt water. Ends of the metal sheeting that protrude above the bank are covered by an a cap that is bolted on.

Treated timber bulkheads are generally less expensive than steel. There are several different types of treatments for the timber used in marine structures including creosote, chromated copper arsenate and a combination of the two.

Design Considerations

Factors influencing design are: exposure to waves, depth of water, height of bank, foundation conditions, penetration of the piling, height and alignment, and the need for erosion protection in front of the bulkhead. Figure 13 depicts a typical bulkhead cross section with many of the necessary structural design precautions.

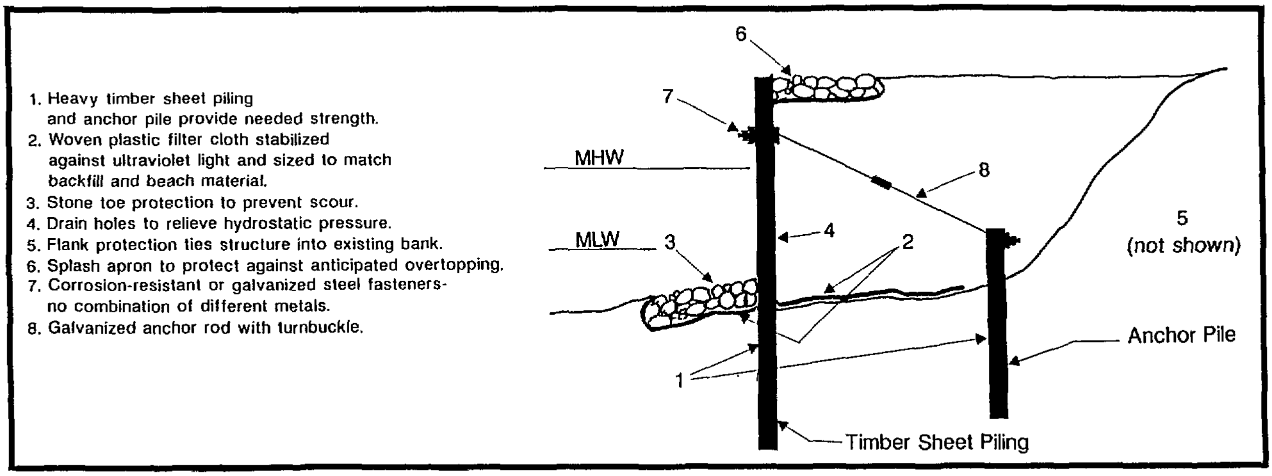


Figure 13. Illustration of structural design considerations for bulkheads (from the U.S. Army Corps of Engineers (1981)).

Bulkheads most commonly fail because of (a) inadequate design or construction using poor quality materials to withstand waves or to prevent overtopping, and (b) undercutting of the front of the structure. The pressure of the soil and water on the landward side can also topple the structure.

Maintenance requirements

Sheet pile bulkheads should be inspected regularly to check for sheet failure and possible loss of soil behind them. Failures may be caused by freezing and thawing, direct wave impact, or debris impact.

The protective coatings on the hardware, sheeting, and pile tops of timber bulkheads should be maintained. Splits in the wood need to be mended on aging bulkheads. Soil washing out from behind the bulkhead should be replaced.

Advantages

Steel bulkheads that are properly designed and built are quite strong and are suitable where severe conditions are expected. Construction materials are available in a variety of sizes and shapes. Steel bulkheads have been in use for many years and design and engineering data are time tested and readily available.

Materials for a timber bulkhead are readily available. The structure will usually provide adequate protection if properly constructed and maintained.

Disadvantages

Steel bulkheads are susceptible to corrosion after a time depending upon the grade of the steel. These structures reflect waves causing erosion at its base (toe).

