# Erosion Management for New York's Great Lakes Shorelines

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*Mixture of shoreline management options on Chaumont Bay, NY. Photo by Roy Widrig, New York Sea Grant.*

The shorelines of Lake Erie and Lake Ontario are a dynamic, ever-evolving environment. The region is continuously affected by hydrologic and climatic forces, as well as human development. Since the last glaciers retreated more than 10,000 years ago, Great Lakes water levels have varied dramatically, as have the flows of water between these five massive lakes and their combined outflow to the Atlantic Ocean. The Great Lakes influence human activities and all aspects of the natural environment, from weather and climate to wildlife and habitat. Our knowledge of the geophysical, ecological, and socioeconomic characteristics of the region is increasing over time but we will continue to be challenged by uncertainty and the evolving nature of the natural system.

Much of New York's Great Lakes shorelines are naturally subject to erosion, which becomes a concern particularly where there are homes, businesses, or other structures nearby. There are a variety of shoreline management options that can be considered for managing erosion risks; however, some coastal landowners are not aware of the full array of erosion protection options that can be applied along the shorelines of Lake Ontario and Lake Erie. This booklet is intended to give New York's coastal landowners an introduction to a number of shoreline management options available for Great Lakes shorelines.

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*An eroded bluff composed of glacial outwash and till, Sterling, New York.*
*Photo by Roy Widrig, New York Sea Grant.*

## How to Use This Document

This booklet provides an overview of shoreline erosion management options along New York's Great Lakes coastlines. It is important to keep in mind that acceptance of erosion risk and the decision to take no action on the shoreline should be considered as an alternative. Determining which shoreline option might be best suited to a specific location requires an understanding of the natural processes at work in a shoreline site; applicable local, state and federal regulations; and the intended function and lifespan of a management option and the property or asset being protected. Several critical factors must be examined during the planning of a proposed shoreline design, such as the level of protection needed, the design storm (magnitude of storm for which the protective feature is designed to withstand), ecosystem and habitat considerations, shoreline slope and orientation, sediment availability, adjacent shoreline conditions, adjacent public uses, and many others.

Additionally, property owners must obtain required local permits, as well as permits from the New York State Department of Environmental Conservation, United States Army Corps of Engineers, and the New York State Department of State prior to construction. Given the complex and variable challenges associated with selecting a shoreline management option, property owners are strongly encouraged to consult a licensed engineer, regulatory agencies, and their local government before moving forward on a proposed project.

*To learn more about dunes and the processes that affect them, refer to the New York Sea Grant fact sheet, "Effects of Erosion and Accretion on Coastal Landforms." www.nyseagrant.org/glcoastal/pdfs/CoastalLandforms.pdf*

## New York's Coastal Geology

The diverse nature of New York's coastline geology leads to an array of shoreline management strategies. Glaciers were responsible for depositing loosely consolidated and easily erodible shoreline materials. The southern shore of Lake Ontario is known for high, steep bluffs and truncated drumlins, composed of gravels, sands, silts and clays. On the eastern shore of Lake Ontario lies complex dune fields of varying ages. Bedrock exposed along the shoreline also exists, with much of the Lake Erie shore composed of steep shale cliffs. On northeast Lake Ontario and throughout the St. Lawrence River, the shorelines are characterized by metamorphic rocks, which are the most erosion-resistant natural shorelines in the state.

This variety of shoreline types ensures that no one method of shoreline management will work throughout New York State. It is important to work with local contractors who have experience on similar shorelines to your own, evaluate a wide range of management options, and consult with experts on any shoreline management techniques.

# *Natural Resiliency Management*

When considering shoreline management options to reduce erosion risk, it is important to consider all available alternatives that benefit not only the shoreline at the site, but neighboring properties, the coastal processes affecting the area, and ecosystem functions. Natural resiliency options provide risk reduction to assets while also conserving or restoring the existing shoreline.

## Coastal Drainage Improvement

The stability of coastal bluffs along New York's Great Lakes depends on the action of the surface water over the face of the bluff as much as it does on the material of the bluff, steepness of the slope and wave action at the toe of the slope. Human disturbances on the bluff may also affect stability.

