SHORE EROSION CONTROL GUIDELINES for Waterfront Property Owners

2nd Edition

MARYLAND DEPARTMENT OF THE ENVIRONMENT
WATER MANAGEMENT ADMINISTRATION

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Cover photo: Team SWAMP, University of Maryland

EXECUTIVE SUMMARY

The Department of the Environment 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 combating shore erosion.

Protection measures which best enhance wetlands and provide for the conservation of fish, plant, and wildlife habitat are encouraged by the State of Maryland. 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 establishment
- Shoreline revetments
- Offshore breakwaters
- Groins

These recommendations are consistent with the objectives of Maryland's Chesapeake and Coastal Bays 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 originally 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 Tidal Wetlands Division is now part of the Maryland Department of the Environment, Water Management Administration. This second edition provides updated guidance on technical approaches and regulatory procedures to assist waterfront property owners. The appropriate shore erosion control method should be selected by considering the degree of erosion control needed, environmental impacts and cost.

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INTRODUCTION

This book provides guidance to waterfront property owners on the Chesapeake Bay and Atlantic Coastal Bays (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 the Environment (MDE), Water Management 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 maybe obtained from: Department of the Environment, Water Management Administration, Tidal Wetlands Division, 1800 Washington Boulevard, Baltimore, Maryland 21230. Phone: (410) 537-3837.

Maryland Shoreline Statistics and Characteristics

The Chesapeake Bay, Atlantic Coastal Bays, and their tidal tributaries include 6,659 miles of shoreline. Approximately 4,579 miles of that shoreline are eroding. Approximately 65% of the shoreline has low to moderate erosion (0-4 feet/year), while 3% of the shoreline experiences moderate to high erosion of at least 4 feet per year (DNR). Statistics compiled by the Department of Environment show that 30 miles of shoreline are stabilized annually. The remaining shoreline that erodes each year is a serious economic and ecological problem because:

• 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 over which the wind blows (fetch) 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, diagramed 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 bank sediments along shorelines.

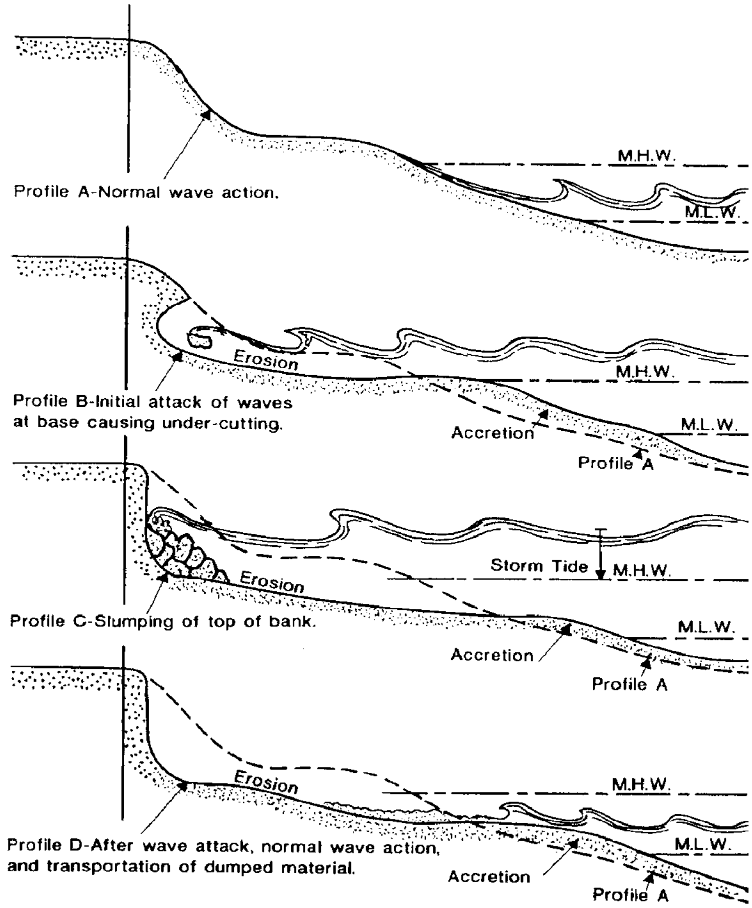


Fig. 1. Wave erosion and transportation of sediments along a beach.

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). Large chunks of ice may strike shorelines and result in erosion.

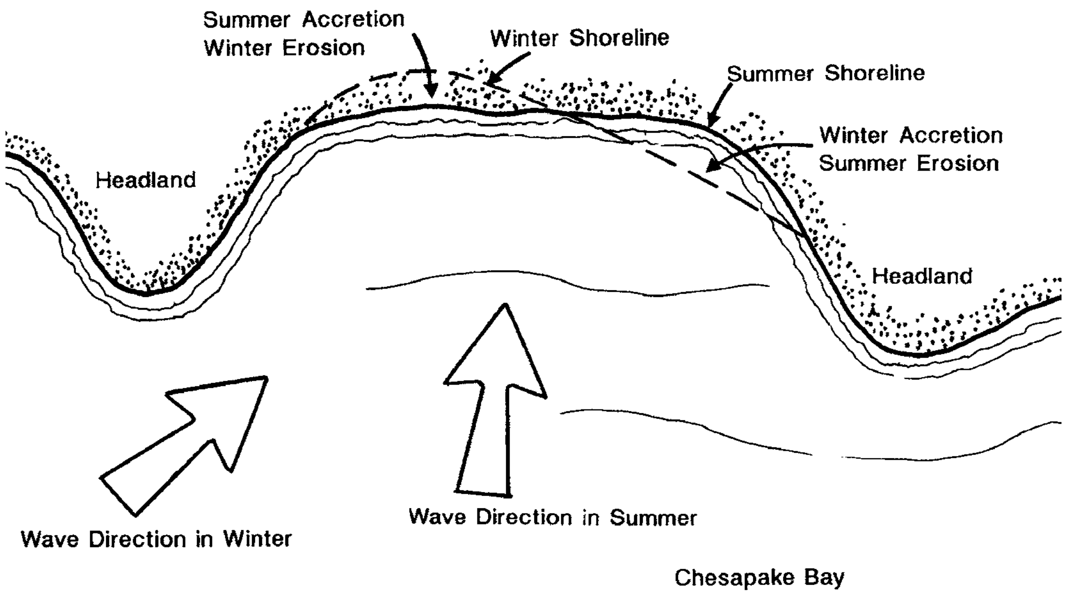


Fig 2. Seasonal changes in erosion and depositional patterns due to changing wave direction exposing new surfaces.

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).

