POINT OF PINES BEACH MANAGEMENT PLAN (DRAFT)

Revere, Massachusetts

Submitted to:
Elle Baker (Project Planner) - City of Revere

Submitted by:

AECOM

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Contents

Beach Management Plan

List of Attachments

1.0 Purpose and Objective

The purpose of this Beach Management Plan is to provide the Point of Pines Beach Association and other stakeholders (such as the City of Revere, Commonwealth of Massachusetts, and private landowners) with near-term and lower cost actions that can be implemented as longer-term climate resilience interventions are designed, permitted, and constructed. Some of the recommended options presented below will require the filing of environmental permit applications. This Beach Management Plan includes a discussion of existing conditions, recommended management activities, and regulatory considerations.

2.0 Background and Existing Conditions

2.1 Geographic Extent of Beach Management Plan

The Point of Pines Beach is located in the northeastern portion of the City of Revere, Massachusetts (Attachment A – Figure 1 (Locus Map)). The geographic area covered by this beach management plan is generally an inverted "L" shape, with the northern end in the vicinity of the Point of Pines Yacht Club and the southern end terminating near Pines Road and Carey Circle (Attachment A – Figure 2 (Overview)). The northern portion of the beach borders on the Saugus River near the Revere/Lynn town line while the southern portion borders on Broad Sound and the Atlantic Ocean to the east. Rice Avenue generally forms the upgradient (landward) boundary of the beach management plan area. The linear distance of shoreline within the Point of Pines Beach Management Area is approximately 0.94 miles.

2.2 Beach Access

Parking options for Point of Pines Beach are limited, with parking available at Carey Circle. However, several pedestrian access paths to the beach are present on the north side of Rice Ave. in the northern portion of the beach management area and numerous pedestrian access paths are present in the vicinity of the intersections of Rice Avenue with Wadsworth Ave., Witherbee Ave., Bateman Ave., Fowler Ave., Whitin Ave., Lancaster

Ave., Bickford Ave., Alden Ave., Delano Ave., Chamberlain Ave., Goodwin Ave., Harrington Ave., and the end of Pines Rd. Many of these footpaths cross the dunes to reach the beach.

2.3 Point of Pines Beach Association and Management Plan Responsibility

The Point of Pines Beach Association (POPBA) is responsible for the majority of the Beach Management Plan area of interest. The segment of beach under POPBA control extends from the Point of Pines Yacht Club in the north to Chamberlain Ave. in the south, with the exception of four small parcels owned by the City of Revere in the vicinity of Fowler Ave. POPBA was founded in 1949 as an organization for the common ownership of 35 acres of Point of Pines Beach. Annual dues are charged for membership in the association and access to the portion of the Point of Pines Beach controlled by POPBA is restricted to members only.

It is anticipated that the responsibility of implementing the recommendations below along with any necessary permitting would be the responsibility of the Point of Pines Beach Association, unless alternative arrangements are made with the City of Revere or the Commonwealth of Massachusetts.

2.4 Wetland Resource Areas

As per MassGIS data layers (MassGIS 2017a; MassGIS 2017b) and aerial imagery (MassGIS 2019), wetland resources present within the Beach Management Plan area that are jurisdictional under the Massachusetts Wetlands Protection Act (WPA; MGL Ch. 131 s. 40), its implementing regulations (310 CMR 10.00), and Title 16 Environment Chapter 16.04 Wetlands Protection of the Revere City Ordinances include: Coastal Bank, Coastal Dune, Coastal Beach, and Land Subject to Storm Flowage (Attachment A - Figure 3 and Figure 4).

2.4.1 Coastal Bank

Coastal Bank is defined in the WPA Regulations at 310 CMR 10.30(2) as “the seaward face or side of any elevated landform, other than a coastal dune, which lies at the landward edge of a coastal beach, land subject to tidal action, or other wetland.” The top of Coastal Bank is found at the seaward facing edge of the top of the existing seawalls and stone revetments within the beach management area. Specifically, this includes the top edge of the cement seawall that runs from the eastern end of the Point of Pines Yacht Club, paralleling the curve of Rice Avenue, to Wadsworth Avenue; the top edge of the seawall that parallels Rice Avenue from Alden Avenue to Harrington Avenue; the top edges of the segments of seawall and stone revetments between Harrington Avenue and Pines Road; and the top edges of the stone revetment segments between Pines Road and Carey Circle.

2.4.2 Coastal Dune

Coastal Dune is defined in the WPA Regulations at 310 CMR 10.28(2) as “any natural hill, mound or ridge of sediment landward of a coastal beach deposited by wind action or storm overwash. Coastal dune also means sediment deposited by artificial means and serving the purpose of storm damage prevention or flood control.” Coastal Dunes are located within the beach management plan area east of the Point of Pines Yacht Club to where Coastal Dune tapers to the seawall near Witherbee Avenue along Rice Avenue; then beginning again as Rice Avenue begins to curve southward, with Coastal Dune continuing parallel along Rice Avenue, tapering out seaward of the seawall between Goodwin Avenue and Harrington Avenue along Rice Avenue. Dune vegetation is generally dominated by American beachgrass (*Ammophila breviligulata*) and accompanied by a variety of other herbaceous plant species (including seaside goldenrod (*Solidago sempervirens*)), depending on the location. Woody vegetation such as sporadic pine (*Pinus* sp.) and patches of beach rose (*Rosa rugosa*) and other shrubs are present, particularly on the central and landward sides of the Coastal Dunes.

2.4.3 Coastal Beach

Coastal Beach is defined in the WPA Regulations at 310 CMR 10.27(2) as “unconsolidated sediment subject to wave, tidal and coastal storm action which forms the gently sloping shore of a body of salt water and includes tidal flats. Coastal beaches extend from the mean low water line landward to the dune line, coastal bank line or the seaward edge of existing human-made structures, when these structures replace one of the above lines, whichever is closest to the ocean.” Coastal Beach exists along the entire Beach Management Plan area and lies seaward of the Coastal Dunes where present and in the absence of Coastal Dunes, Coastal Beach lies seaward of Coastal Bank.

2.4.4 Land Subject to Coastal Storm Flowage

Land Subject to Coastal Storm Flowage is defined in the WPA Regulations at 310 CMR 10.27(2) as “land subject to any inundation caused by coastal storms up to and including that caused by the 100-year storm, surge of record or storm of record, whichever is greater.” The entire Beach Management Plan area is mapped as FEMA 100-year floodplain, with the vast majority of the area as Zone VE (high risk coastal area velocity zone) and lesser components of Zone AE.

2.5 Rare Species

The Massachusetts Natural Heritage and Endangered Species Program (NHESP) has mapped Estimated Habitats of Rare Wildlife (EH 1064) and Priority Habitats of Rare Species (PH 1491) within the entire Beach Management Plan area (MassGIS 2017c; MassGIS 2017d) (Attachment A – Figure 5). Although formal coordination has not been conducted with NHESP as part of this Beach Management Plan, it is anticipated that mapped habitat of rare species likely includes Piping Plover (*Charadrius melodus*) as this species has been observed at Point of Pines Beach (Figure 1 below). Piping plovers are currently listed as Threatened at both the Massachusetts and Federal levels and would need to be considered when implementing any of the recommendations in this Beach Management Plan. Additional information regarding Piping Plovers is provided in Attachment C.

Figure 1. Piping Plover (*Charadrius melodus*) observed at Point of Pines Beach in 2020.

3.0 Recommended Management Activities

The recommendations provided in this section represent a balance between preserving and restoring the natural functions of the dune and beach resources and providing a beach resource for recreational purposes. Some of these recommendations have been implemented in the past or are currently being implemented and should continue while other recommendations are new and should be considered for implementation. Since beach and dune systems are naturally dynamic, some of the recommendations presented below should be reviewed periodically as conditions change within the beach management area.

The recommendations below are organized by several categories: recordkeeping, monitoring, routine and periodic maintenance activities, vegetation planting, construction activities, rare species preservation, and public education, outreach and signage.

3.1 Recordkeeping

Recordkeeping is an important part of a beach management plan and should be established if no recordkeeping system currently exists. One or more individuals should be identified as recordkeepers for the Beach Management Plan and records can be kept either electronically or in written form. The record keeping system should include: dates and locations of the work performed, details of the work performed, equipment used, number of personnel used, duration of the work, photographs, any follow up activities recommended and timing of those follow up activities.

Recordkeeping can also include entries for notable storms that have impacted the beach as well as the extent of damage and changes to the beach and/or dune topography and locations affected. Records can be created after each notable storm and following each management or monitoring activity.

3.2 Monitoring

Conduct annual condition surveys of infrastructure elements (seawalls, walkways, sand fence, etc.) to identify damage or deterioration and suggest recommendations for repair or replacement as needed. Observations of any portions of infrastructure that are owned by the City of Revere or the Commonwealth of Massachusetts should be relayed to the City and appropriate State agency for follow-up. Information regarding the location and ownership of shoreline stabilization infrastructure is provided in Attachment D. The ownership table provided in Attachment D assumes that the owner of the parcel is also the owner of the shoreline stabilization infrastructure on that particular parcel, which is based on the best information currently available. Dates of observations and recommendations should be included as part of the recordkeeping system.

3.3 Routine and Periodic Maintenance

3.3.1 Removal of manmade trash and debris

According to the Point of Pines Beach Association website (http://popba.net/), beach cleaning events are conducted on a regular basis (typically quarterly) during the year. The removal of manmade trash and debris (including bottles, cans, plastic bags, other plastic items, fishing line and other fishing gear, cigarette butts, wood pilings, pieces of lumber, buoys, lobster traps, etc.) within the beach management plan area (including dunes, as necessary) should continue on a routine basis. In addition, trash removal should also occur after storm events should manmade objects wash up on the shore. A carry-in/carry out trash policy should continue to be enforced and added to signage where necessary. Natural wrack (dislodged vegetation, plant fragments, seeds, seaweed, etc.) should be left in place as long as it doesn't present a safety hazard. Natural wrack is an important component of the shoreline ecosystem and provides a vital natural food source for coastal birds (including rare bird species) by providing habitat for invertebrates and other organisms. In addition, when sand becomes entrapped in wrack, especially in the upper beach zone, nutrients in the buried wrack can help support the germination of seeds mixed with the wrack, which in turn can support the stabilization via vegetation of the foredune area.

3.3.2 Repair of walkways, seawall, etc.

The repair of wooden walkways, replacement of faded or damaged signage, damaged seawalls, and other structures should be performed on an as-needed basis within the beach management plan area.

3.4 Construction Activities

3.4.1 Closure of Some Pathways Across the Dunes

Elimination of unnecessary dune paths should be considered in order to protect the dune from continual plant destruction and erosion. Priority areas include the paths identified on Figures 9, 10, 11, 12, and 13 in Attachment A. This includes the undesignated pathways extending north and east from the swing set area (east of Wadsworth Avenue) and the pathway connecting the Wadsworth and Witherbee Avenue beach access paths (the pathway that parallels Rice Avenue). A mix of shrub plantings can be used in these locations to discourage further use as a pathway as well as segments of sand fencing (see Section 3.4.3). Educational signage could be installed indicating that the pathways are in the process of being revegetated which will contribute to the stability and health of the dunes.

Currently, every side street along Rice Avenue has its own pathway that cuts across the dune system to reach the beach, effectively segmenting the dune system at every block. Pathway lengths across the dunes generally decrease as one moves from north to south within the beach management plan area. A recommendation is to close lesser-used pathways (or every other pathway) and replant with native vegetation, which will help reduce the segmentation of the dune and minimize pathways for storm surge flow to reach Rice Avenue and the residences adjacent to it. The approximate distance from block to block is approximately 200 feet, so closure of an existing path to benefit the stability of the dune and minimize storm surge pathways should not result in a substantial access burden for most residents.

3.4.2 Sand Augmentation

The addition of sand on the coastal beach (beach nourishment), creation of artificial dunes or augmentation of existing dunes can be implemented within the beach management plan area. The purpose of sand augmentation is to increase the ability of the coastal beach and coastal dunes to provide storm buffers, flood control, sediment to adjacent beaches, mitigate ongoing erosion, and to enhance the beach management plan area as a recreational resource.

No “soft engineering” shoreline stabilization option will permanently stop all erosion or storm damage within the Beach Management Plan area, but the ability of stabilization options to provide protection depends on many factors, including the specific design and exposure to a particular storm event. All stabilization options will require maintenance to various degrees and frequencies. The design of sand augmentation projects should take into consideration the establishment of stable slope angles, compatible sediments (grain size, grain shape, and color) as well as other factors, such as existing rare species habitat.

Within the beach management area, sparsely vegetated relatively open areas that may favor piping plovers were avoided, including the northeastern sandy point of the management area. Areas identified for sand augmentation include the areas shown on Figures 7, 8, 9, 10, 11, 12, 13, and 14 in Attachment A. Potential sand augmentation areas include: areas where existing footpaths to the beach may be discontinued and could be replanted; the vegetated low dune along the northern periphery of the management area that has been eroded, exposing plants' root systems (from the Yacht Club, westward towards the sandy point); portions of existing dunes where footpaths have eroded the dune surface and should be replanted; and the stretch of shoreline from Pines Road to Alden Avenue that may benefit from beach nourishment and dune augmentation since the beach and dunes in this segment are fairly narrow. The sand augmentation options presented here can be further modified as needed during project design and permitting. Please see Attachment B – MassCZM (Massachusetts Office of Coastal Zone Management) StormSmart Coasts Fact Sheet #1 for additional details regarding artificial dunes and dune nourishment.

3.4.3 Sand Fence Installation

According to the POPBA Fall 2019 newsletter (http://popba.net/wp-content/uploads/2019/11/POPBA__Fall2019.pdf), sand fencing installation was identified as a goal for POPBA. Installation of sand fence around Coastal Dunes is a relatively low-cost option that will help to promote sand accumulation, dune growth, and dune grass and other vegetation protection. Sand fences will also help minimize foot traffic across the dunes, further protecting dune stability. Sand fencing can be installed along the base of and perpendicular to eroded dune sections to trap windblown sand and help rebuild the dune. When wind blows through sand fencing, the fence creates drag that reduces wind velocity and sand particles settle out and are deposited either behind the sand fence or at the base of the fence. Activities to install sand fence should be performed by hand within jurisdictional resource areas (e.g. Coastal Dune, Coastal Beach, etc.) to avoid impacts to existing vegetation. Posts used to support the fencing should be untreated wood posts since steel posts will rust and may pose a hazard to beachgoers and wildlife. Sand fence slat spacing is typically comprised of a 1:1 ratio of open space to slat material.

Potential locations for sand fencing were identified in Figures 7, 8, 9, 10, 11, 12, 13, and 14 (Attachment A) along dune edges and access paths. Where sand fencing is proposed along access paths or at the seaward entrance of access paths, the fencing will help guide pedestrians to the path and minimize damage from foot traffic. In other locations, sand fencing is proposed to be installed perpendicular to the shoreline to help capture blowing sand, but not create a barrier to movement between the dunes and shoreline for rare bird species or other wildlife that may be present. The fencing locations shown can be adjusted as needed so the seaward end of the fence is not reached by high tides or minor storms. Vegetative plantings can accompany the installation of sand fencing in the locations shown on the figures in Attachment A. MA NHESP should be consulted for any proposed sand fencing project to verify compatibility with rare species that may be present.

3.4.4 Elevated walkways

According to the POPBA Fall 2019 newsletter (http://popba.net/wp-content/uploads/2019/11/POPBA__Fall2019.pdf), walkway installation was identified as a goal for POPBA. If not properly designed, beach access boardwalks, walkways, and stairways can cause erosion and increase storm damage by creating pathways for wind and water damage as well as inhibiting the growth of plants that stabilize dunes. Elevated walkways are recommended for high traffic access paths within the beach management plan area. Elevated walkways allow sand movement of the dunes below them and allow light to reach the dune surface in close proximity to the walkway, helping to support plants that further contribute to dune stability. Walkways should be no wider than 4 feet and no longer than necessary to provide access to the beach. Adequate elevation of the walkway is needed for plant growth and to allow the natural movement of sand under and around the walkway. Walkways should be elevated on posts or piles at least 2 feet above the grade of the surrounding dune to allow mobility of sand and growth of plants. Walkways should be oriented so that they are not perpendicular to the shoreline. This is most important for the segment of elevated walkway in close proximity to the toe of the dune and upper elevations of the beach (Figure 2 below).

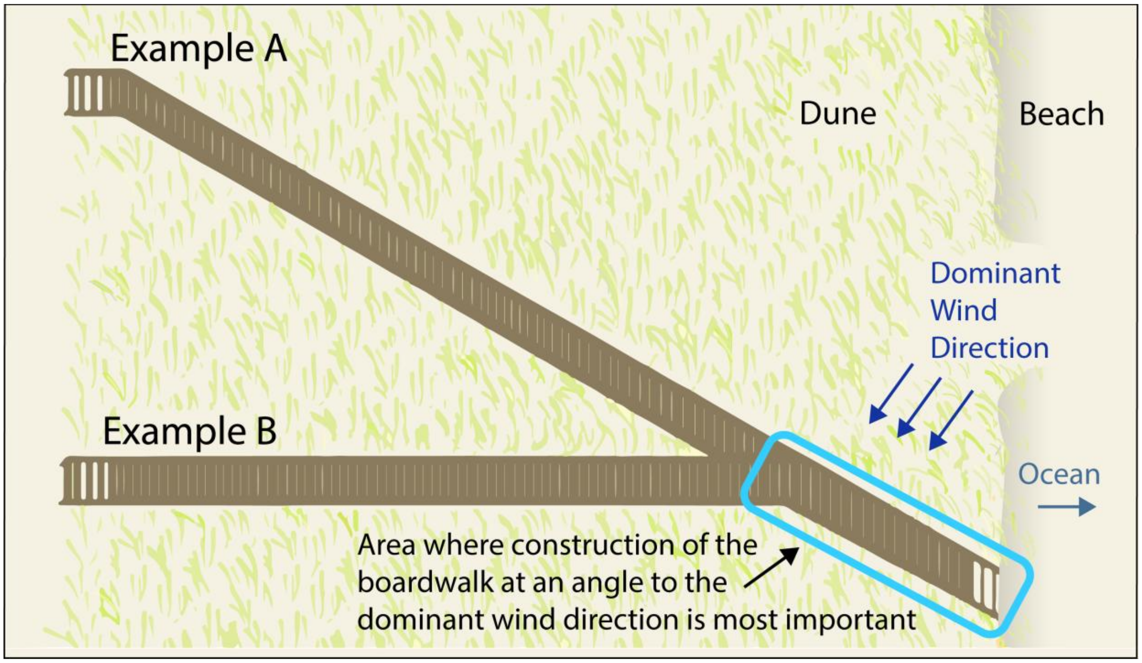

Figure 2. MassCZM guidance regarding proper orientation of elevated walkways.

Where walkways are oriented beyond the footprint of existing paths, the old portions of the paths should be filled with compatible sand and replanted with native salt-tolerant vegetation. Decking and materials used should be selected for durability and compatibility with the dune environment (for example, composite decking and wooden support structures and handrail components. Elevated walkways can begin in the vicinity of the trail head at Rice Avenue and terminate several feet beyond the toe of the dune.

Potential locations for elevated walkways were identified in Attachment A - Figures 8, 10, 11, 12, and 13 and include the pathway just east of the Yacht Club parking lot, Wadsworth Avenue, Bateman Avenue, Whitin Avenue, Bickford Avenue, and Delano Avenue. The existing path from Witherbee Avenue can be maintained in its current state to accommodate beach access by construction vehicles and equipment as needed. While the locations of potential elevated boardwalks are suggested here in this beach management plan, the final locations and design chosen can be prioritized based on a variety of considerations including long-term dune stability, rare species habitat protection, light availability for dune vegetation, and volume of typical foot traffic, among others. Please see Attachment B for additional details regarding the construction of elevated walkways.

Figure 3. Example of an elevated walkway over dunes (Newburyport, MA).

Figure 4. Example of an elevated walkway constructed of a combination of composite decking and wooden framing and handrails (Newburyport, MA).

3.5 Vegetation Planting

The dunes within the beach management plan area are susceptible to erosion from human traffic, wind, rain, high tides, storm events, and other factors. Vegetation on the dunes plays a particularly important role in helping to: hold the dunes together as a result of their root systems; slow wind speeds at the surface of the dunes which in turn helps to trap blowing sand; absorb the impact of rain on the surface of the sand helping to buffer erosion; and provide wildlife habitat value including a source of seed and cover for some species of wildlife, among other benefits.