Timber bulkheads are also susceptible to erosion at the base unless toe protection, such as stone, is used. The creosote and chromated copper arsenate used to prevent infestations by borers and rot can cause burns and may adversely affect other marine organisms. The structural members of timber bulkheads can splinter. Wave reflection off the vertical face of timber and steel bulkheads produces unsuitable habitats for marine organisms. The cost of constructing steel sheet pile bulkheads is much higher than that for a timber bulkhead. Bulkheads may also cause increased erosion to adjacent properties.

STRUCTURAL — OTHER

BREAKWATERS

Description

Breakwaters are structures, made of various materials, placed offshore to reflect or decrease wave energy, creating a low energy zone, between the structure and the existing beach. Decreases in wave strength significantly affect the transport of sand by a wave. Sand moving along the shoreline may be slowed or deposited on the beach side of the structure (Figure 14). The decrease in sand moving along the shoreline may cause increased erosion to adjacent properties. This erosion can be minimized by adding sand between the breakwater and the beach. Breakwaters may be used to protect selected areas of shoreline, headlands or harbors.

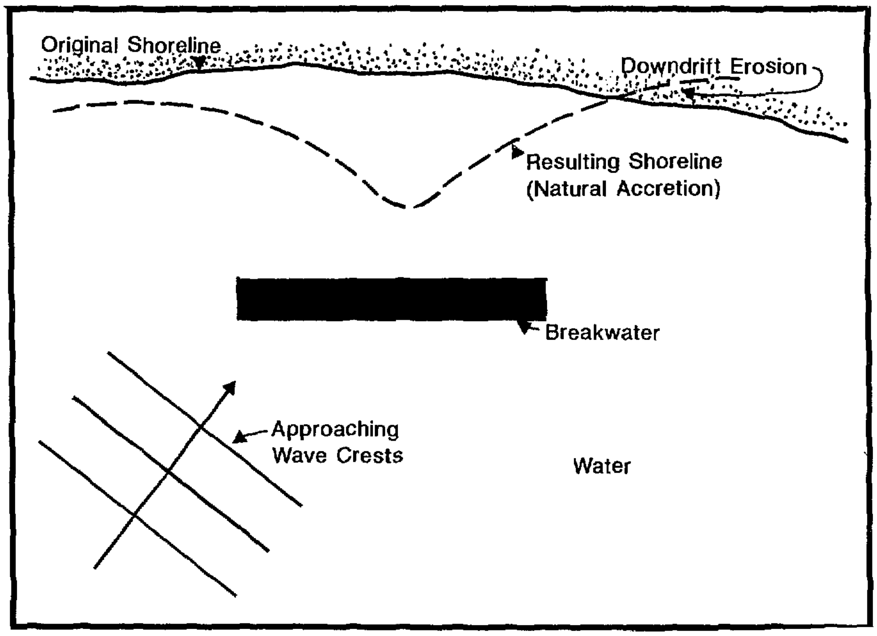


Figure 14. Breakwater exhibiting the deposition of sand on the leeward side.

Breakwaters are structures that extend from the bottom to a designed height above the normal water level.

Site Characteristics

A gently sloping beach with an unacceptable rate of erosion is the basic type of site suitable for offshore breakwaters. Movement of sand along a shoreline is necessary to produce the desired effect, a build up of sand between the structure and the beach. If the movement of sand along the shoreline is not to be interrupted, then proper design of the structure is essential. In addition, the placement of sand between the structure and the beach may be necessary to offset erosion to adjoining properties.

Construction Materials

Breakwaters may be constructed of large stones, gabions, concrete rubble, concrete form structures, metal or wood sheeting or sand filled bags. Other materials, such as plastics, are also occasionally used.

Design Considerations

The effectiveness of a breakwater depends upon its height, amount of water and sand allowed through, distance from shore, length, spacing of each unit, type of soil under the structure, structural weight, and foundation type. The most important of these is the height, because it controls how much of each wave reaches the shoreline. Breakwaters are usually installed in shallow water (less than 4 feet deep) due to the cost.

The service of a professional engineer is advised for the construction of offshore breakwaters due to the complex nature of their design.