*Bluff erosion at Chimney Bluffs State Park.*
*Photo by Emily Sheridan, New York State Department of Environmental Conservation.*


*Green to gray shoreline options.*
*Produced by Joe Ruszala, United States Army Corps of Engineers.*

Surface erosion can be minimized by collecting and diverting runoff from the face of the slope, by minimizing hard-surfaced areas, which tend to shed rainwater more rapidly than natural ground surfaces, and by proper use of vegetation to slow runoff.

## Types

Drainage improvements can include the use of perforated or permeable conduits buried beneath the surface of the ground. These pipes are laid in a trench excavated parallel to the top of the bluff.

**Corrugated Plastic Tubing:** Water enters this pipe through small holes or slits. The corrugations help provide some additional strength to prevent flattening, but the tube may still be crushed if it is not placed on a well-prepared bed and covered with a uniformly sized backfill material. Usually the tubing is covered with a thin geotextile fabric to keep smaller sediment from plugging the tubing holes.

**Rain Capture Techniques:** Capturing rainfall before it has a chance to infiltrate through the soil to the bluff face can also aid in drainage improvement. Upland retention ponds can slow the infiltration of water, and rain gardens can use excess runoff to sustain plant life. Redirecting roof runoff to surface drainage can also mitigate rainfall infiltration.

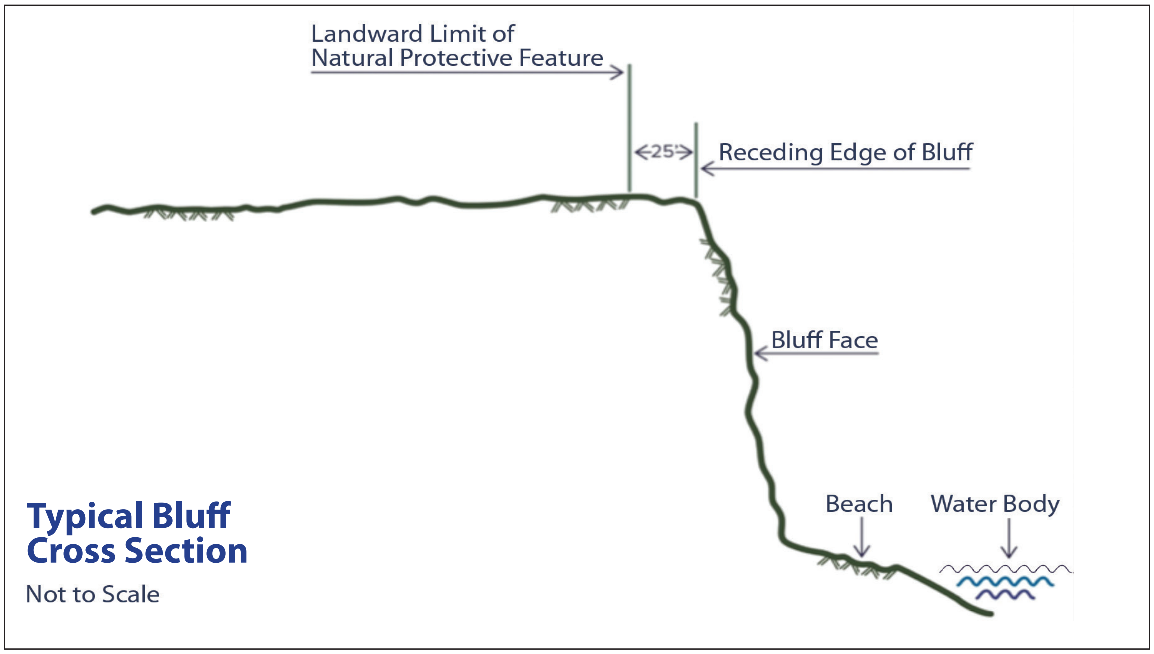
## Design Considerations

**Depth:** The depth of the trench is dictated by the depth from the surface of the ground to the impermeable clay or hardpan layer acting as a barrier to normal groundwater movement. Note that if the depth of the barrier layer is too great, drainage conduits may not be feasible. The conduit is then laid into the trench, and the trench is backfilled with uniform porous materials, such as gravel and coarse sand.