Vegetation planting within the beach management plan area can be performed in existing dune areas that currently have no vegetation or sparse vegetation as a result of pedestrian traffic or erosion or can also be included in areas identified for sand augmentation once the sand has been placed, which can help stabilize bare sand areas and help build dune volume. Unlike solid manmade structures such as seawalls, vegetated areas can help absorb and dissipate wave energy rather than reflect it to other areas which can exacerbate erosion and other storm-related damage.

Dunes susceptible to erosion within the beach management plan area can be planted with American beachgrass and other native salt-tolerant dune vegetation discussed below. American beachgrass naturally occurs at Point of Pines beach and is the preferred dune restoration species in areas that are susceptible to blowing sand since it quickly establishes a dense root system, helps to rapidly accumulate blowing sand, and is able to withstand a certain level of overwash. More landward portions of the dunes that are less susceptible to direct wave and overwash action can be planted with a mix of grasses such as little bluestem (*Schizachrium scoparium*) and purple lovegrass (*Eragrostis spectibilis*) and woody plant species such as bearberry (*Arctostaphylos uva-ursi*), beach heather (*Hudsonia tomentosa*), Northern bayberry (*Myrica pensylvanica*), and beach plum (*Prunus maritima*). These species are less adapted to overwash and are therefore better choices for more landward portions of the dunes. Larger woody species (trees and shrubs) should not be planted on the face of banks because their height and weight can destabilize the bank and make them vulnerable to toppling by erosion or high winds as noted in Fact Sheet #3 in Attachment B. It should be noted that pines (*Pinus* sp.) as well as a variety of woody shrubs and mixed grasses are currently thriving on the landward portions of the dunes within the beach management area. The native species currently present (which also include some of the species indicated above) can serve as example species to be planted in these landward areas since they are adapted to thrive in existing conditions.

Planting of the species indicated above can generally occur early to mid-spring when moisture levels of the dunes are relatively higher or September through the winter if conditions allow. Planting work should be conducted by hand, and care should be taken to protect existing vegetation. Watering of newly installed plants could occur on an as-needed basis. The addition of organic compost to the planting holes, particularly woody plantings, may help the establishment of root systems as a result of aiding in water retention. For plantings on areas where sand has been brought in, plantings often benefit from a limited application of water-soluble time-release fertilizer approximately a month after planting.

Sources of erosion as mentioned above include human traffic, wind, rain, high tides, and storm events and should be addressed in conjunction with proposed planting in order to improve the potential success of the plantings. Measures can include restricting pedestrian traffic through an area to be planted, establishing stable slope angles prior to planting if needed, etc. Additional considerations should include supplemental watering of newly installed plants since their smaller root systems will take time to develop. Vegetation planting projects will likely require ongoing maintenance to increase the chance of success. Maintenance requirements can include watering and replacing dead plants until the planted vegetation becomes successfully established. Invasive plants within the beach management plan area should be removed and replaced with native salt-tolerant plants.

Many areas were identified for vegetation planting within the beach management plan area. These specific locations are shown in Attachment A on Figures 7, 8, 9, 10, 11, 12, 13, and 14 and are identified by planting unit type. Two types of planting units are identified and include American beachgrass and mixed grasses/mixed woody plants, respectively. Please see Attachment B – MassCZM StormSmart Coasts Fact Sheet #3 for additional details regarding vegetation plantings.

3.6 Rare Species Preservation

MA NHESP should be consulted to verify the rare species that may be present within the Beach Management Plan area. Shorebird surveys can be conducted at Point of Pines Beach in coordination with MA NHESP and Mass Audubon. Trained observers can be used to monitor for nest sites. If nest sites are observed, an exclusionary zone can be established around each nest site (for example, a 150-foot radius zone) using posts, rope from post to post (or other methods), and signage to alert beachgoers to avoid the area(s). Nest sites should be monitored until the chicks have fledged and post and signs can be removed for the remainder of the season. During active nesting and fledging periods, POPBA should ensure that any maintenance activities or proposed actions including beach raking, trash removal, project construction, etc. are staffed appropriately with wildlife stewards to ensure chicks and adults are not harassed, injured or killed by these activities and in accordance with MA NHESP and USFWS guidelines.

3.7 Public Education, Outreach and Signage

According to the POPBA Fall 2019 newsletter (http://popba.net/wp-content/uploads/2019/11/POPBA__Fall2019.pdf), many signs that had been posted in scattered locations near each beach path entrance were consolidated onto a single sign, which resulted in a more coherent signage look where messages from separate signs could instead be viewed on a single sign. Depending on the recommended action that is implemented, additional signage or publication of educational materials (flyer boxes at trail heads and/or on the POPBA website) may be useful in educating beachgoers on the importance and fragility of the dune and beach system in an attempt to engage members to be informed stewards of the Point of Pines Beach. Although physical printed flyers containing educational materials could be installed at each beach path entrance as an option, QR codes (two-dimensional square barcode) could also be used. The advantage of using QR codes is that beachgoers with smartphones could read the QR codes which would launch a webpage displaying pertinent information without the need to print flyers as well as minimize the potential for paper waste from discarded flyers on the beach. As described above, educational signage could be installed in the swing set area and at the Wadsworth

Avenue and Witherbee Avenue paths to discourage pedestrians from using non-designated pathways across the dunes and the minimize unwanted foot traffic as the plantings establish.

As an additional public education and outreach option, presentations and/or tours can be given of the beach and dune system to educate POPBA members on the ecology of the system. Presentation leaders can include knowledgeable POPBA members, Revere Conservation Commission members, or invited speakers from environmental organizations and agencies.

4.0 Regulatory Considerations

Some of the actions described above will require permits from or coordination/review with agencies at the local, state, and/or federal levels. Below is a list of the most applicable regulatory considerations within the beach management plan area organized by governmental level:

4.1 Local Level

City of Revere Conservation Commission

The Revere Conservation commission administers the Massachusetts Wetlands Protection Act (WPA; MGL Ch. 131 s. 40), its implementing regulations (310 CMR 10.00), and Title 16 Environment Chapter 16.04 Wetlands Protection of the Revere City Ordinances.

The purpose of the City of Revere's Chapter 16.04 ordinance (Wetlands Protection) is to protect the wetlands of the city by controlling the activities deemed to have a significant effect upon wetland values, including but not limited to the following: public or private water supply, groundwater, flood control, erosion control, storm damage prevention, water pollution, fisheries, shellfish, wildlife, recreation and aesthetics (collectively, the "interest protected by this chapter"). As per the Ordinance, "*No person shall remove, fill, dredge, alter or build upon or within one hundred feet of any bank, fresh-water wetland, coastal wetland, beach, dune, flat, marsh, meadow, bog, swamp, or upon or within one hundred feet of lands* *bordering on the ocean or upon or within one hundred feet of any land under said waters or upon or within one hundred feet of any land subject to tidal action, coastal storm flowage, flooding or inundation, or within one hundred feet of the one-hundred-year storm line, other than in the course of maintaining, repairing or replacing, but not substantially changing or enlarging, an existing and lawfully located structure or facility used in the service of the public and used to provide electric, gas, water, telephone, telegraph and other telecommunication services, without filing written application for a permit so to remove, fill, dredge, alter or build upon, including such plans as may be necessary to describe such proposed activity and its effect on the environment, and receiving and complying with a permit issued pursuant to this chapter*."

Jurisdiction of the Revere Conservation Commission includes any activity within a resource area, or within 100 feet of a resource area, that will remove, fill, dredge, build upon, degrade, or otherwise alter an area subject to protection under the bylaw.

Actions such as dune or beach nourishment, vegetation plantings, sand fence installation, walkway installation, etc. would require the filing of a Notice of Intent with the Revere Conservation Commission and MassDEP. The permit issued by the Revere Conservation Commission would be an "Order of Conditions".

4.2 State Level

Massachusetts Wetlands Protection Act and its Implementing Regulations

Similar to the City of Revere Wetland Protection Ordinance, the Massachusetts Wetlands Protection Act (WPA; MGL Chapter 131 §40) states: "*No person shall remove, fill, dredge or alter any bank, riverfront area, fresh water wetland, coastal wetland, beach, dune, flat, marsh, meadow or swamp bordering on the ocean or on any estuary, creek, river, stream, pond, or lake, or any land under said waters or any land subject to tidal action, coastal storm flowage, or flooding, other than in the course of maintaining, repairing or replacing, but not substantially changing or enlarging, an existing and lawfully located structure or facility used in the service of the public and used to provide electric, gas, sewer, water, telephone, telegraph and other telecommunication services, without filing written notice of his intention to so remove, fill, dredge or alter, including such plans as may be necessary to describe* *such proposed activity and its effect on the environment and without receiving and complying with an order of conditions and provided all appeal periods have elapsed*."

In addition to regulations regarding work within the 100-foot Buffer Zone, the coastal portion of the WPA regulations within 310 CMR 10.00 includes jurisdiction over work within Coastal Bank, Coastal Dune, Coastal Beach, and Land Subject to Coastal Storm Flowage. Work within these areas for projects such as dune or beach nourishment, vegetation plantings, sand fence installation, walkway installation, etc. would require the filing of a Notice of Intent simultaneously with the Revere Conservation Commission and MassDEP. Although the Revere Conservation Commission is ultimately the issuing authority for the Order of Conditions, MassDEP has the authority to rule on any appeal of local Conservation Commission decisions including any pertaining to Point of Pines Beach proposed actions. The appeal of any Order of Conditions is required to follow the procedures set forth in the WPA 310 CMR 10.00. MassDEP also provides comments on Notices of Intents (i.e. wetland permit applications) filed with municipal Conservation Commissions, and therefore may submit comments to the Revere Conservation Commission for their consideration during review of any NOI submitted under the MA WPA.

Massachusetts Environmental Policy Act (MEPA)

The Massachusetts Executive Office of Energy and Environmental Affairs (EEA) implements the Massachusetts Environmental Policy Act (MEPA; 301 CMR 11). MEPA review is required for projects exceeding certain thresholds that are undertaken by a state agency, require a permit issued by a state agency, or involve financial assistance by a state agency. When a project meets or exceeds review thresholds established in 301 CMR 11.03, the project proponent is required to submit an Environmental Notification Form (ENF) as part of the MEPA review process. Depending on the thresholds met or exceeded beyond the requirements for an ENF, project proponents may also need to prepare and submit a Draft and possibly Final Environmental Impact Report (EIR). The culmination of the MEPA review process is the issuance of a Certificate from the Secretary of Environmental Affairs. MEPA thresholds for an Environmental Notification Form (ENF) may potentially be met or exceeded depending on the scope of recommendations chosen and include: greater than two acres of disturbance of designated priority habitat, as defined in 321 CMR 10.02, that results in a take of a state-listed endangered or threatened species or species of special concern; alteration of coastal dune, barrier beach or coastal bank; and/or new fill or structure or expansion of existing fill or structure, except a pile-supported structure, in a velocity zone or regulatory floodway. Proposed actions ultimately chosen will need to be checked against the MEPA review thresholds to determine if the proposed action is subject to MEPA review.

Coastal Zone Management Act

The Massachusetts Office of Coastal Zone Management (MassCZM) implements the federal Coastal Zone Management Act in Massachusetts. Projects requiring federal funding or federal permitting that also exceed certain MEPA thresholds must obtain a Coastal Zone Management Federal Consistency Certification and demonstrate that the project is consistent with the policies of MassCZM.

Massachusetts Division of Fisheries and Wildlife

The Massachusetts Endangered Species Act (MESA; 321 CMR 10.00) requires agency review for any non-exempt activity within sites mapped by the Massachusetts Natural Heritage and Endangered Species Program (NHESP) as Estimated Habitats of Rare Wildlife (for projects under the Massachusetts WPA) and/or Priority Habitats of Rare Species (for projects under MESA). Mapped habitat, including both Estimated and Priority Habitat, exists within the entire Beach Management Plan area. Activities within Estimated Habitat would be reviewed by MassDFW as part of a submittal of a Notice of Intent under the MA WPA. A formal request for MESA review, via the submission of a MESA Project Review Checklist package, would be needed for any non-exempt activity within Priority Habitat. MassDFW review under MESA would be required for dune or beach nourishment, vegetation plantings, sand fence installation, walkway installation, etc.

Massachusetts Department of Environmental Protection (MassDEP) Waterways Program

Massachusetts Waterways Regulations at 310 CMR 9.00 indicate that a Chapter 91 License or Permit application would need to be submitted for work within all waterways, including all flowed or filled tidelands. Activities requiring a License Application include any construction, placement, excavation, addition, improvement, maintenance, repair, replacement, reconstruction, demolition or removal of any fill or structures, not previously authorized, or for which a previous grant or license is not presently valid. Activities requiring a Permit Application include any beach nourishment, dredging, and any disposal involving the subaqueous placement of unconsolidated material below the low water mark, among other activities.

Massachusetts Department of Environmental Protection – 401 Water Quality Certification

314 CMR 9.00 is applicable for any activity proposed that would result in a discharge of dredged material, dredging, or dredged material disposal greater than 100 cubic yards that is also subject to federal regulation. Such projects would require the submittal of a 401 Water Quality Certification permit application to MassDEP. These activities may include coastal engineering structure installation or maintenance, among other projects. Reviews are divided into Major Projects (5,000 cubic yards of dredging or more) and Minor Projects (less than 5,000 cubic yards of dredging). Beach nourishment activities with a Final Order of Conditions issued under M.G.L. c. 131, § 40 do not need a 401 WQC. Proposed activities would need to be reviewed further to determine if a 401 WQC is required.

4.3 Federal Level

US Army Corps of Engineers – New England District

The US Army Corps of Engineers (USACE) regulates construction and other work in navigable waterways under Section 10 of the Rivers and Harbors Act of 1899, and has authority over the discharge of dredged or fill material into "waters of the United States", which includes wetlands under Section 404 of the Clean Water Act. Within the Beach Management Area, this includes the discharge of fill material below the high tide line.

Depending on the specific project and levels of impact, a 404 application would be submitted under the Massachusetts Programmatic General Permit or as an Individual Permit. Submittals for authorization under the Massachusetts General Permit (GP) include self-verification (SV) or a preconstruction notification (PCN) depending on the proposed level of impact and other factors. If conditions of an SV or PCN cannot be met, then an individual permit (IP) is required. Depending on the scope of work chosen under these recommendations and the equipment involved, GP 1 (Maintenance), GP 5 (Dredging, Disposal of Dredged Material, Beach Nourishment, and Rock Removal and Relocation), GP 7 (Bank and Shoreline Stabilization), and/or GP 14 (Temporary Construction, Access, and Dewatering) may apply. Specifics of the most applicable General Permits are discussed below:

GP 1: Activities authorized under GP 1 include the repair, rehabilitation, or replacement of any previously authorized, currently serviceable structure, or fill and temporary structures, fills, and work, including the use of temporary mats, necessary to conduct the maintenance activity.

GP 5: Activities authorized under GP 5 includes new, maintenance, and improvement dredging with the disposal of dredged material use for beach nourishment provided the Corps finds the dredged material suitable; and beach nourishment from upland sources.

GP 7: Activities authorized under GP 7 include Bank and shoreline stabilization activities in waters of the U.S. necessary for erosion control or prevention, such as vegetative stabilization, sills, rip rap, revetment, gabion baskets, stream barbs, and bulkheads, or combinations of techniques (e.g., living shorelines), provided the activity meets all of the following criteria: (a) No material is placed in excess of the minimum needed for erosion protection; (b) No material is of a type, or is placed in any location, or in any manner, that will impair surface water flow into or out of any waters of the U.S.; and (c) No material is placed in a manner that will be eroded by normal or expected high flows (properly anchored native trees and treetops may be used in low energy areas. An IP would be required for breakwaters, groins or jetties.

GP 14: Activities authorized under GP 14 include temporary structures, work, and discharges, including cofferdams, necessary for construction activities or access fills or dewatering of construction sites that are not authorized under another GP activity. An IP would be required for (a) Permanent structures or impacts; (b) Temporary impacts in tidal waters that are >1 acre; >5000 SF in saltmarsh, mud flats, or riffle and pool complexes; or >1000 SF in vegetated shallows; (c) Use of cofferdams to dewater wetlands or other aquatic areas to change their use; (d) Temporary stream crossings (see GPs 8 - 10); (e) Structures or fill left in place after construction is completed.

The scope of any proposed action under this beach management plan would need to be reviewed to determine what level of authorization may be needed under US Army Corps of Engineers jurisdiction. Projects that require an IP will also require an individual 401 Water Quality Certification (WQC) from the Massachusetts Department of Environmental Protection (MassDEP) and Coastal Zone Management (CZM) individual consistency concurrence from the Massachusetts Office of CZM. Any activity under these GPs that requires authorization under §404 of the CWA for the discharge of dredged or fill material into waters of the U.S. also requires applicants to obtain a §401 water quality certification (WQC) from the State (hereinafter referred to as "§401 WQC") or a Final Order of Conditions from the town or city which serves as the WQC.

5.0 Summary

In summary, this Beach Management Plan provides the Point of Point of Pines Beach Association and other stakeholders with several options that can be implemented in the near-term and at lower costs actions while longer-term climate resilience interventions are designed, permitted, and constructed. As with any coastal environment subject to wind, waves, and storm action, the options presented will require periodic maintenance as needed. However, proper application of the recommendations described above will serve to enhance the Point of Pines Beach's ability to provide valuable storm damage functions, wildlife habitat and rare species protection, and recreational opportunities for Point of Pines Beach Association members.

6.0 References

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MassCZM 2020b. CZ-Tip - Basics of Building Beach Access Structures that Protect Dunes and Banks. CZ-Tip - Basics of Building Beach Access Structures that Protect Dunes and Banks | Mass.gov

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ATTACHMENT A

Figures

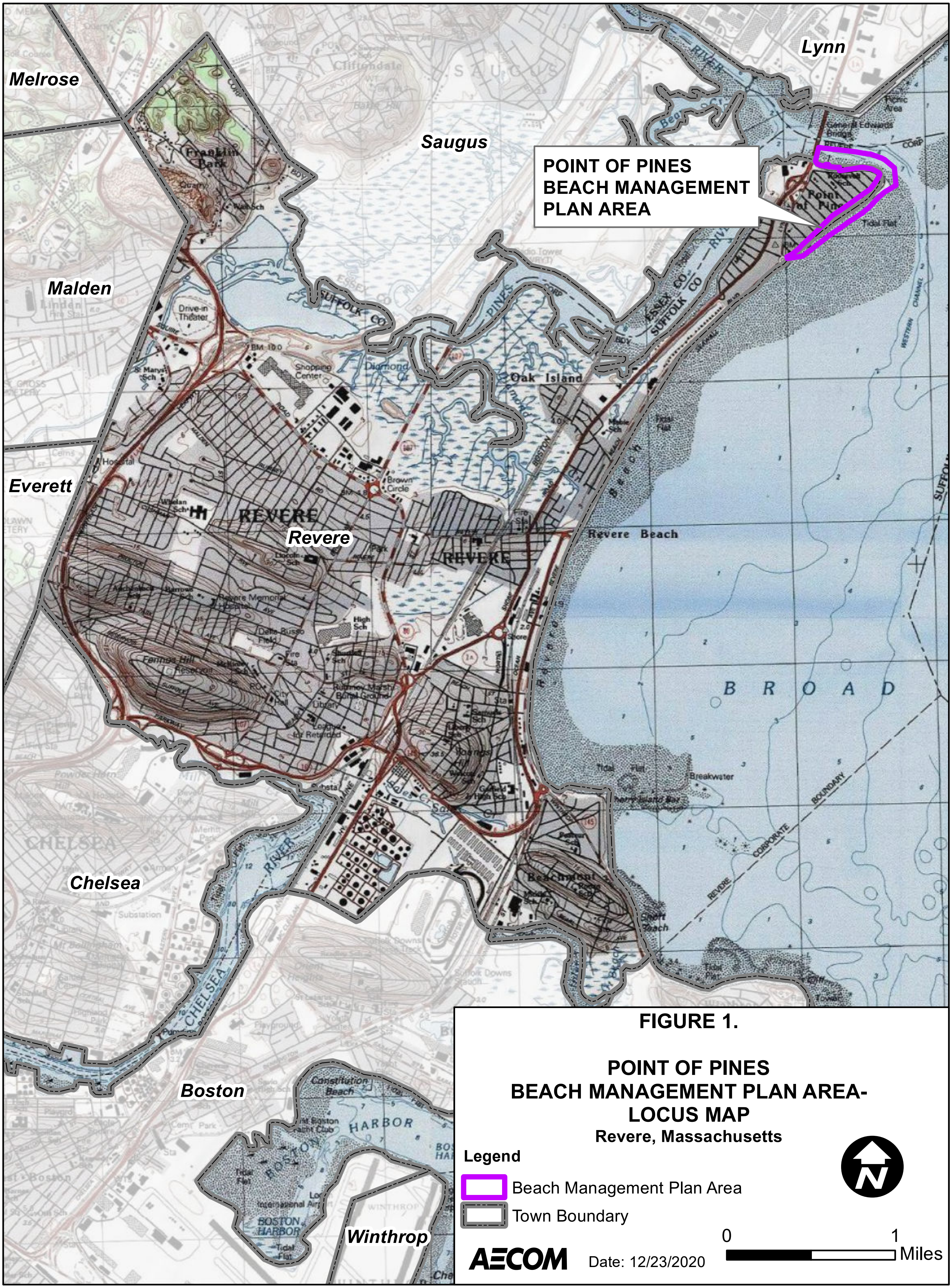

FIGURE 1.