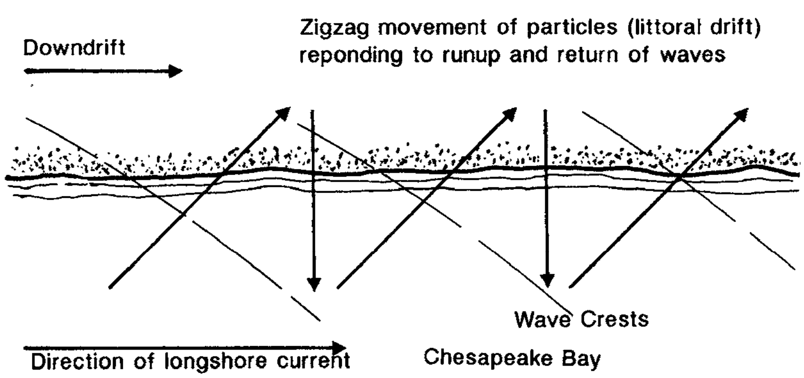


Fig. 3. The zigzag pattern of sand movement along a shoreline.

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).

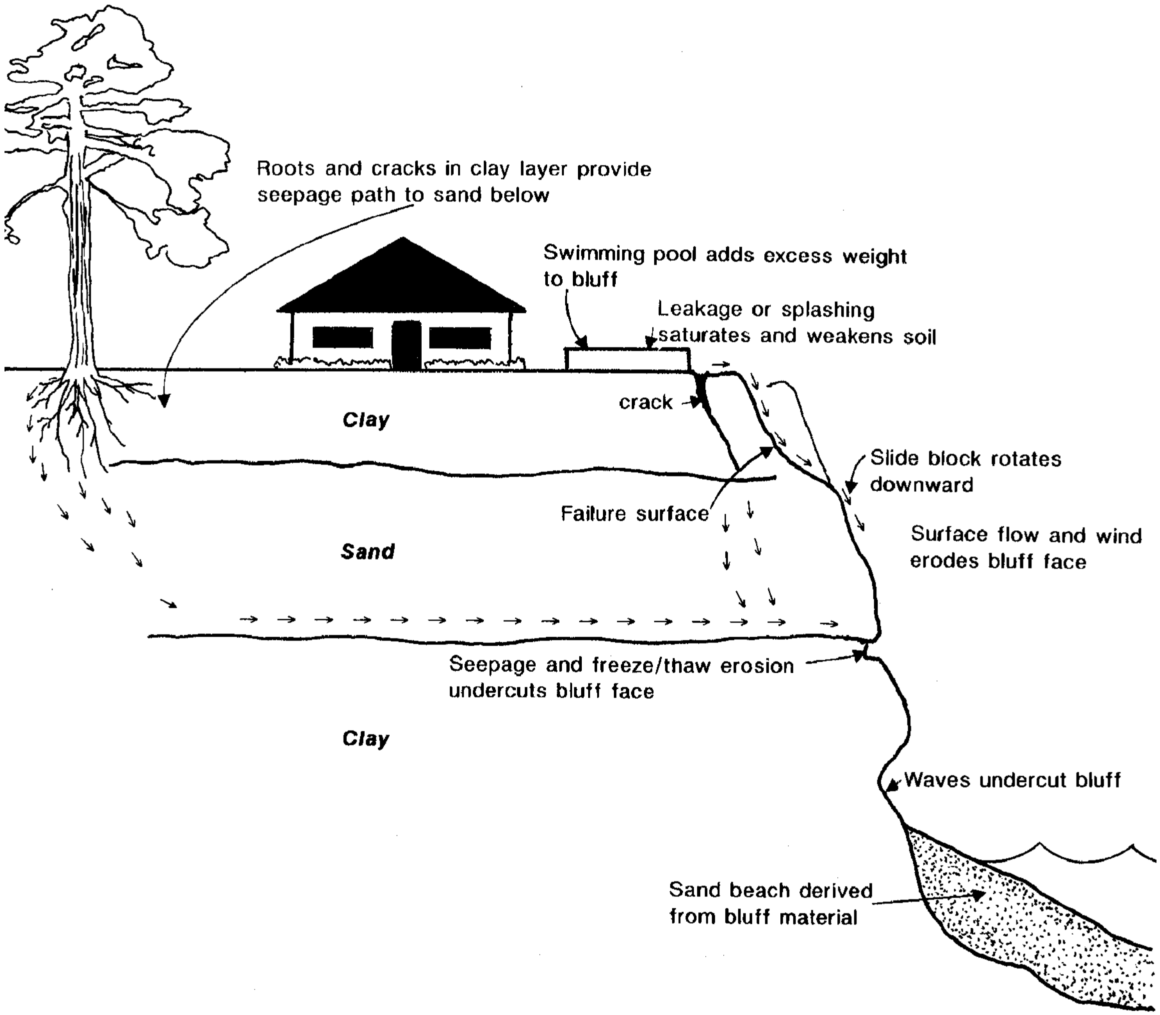


Fig 4. The combination of wave and groundwater erosion on a high bank.

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, "Shoreline Change Maps for Tidewater Maryland." Shorelines are depicted from various maps drawn over time from the mid 1800's through the 1990's. The maps may be viewed at various scales at http://www.mgs.md.gov/coastal/maps/schangepdf.html. The maps can be 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 from the Publications Office (410-554-5505). Maps are not intended for legal or detailed design use.

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. A variety of erosion control practices are presented in this document. General design and installation considerations are described, but will be site specific. It is important for landowners to understand that all types of erosion control practices are subject to failure, and that the success of the project is highly dependent upon site conditions, practice selection, installation, and maintenance.

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 before you or your community decides 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 Tidal Wetlands Division in MDE at (410) 537-3745, or Shore Erosion Control Program in DNR, at (410) 260-8909 or (410) 260-8926, the local Soil Conservation District Office or consult the telephone directory for engineering or marine contracting firms in your area. The Corps of Engineers and local office for building permits may also offer advice.

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

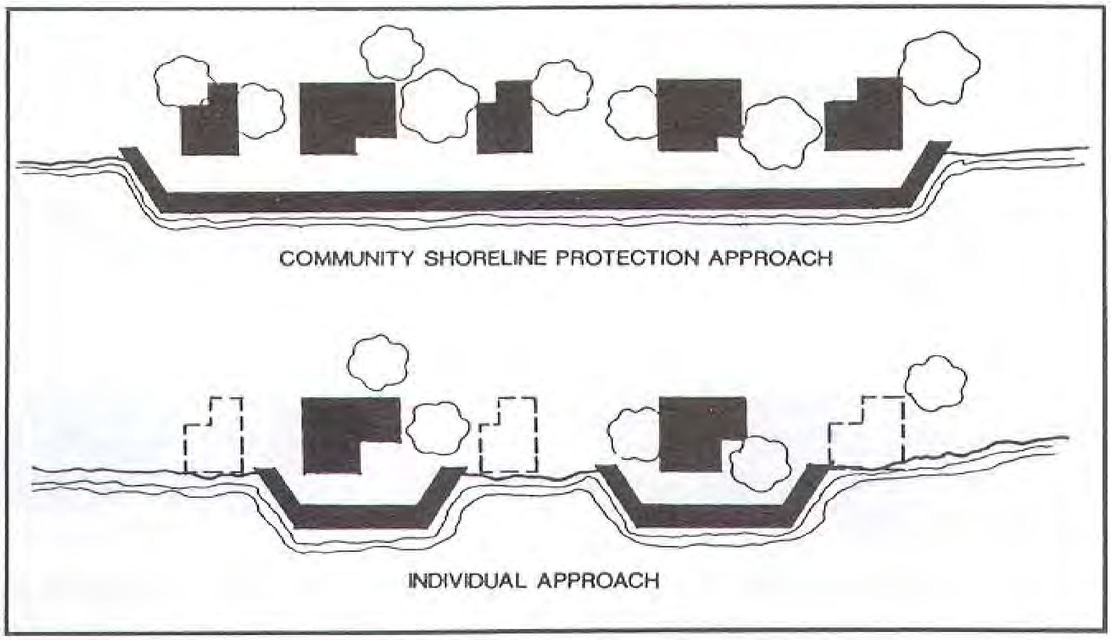


Fig. 5. The single versus the community approach to shore protection.