**Slope:** It is important that the pipe is laid at an angle to prevent silt from building up in the pipe and eventually clogging it.

**Length:** Subsurface and surface drainage projects should ideally extend for the entire length of the area affected by groundwater seeps or surface erosion.

**Filtration:** Fine sands can enter a subsurface drainage pipe through the joints between sections or through the holes in the tubing. If water flows are gentle, this material could settle out, clogging the pipe. To prevent this, in sandy soils the joints (or the tube) should be wrapped with filter cloth.




*Cross-section of a typical Great Lakes bluff.*
*Provided by the New York State Department of Environmental Conservation.*

## Coastal Bluff Reshaping for Stabilization

When a coastal slope is steeper than the angle at which the soil particles will remain naturally in place, the potential for slope erosion is greatly increased. This is particularly true if the surface is devoid of vegetation, if moisture is added to the soil, if the toe is undercut at its base by wave action, or if additional weight is placed at the top of the slope. Provided there is sufficient land area at the top of the slope, a coastal bluff could be regraded to a reduced angle to increase its stability. Regrading by itself is not a solution to surface erosion, but instead must be performed as part of an overall stabilization project, including revegetation of the slope. Toe protection is generally necessary, but should be evaluated based on site conditions.

### Types

**Cutback:** A cutback slope stabilization involves reducing the slope of a bluff by removing material completely, grading the slope to a more stable angle.

**Terraced:** Terraced slope designs remove steep slope material and flatten parts of the slope. Materials placed within the vertical portions of the terrace create a stepped shape to the shoreline.

All methods listed previously should be accompanied by revegetation for improved stabilization and, if deemed necessary, toe protection.

### Limitations, Advantages and Disadvantages, Effects of Coastal Processes or Ecological Impacts

Slope reshaping does not provide protection to adjacent areas, nor does it protect against erosion resulting from direct wave action at the toe of the slope. The amount of fine sediment in the nearshore system may decrease by reducing the amount of clays or silts being eroded away from the slope. Bluff reshaping, coupled with revegetation, can aid in restoration of the local ecosystem. Note that bluff reshaping may not be necessary in all situations, as natural erosion of the bluff contributes sediment into the nearshore and can build up fronting beaches.

### Design Considerations

The slope and material of the bluff and whether or not vegetation can be established are important factors to consider. It is also important to consider the potential impact to any landward structures.

*Ongoing dune revegetation and sand fencing placed at Sandy Island Beach State Park. Photo by Roy Widrig, New York Sea Grant.*

## Dune Restoration and Fencing

Dunes are mounds or ridges of sand deposited by the wind immediately landward of the beach. Dunes not only provide a natural barrier to wave impacts, but they also supply sediment to the littoral zone. Rooted vegetation and sand fencing can act to restore or build a dune by trapping sand transported by the wind. Dunes created with fencing should be stabilized with appropriate and native vegetation to lessen the erosion from wind or wave action.

*To learn more about dunes and the processes that affect them, refer to the New York Sea Grant fact sheet, "Effects of Erosion and Accretion on Coastal Landforms."*

### Types

**Dune Restoration and Conservation:** Dune conservation protects these features by allowing them to act dynamically. Dunes are allowed to re-form and change over time without significant human intervention and may include minimal management, such as installation of sand fencing, removal of invasive or non-native plant species, and planting of native vegetation such as beach grass.

### *Littoral Zone*

*The littoral zone is the area within the lake, closest to the land, where sediment can be transported by wave action.*

**Fencing:** Sand or snow fencing is designed to capture wind-blown sand in dune environments. Fencing usually consists of thin wooden slats held together with twisted wire. Fencing allows the passage of sand through the slats while dissipating wind speed and contributing to the growth of the dune by depositing sand on the lee side of the fence.

**Vegetation:** Early planting of beach grass, wheat grass, wild rye and dune willows (to initiate stabilization) can be followed with planting wormwood, sand cherry and chokecherry. Cottonwood and Basswood thrive on dunes for long-term stabilization.