Maintenance Requirements

The maintenance required for breakwaters is the same as that for revetments and bulkheads.

Advantages

Protection is accomplished without the placement of a structure on the shoreline. Recreational use of the shoreline for swimming and sunbathing is preserved and may be improved. Minimal impact on the environment occurs when stone is used in the construction of a breakwater.

Disadvantages

These structures are subject to erosion at the base and physical damage from large waves.

GROINS

Groins are structures that interrupt the flow of sand for the purpose of widening an already existing beach and thus provide additional protection for the beach. They are not designed for the purpose of creating a beach.

Description

Groins are narrow structures of varying lengths and heights that extend, fingerlike, into the water and are usually constructed perpendicular to the shoreline (Figure 15).

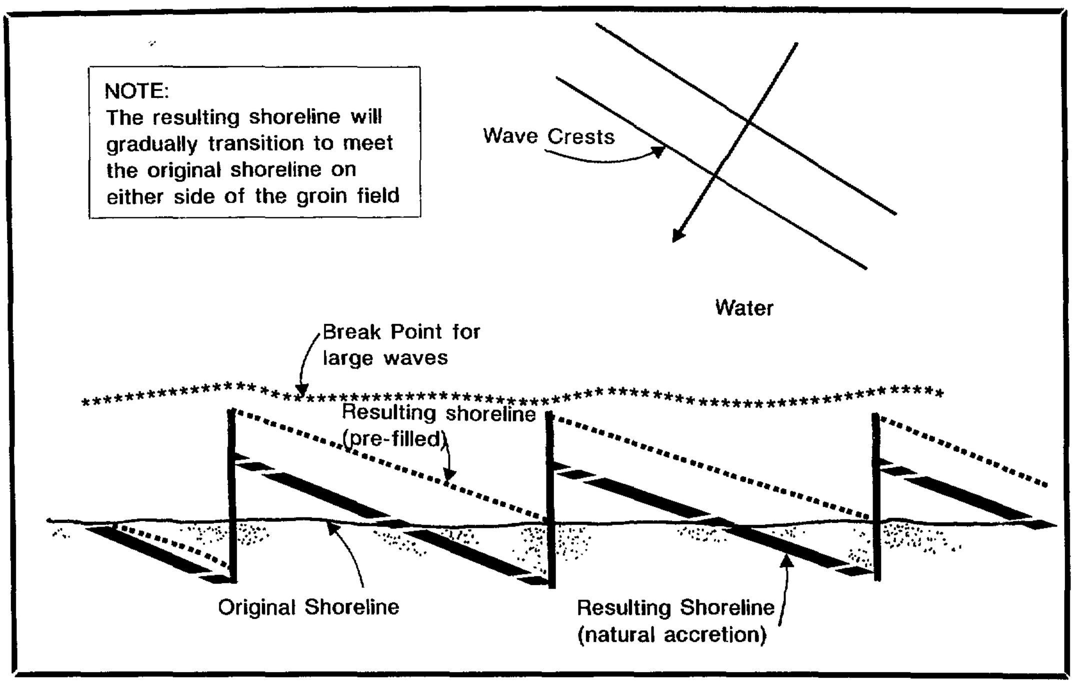


Figure 15. Groin field with typical sediment buildup.

Used singularly, or in groups known as groin fields, their primary purpose is to trap and retain sand, filling the areas of shoreline between them. Groins interrupt the movement of sand along the shoreline. Ideally, the area between the groins is filled, then sand can continue moving along the shoreline. Sand usually accumulates between the groins with more accumulation on one side than the other dependent on the direction of the movement of sand along the shoreline. The accumulation of sand between the groins acts as a barrier that waves can attack and erode without damaging upland areas. An adequate quantity and movement of sand along the shoreline is necessary to produce accumulations of sand between the groins. If sand transport is equal in both directions, groins may not be effective.