FINANCIAL and TECHNICAL ASSISTANCE

Waterfront property owners suspecting an erosion problem on their shoreline should contact the Department of the Environment (410) 537-3837 or Department of Natural Resources for assistance at (410) 260-8909 or (410) 260-8926. 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 from MDE, DNR, or other federal or private organizations. The Department of Natural Resources has a list of potential funding sources at http://shorelines.dnr.state.md.us/financial.asp#srp. Program requirements and availability of funds is subject to change so interested persons should check with the appropriate entity for most current information.

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 the Environment 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 and State permit applications are submitted on a joint application to the Maryland Department of the Environment.

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

Many shore erosion control practices are automatically authorized by the Corps under a State Programmatic General Permit, provided that they meet certain criteria and are authorized by MDE. Federal permits will not be issued until State Water Quality Certification and State Coastal Zone Consistency determinations have been provided to the Corps by MDE. 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 the Environment 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 establishment

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. The application form and instructions are available online at:
www.mde.state.md.us/Programs/WaterPrograms/Wetlands_Waterways/permits_applications/index.asp.

County offices may also have copies of the form.

This single application should be submitted to:

The Department of the Environment
Water Management Administration
Permit Service Center
1800 Washington Boulevard
Baltimore, Maryland 21230
Phone: (410) 537-3837

The Permit Service Center distributes copies of the joint application to all federal and State wetland regulatory agencies for review and comment. A public notice is required for certain types of projects, providing opportunity for a public hearing and submittal of comments.

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 and Coastal Bays 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. For these reasons, bulkheads are discouraged in Maryland. 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. Landowners, contractors, and consultants, are encouraged to refer to MDE's current sample drawings, but designs should be site specific.

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 and have minimal encroachment into the channel are encouraged by the State of Maryland.

SELECTION OF EROSION CONTROL MEASURE

Maryland law requires that a specific order of preference be followed when selecting a shoreline stabilization practice. The first step is to determine whether or not the erosion is severe enough that an erosion control measure must be installed, or that the problem can be averted by moving an existing structure. If stabilization is necessary, then a non-structural shoreline stabilization method must be used unless certain other circumstances apply. Below is the order of preference for all types of practices:

<u>No Action and Relocation</u>

- Relocation of threatened structures

<u>Non-Structural Practices (“Living Shorelines”)</u>

- Non-structural stabilization including beach nourishment, slope grading and planting, and marsh establishment, with or without additional protection elements.

- Sand Containment Structures

Structural Practices

- Shoreline revetments
- Offshore breakwaters
- Jetties/Groins

These recommendations are consistent with the provisions of Maryland's Chesapeake and Coastal Bays 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.

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 conditions 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 maybe 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.

NON-STRUCTURAL/LIVING SHORELINE

After an applicant has demonstrated to MDE’s satisfaction that the “no action” or relocation alternatives are not sufficient to address an erosion problem, then a non-structural shoreline stabilization method must be used. Non-structural shoreline stabilization methods are sometimes also referred to as “Living Shoreline” practices. Exceptions to this requirement may be granted by MDE for certain areas that have been pre-determined to be unsuitable or impracticable for non-structural/Living Shoreline stabilization. MDE will designate these areas on maps. Criteria for designating areas may include:

(a) Areas that lack an adjacent natural shoreline;
(b) Proximity to navigation channels, where a nonstructural practice may impede passage of vessels;
(c) High energy shoreline-----severely eroding shorelines where nonstructural methods are impractical;
(d) Inaccessible shoreline-----landform characteristics such as very steep, high banks, and nearshore shallow water that prohibits both land or barge access necessary for the transportation of construction materials to the site; and
(e) Commercial vessel berthing-----commercial water-dependent facilities when loading and unloading operations require a bulkheaded shoreline.

Contact MDE at (410) 537-3837 or www.mde.state.md.us for the most current information on shoreline stabilization methods or available maps depicting areas where structural stabilization practices may be permitted.

If an area is not pre-designated for allowable structural stabilization methods, applicants have the opportunity to demonstrate that nonstructural stabilization is not feasible by demonstrating to MDE's satisfaction that other constraints to these methods on a particular site cannot be overcome, including:

(f) Presence of channel width inadequate to support a nonstructural shoreline stabilization measure;

(g) Adverse impacts on tidal flushing of waterway from establishment of a nonstructural shoreline stabilization measure;

(h) Adverse impacts on navigation;

(i) Lack of suitable bottom elevation and slope at mean low water for sustaining a nonstructural shoreline stabilization measure, as measured in the field;

(j) Severe tides and wave action;

(k) Bank elevation and orientation that would prevent grading and successful establishment of vegetation;

(l) Other physical constraints to successful establishment of a nonstructural shoreline stabilization measure; or

(m) Other environmental factors or benefits that would be adversely affected by the proposed nonstructural shoreline stabilization practice.

The selection of any of shoreline stabilization method requires careful planning, design, and construction considerations to withstand the erosive forces that may be encountered.

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. Beach nourishment should only be considered where natural beaches have existed at a site and there is a natural source of sand to help sustain the beach.

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. The direction and rate of movement of sand along the shoreline should be determined. If the rate is high then beach nourishment may not be appropriate. 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 a 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. However, this practice may also require careful

management of vegetation on the slopes. There are typically restrictions on removing trees. Pruning of tree limbs may be an acceptable alternative to removing trees.