### Limitations, Advantages and Disadvantages, Effects of Coastal Processes or Ecological Impacts

Dunes only make up a small percentage of New York's Great Lake shorelines, but they are valuable ecosystems and provide risk reduction benefits. Conservation and restoration of dunes help maintain natural coastal processes. The use of vegetation and fencing to help stabilize and/or build up dunes cannot guarantee protection against erosion from wind, waves, or human activities. Fencing and revegetation can restore or create rare protected ecosystems.

### Design Considerations

Management of dunes must avoid foot traffic through vegetated areas. To help direct walking traffic, pile-supported dune walkovers may be constructed over dune habitat.

Dune fencing should be placed as far landward as possible and above the average lake level with a spacing of 50% wooden slat to 50% open space. In order to avoid scour (erosion at the base of the fence), fence posts should be at least 4 feet apart and buried no more than 4 feet into the dune. Revegetation on the landward side of sand fencing is recommended for stabilization of dunes.

## Relocation

Siting of new development or relocation of existing development set a sufficient distance back from the coastal landforms such as bluffs, dunes, or beaches, or in a location that avoids hazards. Setbacks are established through local and New York State regulations and can be based on factors such as erosion rate per year, or risk of flood hazards.

### Limitations, Advantages and Disadvantages, Effects of Coastal Processes or Ecological Impacts

Relocations and setbacks will have variable costs and may not be feasible in every location. These types of measures are site specific and dependent on the design of the existing structure on the parcel as well as the level of risk from coastal hazards. Relocation or movement of structures away from the shoreline would allow natural shoreline processes to continue while reducing risk of damage to the structure, and would not be detrimental to existing shoreline ecosystems.

### Design Considerations

New buildings or relocated ones should not be located in hazardous areas and should comply with any established setbacks. A voluntary setback could be determined, for example, based on the projected lifetime of the structure and the erosion rate per year. For example, if a structure is expected to have a lifetime of 50 years, and the erosion rate is 2 feet per year, a minimum potential setback would be 100 feet. This can be determined in consultation with engineering professionals or local/state agency staff. In most cases, the size of the land parcel (acreage) is important in determining if relocation is possible, but relocation to another area entirely is also possible. Owners/applicants must secure permits and variances, if needed, before relocating structures. These types of adaptive measures should consider water level variations as well as potential climate change impacts, such as increased wave action from severe storms.

*Nature-based shoreline employed at Sodus Bay (Wayne County, NY).*
*Photo by Emily Sheridan, New York State Department of Environmental Conservation.*

## Nature-Based Features

Nature-based features are defined by using a more natural, or green, approach to shoreline erosion management by using a footprint of mostly native material (including but not limited to root wads, sand, logs, and vegetation). Nature-based features can incorporate vegetation exclusively or in combination with harder structures for stability. Sometimes these approaches are called 'living shorelines' or 'hybrid' approaches. The amount of structure needed depends on a number of factors, such as site conditions and upland land use. A more engineered shoreline option that includes both green and gray elements may be necessary and more effective in high wave energy environments. Nature-based features should be designed to mimic natural landforms, the local coastal processes, and should support the ecosystem.

***accretion***

*Gradual accumulation of sediments, such as at beaches and sand dunes*

### Example components of Nature-based Features

**Coir Logs:** Coir logs, which are cylinders of tightly wound, woven or netted coconut coir twine, are used as toe protection and to stabilize erodible banks and shorelines. Vegetation can be planted directly on top of the coir logs, which biodegrade into the slope while roots stabilize the slope. Coir logs are generally only used in low wave energy environments, such as embayments.

**Sills:** Low-profile breakwaters, or sills, are typically parallel to the shore and can help dissipate wave energy by forcing wave breaking. Sills are typically made of rocks or boulders and placed a certain distance offshore. When wave energy is dissipated before hitting the shoreline, sediment is better retained along the shore and less erosion is likely to occur, helping to build up the shoreline. Nature-based features that include sills are used in combination with wetland restoration to help protect wetland shorelines and support sediment accretion. Sills generally work best in low wave energy environments, such as embayments.