Site Characteristics

The shoreline should be a gently sloping beach. It is important to consider the direction and amount of sand moving along the shoreline before choosing groins as a method of shore erosion control.

Construction Materials

Stone, concrete, gabions, timber and steel are the primary materials used in the construction of groins (Figure 16). Many other materials are also used but are not as dependable as these. Quarry stone should be considered where locally available. The structural form of a stone used in construction of a groin is about the same as for a stone revetment. Filter cloth should be installed under any stone or rubble groins.

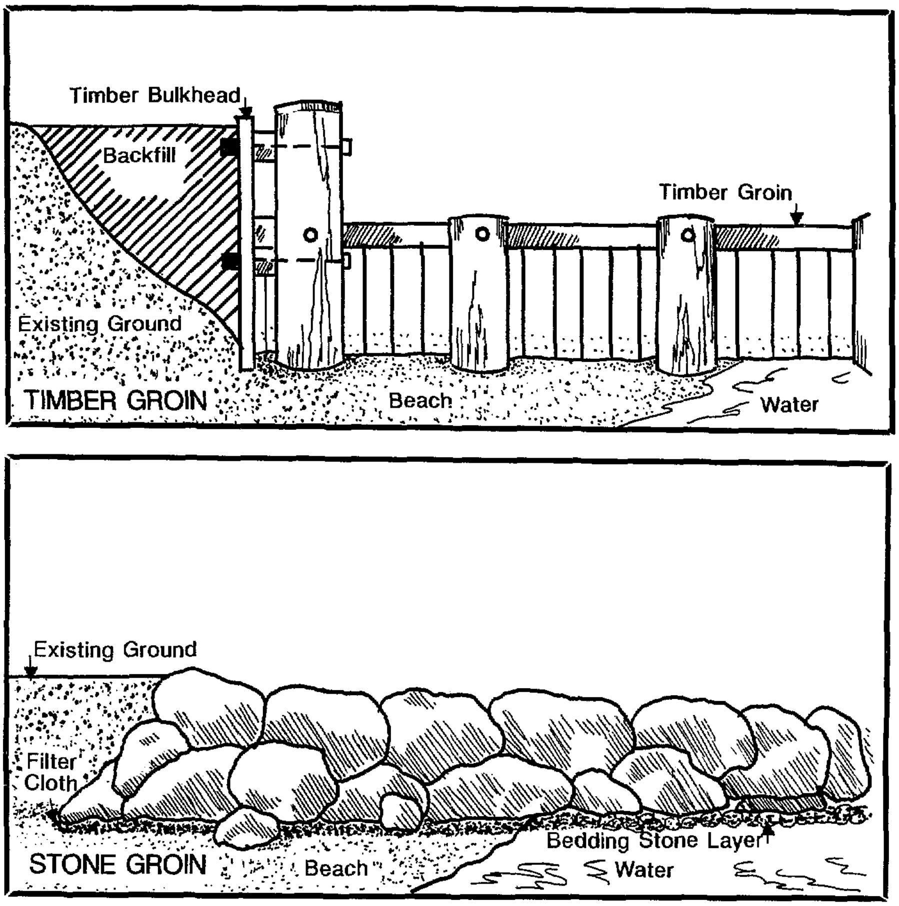


Figure 16. Timber and a stone groins (the view of a steel sheet groin would be similar to the timber and the view of a concrete rubble groin would be similar to the stone groin).

Timber and steel groins do not require the use of filter cloth. Recommendations for construction materials contained in the section for sheet pile bulkheads applies to groin construction.

If the movement of sand along the beach is mixed with too much clay or silt, filling the area between the groins with sand from an outside source is necessary.