POINT OF PINES BEACH MANAGEMENT PLAN AREA- LOCUS MAP

Revere, Massachusetts

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FIGURE 2.

POINT OF PINES
BEACH MANAGEMENT PLAN AREA-
OVERVIEW
Revere, Massachusetts

Legend

Seawall - Private

Beach Management Plan Area

1 inch = 400 feet

0 400 Feet

AECOM

Date: 12/23/2020

FIGURE 3.

POINT OF PINES
BEACH MANAGEMENT PLAN AREA

MASSDEP WETLAND RESOURCE AREAS IN THE VICINITY OF POINT OF PINES BEACH
Revere, Massachusetts

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FIGURE 4.

POINT OF PINES BEACH MANAGEMENT PLAN AREA

LAND SUBJECT TO COASTAL STORM FLOWAGE (FEMA 100-YEAR FLOODPLAIN) IN THE VICINITY OF POINT OF PINES BEACH

Revere, Massachusetts

Legend

Seawall - Private

Beach Management Plan Area

FEMA National Flood Hazard Layer

Flood Zone Designations

AE: 1% Annual Chance of Flooding, with BFE

VE: High Risk Coastal Area

X: 0.2% Annual Chance of Flooding

1 inch = 400 feet

0 400 Feet

AECOM

Date: 12/29/2020

FIGURE 5.

POINT OF PINES BEACH MANAGEMENT PLAN AREA

MA NHESP EXTIMATED HABITATS OF RARE WILDLIFE (EH 1064) AND PRIORITY HABITATS OF RARE SPECIES (PH 1491) IN THE VICINITY OF POINT OF PINES BEACH
Revere, Massachusetts

Legend

- Seawall - Private
- Beach Management Plan Area
- NHESP Priority Habitats of Rare Species
- NHESP Estimated Habitats of Rare Wildlife

1 inch = 400 feet

0 400 Feet

AECOM

Date: 12/29/2020

FIGURE 6.

POINT OF PINES BEACH MANAGEMENT PLAN AREA

RECOMMENDED ACTION - OVERVIEW
Revere, Massachusetts

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FIGURE 7.

POINT OF PINES
BEACH MANAGEMENT PLAN AREA

RECOMMENDED ACTION - DETAIL 1
Revere, Massachusetts

Date: 1/13/2021

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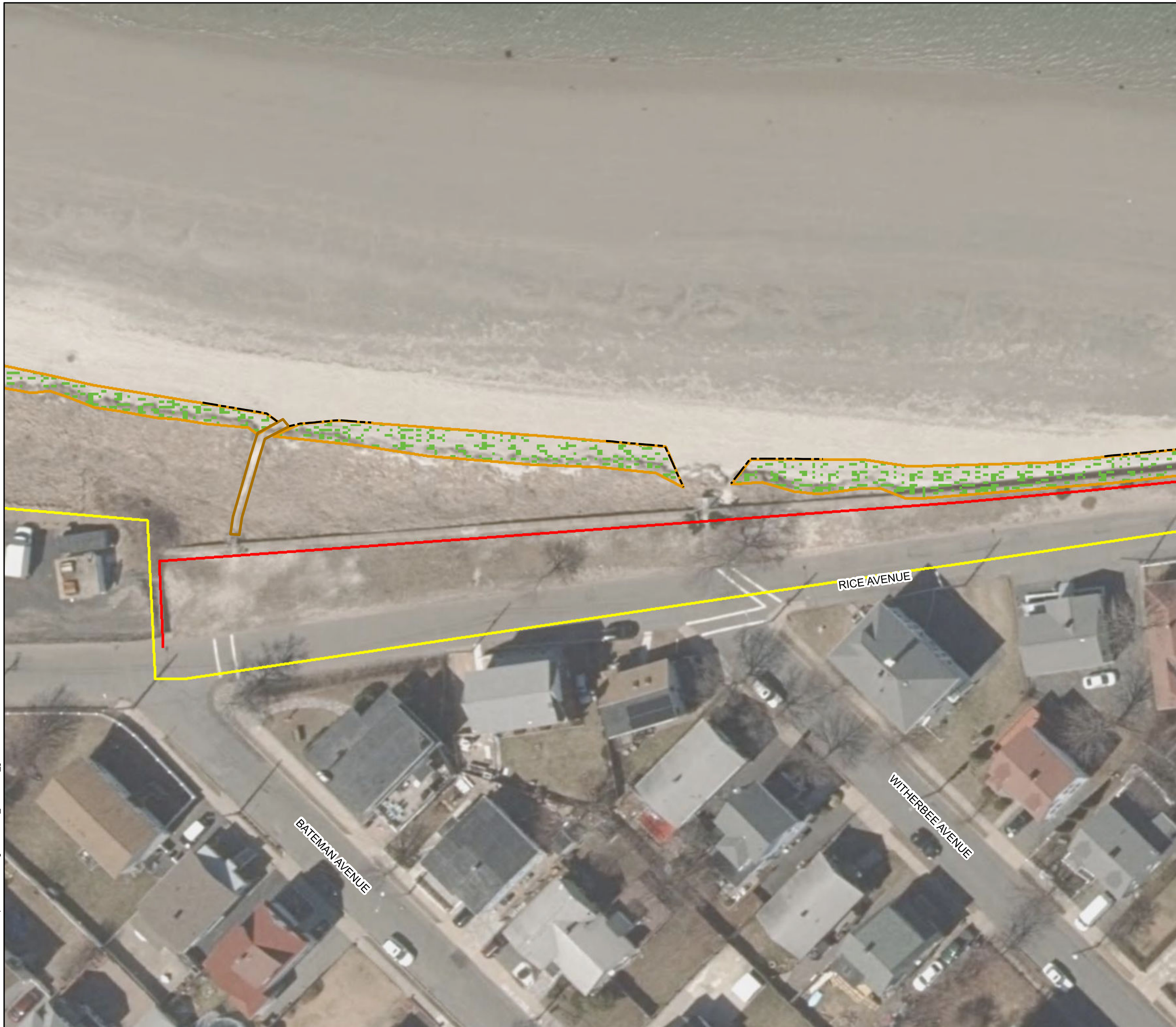

FIGURE 8.

POINT OF PINES
BEACH MANAGEMENT PLAN AREA

RECOMMENDED ACTION - DETAIL 2
Revere, Massachusetts

Legend

- Seawall - Private
- Beach Management Plan Area
- Proposed Elevated Boardwalk
- Sand Fence
- Sand Augmentation w/American beachgrass

1 inch = 60 feet

0 30 60 Feet

AECOM

Date: 1/13/2021

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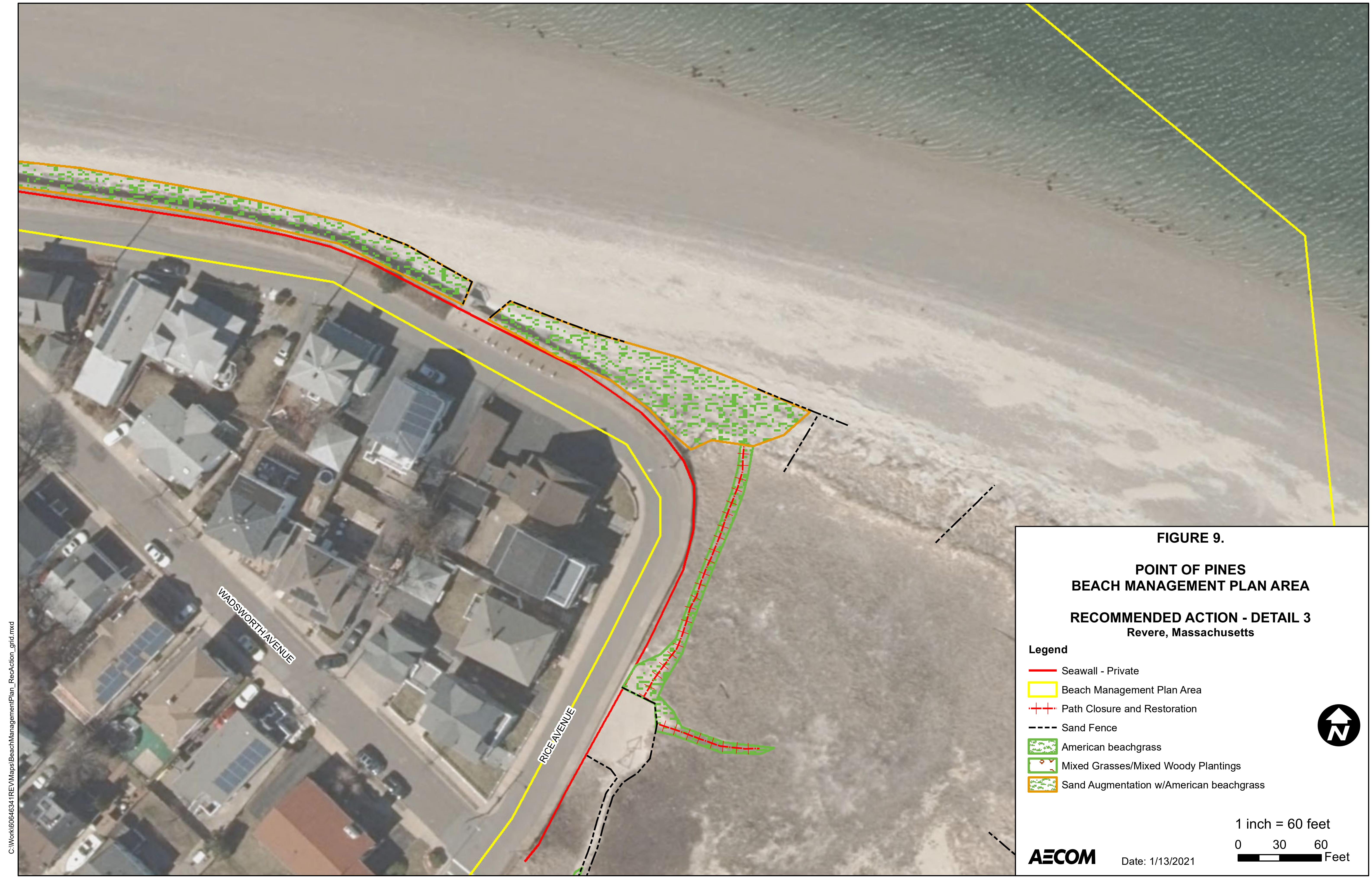
WADSWORTH AVENUE
RICE AVENUE
FIGURE 9.
POINT OF PINES
BEACH MANAGEMENT PLAN AREA
RECOMMENDED ACTION - DETAIL 3
Revere, Massachusetts
Legend
Seawall - Private
Beach Management Plan Area
Path Closure and Restoration
Sand Fence
American beachgrass
Mixed Grasses/Mixed Woody Plantings
Sand Augmentation w/American beachgrass
1 inch = 60 feet
0 30 60
Feet
AECOM
Date: 1/13/2021
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FIGURE 10.

POINT OF PINES
BEACH MANAGEMENT PLAN AREA

RECOMMENDED ACTION - DETAIL 4
Revere, Massachusetts

Legend

- Seawall - Private
- Beach Management Plan Area
- Path Closure and Restoration
- Proposed Elevated Boardwalk
- Sand Fence
- American beachgrass
- Mixed Grasses/Mixed Woody Plantings
- Sand Augmentation w/American beachgrass

1 inch = 60 feet

0 30 60 Feet

AECOM

Date: 1/13/2021

FIGURE 11.

POINT OF PINES
BEACH MANAGEMENT PLAN AREA

RECOMMENDED ACTION - DETAIL 5
Revere, Massachusetts

Legend

- Beach Management Plan Area
- Path Closure and Restoration
- Proposed Elevated Boardwalk
- Sand Fence
- Mixed Grasses/Mixed Woody Plantings
- Sand Augmentation w/American beachgrass

1 inch = 60 feet

0 30 60 Feet

AECOM

Date: 1/13/2021

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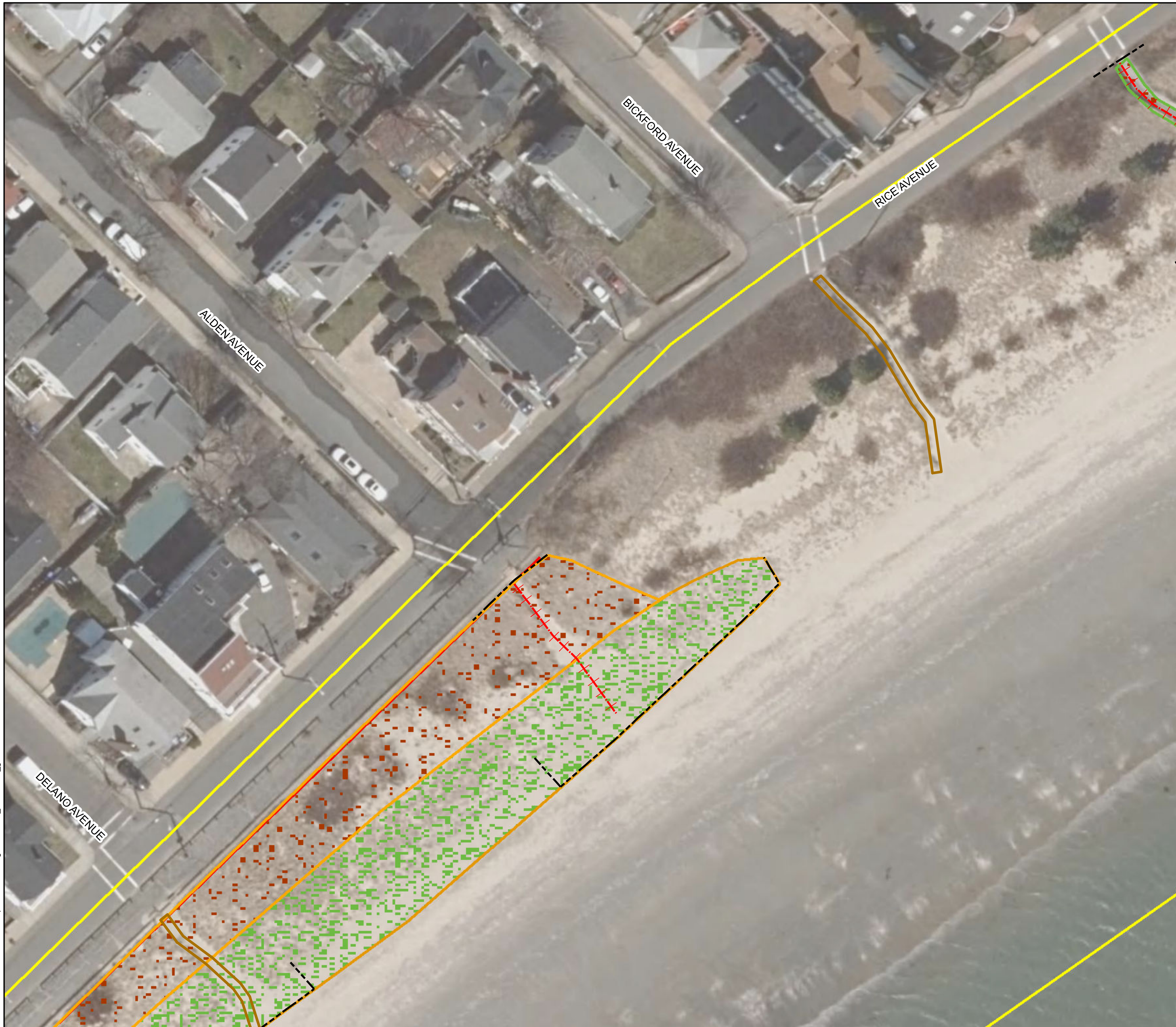

FIGURE 12.

**POINT OF PINES
BEACH MANAGEMENT PLAN AREA**

RECOMMENDED ACTION - DETAIL 6
Revere, Massachusetts

Legend

- Seawall - Private
- Beach Management Plan Area
- Path Closure and Restoration
- Proposed Elevated Boardwalk
- Sand Fence
- Mixed Grasses/Mixed Woody Plantings
- Sand Augmentation w/American beachgrass
- Sand Augmentation w/Mixed Grasses/Woody Plantings

1 inch = 60 feet

0 30 60 Feet

AECOM

Date: 1/13/2021

FIGURE 13.

POINT OF PINES
BEACH MANAGEMENT PLAN AREA

RECOMMENDED ACTION - DETAIL 7
Revere, Massachusetts

FIGURE 14.

POINT OF PINES
BEACH MANAGEMENT PLAN AREA

RECOMMENDED ACTION - DETAIL 8
Revere, Massachusetts

Legend

- Seawall - Private
- Beach Management Plan Area
- Sand Fence
- Sand Augmentation w/American beachgrass
- Sand Augmentation w/Mixed Grasses/Woody Plantings

1 inch = 60 feet

0 30 60 Feet

AECOM

Date: 1/13/2021

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ATTACHMENT B

MassCZM StormSmart Fact Sheets

and Guidance Documents

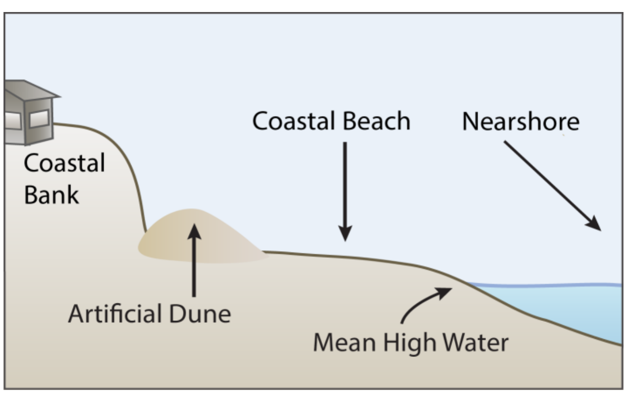
StormSmart Properties Fact Sheet 1: Artificial Dunes and Dune Nourishment

The coast is a very dynamic environment and coastal shorelines—especially beaches, dunes, and banks—change constantly in response to wind, waves, tides, and other factors such as seasonal variation, sea level rise, and human alterations to the shoreline system. Consequently, many coastal properties are at risk from storm damage, erosion, and flooding. Inappropriate shoreline stabilization methods can actually do more harm than good by exacerbating beach erosion, damaging neighboring properties, impacting marine habitats, and diminishing the capacity of beaches, dunes, and other natural landforms to protect inland areas from storm damage and flooding. StormSmart Properties—part of the Massachusetts Office of Coastal Zone Management's (CZM) StormSmart Coasts Program—provides coastal property owners with important information on a range of shoreline stabilization techniques that can effectively reduce erosion and storm damage while minimizing impacts to shoreline systems. This information is intended to help property owners work with consultants and other design professionals to select the best option for their circumstances.

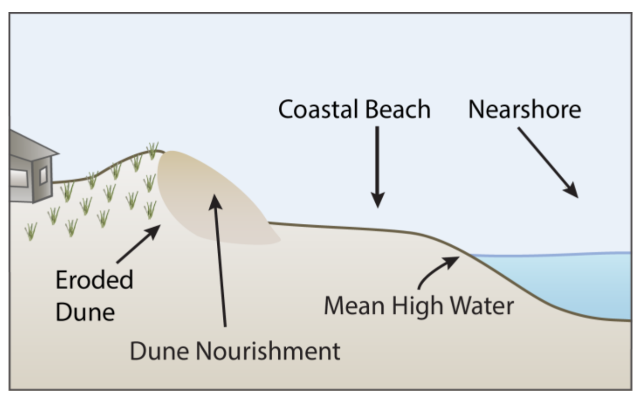
What Are Artificial Dunes and Dune Nourishment?

A dune is a hill, mound, or ridge of sediment that has been deposited by wind or waves landward of a coastal beach. In Massachusetts, the sediments that form beaches and dunes range from sand to gravel- and cobble-sized material. An artificial dune is a shoreline protection option where a new mound of compatible sediment (i.e., sediment of similar size or slightly coarser) is built along the back of the beach, seaward of the area to be protected. (Artificial dunes may be called cobble berms when larger pebble- and cobble-sized materials are used.) Dune nourishment provides shoreline protection by adding compatible sediment to an existing dune. With artificial dunes and dune nourishment, sediment is brought in from an offsite source, such as a sand and gravel pit or coastal dredging project.