***downdrift***

*Refers to the direction of the net longshore transport, or the predominant direction of sediment movement in the littoral zone.*

### Limitations, Advantages and Disadvantages, Effects of Coastal Processes or Ecological Impacts

Nature-based shorelines can help maintain or restore coastal processes and stabilize shorelines. Maintenance costs can be high due to replacement of living material, but can decrease over time. Additionally, completely hardened approaches need more maintenance over time. Nature-based features are more adaptable than hardened approaches, and also provide habitat, nesting, or foraging opportunities to coastal species. In some cases, such as when critical infrastructure is threatened by an actively eroding shoreline, nature-based shorelines may not be an appropriate solution by themselves. Additional solutions should be explored to help reduce risk.

### Design Considerations

Nature-based shorelines are not appropriate everywhere. The wave energy of any shoreline environment is key in the efficacy of any shorelines project. In some cases, wave energy may be too intense and nature-based shorelines may not be effective. In the Great Lakes, ice is also an important consideration for the design and location of a nature-based feature. These features should only utilize native vegetation and continued maintenance/adaptive management plans should be established.

## Engineered Beaches

Beaches, which are natural coastal landforms, can be very effective at reducing the amount of wave energy reaching upland areas of the shore. When a beach is nourished or maintained for the purpose of providing protection, it is considered an erosion control structure and could be referred to as a protective beach.

### Limitations, Advantages and Disadvantages, Effects of Coastal Processes or Ecological Impacts

Beach replenishment will not stop or prevent beach erosion itself. This approach adds sediment back to the beach that may have been lost in the past. Protective beaches may decrease erosion on downdrift beaches by providing more sand to the nearshore system and may accelerate shoaling in downdrift or nearshore areas. Engineered beaches are not permanent, as the sediment is typically lost to the system over time. Note that beaches are naturally dynamic, and maintaining a certain width/height of a beach is a long-term management strategy. Established beaches could attract desirable wildlife, including shorebirds, and restore habitat connectivity to a depleted shoreline.

### Design Considerations

Fill used in beach nourishment projects must be clean (approved by NYSDEC) and match the grain size distribution of the natural material used to build the beach. This could include dredging or importing material from an offsite source. In order to maintain the designed size of the beach, ongoing maintenance is generally required, including re-nourishment of sand over time. Beach nourishment projects are only effective along longer stretches of shoreline. Sand placed in front of a single parcel will have a minimal effect and will be quickly washed away. Engineered dunes can be designed and constructed in conjunction with engineered beaches to provide an additional level of protection.

# *Traditional Gray Shoreline Structures*

Hard, or gray shoreline structures should be proposed in areas where other alternatives will not provide the necessary level of protection. Areas that are exposed to high wave energy and ice are more suitable for a hardened approach. Permitting of these structures is considered only when all alternative methods (relocation, setbacks, natural and nature-based features) have been deemed unfeasible.

Hard structures generally impede important coastal processes such as littoral drift of sediments and can compound impacts from intense wave energy, resulting in significant erosion to neighboring shorelines. Gray shoreline structures may also deplete sensitive coastal ecosystems and disrupt habitat connectivity.

*Ice-covered rock rip-rap revetment, Irondequoit Bay (Monroe County, NY). Photo by Roy Widrig, New York Sea Grant.*

## Revetments

A revetment is a structure typically composed of stone, built at and parallel to the toe of a bluff or embankment. Revetments are typically sloped and can be utilized in areas with moderate to intense wave energy.

### Types

Revetments are generally constructed using large, angular rocks as an armor layer, which is exposed to wave energy. The numerous spaces between the rocks provide release of hydrostatic pressure from behind the structure as well as dissipate the oncoming wave energy. The armor stone sits on a foundation of bedding stone over geotextile fabric to provide a suitable foundation.

### Limitations, Advantages and Disadvantages, Effects of Coastal Processes or Ecological Impacts

Revetments are designed to provide risk reduction to upland areas but do not provide protection to adjacent areas. They may contribute to downdrift erosion by preventing additional sediment from entering the littoral drift system. Wave energy reflection can cause scour at the toe of the structure. However, this effect is less than with seawalls (see Seawalls) or bulkheads (see Bulkheads) because of the dissipation of wave energy on the sloped, irregular face of the structure. By hardening the shoreline, coastal ecosystems are impeded and often cannot recover from the loss of habitat connectivity.