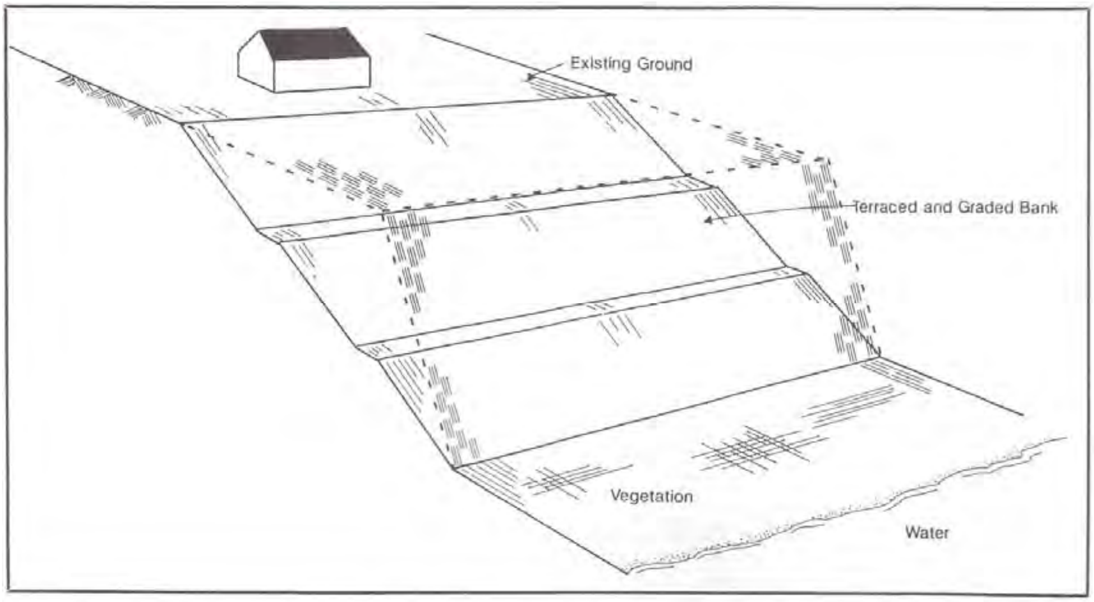


Fig. 6. Grading, planting, and terracing.

Site Characteristics
The shoreline must have a steep slope where erosion is present. Grading and terracing are undesirable when the bank is predominantly vegetated. In areas of small or moderate erosion, planting is the preferred option.

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
First, try to identify the specific area of concern. Consider whether or not the practice can be limited to the toe of the slope, to reduce disturbing the remainder of the slope and its vegetation. If the slope is steep and soils are highly erodible, contact the local Critical Areas office, Soil Conservation District and local government office as additional review and approvals may be needed. Removal of vegetation is restricted in most cases, as bank vegetation often provides vital shoreline protection against wave action that may overtop adjacent marshes. 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. Regraded banks should be stabilized with native 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
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 and results in loss of a natural shoreline and habitat benefits. It cannot be done where bulkheads or revetments are adjacent to or in the proximity of your property.

MARSH ESTABLISHMENT

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.

Some marsh establishment practices consist of a marsh, or other natural shoreline with a supplemental structural component. These practices are designed to provide both the habitat benefits of a natural shoreline with additional protection against erosion from more wave action. The supplemental structural element is typically an offshore sill. Marshes may also be placed in front of existing bulkheads to restore some habitat to the site.

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.

Marshes may be created on most shorelines if there is a supplemental structural practice, including moderate to high energy systems. However, marshes are not recommended where they are not a natural feature along a comparable natural shoreline. In cases where marshes are naturally absent or very limited along the shoreline, other types of natural plantings may provide habitat and shoreline stabilization.

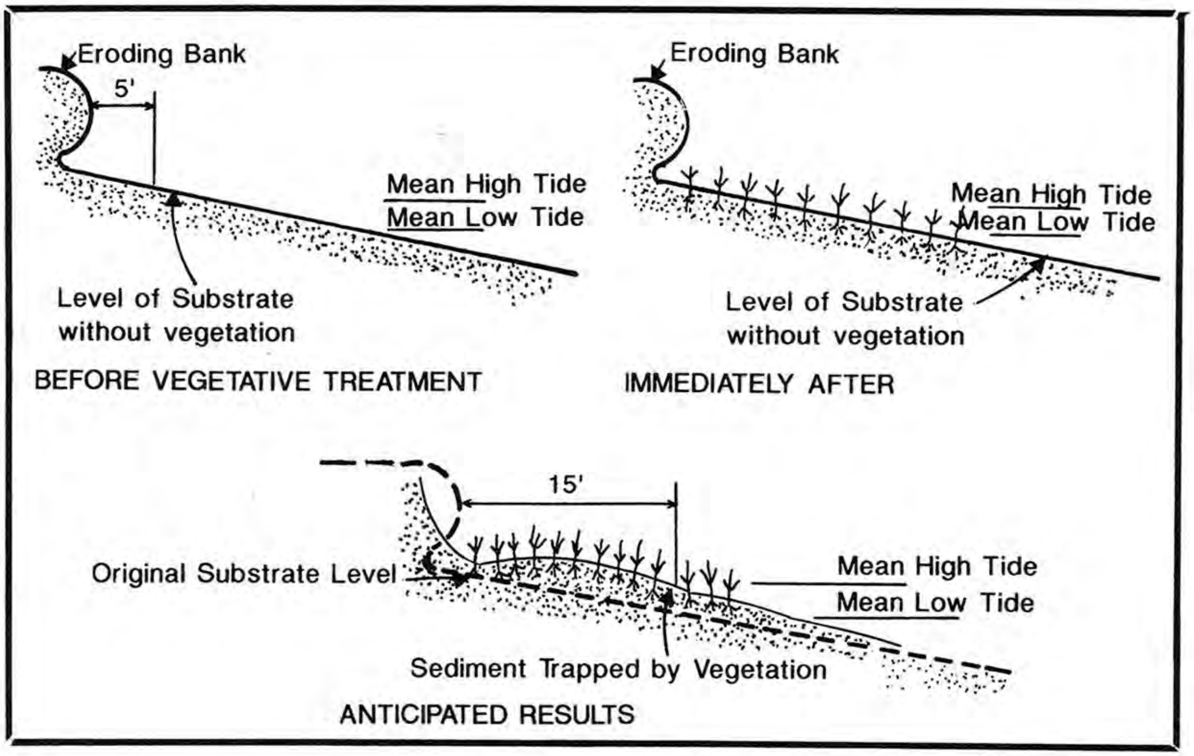


Fig. 7. Potential role of vegetation in tidal shoreline stabilization.

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.

Construction Materials

Adding sediments similar to the existing beach may be necessary before marsh creation can be performed. Additional stabilization may be needed from a sill made of stone or a fiber log. Fiber logs may be installed at the landward or channelward edge of the marsh. Fiber logs provide temporary stabilization and degrade while the marsh develops.

Fig. 8. Fiber logs provide temporary stabilization for a newly created marsh. A fence prevents waterfowl from eating young plants. (photo: Department of Natural Resources

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

Marsh Plants:
Smooth Cordgass (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 *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. 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 *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. Further information on planting these and other species can be obtained from county offices of the Natural Resources Conservation Service.

Design Considerations
Marsh establishment 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.

Surface drainage must also be considered. Runoff from the land, gutters, or stormwater outfalls may accumulate as concentrated flow and create small gullies and channels that can de-stabilize and erode a marsh project.

Detailed design and construction guidance is shown below.

If a supplemental structural practice is used, the material must be placed so as not to impede the movement of wildlife or high tides into the marsh.

The State of Maryland considers the use of vegetation for shore erosion control to be an important part of its Chesapeake Bay and Coastal Bays restoration efforts. 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 ensure the undisturbed growth of the remaining plants. The removal of debris and selective pruning of trees is also a good maintenance practice to ensure that sunlight reaches plants. 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.

Rock that is used to supplement protection must be replaced or re-installed if it breaks away from the approved structure.

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 be used along shorelines with low to moderate erosion rates. A supplemental structural practice may be necessary in moderate to higher energy systems.