No shoreline stabilization option permanently stops all erosion or storm damage. The level of protection provided depends on the option chosen, project design, and site-specific conditions such as the exposure to storms. All options require maintenance, and many also require steps to address adverse impacts to the shoreline system, called mitigation. Some options, such as seawalls and other hard structures, are only allowed in very limited situations because of their impacts to the shoreline system. When evaluating alternatives, property owners must first determine which options are allowable under state, federal, and local regulations and then evaluate their expected level of protection, predicted lifespan, impacts, and costs of project design, installation, mitigation, and long-term maintenance.



This diagram shows an artificial dune built seaward of an eroding coastal bank to protect the bank from further erosion that could endanger the house.



This diagram shows a dune nourishment project that added sediment to the seaward side of an eroded dune to enhance the ability of the dune to protect the house.

Artificial and nourished dunes can be used in conjunction with many other techniques for erosion management. See the following StormSmart Properties fact sheets on related techniques: *Controlling Overland Runoff to Reduce Coastal Erosion*, *Planting Vegetation to Reduce Erosion and Storm Damage*, *Bioengineering - Coir Rolls on Coastal Banks*, *Sand Fencing*, and *Beach Nourishment*.

How Artificial Dunes and Dune Nourishment Reduce Storm Damage

Dunes provide a physical buffer between the sea and inland areas—a buffer that can naturally shift during storms. As waves hit a dune and its sediments move and shift, the wave energy is absorbed, protecting landward areas from the full brunt of the storm. The height, length, and width of a dune relative to the size of the predicted storm waves and storm surge (water buildup above the average tide level) determines the level of protection the dune can provide. The recommended size for an artificial or nourished dune will depend on the desired level of protection, the predicted wave energy and storm surge for the area, and site constraints (such as beach width and proximity to sensitive resource areas).

Artificial and nourished dunes not only increase the direct level of protection to inland areas by acting as a physical buffer, the added sediment from dune projects supports the protective capacity of the entire beach system (i.e., dune, beach, and nearshore area). Sand eroded from the dune during a storm is not lost or wasted, but added to the surrounding beach and nearshore area where it dissipates wave energy, reducing the strength of incoming storm waves. But to maintain the dune as an effective physical buffer, sediment must be added regularly to keep dune's height, width, and volume at appropriate levels.

The photo on the left shows a dune nourishment project where sand was added in front of the eroded face of an existing dune. The sand was planted with beach grass to enhance the protection provided to the house behind it.

In the project shown in the photo below, a dune that was severely eroded during the Blizzard of '78 was nourished with a combination of sand, gravel, and cobble—sediments of the same size range as the natural dune. The highest point of the dune is about 20 feet above sea level. This photograph was taken in October 2008, demonstrating how well the dune has held up over time.
(Photos: CZM)

Relative Benefits and Impacts Compared to Other Options

Under the Massachusetts Wetlands Protection Act, new hard structures are typically prohibited on all beaches and dunes. On coastal banks, hard structures are only allowed when necessary to protect buildings permitted before August 10, 1978, and only if no other alternative is feasible. In many cases, dune projects and other non-structural alternatives are therefore the only options available for reducing erosion and storm damage on coastal properties.

The major benefit of artificial dunes and dune nourishment projects is that unlike seawalls, rock revetments, or other "hard" shoreline stabilization structures, dunes dissipate wave energy rather than reflecting waves onto beaches or neighboring properties. The design of a hard structure affects how much wave energy is reflected, for example vertical walls reflect more wave energy than sloping rock revetments. These reflected waves erode beaches in front of and next to a hard structure, eventually undermining and reducing the effectiveness of the structure and leading to costly repairs. This erosion also results in a loss of dry beach at high tide, reducing the beach's value for storm damage protection, recreation, and wildlife habitat. Hard structures also impede the natural flow of sand, which can cause erosion in down-current areas of the beach system. Dune projects, however, increase protection to landward areas while allowing the system's natural process of erosion and accretion to continue. In addition, because of their more natural appearance, dunes can be more aesthetically pleasing than hard structures.

In general, therefore, the impacts of dune projects are relatively minor when compared to hard structures. The most significant factor in determining the potential impact is the proximity of the dune project to sensitive habitats. For example, dune projects near salt marsh, horseshoe crab spawning grounds, and other sensitive habitats can smother plants and animals if dune sediments are eroded quickly and carried to these areas. In addition, dune projects in nesting habitat for protected shorebird and turtle species (i.e., species that are considered endangered, threatened, or of special concern in Massachusetts) can inhibit nesting success.

Other potential impacts from dune projects can be caused by using sediment of an inappropriate grain size or building a dune with a slope that is too steep. If the sediments brought in are finer than the existing beach sediments, they can erode quickly and may smother nearby sensitive areas, such as shellfish and eelgrass. If the introduced sediments are too large, they may not move and shift as intended and can therefore reflect wave energy, causing erosion of the beach in front of or near the dune. As for the slope, steep dunes are unstable and erode rapidly. This can cause a scarp, which looks like a carved out area in the dune with an almost vertical slope. Scarps can make beach access dangerous and impede the movement of wildlife over the dune.

Design Considerations for Dune Projects

This section covers a variety of factors that should be considered to minimize adverse impacts and ensure successful design, permitting, construction, and maintenance of an artificial dune or dune nourishment project.

Appropriate Locations

Dune projects are appropriate for almost any area with dry beach at high tide and sufficient space to maintain some dry beach even after the new dune sediments are added to the site. Dune projects can be used in combination with other natural coastal landforms or hard structures.

Sacrificial Dunes - Dunes constructed in areas with narrow beaches at high tide are often called "sacrificial dunes" because they are expected to provide relatively short-term protection before they are eroded and need to be replaced. Sacrificial dunes are typically constructed when there are fewer shoreline protection options available due to regulatory or physical limitations. With sacrificial dunes, it is often appropriate to use coarser sediments than the existing beach and dune to provide greater protection and increase project longevity.

For example, artificial dunes can be placed seaward of an eroding bank to reduce bank erosion or seaward of an existing rock revetment or seawall to minimize wave reflection that exacerbates beach erosion and undermines the structure.

In areas with no beach at high tide, the protection provided by dune projects is relatively short-lived because the added sediments are readily eroded and redistributed to the nearshore by both regular waves and tides and storms. In these situations, increasing the width of the beach through beach nourishment may be a preferred shoreline protection option (see *StormSmart Properties Fact Sheet 8: Beach Nourishment*). For projects on narrow beaches where the seaward part of a dune would be reached by extreme high tides or minor storm tides, the dune will likely erode quickly and require frequent maintenance to retain the level of protection the project was designed to provide.

"Compatible" Sediments - Size, Shape, Color, and Texture

Dune projects require the use of compatible sediments—sediments that are too fine will erode quickly, reducing project effectiveness and potentially impacting nearby resource areas, while sediments that are too large may not move and shift as intended and could increase erosion and other problems. Consequently, the percentage of sand-, gravel-, and cobble-sized sediment should match, or be slightly coarser than, the existing beach/dune sediments.

Using sediments with slightly larger grain sizes can provide improved erosion control and storm damage protection. More energy is needed to move this larger material, absorbing wave energy more effectively and eroding less readily. In addition, when a dune is overtopped during a storm, the sand is typically moved seaward into the beach system (where it dissipates wave energy). The larger sediments shift landward and provide direct protection from storm waves. However, because of the potential impacts of using material that is too large, decisions about the range of sediment sizes (i.e., percentage of sand, gravel, and cobble) should be based on specific site conditions, potential impacts, and the desired level of shoreline protection. In addition, if sediments with larger grain sizes shift to the beach area during a storm, they can negatively affect the quality of the beach for recreation and habitat for protected species.

The shape of the material brought in is also important, primarily for larger-grained sediments (gravel and cobble). These sediments should be rounded (like natural beach sediments) rather than angular (crushed). Rounded grains readily roll and slide against each other, and this movement dissipates more wave energy. If rounded material is not used, the ability of the dune to move and shift can actually be reduced rather than improved by the project.

The color and texture of the sediment purchased for a dune project can affect the aesthetics of the site—but because this impact is temporary and does not interfere with the way the shoreline system functions, addressing it is optional. As for color, some sediment from upland sources appears orange when compared to the typical white-to-gray color of Massachusetts dunes. The orange hue is often due to iron staining, which does bleach out in the sun over time. With texture, some compatible sediment sources contain a small percentage of fine silt, which can stick to recreational beach users. Although the silt naturally blows or washes away with time, "washed" sediment with lower silt content can be requested from inland sand and gravel pits.

Volume of Material

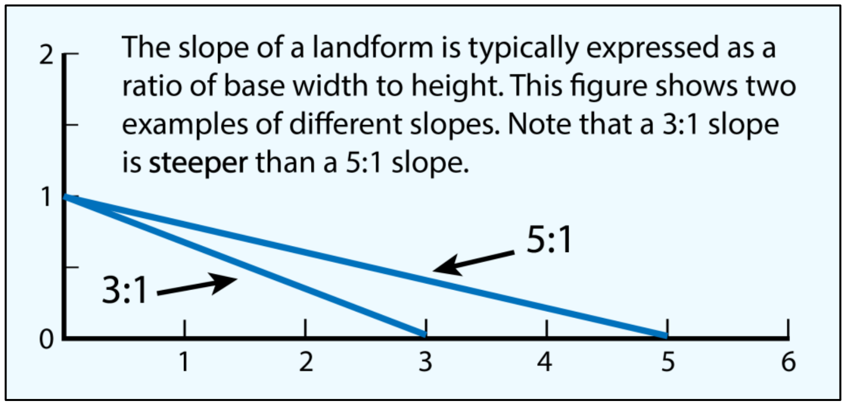
The volume of sediment needed for a dune project will depend on: 1) the elevation of the beach and existing dune (if any) relative to the predicted water level during a major coastal storm event, and 2) the level of protection desired. The lower the existing beach/dune and the higher the predicted water level during a storm, the greater the volume of material that is needed to achieve a certain level of protection.

Vegetation and Sand Fencing for Erosion Control

Planting the dune with native, salt-tolerant, erosion-control vegetation with extensive root systems is highly recommended to help hold the sediments in place. However, planting may be restricted in nesting habitat for protected shorebirds and turtles. Sand fencing can also be installed to trap windblown sand to help maintain and build the volume of a dune. See StormSmart Properties fact sheets *Planting Vegetation to Reduce Erosion and Storm Damage* and *Sand Fencing* for more information. Christmas trees are not recommended for trapping sand because a large section of the dune is disturbed when they are removed by waves, increasing dune erosion. Placing brush and other dead plant material on the dune can prevent living plants from becoming established, causing further destabilization. Christmas trees and brush can also degrade nesting habitat for protected shorebirds by physically occupying otherwise suitable nesting habitat and impeding chick movement.

Dune Slope

Steep dunes are unstable and may erode rapidly and cause problematic scarps. To avoid this problem, the seaward slope of the dune should typically be less than 3:1 (base:height). The slope selected for the project will be based on the existing beach and dune slope, the width of the dry beach, and the grain size of the dune sediments. In addition, there should be some dry beach between the dune and the average high tide line to prevent rapid erosion.



Minimizing Impacts to Habitat and Wildlife

Impacts to sensitive habitats can be avoided by placing dunes as far landward as possible and using sediments of appropriate size. For dune projects proposed in or adjacent to nesting habitat for protected shorebirds and turtles, the slope and height of the dune, time of year for construction, and density of vegetation planted may need to be modified to allow for successful nesting. The Natural Heritage and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife can provide information on the species listed as endangered, threatened, and of special concern in Massachusetts, including their location and any special design or permitting requirements under state regulations. For projects proposed near horseshoe crab spawning habitat, work should not be done during the spawning season. The Massachusetts Division of Marine Fisheries can provide additional information on horseshoe crab protection. Dune projects may also smother existing vegetation that helps to stabilize the area, an impact that can typically be addressed by replanting similar vegetation on the new dune.

Heavy Equipment Use

Access for heavy equipment must be carefully planned to avoid destruction of existing vegetation; creation of ruts; destabilization of banks, beaches, or other landforms; impacts to wildlife and nesting habitat for protected shorebird and turtle species; and related impacts. In addition, heavy equipment operators should avoid running over the dune multiple times, which can compact sediments and prevent them from moving and shifting to effectively dissipate wave energy. When mechanical equipment is being used, contractors should keep hazardous material spill containment kits on-site at all times in case there is a release of oil, gasoline, or other toxic substances.

Permitting and Regulatory Standards

Most options for addressing coastal erosion, storm damage, and flooding are likely to require a permit under the Massachusetts Wetlands Protection Act through the local Conservation Commission. Additional permits may be needed from the Massachusetts Department of Environmental Protection (MassDEP) Waterways Program and the U.S. Army Corps of Engineers if the project footprint extends below the mean high water line or seaward of the reach of the highest high tide of the year, respectively. Permits or approvals may also be required from other state agencies and local departments, depending on the project location and the work involved. Often, Conservation Commission staff are available to meet with applicants early in the design process to go over the important factors that need to be considered.

Generally, regulatory programs are supportive of projects that add sediment to the beach and dune system rather than proposing a hard structure. To obtain a permit, projects need to be designed with appropriate sediment and should not be located in sensitive resource areas (e.g., salt marsh), which are protected by the various regulatory programs.

Professional Services Required

A coastal geologist, engineer, or other environmental professional with expertise in designing dune projects should be consulted to: 1) identify regulatory requirements and ensure the project fully conforms with those requirements; 2) determine the conditions at the site that will affect the project (such as the width of dry beach above high tide, wave exposure, and predicted flood elevations); 3) determine if other shoreline stabilization techniques are needed in addition to the dune project; 4) determine the appropriate grain-size range to be used by taking and analyzing sediment samples of the existing beach and dune; 5) recommend appropriate volumes of sediment for various levels of protection; 6) select appropriate plant species and develop planting and maintenance plans; 7) identify the best time of year to install the various components of the project; 8) prepare plans for permitting; 9) develop an access plan if heavy equipment is needed; and 10) prepare design specifications for construction. The consultant can also oversee permitting, construction, monitoring, and maintenance of the project. For dune projects with gravel or cobble, it is particularly important that the consultant have direct experience designing shore-protection projects using this type of material.

Project Timeline

It may take as little as four to six months to have a dune project designed, permitted, and installed, assuming that only a Massachusetts Wetlands Protection Act permit is required—but it can take longer, depending on the factors involved. Factors influencing this timeline include the contractor's experience with designing and permitting similar projects, completeness of permit applications, special considerations in the permitting process (such as objections by abutters, sensitive resources to be protected, and availability of access for construction), the need for special timing to avoid impacts (e.g., a prohibition on construction during endangered species nesting season), and/or weather conditions during construction.

Maintenance Requirements

Regular maintenance of dune projects will include adding sediment to retain the desired level of protection. The amount of sediment that should be added and how frequently it is needed will depend, in part, on the proximity of the dune to the reach of high tide, the frequency and severity of storms, the initial design of the dune (e.g., grain size, volume, height, and slope), and how established the root system of any vegetation is before a storm hits. For dune projects that include plantings, plants should be replaced (at the appropriate time of year) if they are removed by storms or die (until the plants become fully established, losses are more common). See *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage* for more information for more information. A schedule and plan for replacing sediments and plants should be included in the original permit application for the project so that maintenance can be conducted without additional permitting.

Project Costs

With dune projects, there are typically a range of options available that give increasing levels of protection with increased construction costs. In general, the greater the quantity of sediment that is used in the project, the greater the construction costs, the lower the maintenance costs, and the greater the level of protection provided for the site. In addition, whenever you hire a professional to conduct work on your property, total costs are expected to vary significantly based on site-specific considerations. The considerations that most influence the costs of dune projects are the severity of erosion, the width and elevation of the beach, the volume and availability of sediment needed, the complexity of project design and permitting, and the size and location of the proposed dune. For comparison with other shoreline stabilization options, dune projects typically have relatively low design and permitting costs, low construction costs, and low maintenance costs. See the StormSmart Properties chart, *Relative Costs of Shoreline Stabilization Options* (PDF, 99 KB), for a full comparison.

Additional Information

Artificial or nourished dunes can be used in conjunction with many other techniques for erosion management. See the following CZM StormSmart Properties fact sheets for additional information:

- *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage*
- *StormSmart Properties Fact Sheet 4: Bioengineering - Coir Rolls on Coastal Banks*
- *StormSmart Properties Fact Sheet 5: Bioengineering - Natural Fiber Blankets on Coastal Banks*
- *StormSmart Properties Fact Sheet 6: Sand Fencing*
- *StormSmart Properties Fact Sheet 8: Beach Nourishment*

The following publications and websites also provide valuable information on dunes:

- *Beach Nourishment: MassDEP's Guide to Best Management Practices for Projects in Massachusetts* (PDF, 2 MB) describes the steps for beach nourishment projects, which are very similar to dune projects. The *Technical Attachments* (PDF, 1 MB) give detailed information on sampling beach sediments, evaluating offsite source material, and monitoring project performance.
- CZM's Coastal Landscaping website focuses on landscaping with salt-tolerant vegetation to reduce storm damage and erosion and includes information on appropriate plants, planting plans, invasive species, and tips on plant care, along with links to other references.
- CZM's *Landscaping to Protect Your Coastal Property from Storm Damage and Flooding fact sheet* (PDF, 962 KB) gives specific information for homeowners on appropriate plants for erosion control in coastal areas.
- *Coastal Dune Protection and Restoration—Using 'Cape' American Beachgrass and Fencing* (PDF, 3 MB) by the Woods Hole Sea Grant and Cape Cod Cooperative Extension Program includes case studies and tips on dune restoration, along with information on preserving shorebird habitat and understanding the permit process.
- *Salisbury Beach Dune Walkover Access Design Standards* (PDF, 14 KB) gives general design standards for walkways over coastal dunes that minimize potential adverse effects. These standards are widely applicable.
- *The Ballston Beach Barrier Dune Restoration Project* (PDF, 1 MB) documents innovative sand fencing techniques used to restore a dune on a barrier beach in Truro.

- CZM's *Environmental Permitting in Massachusetts* gives brief descriptions of major environmental permits required for projects proposed in Massachusetts.
- *Guidelines for Barrier Beach Management in Massachusetts* (PDF, 12 MB), which was produced by the Massachusetts Barrier Beach Task Force in 1994, provides an overview of the Massachusetts Wetlands Protection Act Regulations and the function of beaches, dunes, and other resource areas (in Chapter 2). It also gives information on various erosion management techniques, their potential impacts, and measures to minimize those impacts (Chapter 5).
- Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00) cover work in wetland resource areas and buffer zones.
- The Natural Heritage and Endangered Species Program website provides information on protected species in Massachusetts, habitat maps, and regulatory review for projects in or adjacent to these habitats.
- The Massachusetts Division of Marine Fisheries can provide information on horseshoe crab protection and other fisheries resources.
- The Massachusetts Ocean Resource Information System, or MORIS, is a web-based mapping tool for interactively viewing coastal data. It includes shoreline change data, which should be considered when evaluating and designing shoreline stabilization projects. Other data layers in MORIS (such as endangered species habitat, shellfish, and eelgrass) can help identify sensitive resource areas within or near the project site.

Commonwealth of Massachusetts
Charlie Baker, Governor

Executive Office of Energy and Environmental Affairs
Matthew A. Beaton, Secretary

Massachusetts Office of Coastal Zone Management
Bruce K. Carlisle, Director

Massachusetts Office of Coastal Zone Management | 251 Causeway Street, Suite 800 | Boston, MA 02114 | (617) 626-1200
CZM Information Line: (617) 626-1212 | **CZM Website**: www.mass.gov/czm

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StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion

The coast is a very dynamic environment and coastal shorelines—especially beaches, dunes, and banks—change constantly in response to wind, waves, tides, and other factors such as seasonal variation, sea level rise, and human alterations to the shoreline system. Consequently, many coastal properties are at risk from storm damage, erosion, and flooding. Inappropriate shoreline stabilization methods can actually do more harm than good by exacerbating beach erosion, damaging neighboring properties, impacting marine habitats, and diminishing the capacity of beaches, dunes, and other natural landforms to protect inland areas from storm damage and flooding. StormSmart Properties—part of the Massachusetts Office of Coastal Zone Management's (CZM) StormSmart Coasts Program—provides coastal property owners with important information on a range of shoreline stabilization techniques that can effectively reduce erosion and storm damage while minimizing impacts to shoreline systems. This information is intended to help property owners work with consultants and other design professionals to select the best option for their circumstances.