Design Considerations

Important design considerations for groins include:

- Height
- How far they should extend into the water or onto the land
- Spacing between structures, if you are constructing a groin field
- How much sand and water should be allowed to pass through the groins

Groins may be built either high or low in relation to the existing beach profile. High groins effectively block the movement of sand along the shoreline, provided sand cannot pass through them. Low groins, built so waves can wash over them, permit sand to pass over the structure and nourish adjacent beaches.The extension of a groin must be sufficient enough to create a desired beach while allowing adequate passage of sand around the end. A groin extending beyond the area of the shoreline where the waves break, forces sediments too far offshore to be returned to the adjacent shorelines. The groin should extend inland far enough so that storm waves cannot erode around the upland side, making the structure ineffective.

The correct spacing of groins depends on their length, wave strengths in the area, the amount of sand moving along the shoreline and the desired final shoreline shape. Properly designed groins are spaced so that sand accumulates along the entire length of the area between groins. The shoreline erodes in some areas between groins that are positioned too far apart. Groins placed too close to one another may not allow for sand accumulation. Generally, groins are spaced two or three groin lengths apart.

The use of groins must be carefully considered. Many of the regulating agencies do not approve groin construction due to possible erosion of the adjacent shoreline.

Maintenance Requirements

The maintenance requirements for groins are essentially the same as discussed for those of revetments and bulkheads. In addition, the area between groins in a groin field should be monitored for sand loss. The addition of sand, if necessary, into the area between groins will protect upland areas and decrease the amount of time required for the area between the groins to fill naturally.

Advantages

Increasing the size of a beach provides a buffer, where wave energy may be absorbed, resulting in protection for upland areas. The stabilization of a beach may possibly add to the recreational value of the beach.

Disadvantages

Sand moving along a shoreline is interrupted by a groin, usually resulting in sand starvation of adjacent properties. Groin placement does not necessarily guarantee sand accumulation.

RECOMMENDATIONS FOR SHORE EROSION CONTROL STRUCTURES

Several important recommendations which should be considered in designing or maintaining all shore erosion structures are discussed below:

1) *Select the proper crest (top) elevation for any vertical structure.* Consider the combination of maximum tide and waves (run-up) that can be expected in the lifetime of structures. The height of structures necessary to prevent overtopping by waves depends upon the water depth and the maximum potential wave height at a site. Increases in the height and depth of structures increases the costs for materials and labor. The structure should be designed to withstand the forces of a storm that would occur once every 20 to 30 years on the average. An adequately designed structure provides protection for most storm conditions encountered without the undue higher costs of a more elaborate structure.

2) *Select the proper stone armor weight for revetments.* Shore protection structures must be strong. This can be accomplished by using heavy and massive components unlikely to be dislodged by waves or ice. The stone for revetments should be clean, hard, dense, durable and free of cracks and cleavages. For sloping revetments built in Maryland's Chesapeake Bay, a minimum stone weight of 650 pounds is recommended, unless the water depth fronting a particular structure is shallow, limiting the wave heights attacking the shore.

3) *Always include filter cloth in the design.* The purpose of filter cloth is to prevent soil from washing out behind or under the erosion control structure. The life of filter cloth is not well established, its use is certainly recommended. Filtering, one of the most important design details, is probably the most neglected and, therefore, poorly designed filters have caused more structures to fail than any other contributing factor. A properly designed filter allows water but not sand to pass through. Water must flow through a structure in order to eliminate the buildup of water pressure. Filtering can be provided through the use of graded stone on gravel in a range of sizes, or through woven, or non-woven synthetic filter cloths.

4) *Provide a bedding of small stone covered with armor stone at the toe of bulkheads.* Advantages gained by providing armor stone toe protection for bulkheads include:
   - Reduction in the number of waves hitting the bulkhead
   - Less water will spray over the top of the bulkhead
   - Erosion of the soil at the base of the bulkhead will be eliminated, therefore making it more structurally sound
   - Creation of a more favorable habitat for marine organisms

   The installation of armor stone toe protection should include filter cloth and a bedding layer of small stones. The small stones will reduce the potential for rupture of the filter cloth. Ideally, the armor stone should be piled as high as the highest storm waves expected. In many places the cost of using armor stone may be nearly as costly as a revetment. Under these circumstances it may be more prudent for the property owner to just construct a revetment instead of a bulkhead.