Detailed Design and Construction Guidance

Design the Project to Allow for Adequate Sunlight. The marsh plantings should get sun—without sufficient sunlight, they will not be able to grow and form a healthy project. 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 to allow for the daily minimum amount of direct sunlight. It is important, especially on cliff properties, to trim limbs trees so that the *Spartina* grasses can get enough sunlight. Be certain to contact your local Chesapeake or Coastal Bay Critical Area contacts about restrictions on removal of vegetation in buffers to waterways. Tree removal is generally restricted.

In Figure 9, a property is shown where shade from trees growing on the edge of the cliff bank behind the marsh have stunted the growth of *Spartina alterniflora* and destroyed much of the high marsh.

Fig. 9. Shaded Marsh. Photo: Team SWAMP, University of Maryland

Proper Grading and Filling. Proper filling is important for the stability of the marsh and the health of the flora and fauna. Placement of inappropriate substrate (lacking in sand) can lead to sinkholes forming in the marsh and plants will not be able to take root.

A 10:1 slope is recommended to allow creation of both high and low marsh. Contractors should use material such that no more than 10% of the fill substrate shall pass through a standard number 100 sieve.

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. However, if depth increases too much with a short distance, the potential area for planting would be too steep and the project would likely fail.

Figure 10 shows a marsh that was planted on material dredged from under a nearby pier. The resulting substrate was not firm enough for the high marsh to take root resulting in large patches of sunken soil covered with dead *Spartina patens.*

Fig. 10. Sunken Marsh. Photo: Team SWAMP, University of Maryland

In another example of improper fill, Figure 11 depicts a marsh project where the high marsh was planted on rocky rubble that proved inhospitable to the marsh grasses or undersized stone from the sill drifted into the marsh as a result of the high-energy environment. It is only in predominantly sandy areas that any grasses remain.

Fig. 11. Improper Fill. Photo: Team SWAMP, University of Maryland)

Proper planting. It is important to have both high and low marsh for a successful project, as shown in Figure 12, if high and low marsh naturally existed along the shoreline. A 50/50 split between high and low marsh helps to fully stabilize an eroding bank and provide the desired wildlife habitat. A 50/50 split may indicate that the contractor has successfully located the mean high water line; *Spartina alterniflora* thrives in the intertidal zone, and *Spartina patens* lives in the high marsh zone. Both types of marsh plants are important, although *Spartina* grasses are recommended for both. Where applicable, *Spartina* grasses are preferred to plants such as three-square which die during the winter, thus failing to provide erosion control benefits all year round. In upstream areas (fresher water), *Juncus effusus* (soft rush) and *Panicum virgatum* (switchgrass) are good substitutes for *Spartina*.

Fig. 12. Low profile sill and newly created marsh. Photo: Team Swamp, University of Maryland)

Use fencing if necessary to prevent waterfowl from eating new plantings. Waterfowl such as geese may eat all plants, especially newly planted plugs. Lack of vegetation may result in the sand fill washing away and the project to fail. Fencing as shown in Figures 8 and 13 can prevent or limit waterfowl access to the marsh while allowing smaller aquatic species (fish, crabs, turtles) to use the marsh for habitat.

Fig. 13. Waterfowl exclusion fence. Photo: Maryland Department of the Environment

Stabilize adjacent cliff. In properties with high cliffs, the marsh will not prevent the top of the cliff from eroding due to run off—this erosion may ultimately bury the marsh with eroded sediments. The cliff should be stabilized by either grading with upland plant stabilization or by installing a structural solution such as a retaining wall or ground mesh to hold back erosion. With the cliff stabilized, the marsh can then be used to prevent undercutting at the base of the cliff. Figure 14 is an example of a situation in which the marsh is doing little to prevent further erosion of the cliff behind it; rainwater run-off and storm damage is still a threat to these properties.

Fig. 14. Marsh and eroding cliff. Photo: Team Swamp, University of Maryland

Figure 15 is an example of a marsh project in which the cliff has been properly stabilized, allowing for a healthy marsh to grow at the base of the cliff.

Fig. 15. Marsh and stabilized cliff. Photo: Team SWAMP, University of Maryland

Protect shoreline from excessive wave action. One of the most serious threats to a wetland is the action of waves. Boat wakes and waves propagated by long fetches can slap against a shoreline and wash away all traces of a marsh. Careful design and construction can result in a sill that both protects against erosion while allowing wildlife to use the marsh as habitat. Marshes may be protected by an offshore structure such as a low profile sill or breakwater, or a sand containment structure. A low profile structure can protect the shoreline from wave action while allowing access by wildlife. The structure should not be placed directly on the marsh, as for a revetment. The toe of the sill should be channelward of the mean low water line so that the low marsh is covered by open water at mean high tide. The height of the sill should extend 0 to 1 foot above mean high water.

Marsh creation projects have proven successful with or without protective structures such as sills. Projects without protective structures are most likely to be successful on sheltered waterways where there is low natural wave action and limited wave action from boating activities.

Fig. 16. Low- energy system. Photo: Team SWAMP, University of Maryland)

Marsh Creation With Sill

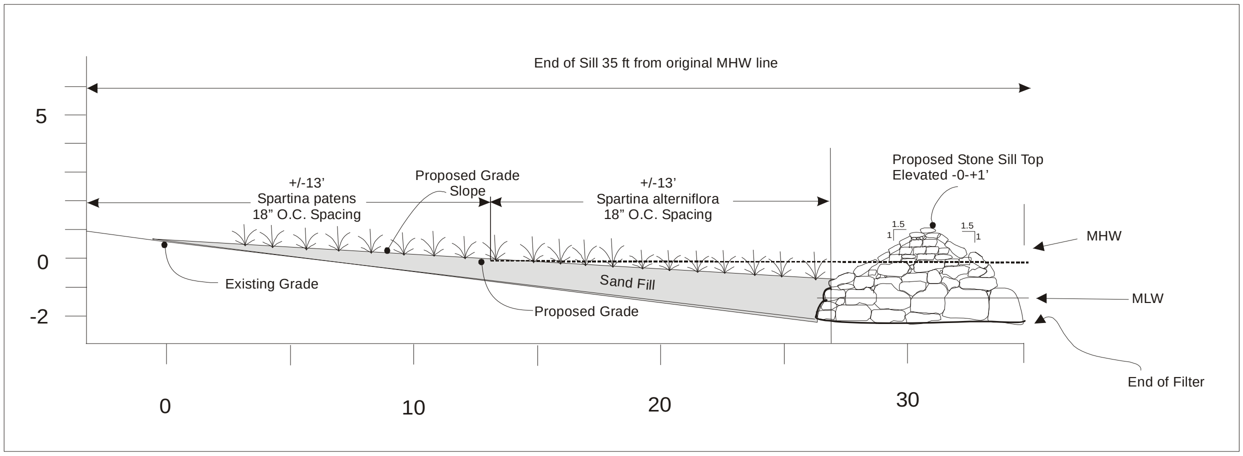


Fig. 17. Profile of marsh creation design with low profile sill.