What Is Runoff and How Does It Cause Coastal Erosion?

Runoff is rainwater, snowmelt, and water from irrigation systems and other sources that does not soak into the ground or evaporate, but instead flows over the ground surface. Runoff causes erosion when water falling on and/or running across bare or sparsely vegetated areas dislodges soil and other sediments. When runoff flows over a coastal bank, dune, or beach, it can erode these landforms from above and exacerbate other coastal erosion problems.

No shoreline stabilization option permanently stops all erosion or storm damage. The level of protection provided depends on the option chosen, project design, and site-specific conditions such as the exposure to storms. All options require maintenance, and many also require steps to address adverse impacts to the shoreline system, called mitigation. Some options, such as seawalls and other hard structures, are only allowed in very limited situations because of their impacts to the shoreline system. When evaluating alternatives, property owners must first determine which options are allowable under state, federal, and local regulations and then evaluate their expected level of protection, predicted lifespan, impacts, and costs of project design, installation, mitigation, and long-term maintenance.

Channels or gullies on the face of a bank or dune are a sign of a runoff problem. As shown in the photograph on the right, sediment carried by runoff is often deposited in a fan-shaped pile at the base of the slope. The channels and fan-shaped deposits are both indicators that runoff is eroding the bank. Similarly, runoff can erode soil from behind concrete seawalls and under rock revetments (i.e., shoreline stabilization structures constructed of sloping rock), causing them to slump or collapse. Indicators that runoff may be contributing to the failure of seawalls and revetments include channels in the bank above the structure or sinkholes behind the structure. If overland sources of runoff are not successfully managed, the effectiveness of other shoreline stabilization techniques can be compromised.

Runoff has eroded a channel in this bank face, exacerbating the coastal erosion problem. Some of the eroded material has been deposited in a fan-shaped mound at the base of the bank. **(Photo: CZM)**

General Approaches to Runoff Control

Controlling runoff from upland sources helps reduce a significant cause of erosion on many beaches, dunes, and banks. Efforts to control runoff focus on reducing the quantity and velocity of water flowing across the land surface and changing the direction of flow as necessary to address specific erosion problems. Runoff control approaches include:

- Removing and reducing impervious surfaces (i.e., pavement, concrete, and other impermeable materials) and planting natural vegetation to help slow the flow of runoff and allow the water to naturally seep into the ground. For example, converting asphalt or concrete driveways to grass, crushed-shell, or other surfaces that allow water to soak into the ground is an excellent way to reduce impervious surfaces.
- Capturing runoff so that it can be infiltrated into the ground over a broad area or reused for irrigation.
- Redirecting the flow of water away from erosion-prone areas by regrading the ground surface, constructing a barrier of soil or other sediment (known as a berm), and removing landscaping elements that channel runoff.
- Maintaining the soil's natural capacity to absorb water by preventing saturation from lawn watering and other irrigation.

***Several options are available for installing grass driveways, including this grass and paver system. As with all runoff control options, site conditions and potential impacts should be fully evaluated in project design.* (Photo: CZM)**

Runoff control techniques should address the specific patterns and sources of runoff on the site based on a comprehensive evaluation of site conditions. These conditions include the location and extent of impervious and vegetated surfaces, soil types, slope and elevations on the property, and sources and amounts of water coming from both on- and off-site. An experienced professional may need to be consulted for additional guidance regarding project design, and the local Conservation Commission should be contacted about permitting.

***This lawn was regraded to slope inland, and a buffer of native shrubs was planted along the top of the bank to stabilize the area and direct runoff away from the bank. These measures reduced runoff flowing over the bank so that a bioengineering project with natural fiber blankets, coir rolls, and vegetation could be successfully installed.* (Photo: CZM)**

This figure demonstrates how a typical coastal property could be modified to reduce runoff and where appropriate runoff control techniques could be sited. **(Graphic: New England Environmental, Inc.)**

The following factors should be addressed to ensure that the runoff control options selected do not create unintended negative impacts:

- **Channelization of Runoff** - Improperly managing runoff can have negative impacts, particularly if the runoff is channelized or redirected onto adjacent properties where it inadvertently increases erosion and flooding issues or where it would impact sensitive environmental resources, such as salt marsh. To avoid these impacts, runoff control options should include components that redirect and spread the flow of water across a broad vegetated area or into a rain garden or vegetated swale (i.e., specially constructed depressions in the ground that are planted with vegetation).

- **Protected Species and Other Sensitive Resources** - If a project is proposed in or adjacent to nesting habitat for protected shorebird or turtle species (i.e., species that are considered endangered, threatened, or of special concern in Massachusetts), project modifications may be required. For example, timing restrictions or other special conditions may be necessary to avoid digging up and destroying rare turtle nests. In addition, planting vegetation in open sandy areas may be prohibited because this habitat is needed for piping plovers and diamond-backed terrapin nesting. Additional information on protected species is available from the Natural Heritage and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife. Project modifications may also be necessary in horseshoe crab spawning areas, and information is available from the Massachusetts Division of Marine Fisheries. Finally, projects must be designed to protect any nearby wetland resources, such as salt marsh and eelgrass beds.

- **Impermeable Soil Layers on Banks** - When there is an impermeable layer of soil (like clay) underlying permeable sediments in a coastal bank, water that infiltrates into the ground may flow along this impermeable layer toward the bank face. This concentration of water flow may exacerbate erosion where the water breaks out onto the bank face. The runoff control techniques described below may address this issue. However, it is not always obvious that this situation exists and is exacerbating erosion on a bank. Therefore, professional assistance may be needed to identify the problem and determine the most appropriate techniques to address it.

Design Considerations for Common Runoff Control Techniques

The following section describes a variety of techniques that can be used to help control runoff erosion problems. Specific suggestions for proper design, construction, and implementation are listed for each technique.

Reduce Impervious Surfaces

Reducing the area covered by impervious surfaces slows overland flow and allows water to naturally seep into the ground. To reduce impervious cover:

- Construct driveways or patios with pea stone, gravel, crushed shells, or other pervious materials, rather than using impermeable pavement or concrete.
- Avoid the use of dense-graded aggregate, stone dust materials, and other products that prevent water from permeating into the ground on driveways, patios, or walkways. These products are designed to eliminate voids in the compacted surface, which causes these areas to become impervious.
- Minimize the footprints of proposed buildings and impervious surfaces as much as possible.

Additional Benefit - Improved Coastal Water Quality
Contaminants carried in runoff can significantly harm coastal water quality. Oils and greases washed from roadways and driveways and pesticides from lawns can introduce toxins to coastal waters. Bacteria in runoff can lead to closed shellfish beds and swimming areas. Nutrients from fertilizers, pet waste, or septic systems can lead to nuisance plant or algae growth, which can reduce oxygen supplies (leading to fish kills and odors) and shade out eelgrass beds. Runoff control techniques allow the runoff to seep into the ground where some contaminants may be filtered out by the soil or absorbed by plant roots, minimizing contamination of coastal waters.

Replace Lawns with Natural Plantings

Lawns exacerbate runoff issues because water readily runs over mowed grass and the soils under lawns tend to compact to create an impervious surface. Replacing lawn with longer grass, shrubs, and other vegetation can therefore significantly improve runoff problems. Where possible:

- Restrict the use of mowed lawns to areas needed for pathways and recreation.
- Avoid mowing the lawn right up to the edge of the dune, bank, beach, or marsh (which has the added advantage of keeping people back from the edge—foot traffic may exacerbate erosion).

Extensive irrigated lawns that slope seaward have exacerbated the erosion of this coastal bank. **(Photo: CZM)**

Plant Vegetated Buffers

Vegetated buffers are strips of high grasses, shrubs, and other plants (other than lawn). These buffers absorb runoff, slow its overland flow, and break the impact of raindrops or wave splash. The plant roots also bind the soils and help improve the stability of the area. See *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage* for additional information on using plants for coastal erosion control. To improve the success of runoff control projects:

- Plant vegetated buffers 5-10 feet in width landward of the top of the bank, dune, or beach to be protected.
- Plant salt-tolerant grasses with extensive root systems to provide more immediate erosion control. Though trees and shrubs may look more stable, grasses can grow more quickly and effectively stabilize large areas and require less maintenance to thrive.
- Plant native and salt-tolerant species that are adapted to local conditions and require less maintenance, watering, and pest control.
- Select appropriate species for site conditions, plant at the appropriate time of year (generally spring or fall), and follow the specific instructions for watering, fertilizing, and general care and maintenance.
- Plant trees far enough back from the top of coastal banks to ensure that their weight does not contribute to bank instability.
- If trees on or near the bank are leaning, they may increase instability of the bank and may need to be pruned or removed.
- Do not place dead plant material, such as lawn clipping, brush, and discarded Christmas trees, on a bank or other coastal area. These dead plant materials limit the natural growth and establishment of plants and do not have roots that help bind soils together. Many municipal landfills accept yard waste for composting.
- Some of the most effective plants for vegetated buffers in coastal areas include beach plum, bayberry, Virginia or Carolina rose, arrowwood viburnum, sweet fern, and bearberry.

Fertilizer can cause nuisance plant or algae growth that can degrade water quality. The nitrogen in fertilizer is a particular problem in coastal waters. Consequently, the use of fertilizer on vegetated buffers, as in all coastal areas, should be limited as much as possible. When designed and maintained correctly, vegetated buffers actually filter out nitrogen and other contaminants from inland sources, helping to reduce coastal water contamination.

Install Vegetated Swales and Rain Gardens

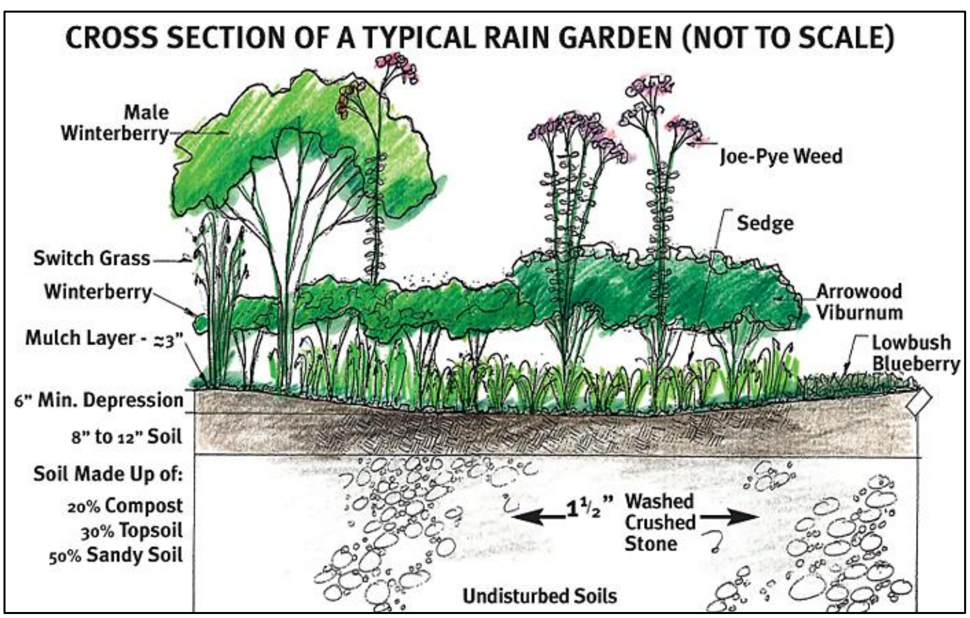
Vegetated swales are channel-like depressions in the ground used to slow, filter, and direct water to another location. Rain gardens are wider and flatter depressions that allow for the maximum collection and infiltration of water. Swales and rain gardens both use plants that tolerate both wet and dry conditions to ensure plant survival (swales often use grasses, while rain gardens are planted with a mix of grasses, perennials, shrubs, and trees).

A large rain garden. **(Photo: Massachusetts Bays National Estuary Program)**

To maximize effectiveness and prevent problems:

- Place swales/rain gardens downslope from a downspout, driveway, or other impervious surface in a relatively flat area (with less than a 5% slope), at least 50 feet away from septic systems, 100 feet away from wells, and 10 feet away from a dwelling foundation. Regrade the area if necessary to create an appropriate location for the swale/rain garden. Consult with your municipal board of health before installing a rain garden or swale near a septic system or well to make sure the proposed setback is sufficient.
- Locate vegetated swales/rain gardens as far away from the top of a bank as possible to reduce the amount of groundwater that may flow toward the bank face and potentially cause erosion.
- Determine the appropriate size of the swale/rain garden needed to effectively capture the runoff based on average yearly rainfall, soil infiltration rates, the size of the area that runoff is draining from, and impervious surface cover. Swales and rain gardens constructed in wetland resource areas will need to meet specifications contained in the *Massachusetts Stormwater Handbook* if a permit is required by the Conservation Commission.
- Plant a series of interconnected swales/rain gardens if one is too small to hold and infiltrate the amount of water flowing into it.
- If necessary, add amendments to clay or poorly drained soils to increase the infiltration capacity of the swale/rain garden. Some of the existing soil may need to be removed and replaced with a layer of gravel, planting soil mix, and mulch.
- To help prevent runoff from washing out the mulch or soil in large storm events, consider installing a temporary erosion-control blanket made of natural fibers over the swale/rain garden to stabilize the soil until the plants become established. (See *StormSmart Properties Fact Sheet 5: Bioengineering - Natural Fiber Blankets on Coastal Banks* for further information.) In addition, if concentrated flow is being introduced from a driveway, downspout, or other source, spread a layer of crushed stone across the entrance point where the water comes into the swale/rain garden to slow the speed of the flow.

As with vegetated buffers, select appropriate plants for site conditions, plant at the appropriate time of year (generally spring or fall), and follow the specific planting and care instructions. (See *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage* for other tips.)



Adapted illustration courtesy of Comprehensive Environmental, Inc.

Regrade Site to Direct Water Away from the Shoreline

Regrading the area landward of a bank, dune, or beach can ensure that runoff flows away from the shoreline. With this technique:

- Grade the site to slope toward vegetated swales or rain gardens. As mentioned above, swales/rain gardens should be placed well away from the top of a bank.
- To prevent basement flooding, do not direct the water toward a dwelling.
- To prevent erosion of the regraded area, consider covering exposed soils with a temporary erosion-control blanket and successfully plant the area as soon as possible. See the *StormSmart Properties Fact Sheet 5: Bioengineering - Natural Fiber Blankets on Coastal Banks*.
- Avoid regrading work during heavy rains when exposed soils are more vulnerable to erosion.
- Avoid making slopes too steep, which will accelerate the flow of runoff and may cause additional erosion problems. Consult a professional for site-specific assistance in determining the appropriate slope.

Construct a Vegetated Berm

A berm (i.e., a mound of soil or other sediment built as a barrier) can be used as a "speed bump" to slow the flow of runoff. It is important to:

- Strategically construct vegetated berms to address specific runoff problems. For example, place a berm landward of the top of a coastal bank to redirect runoff away from the shoreline, or use a berm as a barrier to block or redirect runoff from roads, other properties, and other offsite sources.
- Determine the height and overall shape of the berm based on site conditions, such as soil characteristics, existing vegetation, site slope, and volume of water flowing toward the berm. The steeper the slope of the site, the faster the water will be flowing, requiring a higher berm to redirect the flow. As for shape, a berm is generally more stable when its base is twice the width of its height.
- Select sediments to construct the berm based on the amount of runoff. For average water flow, a mix of sediments (such as well-drained soil and sand) provides an effective physical barrier while also allowing for infiltration. For higher water flow, coarser materials (such as sand and gravel) provide greater flow-through and infiltration (to avoid the pooling of water behind the berm).
- Cover the berm with a layer of topsoil and plant/seed the area to stabilize the soil (see *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage*).
- Consider using a short-term natural fiber blanket to stabilize the berm while the plants get established (see *StormSmart Properties Fact Sheet 5: Bioengineering - Natural Fiber Blankets on Coastal Banks*).

Capture Roof Runoff

Significant quantities of rainwater and snowmelt run into roof downspouts. This water can be directed into a rain barrel, where it can be stored for reuse as irrigation water, or into a system designed to immediately infiltrate the water into the ground, such as a drywell or a French drain. When using these techniques:

- Place rain barrels below downspouts (55 gallon drums are the most common size for rain barrels). Cut the downspout to fit directly into the rain barrel. Special adaptations can be used, such as a spigot to attach hoses to reuse the water or an overflow hose to direct any overflow away from the foundation. Rain barrels should have a screen and cover to keep out mosquitoes, leaves, and debris.

- Design the drywells/French drains to channel water away from foundations. For sites directly adjacent to banks, French drains are generally preferred over drywells because they disperse the water infiltration, which helps ensure that the water successfully seeps into the ground and does not flow toward the bank face.
- Base the storage capacity of the drywell/French drain on the quantity of roof runoff, as well as on the depth of the water table. The bottom of the drywell/French drain should be at least two feet (but preferably four feet) above the seasonal high groundwater level.
- Drywells need to be at least 10 feet from building foundations, 50 feet from vegetated wetlands or tops of coastal banks, 50 feet from any component of a septic system, and 100 feet from wells.

Avoid or Reduce Watering of Lawns and Plants

Watering less keeps soils from becoming saturated, allowing them to more effectively soak up rainwater and other runoff. To water less:

- For the first year, if necessary, use a temporary irrigation system (such as drip tubing on a timer) while newly planted vegetation becomes established (see the planting instructions for specific watering requirements). Once the plants are established, watering is only required during extreme drought.
- When nature does not provide enough water to keep a lawn green and growing, allow it to go dormant. Though it may appear dead, this dormant state allows grass to preserve the vital parts of the plant during times of heat and low moisture and revive with the first saturation.
- Avoid cutting grass too short (generally no shorter than 2 inches). Taller grass has a deeper and more extensive root system, which enables the lawn to better withstand heat and drought.
- Plant less lawn grass and more drought-tolerant grasses and vegetation.

Slow the Flow of Water

By allowing water to spread out and flow over a wider vegetated surface, infiltration will increase, erosive forces will decrease, and runoff will be reduced. Specifically:

- Reduce the use of walls, solid fencing, curbs, etc., that concentrate runoff and create channels and gullies.
- Design discharge points for downspouts or other conduits of water to avoid causing scour, gullies, erosion, or alteration to vegetation. Place splash blocks or level spreaders (structures designed to uniformly distribute concentrated flow over a large area), or small amounts of gravel, at these discharge points to minimize erosion.
- Eliminate curbs or small retaining walls for defining the boundaries (such as between a driveway and lawn), which can channelize runoff and concentrate erosive forces. Replace curbs or walls with vegetated swales or rain gardens that promote infiltration and avoid channelization.
- If road runoff is an issue on your property, contact your town or city to determine if there is a drainage easement (an attachment to a property deed which states that access to part of the property is given to a third party, usually a community, for the purpose of maintaining drainage). If there is no easement, consider rain gardens parallel to the roadside to promote infiltration of road runoff. If there is an easement, work with your local officials to address the issue.

Heavy Equipment Use

If heavy equipment is needed for a project to address runoff, equipment access must be carefully planned to avoid destruction of existing vegetation; creation of ruts; destabilization of banks, beaches, or other landforms; impacts to wildlife and protected species habitat; and related impacts. When mechanical equipment is being used, contractors should keep hazardous material spill containment kits on-site at all times in case there is a release of oil, gasoline, or other toxic substance.

Permitting and Regulatory Standards

Most options for addressing runoff will likely require a permit under the Massachusetts Wetlands Protection Act through the local Conservation Commission if they are within 100 feet of any "wetland resource area" defined under the Act (these resource areas include coastal banks, dunes, beaches, and floodplains). For very large projects, additional permits may be needed from the local, state, or federal agencies. Permits or approvals may also be required from other state agencies and local departments, depending on the location and the work involved. Often, Conservation Commission staff are available to meet with applicants early in the design process to go over the important factors that need to be considered.

Generally, regulatory programs are supportive of runoff control projects, provided they do not interfere with the ability of coastal landforms to naturally move and shift. To obtain a permit, projects need to be designed to minimize impacts to neighboring properties and sensitive resource areas (e.g., beaches and dunes) and prevent impacts to salt marsh, which is protected by the various regulatory programs.