5) *Provide erosion control structures along property lines to prevent erosion along the side and behind the erosion control structure.* If a specified reach of beach has been protected completely, erosion on the side and behind the erosion control structures will not occur at those properties within the reach. However, if only a segment of the shoreline has been protected, adjacent shoreline could erode rapidly. The increased erosion could possibly endanger the shore protection structure. To prevent this, structures should be designed to protect the side and back of the erosion control structure consistent with the erosion rate and design life of the structure. Lengthening these structures may be necessary depending upon the erosional rate.

6) *Finally, more frequent maintenance of many erosion control structures should be performed.* Periodic maintenance of structures is necessary due to annual storm and winter damage. The maintenance varies with the structural type, but annual inspections should be made by property owners. For stone revetments, the replacement of stones that have been dislodged is necessary. For timber bulkheads, protective coatings should be maintained on hardware, sheeting and pile tops. Splits in the wood should be mended on aging bulkheads, and any backfill that has washed out should be replaced. Steel bulkheads should be inspected for sheet pile deterioration and for loss of backfill. Gabion baskets should be inspected for corrosion failure of the wire (the plastic coating can be removed by improper handling during construction or abrasion by stones inside the baskets). Baskets that are damaged should be replaced because waves will quickly empty them. Through periodic monitoring and maintenance, erosion control structures will protect the shoreline longer.

OTHER CONTROLS

INFILTRATION AND DRAINAGE CONTROLS

The erosion of steep bluffs along the shoreline may require the use of infiltration and groundwater drainage controls. Infiltration controls are designed to promote downward percolation of surface runoff while drainage controls divert water already present on the surface and in the soil. An example of an infiltration method: Water coming off the roof of a structure is collected by a gutter system and then diverted into a dry well. A drainage control could be a ditch or a swale on the surface. Subsurface drainage controls are complex and require the assistance of an engineer to analyze site conditions and offer a solution.

COMBINATION METHODS

The erosion controls described in this document may be used in various combinations, to complement each other and accomplish the desired protection when a single method is not enough. The nature of the erosion and desired extent of protection suggests which methods should be combined.

Marsh creation and beach nourishment may be considered for use with other methods to produce effective protection measures depending upon wave strength. Beach nourishment may be used in combination with groin fields and breakwaters.

Large waves can damage new marsh vegetation. Therefore, it may be necessary to provide temporary structural protection such as groins until the vegetation becomes established.

GLOSSARY

While not all of these terms are used in this book, many are used by shore erosion control professionals.

Accretion	Accumulation of sand or other beach material at a point due to the natural action of waves, currents and wind. A build-up of the beach (see Deposition).
Alongshore	Parallel to and near the shoreline; same as longshore (see Littoral drift, Longshore Current).
Apron	Predominantly used in stone revetments, referred to as "splash apron", to prevent loss of earth materials supporting the structure.
Bank	The rising ground landward of a beach, whether it be a bluff, bank, or gentle slope.
Bar	A fully or partly submerged mound of sand, gravel, or other unconsolidated sediment built on the bottom in shallow water by waves and currents.
Batterpile	Generally a timber pile; driven into the bottom to provide lateral support to a vertical protective structure.
Beach	A shoreline of unconsolidated material; extending from the low water line to a point landward where either the topography abruptly changes or permanent vegetation first appears.
Bluff	High, steep, broad-face bank at the water's edge (see Cliff).
Boulders	Large stones with diameters greater than 10 inches. Larger than cobbles.
Breaker	A wave as it spills, plunges or collapses on a shore.
Breaker Zone	Area offshore where waves break.
Breakwater	A structure aligned parallel to shore, designed to protect any landform or water area behind them from the direct assault of waves.
Bulkhead	A structure that retains or prevents the sliding of land or protects land from wave damage.
Clay	Extremely fine-grained soil with individual particles less than 0.00015 inches in diameter.
Cliff	High steep face of rock at the water's edge (see Bluff).
Cobbles	Rounded stones with diameters ranging from 3-10 inches. Cobbles are larger than gravel but smaller than boulders.
Crest	Upper edge or limit of a shore protection structure.
Current	The flow of water in a given direction.
Deposition	An accumulation of sediment on a beach, same as accretion.
Design Life	The minimum period of time a structure is expected to function, commonly established through an engineering design procedure.