Staggered or dog-legged vents in sills. While sills are often important for a successful project, it is essential that they be constructed in such a way that allows for flushing and wildlife access to the shore. Large obtrusive sills without vents prevent proper flushing of marsh and trap sediment and dead vegetation, which can strangle the marsh, in addition to blocking wildlife access. However, vents can facilitate erosion where the wave action is persistent. Therefore, it is recommended that vents are constructed such that they are placed in a doglegged or staggered system or contain additional stone on a liner when sills are placed in a linear manner. Marsh creation may be placed in front of a damaged bulkhead for additional stabilization and wildlife benefits as an alternative to replacing the bulkhead (Figure 22).

Offset or Staggered Vented Sill

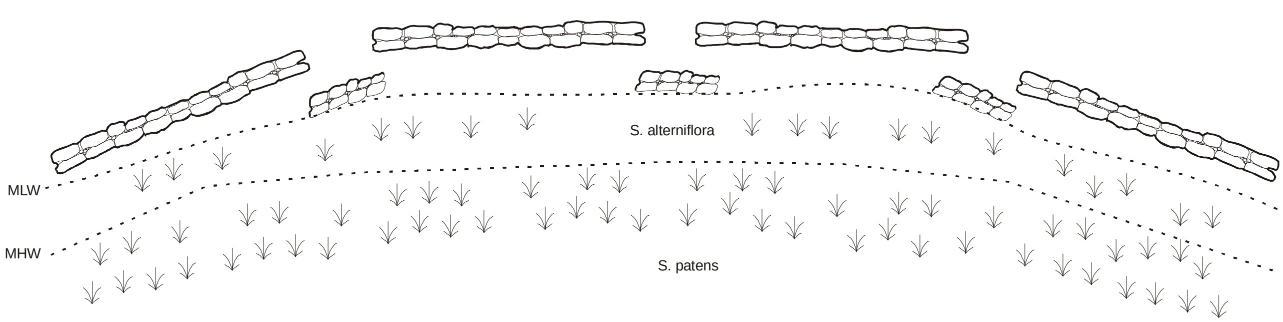
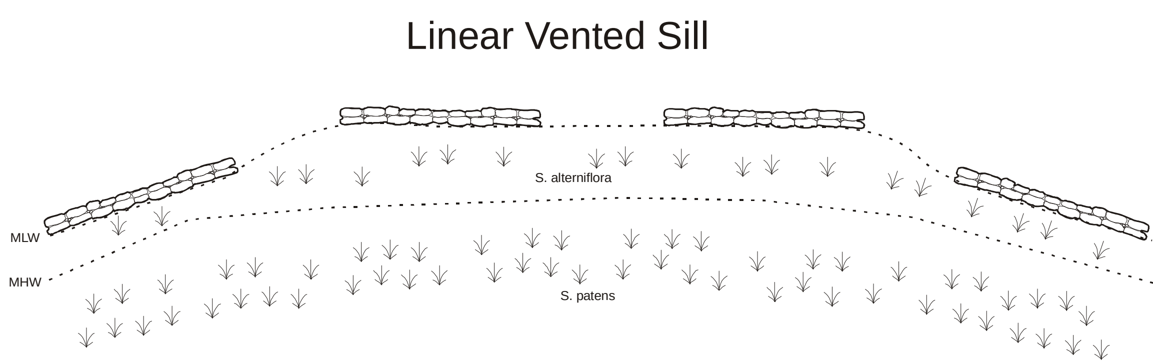
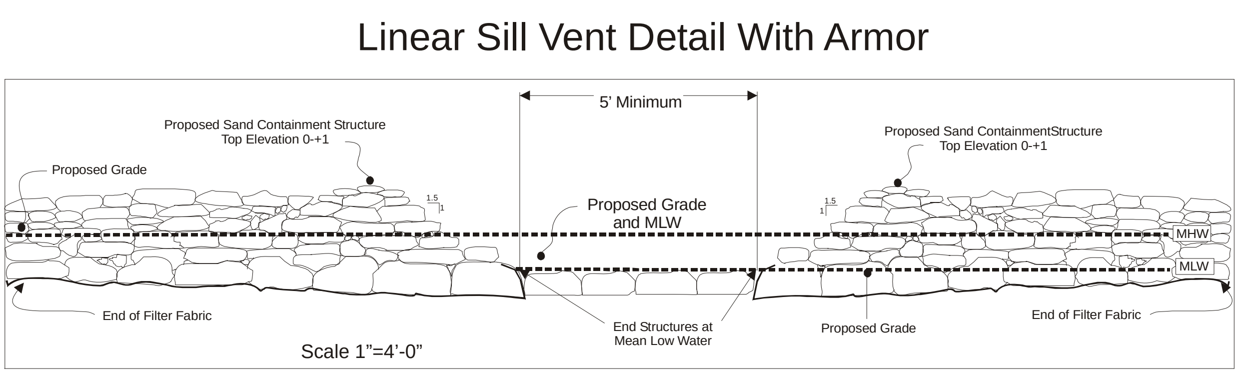


Fig. 18. Plan view of offset or staggered vented sill.

Figure 19 shows a staggered vented sill prior to planting the marsh.

Fig. 19. Staggered and vented sill. Photo: Maryland Department of Natural Resources





Figs. 20 and 21. Plan and profile views for linear vented sill, with rock lining at opening.

Fig. 22. Marsh and vented sill placed in front of bulkhead. (Photo: Maryland Department of Natural Resources)

The following photograph is an example of marsh establishment project that failed due to improper grading and a structure that was too large and close to the marsh. An excessive amount of riprap was used, eliminating access by aquatic wildlife. The elevation of the marsh is too high due to improper grading that limits tidal flooding of the marsh plants.

Fig. 23. Failed marsh establishment project. (photo: Maryland Department of the Environment)

Properly maintain the marsh creation project. Proper maintenance will help ensure that the marsh creation project remains successful at preventing erosion and providing wildlife habitat. Maintenance suggestions:

1) Remove debris and trash.
2) Do not mow vegetation.
3) Limit use of lawn fertilizers.
4) Re-plant as necessary.

SAND CONTAINMENT STRUCTURES

Description

Sand containment structures are low profile structures designed to hold sand for the purpose of creating and protecting a beach and/or marsh. Containment structures are placed perpendicular to the shoreline and help trap sediment to maintain the marsh. The channelward end of the structure should be at the approximate edge of the plantings at mean low water. Sand containment structures are similar to groins.

Site Characteristics

The shoreline should be gently sloping. Sand must be naturally present in the system to create the beach. It is important to consider the direction and amount of sand moving along the shoreline before choosing sand containment structures as a method of shore erosion control.

Construction Materials

See discussion on groins and marshes.

Design Considerations

See discussion on groins and marshes.

Fig. 24. Sand containment structure. Structural components placed perpendicular to the shoreline retain sand to establish a beach. These areas may also be planted. Photo: MDE

Maintenance Requirements

See discussion on groins.

Advantages

See discussion on groins. Sand containment structures also provide nesting habitat for aquatic life that requires a beach, such as turtles and horseshoe crabs.

Disadvantages

See discussion on groins.

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. Structural practices may only be used in areas pre-designated on maps maintained by MDE, or unless non-structural measures are not feasible.