### Design Considerations

Revetments consist of three components: a filter layer (also known as a bedding layer), an armor layer, and toe protection. The armor layer must resist wave action and should be placed on a slope no steeper than 1.5 horizontal to 1.0 vertical ratio, and ideally a slope of 2 horizontal to 1 vertical or shallower should be used. The toe protection is made up of heavier stones of adequate size keyed in to prevent waterward displacement of the rest of the revetment due to wave scour or undercutting at the toe. A revetment should be built at an elevation adequate to prevent frequent overtopping during the design storm. A revetment should be constructed above ordinary high water where possible.

**Flanking:** Erosion progressing around the structure's ends is a potential problem for revetments, and can be prevented by constructing wingwalls or returns at the ends of the structure to tie the structure into the shoreline.

## Seawalls

A seawall is a structure built parallel, or nearly parallel, to the shore that separates the land and the water for the purpose of protecting against erosion from wave damage and flood impacts. Seawalls are often vertical or nearly vertical which results in reflection of wave energy. This can result in scour at the toe of the wall. A secondary function of a seawall is that it acts as a bulkhead or retaining wall, holding back the land behind it. Small seawalls are often called bulkheads and are sometimes difficult to distinguish functionally from bulkheads. The two terms are also often incorrectly used interchangeably (see Bulkhead).

### Types

**Cast-in-Place and Pre-Cast:** Seawalls may be cast-in-place or pre-cast concrete that rely on their own weight and/or anchoring systems to keep them upright. They may have smooth or rough faces and have various face shapes, such as stepped and curved.

**Other materials:** Seawalls may be constructed of a wide variety of materials besides concrete, such as sheet steel pile and timber. The smoothness, shape, and material of the seawall all impact the extent of wave action, absorption or reflection of wave energy, and toe scour.

### Limitations, Advantages and Disadvantages, Effects of Coastal Processes or Ecological Impacts

Seawalls provide risk reduction to the upland, but often at the cost of the shoreline itself and adjacent areas. Seawalls are the most structurally sound option when they are built, but over time may require more upkeep and maintenance. Because seawalls prevent sediments from behind the wall from entering the littoral system, they may deplete some of the downdrift shoreline. These structures reflect wave energy, which may increase toe scour in front of the seawall, and can also contribute to beach depletion, or beach steepening immediately in front of or adjacent to the structure. Seawalls disrupt habitat connectivity and remove important shoreline plants and animals from their natural habitat.

*Concrete and steel sheet pile seawall protecting a small harbor, Selkirk Shores State Park (Jefferson County, NY). Photo by Emily Sheridan, New York State Department of Environmental Conservation.*

## Design Considerations

An appropriate design will avoid abrupt, shore-perpendicular ends at property boundaries, and have a deep foundation. In general, both revetments and seawalls are to be "rounded" off at the ends and/or meet the existing bluff/bank slope contours. This will reduce the potential for erosion at the adjacent property that could work its way back behind the structure and cause upland slope failure and possible failure of the end of the revetment or seawall. If existing structures are present at adjacent properties, the proposed design must transition to these as smoothly as possible. Toe stone may be necessary to minimize scour, depending on site conditions. A seawall should be constructed above ordinary high water where feasible.

**Flanking:** Flanking is a potential problem for seawalls and bulkheads, and can be prevented by constructing wingwalls or returns at the ends of the structure to tie the structure into the shoreline.

# Bulkheads

A bulkhead is a structure built parallel, or nearly parallel, to the shoreline along a bank, at the toe of a bluff, or along a beach to prevent upland erosion. A bulkhead may also be called a retaining wall. Secondary functions are to protect the land against wave action and to reclaim lost land by backfilling. A bulkhead does not ensure the stability of the land behind it, such as an unstable bluff. Bulkheads are fairly effective at deflecting wave action. A major difference between seawalls and bulkheads is related to the construction and type of materials used. Since a bulkhead's primary function is holding back the land and not taking the full brunt of storm wave energy, a bulkhead can be constructed of lighter materials and be smaller in size than a seawall.