Diurnal	Period or cycle lasting approximately one day. A diurnal tide has one high and one low in each cycle.
Dune	A hill or mound of loose, wind-blown material, usually sand.
Erosion	The wearing away of land by the action of natural forces.
Fastland	Land that is not regularly inundated by high water.
Fetch	The linear distance of open water where waves are generated by the wind of a certain direction, speed and duration.
Filter Cloth	Synthetic textile with openings for water to escape, but prevents the passage of soil particles.
Gravel	Small, rounded granules of rock with individual diameters ranging from 0.18-3 inches. Gravel is larger than sand but smaller than cobble.
Groin	A shore protection structure built perpendicular to the shore to trap sand and retard shore erosion.
Groin field	Series of groins acting together to protect a section of the beach. Also called a groin system.
High Water Line	Intersection of the level of mean high water with the shore. Shorelines on navigation charts show approximations of the high water line.
Impermeable	Not having openings large enough to permit water to freely pass.
Intertidal Zone	The land area alternately inundated and uncovered by tides. Usually considered to extend form mean low to mean high water
Jetty	Structures used at inlets to stabilize the position of the navigational channel, to shield vessels from wave forces, and to control the movement of sand along the adjacent beaches so as to minimize the movement of sand into the channel.
Lee	Sheltered, the area located on the side facing away from the wind.
Leeward	Direction toward which wind is blowing or waves are traveling.
Littoral	Off, on, or along the shore. The region along the shore.
Littoral Drift	The sediments moved along the shore by waves and longshore currents.
Littoral Transport	The movement of sediments in the nearshore zone by waves and currents. Transport of sediments can be, either parallel or perpendicular to the shoreline.
Longshore	Parallel to and near the shoreline; same as alongshore.
Longshore Current	Current in the breaker zone moving essentially parallel to the shore and usually caused by waves breaking at an angle to the shore (also called alongshore current).
Longshore Transport Rate	The rate of the transport of littoral drift parallel to shore; usually expressed in cubic yards per year (see Littoral Drift).
Low tide	The minimum elevation reached by each falling tide.
Marsh	An area of soft, wet, or periodically inundated land, generally treeless, and usually characterized by grasses and other low growth.
Mean High Water	Average height of the daily high waters over a 19-year period. For semidiurnal or mixed tides, the two high waters of each tidal day are included in the mean. For diurnal tides, a single daily high water is used to compute the mean.