Professional Services Required

Certain techniques that do not alter the property, such as reducing lawn irrigation or installing a rain barrel, can be easily done by the homeowner without a permit. Other simple projects, like planting a buffer strip of native vegetation along the top of a bank or replacing a paved driveway with crushed shell, can often be permitted and conducted by the homeowner in consultation with the local Conservation Commission. A homeowner may also be able to install rain garden or vegetated swale, depending on the complexity of the design. Because of the impacts that can be caused by inappropriately directed runoff, however, projects in or adjacent to sensitive resource areas (e.g., endangered species habitat) or that redirect the flow of runoff are likely to require professional services. A registered professional civil engineer, registered landscape architect, or other environmental professional with experience in managing runoff and landscaping for runoff control can be chosen to: 1) study the landscape and identify the current runoff sources under various storm conditions; 2) identify options to increase permeability, reduce channelization, and redirect runoff away from the shoreline without impacting sensitive resource areas or neighboring properties; 3) determine if any permits are required for the project; 4) identify regulatory requirements and ensure the project fully conforms with those requirements; 5) prepare plans for permitting; 6) prepare design specifications for construction; and, if needed, 7) oversee construction, monitoring, and maintenance.

Project Timeline

It may take as little as two to six months to design, permit, and install a runoff control project, assuming only a Massachusetts Wetlands Protection Act permit is required—but it can take longer, depending on the factors involved. Factors influencing this timeline include the contractor's experience with designing and permitting similar projects, completeness of permit applications, special considerations in the permitting process (such as objections by abutters and sensitive resources to be protected), the need for special timing to avoid impacts (e.g., a prohibition on construction during endangered species nesting season), and/or the weather conditions during construction.

Maintenance Requirements

Many runoff control techniques, such as reducing impervious surfaces and regrading the site away from the shore, require no maintenance when designed and installed successfully. Other techniques require only routine maintenance similar to other yard maintenance requirements. For example, runoff reduction projects using live plants require replacement of dead plants and may require watering during periods of drought.

For rain barrels, debris must be cleared away from the inlets on a regular basis. In addition, unless the rain barrel can withstand freezing temperatures, it should be cleaned out at the end of the fall and stored indoors. Keep roof gutters and other pipes clean to minimize the amount of sediment and other particulates that may enter a rain barrel, dry well, or French drain. Dry wells and French drains should be inspected regularly and cleaned to maintain proper function and drain time, which is 72 hours or less. If soils become compacted or clogged, they will not be able to handle additional water and may cause water to back up. The dry well or French drain may need to be replaced if drain times fall below the specified requirements.

When rainfall exceeds levels the project was designed to handle, more intensive maintenance activities are necessary. For example, a berm may require reconstruction if it is eroded or may need to be replanted if vegetation is damaged during severe rains (immediate repairs may be needed to ensure no further deterioration). After a severe rain event is a good time to evaluate whether the runoff control project functioned as intended. A brief consultation with the professional who designed the project can help to determine whether any modifications are needed.

Project Costs

With runoff control projects, there is typically a range of options available that address increasing runoff quantities. In addition, whenever you hire a professional to conduct work on your property, total costs are expected to vary significantly based on site-specific considerations. The considerations that most influence the costs of runoff control projects are the severity of erosion, volume of runoff that needs to be redirected, size of the area that needs to be addressed, quality of materials used, and complexity of project design and permitting. In addition, the type of runoff control and size of the area to be addressed will determine the construction and maintenance costs. In comparison with shoreline stabilization options, runoff control projects typically have relatively low costs for design and permitting, construction, and maintenance. See the StormSmart Properties chart, *Relative Costs of Shoreline Stabilization Options* (PDF, 99 KB), for a full comparison.

Additional Information

Related techniques covered in the CZM StormSmart Coasts menu of shoreline stabilization options are *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage* and *StormSmart Properties Fact Sheet 5: Bioengineering - Natural Fiber Blankets on Coastal Banks*.

The following resources also provide valuable information on runoff control:

- CZM's Coastal Landscaping website includes information on landscaping coastal areas with salt-tolerant vegetation to reduce storm damage and erosion.
- CZM's *Landscaping to Protect Your Coastal Property from Storm Damage and Flooding fact sheet* (PDF, 962 KB) gives specific information for homeowners on appropriate plants for erosion control in coastal areas.
- CZM's CZ-Tip - Keep Waterways Clean by Filtering Pollutants with Plants discusses reducing runoff impacts by planting vegetated buffers.
- The Massachusetts Department of Environmental Protection's (MassDEP) Vegetated Buffer Strips: Slow the Flow to Protect Water Quality explains how vegetated buffer strips function and how to create them.
- The U.S. Environmental Protection Agency's (EPA) National Menu of Stormwater Best Management Practices has searchable fact sheets on berms, regrading, swales, and other stormwater control practices.
- EPA's GreenScaping: The Easy Way to a Greener, Healthier Yard provides information on yard maintenance to reduce water usage.
- *Rain Gardens Across Maryland* (PDF, 14 MB) discusses locating, siting, and designing rain gardens and calculating impervious surfaces (rainfall depths and plant species are specific to Maryland).

- CZM's *[Environmental Permitting in Massachusetts]* briefly describes major environmental permits required for projects proposed in Massachusetts.
- Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00) cover work in wetland resource areas and buffer zones.
- MassDEP's *Erosion & Sedimentation Control Guidelines* (PDF, 4 MB) give best management practices for managing sediment and runoff.
- MassDEP's *Massachusetts Stormwater Handbook* provides design specifications for rain gardens, drywells, and swales.
- The Natural Heritage and Endangered Species Program website provides information on protected species in Massachusetts, habitat maps, and regulatory review for projects in or adjacent to these habitats.
- The Massachusetts Division of Marine Fisheries can provide information on horseshoe crab protection and other fisheries resources.
- The Massachusetts Ocean Resource Information System, or MORIS, is a web-based mapping tool for interactively viewing coastal data. MORIS data layers, such as endangered species habitat and shellfish, can help identify sensitive resource areas within or near the project site.

Commonwealth of Massachusetts
Charlie Baker, Governor

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Massachusetts Office of Coastal Zone Management | 251 Causeway Street, Suite 800 | Boston, MA 02114 | (617) 626-1200
CZM Information Line: (617) 626-1212 | **CZM Website**: www.mass.gov/czm

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StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage

The coast is a very dynamic environment and coastal shorelines—especially beaches, dunes, and banks—change constantly in response to wind, waves, tides, and other factors such as seasonal variation, sea level rise, and human alterations to the shoreline system. Consequently, many coastal properties are at risk from storm damage, erosion, and flooding. Inappropriate shoreline stabilization methods can actually do more harm than good by exacerbating beach erosion, damaging neighboring properties, impacting marine habitats, and diminishing the capacity of beaches, dunes, and other natural landforms to protect inland areas from storm damage and flooding. StormSmart Properties—part of the Massachusetts Office of Coastal Zone Management's (CZM) StormSmart Coasts Program—provides coastal property owners with important information on a range of shoreline stabilization techniques that can effectively reduce erosion and storm damage while minimizing impacts to shoreline systems. This information is intended to help property owners work with consultants and other design professionals to select the best option for their circumstances.

How Vegetation Reduces Erosion and Storm Damage

Dunes, banks (also known as bluffs), and other coastal landforms are susceptible to erosion from tides, currents, wind, and coastal storms. Overland runoff, which is the water from rain, snowmelt, sprinklers, and other sources that does not readily soak into the ground or evaporate but instead flows over the ground surface, can also cause erosion by dislodging vegetation, sand, gravel, and other sediments. Salt-tolerant plants with extensive root systems can help address both kinds of coastal erosion problems. First, plant roots hold sediment in place, helping to stabilize the areas where they are planted. Second, by absorbing water, breaking the impact of raindrops or wave-splash, and physically slowing the speed and diffusing the flow of overland runoff, plants reduce runoff erosion. Vegetation also helps trap windblown sand, which is particularly important for building dune volume, increasing the dune's ability to buffer inland areas from storm waves, erosion, and flooding. Finally, high grasses, shrubs, and other vegetation can be planted to limit foot traffic in erosion-prone areas.

Vegetation can be used in conjunction with many other techniques for erosion management. See the following StormSmart Properties fact sheets on related techniques: *Artificial Dunes and Dune Nourishment*, *Controlling Overland Runoff to Reduce Coastal Erosion*, *Bioengineering - Coir Rolls on Coastal Banks*, *Bioengineering - Natural Fiber Blankets on Coastal Banks*, *Sand Fencing*, and *Beach Nourishment*.

No shoreline stabilization option permanently stops all erosion or storm damage. The level of protection provided depends on the option chosen, project design, and site-specific conditions such as the exposure to storms. All options require maintenance, and many also require steps to address adverse impacts to the shoreline system, called mitigation. Some options, such as seawalls and other hard structures, are only allowed in very limited situations because of their impacts to the shoreline system. When evaluating alternatives, property owners must first determine which options are allowable under state, federal, and local regulations and then evaluate their expected level of protection, predicted lifespan, impacts, and costs of project design, installation, mitigation, and long-term maintenance.

Beachgrass was planted to stabilize an eroded dune and trap windblown sand to build dune volume. **(Photo: CZM)**

A variety of salt-tolerant vegetation was planted on the face of this bank to stabilize fill added to address bank erosion. **(Photo: CZM)**

Shrubs were planted at the top of this bank to slow runoff. On the bank face, natural fiber blankets were installed to hold soils in place until the erosion-control vegetation could get established. **(Photo: CZM)**

Relative Benefits and Impacts Compared to Other Options

The major benefit of vegetation projects is that unlike seawalls, rock revetments, or other "hard" shoreline stabilization structures, vegetated areas absorb and dissipate wave energy, rather than reflecting or redirecting waves onto beaches or neighboring properties. The design of a hard structure affects how much wave energy is reflected, for example vertical walls reflect more wave energy than sloping rock revetments. These reflected waves erode beaches in front of and next to a hard structure, eventually undermining and reducing the effectiveness of the structure and leading to costly repairs. This erosion also

Under the Massachusetts Wetlands Protection Act, new hard structures are typically prohibited on all beaches and dunes. On coastal banks, hard structures are only allowed when necessary to protect buildings permitted before August 10, 1978, and only if no other alternative is feasible. In many cases, vegetation projects and other non-structural alternatives are therefore the only options available for reducing erosion and storm damage on coastal properties.

results in a loss of dry beach at high tide, reducing the beach's value for storm damage protection, recreation, and wildlife habitat. Other benefits of vegetation projects are that they preserve the natural character of the coastal environment and provide wildlife habitat.

In general, the impacts of vegetation projects are relatively minor when compared to other options. Vegetation projects in habitat for protected species (i.e., species that are considered endangered, threatened, or of special concern in Massachusetts), however, do have the potential to cause significant impacts, such as removing open sand areas needed for successful nesting of piping plovers and diamond-backed terrapins. Even the planting of native plant species can cause impacts in these areas. See Design Considerations below for information on addressing this issue.

Design Considerations for Vegetation Projects

This section covers a variety of factors that should be considered to minimize adverse impacts and ensure successful design, permitting, construction, and maintenance of vegetation projects.

Appropriate Locations

Vegetation projects are appropriate for virtually any dune or bank along the coast where sand and other sediments are exposed to wind and waves. Because it is relatively difficult to get vegetation established in areas that are regularly inundated or overwashed by tides and waves, however, the longevity and effectiveness of these projects can be limited in certain locations. The techniques discussed in Protecting Plants below can help address this issue.

Protecting Plants

Plants are most vulnerable before their root systems become established. Techniques that can help stabilize dunes and banks while plants get established include: 1) installing natural fiber blankets on the ground surface before planting to hold soils in place while roots get established (see *StormSmart Properties Fact Sheet 5: Bioengineering - Natural Fiber Blankets on Coastal Banks*), 2) using temporary baffles of natural-fiber material to shelter plants from wind, and 3) installing sand fencing to help slow wind, trap sand, and reduce erosion (see *StormSmart Properties Fact Sheet 6: Sand Fencing*). Combining these techniques is more effective than using only one method. On banks, another method to protect the soil around newly planted live vegetation is to plant a salt-tolerant seed mix on the exposed soil. The plants that grow from seed can quickly stabilize the soil so it is not washed away while the live plants are becoming established.

Another important factor for successful plant establishment and survival is water availability. Since new plants with their smaller root systems have a limited capacity to find water in the surrounding soil, a consistent supplementary source of water should be provided directly to these plants while their root systems and foliage are developing. For large planting projects, the use of a temporary, automated irrigation system may be warranted for up to three summers following planting. See the Watering section below for additional details and cautions on using automated irrigation systems.

To further ensure the success of planting projects, sources of erosion, including upland runoff and waves, should be identified and addressed as part of the site evaluation and design process. Runoff should be reduced or redirected to give the vegetation the best chance of survival (see *StormSmart Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion* for details). In areas subject to regular erosion from waves, tides, currents, wind, and coastal storms, additional techniques should be considered to improve site protection. For example, beach nourishment (i.e., adding sediments like sand, gravel, and cobble to widen the beach—see *StormSmart Fact Sheet 8: Beach Nourishment*) can protect vegetation projects by widening beaches in areas with relatively narrow beaches at high tide. For bank projects, dense rolls of natural fiber called coir rolls can protect newly planted areas (see *StormSmart Fact Sheet 4: Bioengineering - Coir Rolls on Coastal Banks*), hay bales can be staked at the base of the bank to provide a short-term buffer from tide and waves, and artificial dunes can be constructed with sediment from an off-site source to buffer the base of the bank (see [*StormSmart Properties Fact Sheet 1: Artificial Dunes and Dune Nourishment*]).

In addition, to protect dune and bank vegetation, pedestrian access to the shoreline should be restricted to designated access paths or walkways and the number of access points should be limited as much as possible. Often, multiple properties can use a common access point. The size of access structures should be minimized as much as possible to limit shading impacts to vegetation.

Lightweight, natural-fiber, erosion-control fabric was installed on this bank to protect the plants from wind until the roots could get established. Boards were placed on top of wooden stakes to provide access during construction, which minimized impacts to the bank from foot traffic. The photo on the right was taken one year after planting. **(Photos: New England Environmental, Inc.)**

An Added Consideration on Banks - Establishing a Stable Slope

On banks, a stable slope is essential for project success. If the bottom of the bank has eroded and its slope is steeper than the upper portion of the bank, the bank is likely unstable. Even when heavily planted with erosion-control vegetation, banks with unstable slopes are extremely vulnerable to slumping or collapse that can endanger property landward of the bank. Before planting vegetation, therefore, the bank slope should be stabilized.

Ideally, soil of a similar type to that on the bank or beach is brought in as fill and added to the lower part of the bank to create a slope that matches or is less steep than the upper slope. However, if adding fill brings the toe of the bank within the reach of high tides, the fill will erode quickly and undermine the rest of the bank. In these cases, regrading the bank slope by removing sediment from the top of the bank may be a better option. While removing part of the upper portion of the bank does reduce the land area between the top of the bank and the property, it can be done in a controlled fashion that improves the overall stability and storm-damage prevention capacity of the bank. And if the slope is not stabilized, bank collapse during a storm could cause substantially more loss of land area to the sea. In addition, any investment in vegetation and other methods to prevent erosion on an unstable bank will be lost if the bank collapses. On sites where the top of the bank is well vegetated with mature, salt-tolerant species with extensive roots, the appropriate approach to stabilize the bank should be carefully developed by a professional with extensive experience successfully stabilizing similar sites.

Sediment was added to this eroding bank to create a shallower and more stable slope before the vegetation was planted. The lower bank was planted with grasses and the upper section with mixed grasses and shrubs. (Photo: CZM)

Plant Selection

Specific site conditions—including wind, salt, soil type and quality, moisture, shifting sands, frequency of coastal storms, and exposure to waves and overwash—dictate the plant species that can grow successfully. Native, salt-tolerant species are recommended for coastal use because they are well adapted to the harsh conditions, require less maintenance to grow and thrive, and provide more diverse food and shelter for wildlife. In addition, only plants with extensive root systems should be selected for erosion-control projects.

On dunes (particularly those closest to the beach where wind and wave action are strongest), American beachgrass is the best species to use for initial plantings. Beachgrass quickly establishes a dense root system, rapidly accumulates sand, and is very resilient to being overwashed by waves. For beachgrass to thrive, it should be planted in a location where wind-blown sand will reach the plants. Other plants recommended for use in combination with beachgrass include little bluestem, purple lovegrass, and seaside goldenrod. Further landward in dunes and beyond the reach of regular wave action, shrubs such as beach heather, lowbush blueberry, bayberry, and beach plum can be planted with grasses to add diversity and improve erosion control.

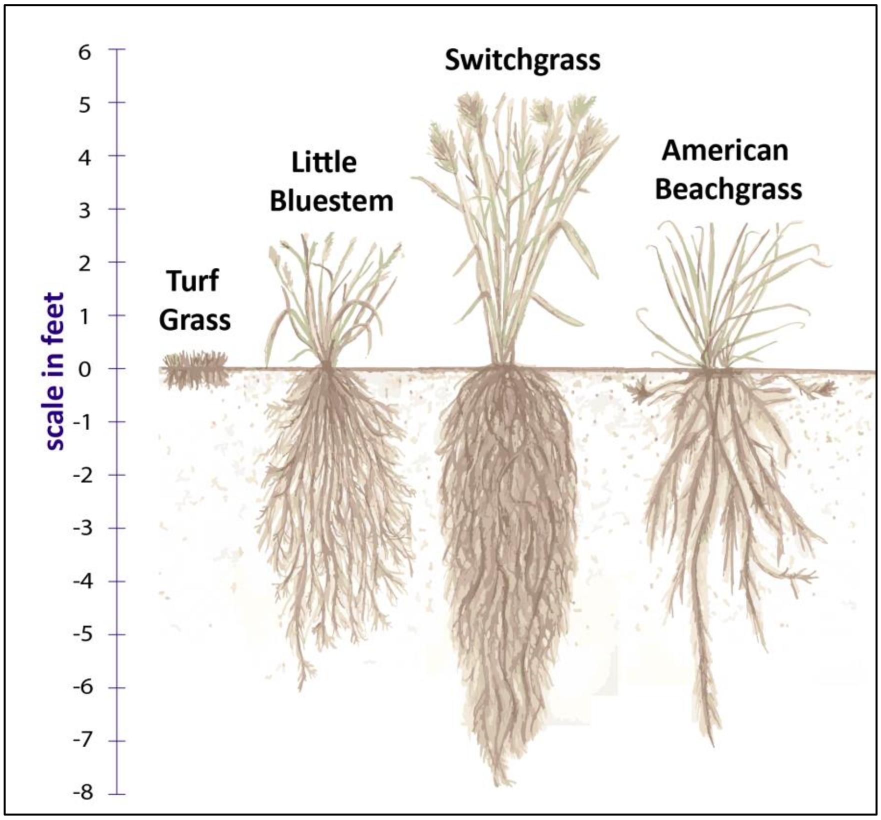
On banks, switchgrass, saltmeadow cordgrass, little bluestem, and other grasses can stabilize exposed areas quickly with their fast-growing, fibrous root systems. While American beachgrass is helpful for initial bank stabilization, it will not thrive on banks that receive little blowing sand. In these areas, it should be planted with other recommended species that will take over as the beachgrass fades. Shrubs, low groundcovers, and perennials that have extensive surface areas and root systems can be used to intercept heavy rainfall and help shelter and stabilize the underlying soils.

Northern bayberry, bearberry, and marsh elder are excellent shrubs for protecting underlying soil in coastal areas. Shrubs are best used higher up on the bank where they are not exposed to waves, and planting a mix of grasses around newly planted shrubs can help stabilize the area while the shrubs become established. Trees and large shrubs should not be planted on the face of a bank because their height and weight can destabilize the bank and make them vulnerable to toppling by erosion or high winds. Existing trees on banks can be pruned back to help address this problem.

It is important to plant a diversity of native species because a stand of only one plant is more susceptible to complete die-out from drought, disease, or pests.

CZM's Coastal Landscaping website provides additional detailed information on appropriate plants for storm damage prevention and flood control on dunes and banks.

Use Only Live Plants for Erosion Control



Turf grass has a very shallow root system compared to these other plants recommended for erosion control. **(Figure redrawn from illustration by Dede Christopher of the Tennessee Valley Authority, Benefits of Riparian Zones)**

Only live plants should be used since brush, lawn clippings, and other dead plant materials prevent live plants from getting established and have no roots to bind soils. Discarded Christmas trees are a particular problem because they leave large, destabilizing holes when they are ripped out by waves. Sand fencing is a much more effective option and does not impede the natural growth of live plants. See *StormSmart Properties Fact Sheet 6: Sand Fencing* for details.

Never Plant Invasive Plants

Invasive species (i.e., introduced species that thrive at the expense of native plants) should never be planted in coastal areas. Oriental bittersweet, bush honeysuckle, vine honeysuckle, autumn olive, and porcelain berry vine are particularly problematic coastal invasives because they have shallow roots, spread rapidly, and can secrete toxic compounds that prevent the growth of other plants. Japanese knotweed is another common invasive that is a problem on coastal sites. Although knotweed has deep roots, it can easily be torn out of the ground, taking large chunks of the soil with it. Because of these growth characteristics, even dense stands of these six species do little to reduce erosion by storm waves, runoff, and wind.