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, holding 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 25) is constructed by placing progressively larger blocks or pieces of stone on filter cloth or fine gravel.

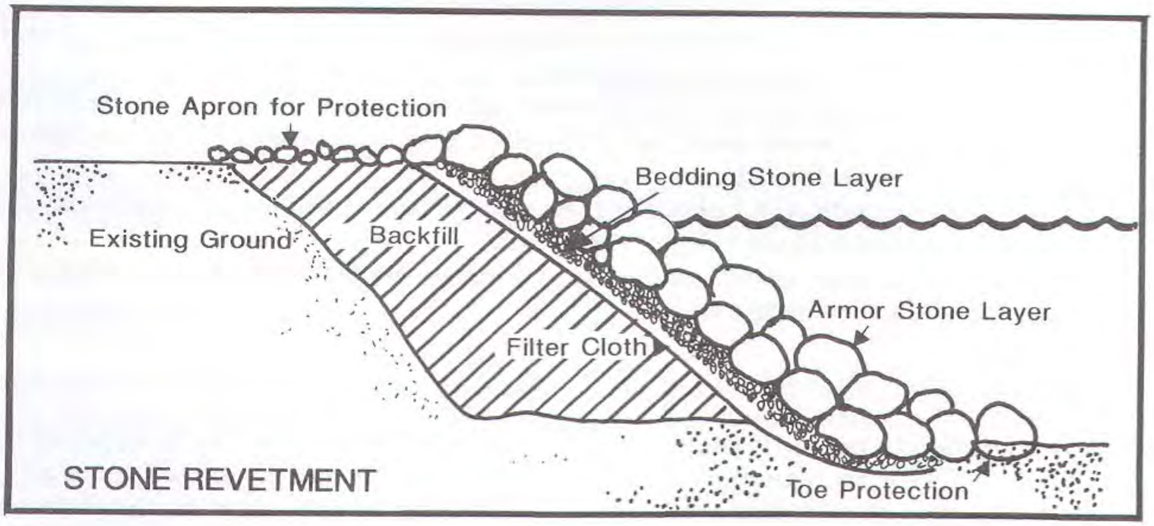


Fig. 25. Profile of a stone revetment.

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).

Construction Materials
Heavy armor stones with an interlocking design or concrete rubble (in some jurisdictions) 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. Rebar must be removed from concrete. Concrete must also be free of petroleum products that would pollute the waters. Road or parking lost asphalt are examples of concrete sources that would not be appropriate.

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. Filter cloth must be laid under the entire structure. Smaller chinking stones fill in the gaps between larger stones and prevent their movement. The soils comprising the area under the revetment must be analyzed to determine if they can support the structure. A revetment is only suitable on a natural bank. A man-made bank with more than minimal fill cannot be compacted sufficiently to support the structure.

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 organic material and firmly compacted before revetment construction proceeds. Organic material, when present in fill material, will decay and create voids in the substrate that will de-stabilize the structure and cause it to fail.

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 maintain the height and width of a revetment. Maintenance activities are required because individual stones comprising revetments 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.

Figs 26 and 27. Failed revetments showing open area where rocks have shifted. (Photos: Maryland Department of Natural Resources)

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.

Fig. 28. A well-constructed and stable revetment. (Photo: Maryland Department of Natural Resources)

STRUCTURAL - WALL TYPE

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. **Wall-type structures are the least preferable alternative for shore erosion control due to the lack of habitat benefits. These structures are also prone to failure under certain circumstances. Waves that overtop the structure and strike the land behind it will weaken the structure.**

GABIONS

Description

Gabions are rectangular wire baskets filled with stone. Figure shows gabions being utilized as a wall type erosion control structure.

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 repaired 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 only suitable in 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 gabion 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 that 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 coating. Gabion baskets are generally not recommended by MDE.

Fig. 29. Failed gabion baskets. Photo: Maryland Department of Natural Resources

BULKHEADS **(Repair Only)**
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. Bulkheads are constructed from steel, aluminum, vinyl, or timber. Note: It is generally against State policy to authorize new bulkheads or replace failed bulkheads with a similar structure.

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

The sheet pile bulkhead maybe cantilevered or anchored. 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 waterside.

Fig. 30. Collapsing bulkhead with additional riprap. (Photo: Maryland Department of Natural Resources)

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. Filter cloth should be placed behind the replacement bulkhead. Figure 13 depicts a typical bulkhead cross section with many of the necessary structural design precautions.

Construction of new bulkheads or replacement of failed bulkheads is prohibited. Existing bulkheads that are damaged but at least 85% functional may be repaired.

Maintenance requirements
Sheet pile bulkheads should be inspected regularly to check for sheet failure and possible loss of soil behind them. Failure 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.

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 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. Bulkhead failures often affect the entire project, and subsequently require of a new stabilization practice. In contrast, when a revetment or marsh creation/or other natural shoreline stabilization project fails, generally only portions of the project need to be replaced at a much lesser cost

Fig. 31. Failed bulkhead with erosion behind structure. (Photo: Maryland Department of Natural Resources)

Fig. 32. Catastrophic bulkhead failure, resulting in need to replace entire structure with different stabilization practice. (Photo: Maryland Department of the Environment)

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 33). 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.

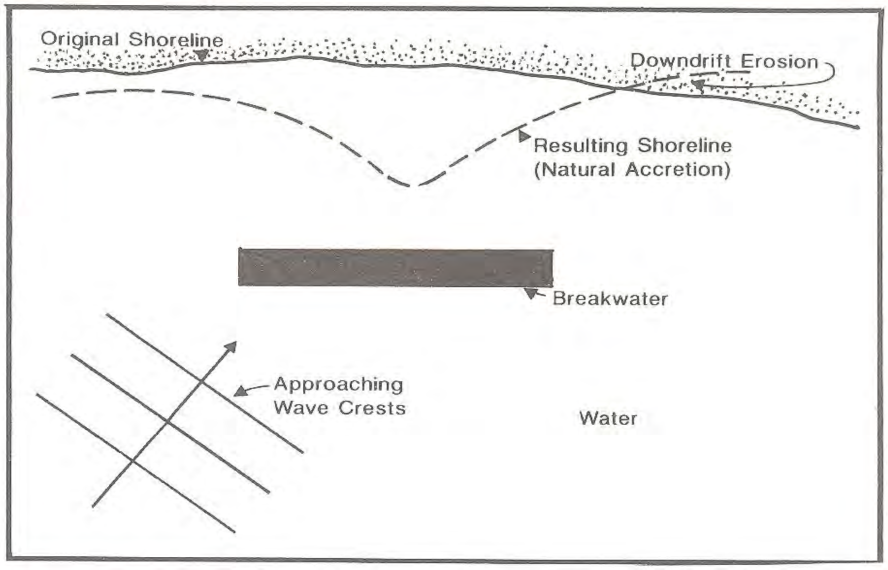


Fig. 33. Breakwater exhibiting the deposition of sand on the leeward side.

Landowners and/or their contractors and engineers are encouraged to call permitting agencies if proposing a breakwater. Pre-application meetings are encouraged. Excluding sand containment structures, these projects require a public notice.