Mean Low Water	Average height of the daily low waters over a 19-year period. For semidiurnal and mixed tides, the two low waters of each tidal day are included in the mean. For diurnal tides, the one low water of each tidal day is used in the mean.
Nourishment	The process of replenishing an existing beach either naturally, by longshore transport or artificially by materials dredged or excavated elsewhere.
Overtopping	The passing of water over a structure from wave run-up or surge action.
Peat	Residual product of partial decomposition of organic matter in marshes and bogs.
Permeable	Having openings large enough to permit free passage of appreciable quantities of sand or water.
Pile	Long, heavy section of lumber, concrete or metal driven or jetted into the earth or seabed as support or protection (see pile sheeting).
Pile Sheeting	Pile with a generally slender, flat cross-section driven into the ground or seabed and meshed or interlocked with like members to form a diaphragm, wall, or bulkhead.
Piling	A group of piles.
Polyvinyl Chloride(PVC)	Plastic material that forms a resilientcoating suitable for protecting metal from corrosion.
Revetment	A facing of stone, concrete, etc., built to protect a scarp, eroding bank or shore structure against erosion by waves or currents.
Riprap	Layer, facing, or protective mound of stones randomly placed to prevent erosion, scour, or sloughing of a structure of embankment; also, the stone so used.
Rubble	Loose, angular, stones along a beach. Rough, irregular fragments of broken rock or concrete.
Sand	Particles with diameters between 0.003-0.18 inches. Sand is larger than silt but smaller than gravel.
Sand Fillet	The accretion of sediments trapped by a groin or other protrusion in the littoral zone.
Scour	The removal of underwater material by waves or currents, especially at the base or toe of the shore structure.
Seawall	A structure separating land and water areas primarily to prevent erosion and other damage by heavy wave action (see Bulkhead).
Seiche	An occasional rhythmical movement from side to side of the water of an enclosed basin, with fluctuations in water level.
Semidiurnal Tide	A tide with two high and two low water in a tidal day, each high and low approximately equal in stage (see Mixed Tide).
Shore	The narrow strip of land in immediate contact with the sea, including the zone between high and low water lines (see Beach).
Shoreline	The intersection of a specified plane of water with the shore or beach (e.g., the high water shoreline would be the intersection of the plane of the mean high water with the shore or beach). A line delineating the shoreline on National Ocean Survey nautical charts and surveys approximates the mean high water line.
Sill	Low offshore barrier structure whose crest is usually submerged, designed to retain sand on its landward side.
Silt	Generally refers to particles having diameters between 0.00015-0.003 inches. Silt is larger than clay but smaller than sand.

Specifications	Detailed description of particulars, such as the size of stone, quality of materials, contractor performance, terms, and quality control.
Storm Surge	The rise above normal water level on the open coast due to the action of wind on the water surface. The storm surge resulting from a hurricane also includes the rise in level due to the atmospheric pressure reduction as well as that due to wind stress.
Tide	The periodic rising and falling of water resulting from gravitational attraction of the moon, sun and other astronomical bodies acting upon the rotating earth. Although the accompanying horizontal movement of the water resulting from the same cause is also sometimes called tide, it is preferable to designate the latter as tidal current, reserving the name Tide for vertical movement.
Tie Backs	Refers to piles and rods set in the backfill area to provide lateral support to a vertical protective structure.
Tie Rods	Steel rod used to tie back the top of a bulkhead or a seawall.
Toe	The channelward base of a structure.
Topography	The configuration of a surface, including relief, position of streams, roads, buildings, etc.
Water line	Juncture of land and sea. This line migrates with the changing of the tides or other fluctuations in water level. Where waves are present on the beach, this line is also known as the limit of backrush (approximately the intersection of land and the stillwater level).
Wave	A ridge, deformation, or undulation of the surface of a liquid.
Wave Direction	Direction from which a wave approaches.
Windward	Direction from which the wind blows.

REFERENCES

Rogers, Golden and Halpern, Inc., 1981, Low Cost Shore *Protection*, Philadelphia, Pa., contract DACW 61-81-D0012 by United States Army Corps of Engineers, 36 p.

United States Army Corps of Engineers, 1981, *Shore Protection Manual*, Vols.1-2 (Vicksburg, Mississippi: United States Army Corps of Engineers Coastal Engineering Research Center).

United Sates Army Corps of Engineers, 1973, *Shore Protection Guidelines*, in *National Shoreline Study*, Vol. 1, Washington D.C., United States Government Printing Office.

United States Army Corps of Engineers, *Low Cost Shore Protection...A Guide for Local Government Officials*, 108 p.

United States Department of Agriculture, Soil Conservation Service, *Vegetation for Tidal Shoreline Stabilization in the Mid-Atlantic States*, 18 p.

TDD (410) 974-3683

The facilities and services of the Department of Natural Resources are available to all without regard to race, color, religion, sex, age, national origin, physical or mental disability.

printed on recycled paper