Removing/Replacing Invasive Plants

Invasive plants should be removed and replaced with appropriate native plants if they are preventing establishment of erosion-control vegetation. Because of their tenacity, successful control of invasive plants can take years to accomplish and may require perpetual monitoring and management. This effort is particularly warranted when bank stability is severely compromised by the invasive plant or when unruly and overgrown invasives can be replaced with lower-growing native species to stabilize the bank and improve coastal views.

INVASIVE PLANTS THAT HINDER EROSION CONTROL

Bush Honeysuckle

(Photo: Leslie J. Mehrhoff, University of Connecticut)

Vine Honeysuckle

(Photo: Chuck Bargeron, University of Georgia)

Oriental Bittersweet

(Photo: James R. Allison, Georgia Department of Natural Resources)

Autumn Olive

(Photo: Leslie J. Mehrhoff, University of Connecticut)

Porcelain Berry Vine

(Photo: Nancy Loewenstein, Auburn University)

Japanese Knotweed

(Photo: Jan Samanek, State Phytosanitary Administration)

All photos courtesy of [Bugwood.org] with specific acknowledgements given.

The photo on the left shows a densely vegetated bank that looks stable, but isn't. The invasive black locust, Asiatic bittersweet, and autumn olive growing on the bank do not have deep, dense roots that help hold soils in place. The photo on the right shows a close up of the exposed soils and erosion at the site. In addition, the roots of these invasive plants secrete toxic compounds and the thick branches shade the area, both of which inhibit the growth of native plants that could stabilize the soil. **(Photos: Wilkinson Ecological Design)**

Removing invasive plants to replace them with native species, however, can temporarily destabilize the bank. For sites where bank regrading is not needed, invasive plants should be cut off at ground level, keeping the roots in place to minimize site disturbance. Many invasive plants can be effectively eliminated by applying limited amounts of herbicide to the cut stems, which kills the remaining root material. Herbicides can only be used in areas where they are allowed by local regulations. A direct and targeted application of herbicides, as opposed to spraying, helps to minimize adverse impacts to existing native vegetation, soils, groundwater, and coastal waters. Invasive plants should also be removed by hand when possible, rather than with heavy equipment. For sites where regrading is needed, the roots of invasive plants can be pulled out to minimize resprouting.

Regardless of the method used, when vegetation is cut or removed, the exposed soils will become more vulnerable to erosion from wind, rain, and waves. Proper scheduling and sequencing of invasive species removal and replanting with native species will minimize this problem, as will the use of other soil stabilization techniques. Consultation with a professional experienced in replacing invasives with native plants in erosion-prone areas is recommended, as the techniques and timing vary between plants.

Time of Planting

Although specific timing varies based on the plant species selected, most vegetation should be planted in early-to-mid spring (when the growing season has started and moisture levels are relatively high) to promote root growth and successful plant establishment. Beachgrass, however, typically does best when planted in unfrozen ground from mid-November through early April, except in areas exposed to strong wind or waves, where it should be planted in early spring to reduce the likelihood it will be washed or blown away in winter storms.

Watering

Established native plants typically do not require watering. When planted at the appropriate time of year, some newly planted species, such as American beachgrass planted on dunes, also do not require watering.

In both dune and bank areas, some supplemental irrigation may be necessary to ensure success in certain circumstances. For most newly planted vegetation, it is generally recommended that a temporary, automated irrigation system be used from April through October during the first two to three growing seasons until the roots can effectively find and absorb water from the surrounding soils. These irrigation rates can typically be reduced each year, with only minimal water needed in the third year, if at all. For American beachgrass and other plants that do not typically require initial watering, temporary irrigation (i.e., for 4-6 months) is needed when these species are planted in the hot, dry summer months.

Permanent irrigation systems and heavy watering are unnecessary and are not recommended, not only because established plants do not require watering (with the exception of times of drought), but also because excess water from permanent irrigation systems generally exacerbates dune and bank erosion and can even lead to bank failure. Excess water on dunes can also reduce soil salinity levels and allow plants that will not survive in the long-term to out-compete appropriate erosion-control plants.

Temporary irrigation systems, such as aerial heads, are good for providing water to large areas of plugs and seeds, while soaker hoses and drip tubing are effective for supporting container plantings, such as shrubs. A timer may be appropriate to deliver a sufficient amount of water (enough to infiltrate well into the soil to help plants develop deep roots) at desired times (often early morning when less water is lost to the heat of the day). The temporary irrigation lines should be left at the surface (so soils will not be disturbed when the lines are removed) and the system should be removed at a determined time (such as when a local Conservation Commission issues a Certificate of Compliance for the project around year 3).

Various methods to improve water retention and nutrient content in the plants and soils can also help significantly boost the survival rates of plants, such as the application of wetting agents (e.g., Yucca extract), beneficial microbes, and organic compost. A professional may need to be contacted to help determine the most appropriate watering methods and applications that will ensure plant establishment while avoiding impacts to coastal resource areas.

Fertilizer

Because sandy soils are typically dry and lack nutrients, it may be necessary to add some organic matter such as compost before planting. For coastal settings, it is appropriate to select plants that require little fertilizer. If the plant label indicates that fertilizer is needed the first year, use only the minimum amount necessary and use slow-release fertilizers composed of water-soluble materials to prevent coastal water pollution. On artificial or nourished dunes where sand has been brought in from off-site, a limited application of time-release fertilizer 30 days after planting is often needed.

Wildlife Protection

Because vegetation can alter habitat, care must be taken with vegetation projects in protected species habitat. Selecting appropriate types of vegetation (e.g., grass vs. shrubs) and increasing the spacing between plantings can reduce impacts to nesting habitat for protected shorebirds and turtles. Detailed guidance is available from the Natural Heritage and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife.

Heavy Equipment Use

If heavy equipment is needed for a vegetation project, equipment access must be carefully planned to avoid destruction of existing vegetation; creation of ruts; destabilization of banks, beaches, or other landforms; impacts to wildlife, particularly nesting habitat for protected shorebirds and turtles; and related impacts. When mechanical equipment is being used, contractors should keep hazardous material spill containment kits on-site at all times in case there is a release of oil, gasoline, or other toxic substances.

Permitting and Regulatory Standards

Most options for addressing coastal erosion, storm damage, and flooding are likely to require a permit under the Massachusetts Wetlands Protection Act through the local Conservation Commission. Permits or approvals may also be required from other state agencies and local departments, depending on the location and the work involved. Generally, regulatory programs are supportive of projects that naturally stabilize dunes and banks with vegetation rather than proposing a hard structure. However, before bringing in a backhoe (or even a shovel or pruning shear) to do any kind of landscaping work on a coastal property, contact your local Conservation Commission to determine if a permit is necessary.

Professional Services Required

Simple dune and bank planting projects may be done by the homeowner after permits have been obtained if needed. More complex projects that involve regrading, however, are likely to require professional services. A landscape architect, biologist, engineer, or other environmental professional with experience designing erosion-control projects in coastal areas using native, salt-tolerant plantings may need to be consulted to: 1) identify regulatory requirements and ensure the project fully conforms with those requirements; 2) determine the conditions at the site that will affect the project (such as the amount of sun or shade, high winds, wave exposure, runoff, and foot traffic); 3) identify invasive species, oversteepened slopes, runoff problems, areas of increased erosion due to adjacent hard structures or development, or other issues that must be considered as part of project design; 4) determine if other shoreline stabilization techniques are needed in addition to vegetation; 5) select appropriate plants and develop a planting and maintenance plan; 6) determine volume and composition of fill, if needed; 7) identify the best time of year to install various components of the project; 8) develop an access plan if heavy equipment is needed; 9) determine what, if any, fertilizer or irrigation is needed; 10) prepare plans for permitting; and 11) prepare design specifications for construction. The consultant can also oversee construction, monitoring, and maintenance of the project.

Project Timeline

It may take as little as two to three months to design, permit, and install a vegetation project, assuming that only a Massachusetts Wetlands Protection Act permit is required. To expedite the process, hire a consultant with appropriate experience in designing and permitting similar projects, make sure that regulatory applications are complete, and anticipate and address special considerations, such as abutter concerns, construction access issues, or time-of-year restrictions (due to endangered species issues, for example). Often, Conservation Commission staff are available to meet with applicants to go over the important factors that need to be considered early in the design process.

Maintenance Requirements

Vegetation projects require ongoing maintenance to ensure their success. Maintenance requirements will vary greatly depending on site conditions. As with all vegetation projects, watering, replacing dead plants, and similar maintenance is initially required to ensure that the vegetation that has been planted becomes successfully established. In areas subject to high rates of erosion and frequent coastal storm damage, plants may need to be replaced frequently on an ongoing basis, particularly when vegetation is not combined with other shoreline stabilization techniques. Planted areas should be inspected regularly and vegetation should be replanted or replaced as necessary. Any area damaged by storms should be restored to pre-storm conditions as soon as possible—an eroded area will continue to deteriorate and will expand rapidly if it is left oversteepened, unvegetated, and exposed to the wind, tides, runoff, and storms. If erosion or plant die-off occurs during the winter, it may not be possible to re-establish plants until the growing season begins in the spring. Other temporary measures can be used to stabilize the site, including adding fill and using natural fiber blankets (see *StormSmart Properties Fact Sheet 5: Bioengineering - Natural Fiber Blankets on Coastal Banks*). A schedule and plan for replacing sediments and vegetation should be included in the original permit application for the project so that maintenance can be conducted without additional permitting.

Project Costs

With vegetation projects, there are typically a range of options available that give increasing levels of protection with increased construction costs. In addition, whenever you hire a professional to conduct work on your property, total costs are expected to vary significantly based on site-specific considerations. The considerations that most influence the costs of vegetation projects are the severity of erosion, the size of the area to be stabilized, the type of runoff control needed, the type and number and size of plants selected, and the need for other temporary site-stabilization techniques or regrading. For comparison with other shoreline stabilization options, vegetation projects typically have relatively low design and permitting costs, low construction costs, and low maintenance costs. See the StormSmart Properties chart, *Relative Costs of Shoreline Stabilization Options* (PDF, 99 KB), for a full comparison.

Additional Information

Vegetation can be used in conjunction with many other techniques for erosion management. See the following CZM StormSmart Properties fact sheets for additional information:

- *StormSmart Properties Fact Sheet 1: Artificial Dunes and Dune Nourishment*
- *StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion*
- *StormSmart Properties Fact Sheet 4: Bioengineering - Coir Rolls on Coastal Banks*
- *StormSmart Properties Fact Sheet 5: Bioengineering - Natural Fiber Blankets on Coastal Banks*
- *StormSmart Properties Fact Sheet 6: Sand Fencing*
- *StormSmart Properties Fact Sheet 8: Beach Nourishment*

The following resources also provide valuable information on vegetation:

- CZM's Coastal Landscaping website focuses on landscaping with salt-tolerant vegetation to reduce storm damage and erosion and includes information on appropriate plants, planting plans, invasive species, and tips on plant care, along with links to other references.
- CZM's *Landscaping to Protect Your Coastal Property from Storm Damage and Flooding fact sheet* (PDF, 962 KB) gives specific information for homeowners on appropriate plants for erosion control in coastal areas.
- *Coastal Dune Protection and Restoration—Using 'Cape' American Beachgrass and Fencing* (PDF, 3 MB) by the Woods Hole Sea Grant and Cape Cod Cooperative Extension Program includes case studies and tips on dune restoration, along with information on preserving shorebird habitat and understanding the permit process.
- CZM's *Environmental Permitting in Massachusetts* gives brief descriptions of major environmental permits required for projects proposed in Massachusetts.
- *Salisbury Beach Dune Walkover Access Design Standards* (PDF, 14 KB) gives general design standards for walkways over coastal dunes that minimize potential adverse effects. These standards are widely applicable.
- *Guidelines for Barrier Beach Management in Massachusetts* (PDF, 12 MB), which was produced by the Massachusetts Barrier Beach Task Force in 1994, provides an overview of the Massachusetts Wetlands Protection Act Regulations and the function of beaches, dunes, and other resource areas (in Chapter 2). It also gives information on various erosion management techniques, their potential impacts, and measures to minimize those impacts (Chapter 5).
- Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00) cover work in wetland resource areas and buffer zones.
- The Natural Heritage and Endangered Species Program website provides information on protected species in Massachusetts, habitat maps, and regulatory review for projects in or adjacent to these habitats.
- The Invasive Plant Atlas of New England provides a comprehensive web-accessible database of invasive and potentially invasive plants in New England.
- The Massachusetts Ocean Resource Information System, or MORIS, is a web-based mapping tool for interactively viewing coastal data. MORIS data layers, such as endangered species habitat and shellfish, can help identify sensitive resource areas within or near the project site.

www.mass.gov/stormsmart-coasts-program

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StormSmart Properties Fact Sheet 4: Bioengineering - Coir Rolls on Coastal Banks

The coast is a very dynamic environment and coastal shorelines—especially beaches, dunes, and banks—change constantly in response to wind, waves, tides, and other factors such as seasonal variation, sea level rise, and human alterations to the shoreline system. Consequently, many coastal properties are at risk from storm damage, erosion, and flooding. Inappropriate shoreline stabilization methods can actually do more harm than good by exacerbating beach erosion, damaging neighboring properties, impacting marine habitats, and diminishing the capacity of beaches, dunes, and other natural landforms to protect inland areas from storm damage and flooding. StormSmart Properties—part of the Massachusetts Office of Coastal Zone Management's (CZM) StormSmart Coasts Program—provides coastal property owners with important information on a range of shoreline stabilization techniques that can effectively reduce erosion and storm damage while minimizing impacts to shoreline systems. This information is intended to help property owners work with consultants and other design professionals to select the best option for their circumstances.

What Are Bioengineering and Coir Rolls?

Coastal bioengineering projects reduce erosion and stabilize eroding shorelines by using a combination of deep-rooted plants and erosion-control products made of natural, biodegradable materials, such as coir rolls. Coir rolls are cylindrical rolls that span 12 to 20 inches in diameter, are packed with coir fibers (i.e., coconut husk fibers), and are held together with mesh. The rolls are typically 10- to 20-feet long and can be stitched together to provide continuous shoreline coverage. In contrast, coir envelopes are coir fabric filled with sand. Coir envelopes have very different impacts and design considerations and should not be confused with coir rolls.

As with all coastal bioengineering projects, salt-tolerant vegetation with extensive root systems is used with coir rolls to help stabilize the site. The vegetation is planted directly into the coir rolls and on the surrounding site. For important instructions on using plants in bioengineering projects, see the *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage*, which includes specific information on how vegetation reduces erosion and storm damage; instructions on selecting, properly planting, and caring for appropriate species; tips on maximizing the effectiveness of vegetation projects and minimizing impacts; and specifics on project design and implementation.

No shoreline stabilization option permanently stops all erosion or storm damage. The level of protection provided depends on the option chosen, project design, and site-specific conditions such as the exposure to storms. All options require maintenance, and many also require steps to address adverse impacts to the shoreline system, called mitigation. Some options, such as seawalls and other hard structures, are only allowed in very limited situations because of their impacts to the shoreline system. When evaluating alternatives, property owners must first determine which options are allowable under state, federal, and local regulations and then evaluate their expected level of protection, predicted lifespan, impacts, and costs of project design, installation, mitigation, and long-term maintenance.

This fact sheet focuses on the use of coir rolls on coastal banks (also known as bluffs), where coir rolls are typically installed at the toe (i.e., base) of the bank—although they can also be installed up the bank face. In coastal areas, coir rolls can also be used to help reduce erosion problems created by hard structures (i.e., seawalls and revetments). See "Appropriate Locations" in the Design Consideration section below for additional information.

This coir roll has been planted with vegetation prior to installation. **(Photo: Wilkinson Ecological Design)**

Coir rolls are often used in conjunction with other techniques for erosion management, such as natural fiber blankets, runoff control, and beach nourishment. Natural fiber blankets are woven mats of natural fibers that are used to stabilize the ground surface while plants become established. Runoff control projects reduce and slow the flow of water over the ground surface, reducing coastal erosion problems. Beach nourishment adds sediment (i.e., sand, gravel, and cobble) from an off-site source to address beach erosion issues. See the following StormSmart Properties fact sheets for more information: *Controlling Overland Runoff to Reduce Coastal Erosion*, *Bioengineering - Natural Fiber Blankets on Coastal Banks*, and *Beach Nourishment*.

How Coir Rolls Reduce Storm Damage on Coastal Banks

If the toe of a bank is eroding, the upper bank may collapse even if it is well vegetated. Coir rolls can be used to protect and stabilize the toe by providing a physical barrier that buffers waves, tides, and currents, reducing erosion of exposed sediments.

Coir rolls provide stability and protection to the site while the vegetation planted in and above the rolls becomes established. As the coir rolls disintegrate, typically over 5-7 years, the plants take over the job of site stabilization. The dense root systems of the plants hold sand, gravel, and soils in place and help reduce erosion from rain, wind, tides, and waves. In addition, by taking up water directly from the ground and breaking the impact of raindrops or wave-splash, the plants slow the rate and reduce the quantity of upland water runoff that can lead to erosion.

For sites exposed to high wave energy, it may be necessary to replace and maintain coir rolls at the toe of the bank to provide longer-term stability. If the beach in front of the bank is narrow or narrows over time, if the beach elevation is too low or erodes down over time, or if the shoreline has a steep drop off below the low tide line, it may be necessary to combine bioengineering with other techniques, such as dune and beach nourishment, to ensure a successful project. (See the following StormSmart Properties fact sheets for more information: *Artificial Dunes and Dune Nourishment* and *Beach Nourishment*.) A professional with demonstrated success installing bioengineering projects in dynamic environments should be consulted to assess each site and make recommendations regarding the appropriate technique or combination of techniques.

Waves and tides eroded the toe of this bank, causing this collapse of a well vegetated section of the bank face. **(Photo: CZM)**

Top left: This photo shows an exposed bank that was eroding at two feet per year before coir rolls and erosion-control vegetation were installed.

Bottom left: This photo shows the site during installation of the coir rolls, which were placed at the toe and up the face of the bank. Natural fiber blankets were also installed on the bank face. The site was then planted with salt-tolerant vegetation.

Bottom right: This photo shows the same site 10 years after project completion. (Note: This site has survived Hurricane Irene and Hurricane Sandy.)

(Photos: New England Environmental)

Relative Benefits and Impacts Compared to Other Options

Coir rolls provide direct, physical protection to a bank. Because they are made from natural, biodegradable materials and are planted with vegetation, coir rolls absorb much more wave energy than seawalls, rock revetments, or other "hard" shoreline stabilization structures, which reflect significantly more of the wave energy that hits them onto beaches or neighboring properties. The design of a hard structure affects how much wave energy is reflected, for example vertical walls reflect more wave energy than sloping rock revetments. These reflected waves erode beaches in front of and next to a hard structure, eventually undermining and reducing the effectiveness of the structure and leading to costly repairs. This erosion also lowers the elevation of the beach in front of the structure, ultimately leading to a loss of dry beach at high tide and reducing the beach's value for storm damage protection, recreation, and wildlife habitat. Coir roll projects also allow some natural erosion from the site while hard structures impede virtually all natural erosion of sediment. Without this sediment supply, down-current areas of the beach system are subject to increased erosion. In addition, coir rolls can often be installed without the use of mechanized equipment that can significantly impact the site. Because they are made with natural fibers and planted with vegetation, coir rolls also help preserve the natural character and habitat value of the coastal environment.

Like all shoreline stabilization options, however, coir roll projects can result in negative impacts when inappropriately designed or sited. While less severe than with hard structures, coir rolls can reflect some wave energy and they can inhibit the natural supply of sediment to down-current areas. Coir rolls made with synthetic materials or covered in wire mesh can cause additional significant impacts. Synthetic and wire mesh that remains after the rolls are degraded or is found on rolls that have been ripped away from a bank during a storm has the potential to entangle wildlife, disrupt navigation (e.g., by getting wrapped around boat propellers), and harm recreational beach users (e.g., rusted wire can puncture bare feet). To help address this issue, local officials often require identification tags to be sewn on coir rolls when they are installed to ensure proper disposal if the rolls are dislodged from the project site. In addition, wire mesh should not be used on coastal sites and the use of synthetic mesh should be minimized. For sites with higher wave energy, it is often necessary to use high density rolls (7-9 pounds per foot) in the bottom row, which are only available with synthetic mesh. This targeted use of synthetic materials is preferable to using more structural options such as a rock revetment to stabilize the site, which have greater adverse impacts.