## Types

**Sheet Pile:** A sheet pile bulkhead is built from interlocking or closely spaced sheets of steel, concrete, aluminum, or treated wood driven or jetted vertically into the ground.

*Concrete bulkhead deflecting waves, Westcott Beach State Park.*
*Photo by Roy Widrig, New York Sea Grant.*

**Cast-in-Place Concrete:** This type of bulkhead resembles a concrete seawall except that it is smaller in size. Like a sheet pile bulkhead, this bulkhead relies upon anchoring to retain its vertical position and to resist wave action.

**Pre-Cast Concrete:** Usually used in low wave energy situations, pre-cast concrete members are set in place, bolted together, anchored, and backfilled. Additional toe protection is essential because these structures do not extend below the bottom and can easily be undercut.

**Treated Timber:** This type of bulkhead is constructed by driving vertical wooden piles into the bottom. Treated planks are then spiked or bolted to the landward side of the piles. Treated timber bulkheads can be constructed with anchors or bracing to increase their strength.

## Limitations, Advantages and Disadvantages, Effects of Coastal Processes or Ecological Impacts

Bulkheads are the most structurally sound when they are built, but over time may require more upkeep and maintenance than other options. Bulkheads may cause some depletion of the downdrift shore by preventing sediment behind the wall from entering the littoral system and replenishing the downdrift area. Breaking and/or reflected waves may increase toe scour, beach depletion, or beach steepening immediately in front of or adjacent to the structure. Bulkheads can be a deterrent for natural movement of wildlife across the land water interface and removes habitat for plant species.

## Design Considerations

An appropriate design will avoid abrupt, shore-perpendicular ends at property boundaries and have a deep foundation. In general, both revetments and seawalls are to be “rounded” off at the ends and/or meet the existing bluff/bank slope contours. This will reduce the potential for erosion at the adjacent property that could work its way back behind the structure and cause upland slope failure and possible failure of the end of the bulkhead. If existing structures are present at adjacent properties, the proposed design must transition to these as smoothly as possible. Toe stone may be necessary to minimize scour, depending on site conditions. A bulkhead should be constructed above ordinary high water where feasible.

*Small rubble mound groin with vegetation, Westcott Beach State Park.*
*Photo by Roy Widrig, New York Sea Grant.*

## Groins

A groin is a structure built generally perpendicular to the shore, extending into the water. Groins are used to build up, widen a beach, or to protect and stabilize a beach by slowing down the rate of erosion. They do this by trapping and holding sediment passing through the area in which they are built. Groins can be used singly or in groups of two or more, known as groin fields. Groins must be engineered for each specific site, and are typically used in areas with large amounts of sand in the littoral system. In operation, groin fields will typically create a sawtooth effect on the shoreline, with sand building up on the updrift side of the groins and erosion taking place downdrift of the structures. Due to the extensive analysis needed to ensure groins will not have negative impact on downdrift areas, privately owned groins are generally not permitted on New York's Great Lakes.

### Types

**Timber:** Timber groins are built of wooden sheet piles to provide the primary support and horizontal members to provide longitudinal integrity.

**Steel:** Steel groins are built of interlocking steel sheet piles supported by vertical round-steel or timber piles. Because the sheet piles are interlocking, they may not need horizontal members for extra strength, except in areas of high wave energies.

**Concrete:** Concrete groins use cast-in-place construction or flat pre-cast sheets on concrete held in place with a cast-in-place cap.

**Rubble Mound:** Rubble-mound groins are constructed of bedding stone built on top of a bed of crushed stone. The structure is capped with an outer layer of heavy armor stone. These groins are used when there is heavy wave action or where there is a ready supply of inexpensive stone.

### Limitations, Advantages and Disadvantages, Effects of Coastal Processes or Ecological Impacts

Groins typically perform well at capturing sediment on the updrift side of the structure, and can dissipate wave energy and stabilize shorelines. Groins may deplete downdrift beaches by cutting off the source of littoral sediments. They require extensive analysis or modeling to ensure they will not have downdrift impacts, and can be expensive to build. Groins can produce small accretion beaches which do not fit the natural environment of the shoreline and become detrimental to the native ecosystem by deterring establishment of shoreline vegetation and impeding movement of aquatic animals.