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 are usually constructed of large stones, concrete rubble, concrete form structures, reef balls, or wood sheeting.

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 axe usually installed in shallow water (less than 4 feet deep) due to the cost. The top of the breakwater must be at least one foot above mean high water. The service of a professional engineer is advised for the construction of offshore breakwaters due to the complex nature of their design. Breakwaters can be fixed or floating and must be marked with pilings for navigation purposes.

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.

Fig. 34. Large offshore breakwaters, with opening. (Photo: Maryland Department of Natural Resources)

JETTIES AND 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. Jetties are similar to groins but are much larger. Both of these structures are usually placed perpendicular to the shoreline, but they may be offset. They are not designed for the purpose of creating a beach. Pre-application meetings and design by certified engineers are strongly urged for these projects.

Description
Groins are narrow structures of varying lengths and heights that extend, fingerlike, into the water and are usually constructed perpendicular to the shoreline

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. 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.

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.

Fig. 35. View of groins. (Photo: Maryland Department of Natural Resources)

Fig. 36. View of groin. (Photo: Maryland Department of Natural Resources)

RECOMMENDATIONS FOR DESIGN AND MAINTENANCE OF SHORE EROSION CONTROL STRUCTURES

Several important recommendations which should be considered in the design or maintenance of all shore erosion structures are discussed below:

1) Use of a certified engineer and experienced contractor is recommended.

2) 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. Increase 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.

3) 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 or Coastal Bays, 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.

4) 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. Filter cloth placement is one of the most important design and construction details. Improper installation of filter cloth has caused more structures to fail than any other contributing factor. A properly installed 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) Use chinking stones for any stabilization projects that use rock or stone. The chinking stone must be installed to prevent the larger stones from moving and causing the structure to fail.

5) 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.

6) 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.

7) 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.

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. The Soil Conservation District may also be able to provide guidance on drainage control.

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 establishment and beach nourishment may be considered for use with other methods to produce effective protection measures depending upon wave strength. Beach nourishment maybe 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.

HOW TO SELECT A CONTRACTOR

All types of shore erosion control practices are subject to failure if they are not properly designed and installed. Proper maintenance may prolong the life of your project.

Improper design and construction are the major causes of project failures. For this reason, you should take care in selecting an engineer and contractor and consider the following questions:

1) Is the design by a certified engineer or licensed and bonded contractor? Do they have experience in various types of shore erosion control to advise you on the pros and cons of different options?

2) Does the contractor have experience in construction of various shore erosion control practices, including the type of project you are interested in? Ask for references and photographs of successful projects.

3) Will the contractor be responsible for obtaining necessary permits and approvals?

4) Will contractor perform required maintenance? Some projects, such as marsh creation, require 5 year monitoring period and with replanting if necessary.

5) Has all of the work received proper authorizations? As the landowner, you are responsible for violations on your property.

6) Was the project built according to approved plan? Construction that deviates from what is on the approved plan may be considered a violation of State/federal/local regulations.

GUIDELINES FOR COMPLETING APPLICATIONS

The construction of your shoreline stabilization project may be delayed if your application is incomplete or unclear. In addition to the information on the application form, the following actions will help ensure a smooth application process:

1) Contact the Tidal Wetlands Division in MDE to discuss your project. Ask if a pre-application meeting is recommended.

2) Inform your neighbors that you are proposing to stabilize your shoreline. Notification of adjacent property owners is a requirement of the application process.

3) Send photographs of the shoreline project area from the left, right, water, and land that accurately reflect the conditions of the shoreline and existing structures.

4) Send clear construction plans showing cross sections plan view (overhead) views of your proposed design. You may use or adapt sample drawings provided by MDE. Plans must show all dimensions for width, length, and height of the structure in relation to the shoreline, mean high water, mean low water, and property lines.

Applications are available online at MDE's web page at:

www.mde.state.md.us/Programs/WaterPrograms/Wetlands_Waterways/permits_applications/index.asp

Paper copies of the application are available from MDE's Wetlands and Waterways Program, 1800 Washington Boulevard, Baltimore, MD 21230.

Local Government Contacts

Your shoreline stabilization practice will require approval from a local government agency. You should apply for State, local, and federal approvals at the same time so the review can be coordinated. A coordinated review reduces the need for multiple revisions to your project.

Contact information is subject to change. Contacts as of September 2006 are:

Chesapeake and Coastal Bays Critical Areas Commission (State)	(410) 260-3478
Anne Arundel County	
Anne Arundel County Planning and Zoning	
Environmental Review	(410) 222-7548
Pier review	(410) 222-7960
Soil Conservation District	(410) 222-7822
Baltimore City	
Office of Planning	(410) 396-5902
Baltimore County	
Department of Environmental Protection and Resource Management	(410) 887-4804
Soil Conservation District	(410) 666-1188
Calvert County	
Department of Planning and Zoning	(410) 535-1600
Soil Conservation District	(410) 535-1521
Caroline County	
Planning & Codes Administration	(410) 479-8100
Soil Conservation District	(410) 479-1202
Cecil County	
Department of Permits & Inspections	(410) 996-5235
Soil Conservation District	(410) 398-4411
Charles County	
Department of Planning & Growth Management	
Permits Section	(301) 645-0692
Soil Conservation District	(301) 934-9588

Dorchester County

Dorchester County Planning & Zoning	(410) 228-9636
Soil Conservation District	(410) 228-5640

Harford County

Department of Planning & Zoning	
Building Permits Section or Environmental Planner	(410) 638-3103
Soil Conservation District	(410) 838-6181

Kent County

Kent County Environmental Planner	(410) 778-7473
Soil Conservation District	(410) 778-5150

Prince George's County

Department of Environmental Resources	(301) 883-5919
Permit Review Division	(301) 883-5900
Soil Conservation District	(301) 574-5162

Queen Anne's County

Queen Anne’s Zoning Administration	(410) 758-4088
Soil Conservation District	(410) 758-3136

St. Mary's County

Department of Land Use & Growth Management	(301) 475-4200
Soil Conservation District	(301) 475-8402

Somerset Co

Department of Technical and Community Services	(410) 651-1424
Soil Conservation District	(410) 651-0390

Talbot

Office of Planning and Zoning	(410) 770-8030
Soil Conservation District	(410) 822-1344

Wicomico

Public Works Department	(410) 548-4810
Soil Conservation District	(410) 546-4777

Worcester

Development Review and Permitting	(410) 632-1200
Soil Conservation District	(410) 632-5439

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 vertical structure composed of wood, stone, concrete, plastic or other similar material designed to retain land or to prevent 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.
Living shoreline	An erosion control practice that uses natural components alone or in combination with other structures for stabilization and wildlife habitat. Natural components or natural components in combination with other structures include sand, plant materials, or sand and plant materials with a sill, breakwater, or other structural erosion control practice.
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	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 resilient coating 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 Containment Structure	A low profile structure build perpendicular to the shoreline to contain sand emplaced to establish a living shoreline project.
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 c 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).

Sill	A low profile offshore structure whose crest is at or slightly above the elevation of mean high water, designed to retain sand and marsh on its landward side.
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 channel ward 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.

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