## Design Considerations

Groins are used in areas rich in sand. They are not effective in areas with sediment finer than sand because silts and clays will not settle on the updrift side of the groin. Instead, these finer sediments remain in suspension and are transported by currents. If the sand supply is not sufficient, continued artificial filling may be required to prevent downdrift starvation and increases in erosion.

**Length and Height:** Groins should be designed in a tapered fashion that allows them to trap sediments without creating an unacceptable downdrift erosion problem. Groins typically extend from the top of the beach berm to wave break zone. At the landward end, the minimum height equals the height of the desired berm to be entrapped or protected. The landward end is generally built as low as safety permits (boating and swimming), above the grade.

**Spacing:** When filled to capacity, the updrift beach should reach to the base of the next updrift groin. If built too far apart, there will be excess erosion between the individual groins. If built too close together, there may not be sufficient time or space for sand to pass around the end of one and come back into the beach to form a fillet before being forced waterward by the next.

# Breakwaters

A breakwater is a structure typically constructed parallel to the shoreline offshore. Breakwaters can either be built from the lake bottom up, floating or bottom anchored. Breakwaters are usually built parallel to the shore, but can be aligned at a slight angle to the shore to meet specific wave or bottom conditions.

Breakwaters provide erosion control by dissipating and deflecting wave energy and creating an area of calmer water (shadow) in their lee (landside). They may result in accretion on the shore in the calm waters in their lee as sediments suspended in the littoral current settle out in the calmer waters. Due to their expense, breakwaters are generally not a feasible option for private property owners, and are generally only built as part of a municipal project.

## Types

**Concrete Caisson:** These structures are built of reinforced concrete boxes, which are floated or barged into position. They are then lowered onto a bottom foundation of stone and filled with sand, stone, or concrete. Concrete caisson breakwaters are usually capped with concrete to keep the fill from being washed out.

**Rubble Mound:** Rubble mound breakwaters are the most common and are constructed of stone or various angular precast concrete units. A foundation bedding stone is used as the base of the structure, which is capped with an outer layer of massive armor stone.

## Limitations, Advantages and Disadvantages, Effects of Coastal Processes or Ecological Impacts

Decreased wave action behind the structure will result in increased deposition when there is sufficient material in littoral currents. The downdrift shore may experience some erosion if a substantial amount of littoral drift is removed from currents behind the structure. If the accretion behind the breakwater increases to the point that the breakwater becomes connected to the shore, creating a tombolo, littoral drift will be totally cut off from the downdrift areas of the beach, possibly resulting in downdrift erosion.

## Design Considerations

**Height:** The desired function of an offshore breakwater can influence its design height and should be designed by a licensed engineer. A structure high enough to dissipate severe storm wave energies approaching the shore will result in calmer, more protected waters behind the structures. However, a higher structure will interrupt longshore drift and may result in increased erosion downdrift. A breakwater built at a lower height can still provide some wave dissipation, particularly for smaller storm events. This would allow some littoral current to continue in its lee.

**Orientation and Spacing:** Special care must be taken in the orientation and spacing of offshore breakwaters to prevent undesirable effects behind or adjacent to the structure as a result of wave refraction and diffraction effects. Breakwaters should be spaced out to not only allow for sediment transport, but to allow for habitat connectivity.


*Erosion is a natural process on New York's Great Lakes, and shorelines within the region are constantly changing shape. When working with New York's Great Lakes shorelines to protect homes and critical infrastructure from erosion, it is important to follow all federal, state and local requirements, and to consult with creditable shoreline contractors and, when needed, engineers.*

*For a list of regulated activities and permits that may apply to your project, please visit www.dec.ny.gov/permits/96314.html*

*For an up-to-date list of shoreline contractors on New York's Great Lakes, visit: www.nyseagrant.org/glcoastal/pdfs/GLCoastalProcesses-ShorelineContractors.pdf*

*To learn more about coastal processes and shoreline resilience in the Great Lakes, please visit New York Sea Grant's website www.nyseagrant.org/glcoastal*



New York Sea Grant
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