Under the Massachusetts Wetlands Protection Act, new hard structures are typically prohibited on all beaches and dunes. On coastal banks, hard structures are only allowed when necessary to protect buildings permitted before August 10, 1978, and only if no other alternative is feasible. In many cases, coir roll projects and other non-structural alternatives are therefore the only options available for reducing erosion and storm damage on coastal properties.

Design Considerations for Coir Rolls on Coastal Banks

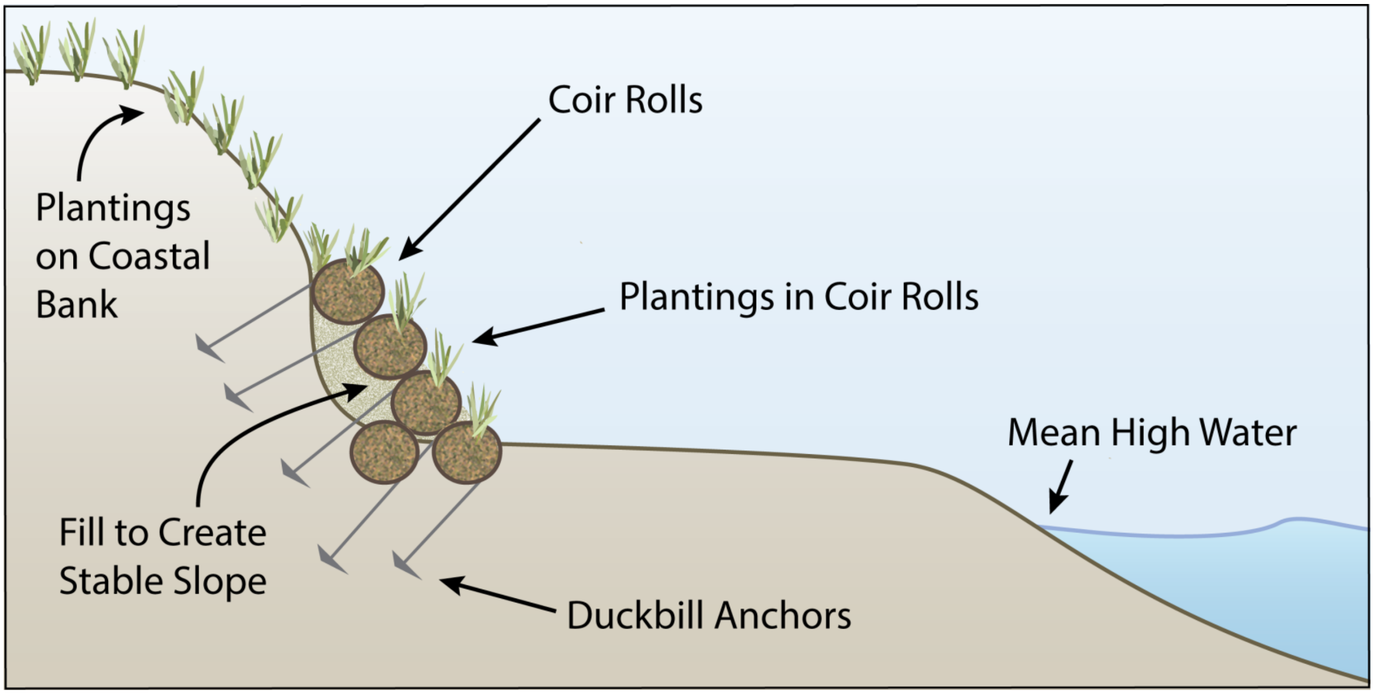
This section covers a variety of factors that should be considered to minimize adverse impacts and ensure successful design, permitting, construction, and maintenance of coir roll bioengineering projects on a coastal banks.

Appropriate Locations

For coastal bank projects, coir rolls can be used on both sheltered sites and sites exposed to wave energy. However, they are most effective in areas with higher beach elevations with some dry beach at high tide, where the rolls are not constantly subject to erosion from tides and waves. If the dry beach is narrow, the beach elevation is relatively low, and/or the site is exposed to moderate wave energy, more than one row of coir rolls will likely be needed on the face of the bank, as well as at the base. In these exposed conditions, the rolls will have a shorter lifespan and will require more frequent maintenance such as resetting, anchoring, or replacement. Additional erosion-control options may be needed at these sites, such as beach nourishment (see *StormSmart Properties Fact Sheet 8: Beach Nourishment*). It is essential to have a site-specific evaluation conducted by a professional with demonstrated experience and success implementing coir roll projects in exposed settings to determine the viability of coir rolls in these areas.

A coir roll, natural fiber blanket, and fill were installed to minimize erosion at the end of this bulkhead. (Photo: Wilkinson Ecological Design)

In some cases, coir rolls can also be used to effectively reduce erosion from hard structures such as seawalls. Coir rolls can be effectively installed at the base of and next to hard structures to help reduce erosion problems under the structure and on neighboring properties. They are also used on the face of the bank above the structure to stabilize the area.



Cross-section of a bioengineering project on a bank in an exposed setting.

Establishing a Stable Slope

On banks, a stable slope is essential for project success. If the bottom of the bank has eroded and its slope is steeper than the upper portion of the bank, the bank is likely unstable. Even when heavily planted with erosion-control vegetation, banks with unstable slopes are extremely vulnerable to slumping or collapse that can endanger property landward of the bank. Before installing coir rolls or planting vegetation, therefore, the bank slope should be stabilized.

Ideally, soil of a similar type to that on the bank or beach is brought in as fill and added to the lower part of the bank to create a slope that matches or is less steep than the upper slope. However, if adding fill brings the toe of the bank within the reach of high tides, the fill will erode quickly and undermine the rest of the bank. In these cases, regrading the bank slope by removing sediment from the top of the bank is a better option. While removing part of the upper portion of the bank does reduce the land area of the property, it can be done in a controlled fashion that improves the overall stability and storm-damage prevention capacity of the bank. And if the slope is not stabilized by either adding fill at the bank toe or regrading the top of the bank, bank collapse during a storm could cause substantially more loss of land area to the sea. In addition, any investment in coir rolls, vegetation, and other site stabilization methods will be lost if the bank collapses. On sites where the top of the bank is well vegetated with mature, salt-tolerant species with extensive roots, the appropriate approach to stabilize the bank should be carefully developed by a professional with extensive experience successfully stabilizing similar sites.

Removing/Replacing Invasive Plants

Invasive plants (i.e., introduced species that thrive at the expense of native plants) should be removed and replaced with appropriate native plants if they are preventing establishment of erosion-control vegetation on a bank. This effort is particularly warranted when bank stability is severely compromised by the invasive plant. Because of their tenacity, successful control of invasive plants can take years to accomplish and may require perpetual monitoring and management. Effective ways to manage invasive species on the bank should therefore be incorporated into project design. See *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage* for more information.

Controlling Erosion from Overland Runoff and Other Sources

To help ensure the success of newly planted vegetation, sources of erosion on the site—including upland runoff and waves—should be identified and addressed as part of the site evaluation and design process. If overland runoff is causing erosion, this runoff should be reduced or redirected to give newly planted vegetation the best chance of survival (see *StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion* for details). In areas subject to regular erosion from waves, tides, currents, wind, and coastal storms, additional techniques can be used to improve site protection. For example, beach nourishment (i.e., adding sediments, such as sand, gravel, and cobble to widen the beach—see *StormSmart Fact Sheet 8: Beach Nourishment*) can protect coir roll projects by widening beaches in areas with relatively narrow beaches at high tide.

Protecting Vegetation

In addition to controlling erosion (see above), other steps should be taken to protect vegetation. Exposed areas should not be planted during the winter when the plants are dormant because wind or waves are likely to pull them out before they can get established. To prevent trampling of plants, pedestrian access to the shoreline should be restricted to designated access paths or walkways and the number of access points should be limited as much as possible. Often, multiple properties can use a common access point. To limit shading impacts to vegetation, access structures should be elevated on open pilings and their size should be minimized as much as possible.

Maintaining Sediment Supply to the System

Bank erosion is an important source of sediment to beaches and dunes in the shoreline system. To maintain this sediment supply, projects using two or more rows of coir rolls can bring in sediment from an offsite source on a regular basis (e.g., annually and after major storms) and place it on the beach in front of the rolls. This sediment will also help provide storm damage protection to the site by dissipating wave energy before it reaches the bank.

Minimizing Reflected Wave Energy

The ends of a coir roll project should be carefully designed to minimize any redirection of waves onto adjacent properties. Tapering the rolls down in number and height so that the project blends in to the adjacent bank helps address this problem.

This bioengineering project with coir rolls, natural fiber blankets, and vegetation was designed to minimize erosion on the adjacent property. At the end of the property, the number of rolls was tapered down to one and the bank's slope was reduced and blended in to the adjacent bank. **(Photo: CZM)**

Project Installation and Coir Roll Anchoring

Coir rolls should be placed end to end and laced together with jute or coir twine to create continuous rolls parallel to the shoreline. The rolls are typically anchored by stakes on the seaward side of the rolls, earth anchor systems, or a combination of these two techniques. Wooden stakes are biodegradable but do not always hold well in areas with higher wave energy. Earth anchors, which are typically used for sites exposed to higher rates of erosion, consist of a metal duckbill anchor that extends into the bank and is connected to the coir roll by wire cables. Although earth anchors are not biodegradable, exposed portions of the cable system can be cut off and removed after the coir rolls have broken down to reduce marine debris impacts.

The anchoring system is critical to the success of the project. A professional is needed to determine the appropriate number and type of anchors for the site. It is also essential that the installation be carefully supervised and conducted by contractors with experience installing projects that have survived multiple storms. Anchors may need to be tightened after a period of time. To improve the longevity of the project, a professional can monitor the rolls over time and identify needed maintenance.

Coir rolls should be fully covered with sediment or tied into the existing bank at both ends of the project to minimize the potential for waves to get behind the rolls and erode the bank. The project can fail if the ends of the coir rolls become exposed.

Coir Roll Configuration and Size

The number of rows of coir rolls needed and their diameter depend on: 1) how exposed the site is to waves, 2) how frequently waves reach the base of the bank, and 3) the steepness of the bank face. In more sheltered sites or on relatively shallow bank slopes, one or two rows of 12-inch-diameter coir rolls may be sufficient. In more exposed areas and on steeper banks, multiple rows of 20-inch-diameter rolls may be needed up the face of the bank to provide effective site stabilization. The bottom row of coir rolls is often buried during installation to prevent undermining by beach erosion during a storm. In some cases, two side-by-side rows of rolls are installed at the base to provide more stability for the rows of rolls above.

Density of Coir Fibers

How densely the coconut husk fibers are packed into the coir rolls is also an important design element. While more densely packed rolls provide greater initial erosion protection, loosely packed rolls can be more heavily planted (because the vegetation can be easily inserted into the roll). This heavy planting allows the plants to become established more quickly, allowing the plant roots to effectively stabilize the site as the coconut fibers degrade. Both high-density and low-density coir rolls can be used together when heavily planted low-density rolls are installed adjacent to high-density rolls to help ensure the high-density rolls become vegetated over time. The professional designing the project should determine where rapid plant colonization or initial structural integrity is most important and then design a mix of rolls accordingly.

Reducing Damage from Sun Exposure

Plants can be used to shade the rolls and slow the degradation of the coir fibers that occurs from exposure to sunlight. The coir rolls can also be covered with sediment and natural fiber blankets (woven mats of natural fibers) to shade the coir rolls and slow degradation.

Heavy Equipment

While heavy equipment is not typically needed for coir roll projects, a mini-excavator or other small mechanized equipment may be necessary. Minimizing the use of heavy equipment can help reduce temporary disturbances from the project. Access for any equipment must be carefully planned to avoid destruction of existing vegetation; creation of ruts; destabilization of banks, beaches, or other landforms; impacts to wildlife and nesting habitat for protected shorebird species (i.e., species that are considered endangered, threatened, or of special concern in Massachusetts); and related impacts. When mechanical equipment is being used, contractors should keep hazardous material spill containment kits on-site at all times in case there is a release of oil, gasoline, or other toxic substances.

Wildlife and Fisheries Protection

If the project is proposed in or adjacent to habitat for protected wildlife species or horseshoe crab spawning areas, there may be limitations on the time of year that the project can be constructed. Information about the location of these resources and special permitting requirements is available from the Natural Heritage and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife (for protected wildlife species) and the Massachusetts Division of Marine Fisheries (for horseshoe crabs).

Permitting and Regulatory Standards

Most options for addressing coastal erosion, storm damage, and flooding are likely to require a permit under the Massachusetts Wetlands Protection Act through the local Conservation Commission. Additional permits may be needed from the Massachusetts Department of Environmental Protection (MassDEP) Waterways Program and the U.S. Army Corps of Engineers if the project footprint extends below the mean high water line or seaward of the reach of the highest high tide of the year, respectively. Permits or approvals may also be required from other state agencies and local departments, depending on the location and the work involved. Often, Conservation Commission staff are available to meet with applicants to go over important factors that need to be considered early in the design process.

Generally, regulatory programs are supportive of projects that use non-structural approaches to manage coastal erosion, such as coir rolls and vegetation, as opposed to hard structures. To obtain a permit, projects need to be designed to comply with regulatory requirements, including minimizing or avoiding impacts to sensitive resource areas such as horseshoe crab spawning areas and protected species habitat, which are protected by the various regulatory programs.

Professional Services Required

An environmental professional with significant experience designing, implementing, and successfully maintaining coir rolls and vegetation projects in coastal areas should be chosen to: 1) identify regulatory requirements and ensure the project fully conforms with those requirements; 2) determine the size, density, and number of rows of coir rolls needed based on site conditions (such as erosion history; exposure to winds, wave climate, and soil types; and runoff patterns); 3) determine whether natural fiber blankets, beach nourishment, or other techniques should be used in conjunction with the rolls; 4) identify any additional site conditions (including oversteepened slopes, erosion from overland runoff, and the presence of invasive species) that must be addressed; 5) select plant species and develop a plan for planting and plant maintenance; 6) identify the volume and composition of fill (if needed to re-establish a stable slope); 7) determine the best time of year to install the various components of the project; 8) develop an access plan if heavy equipment is needed; 9) prepare plans for and oversee permitting; 10) prepare design specifications and oversee construction; and 11) monitor and maintain the project. To ensure that essential design elements are appropriately implemented, *construction should be conducted by a contractor with experience installing coir roll projects that have survived multiple storms and carefully supervised by a consultant with significant experience and demonstrated success with coastal coir roll projects. Monitoring and maintenance by a consultant with significant experience is also strongly recommended.*

Project Timeline

It may take as little as four to eight months to have a bioengineering project with coir rolls designed, permitted, and installed, assuming that only a Massachusetts Wetlands Protection Act permit is required—but it can take longer, depending on the factors involved. Factors influencing this timeline include the contractor’s experience with designing and permitting similar projects, completeness of permit applications, special considerations in the permitting process (such as objections by abutters, sensitive resources to be protected, and availability of access for construction), the need for special timing to avoid impacts (e.g., a prohibition on construction during endangered species nesting season), special timing needed for planting vegetation, and/or weather conditions during construction.

Maintenance Requirements

Bioengineering projects with coir rolls and vegetation require ongoing maintenance to ensure their success. Maintenance needs will depend, in part, on the proximity of the coir rolls to the reach of high tide, the elevation and width of the beach, the frequency and severity of storms, and how established the plants are before a storm hits. To maintain the project's designed level of protection, the coir rolls and vegetation should be inspected regularly, particularly after rain and coastal storms. Any storm damage should be addressed immediately to avoid further deterioration—this includes replacing any sediment that erodes around the coir rolls, resetting or replacing coir rolls as needed, and replanting vegetation (which may have to be conducted at the appropriate time of year). The more frequently high tides and waves reach and overtop the coir rolls, the higher the likely erosion rate and deterioration rate of the rolls. Erosion rates will be even higher if the site is not vegetated. Because the replacement of sediment and plants removed by storms is typically necessary, the original permit application should include a maintenance plan. This plan should specify any replacement materials and activities that may be used on the site and how the site will be accessed so that maintenance can be conducted without additional permitting.

Experience with what works, what doesn't, and how to adjust a design as site conditions change is very important to the success of bioengineering projects, particularly in coastal areas. Therefore, it is strongly recommended that the consultant who designed the project be involved in the monitoring and maintenance after any erosion from rain or coastal storms.

Project Costs

With coir roll projects, a range of options are available that give increasing levels of protection with increased construction costs. In addition, whenever you hire a professional to conduct work on your property, total costs are expected to vary significantly based on site-specific considerations. The considerations that most influence the costs of coir roll projects on coastal banks are: the severity of erosion, the width and elevation of the beach in front of the bank, the grading needed to create a stable slope, the diameter and number of rows of rolls, and the type and size of plants selected.

For comparison with other shoreline stabilization options, the relative costs for coir roll projects are:

- Low-medium for design and permitting.
- Medium-high for construction.
- Low-medium for maintenance.
- Low for mitigation.

See the StormSmart Properties chart, *Relative Costs of Shoreline Stabilization Options* (PDF, 99 KB), for a full comparison.

Additional Information

Bioengineering with coir rolls can be used in conjunction with many other techniques for erosion management. See the following CZM StormSmart Properties fact sheets for additional information:

- *StormSmart Properties Fact Sheet 1: Artificial Dunes and Dune Nourishment*
- *StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion*
- *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage*
- *StormSmart Properties Fact Sheet 5: Bioengineering - Natural Fiber Blankets on Coastal Banks*
- *StormSmart Properties Fact Sheet 8: Beach Nourishment*

The following publications and websites also provide valuable information on bioengineering with coir rolls and vegetation:

- CZM's Coastal Landscaping website includes information on landscaping coastal areas with salt-tolerant vegetation to reduce storm damage and erosion.
- CZM's *Landscaping to Protect Your Coastal Property from Storm Damage and Flooding fact sheet* (PDF, 962 KB) gives specific information for homeowners on appropriate plants for erosion control in coastal areas.
- Woods Hole Sea Grant's Marine Extension Bulletin, *Biodegradable Erosion Control* (PDF, 723 KB), provides information on various components of a coir roll project for coastal erosion control.
- CZM's *Environmental Permitting in Massachusetts* briefly describes major environmental permits required for projects proposed in Massachusetts.
- *Guidelines for Barrier Beach Management in Massachusetts* (PDF, 12 MB), which was produced by the Massachusetts Barrier Beach Task Force in 1994, provides an overview of the Massachusetts Wetlands Protection Act Regulations and the function of beaches, dunes, and other resource areas (in Chapter 2). It also gives information on various erosion management techniques, their potential impacts, and measures to minimize those impacts (Chapter 5).
- Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00) cover work in wetland resource areas and buffer zones.
- The Natural Heritage and Endangered Species Program website provides information on protected species in Massachusetts, habitat maps, and regulatory review for projects in or adjacent to these habitats.
- The Massachusetts Division of Marine Fisheries can provide information on horseshoe crab protection and other fisheries resources.
- The Massachusetts Ocean Resource Information System, or MORIS, is a web-based mapping tool for interactively viewing coastal data. MORIS data layers, such as endangered species habitat and shellfish, can help identify sensitive resource areas within or near the project site.

www.mass.gov/stormsmart-coasts-program

Commonwealth of Massachusetts
Charlie Baker, Governor

Executive Office of Energy and Environmental Affairs
Matthew A. Beaton, Secretary

Massachusetts Office of Coastal Zone Management
Bruce K. Carlisle, Director

Massachusetts Office of Coastal Zone Management | 251 Causeway Street, Suite 800 | Boston, MA 02114 | (617) 626-1200
CZM Information Line: (617) 626-1212 | **CZM Website**: www.mass.gov/czm

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StormSmart Properties Fact Sheet 5: Bioengineering - Natural Fiber Blankets on Coastal Banks

The coast is a very dynamic environment and coastal shorelines—especially beaches, dunes, and banks—change constantly in response to wind, waves, tides, and other factors such as seasonal variation, sea level rise, and human alterations to the shoreline system. Consequently, many coastal properties are at risk from storm damage, erosion, and flooding. Inappropriate shoreline stabilization methods can actually do more harm than good by exacerbating beach erosion, damaging neighboring properties, impacting marine habitats, and diminishing the capacity of beaches, dunes, and other natural landforms to protect inland areas from storm damage and flooding. StormSmart Properties—part of the Massachusetts Office of Coastal Zone Management's (CZM) StormSmart Coasts Program—provides coastal property owners with important information on a range of shoreline stabilization techniques that can effectively reduce erosion and storm damage while minimizing impacts to shoreline systems. This information is intended to help property owners work with consultants and other design professionals to select the best option for their circumstances.

What Are Bioengineering Projects and Natural Fiber Blankets?

Coastal bioengineering projects reduce erosion and stabilize eroding shorelines by using a combination of deep-rooted plants and erosion-control products that are made of natural, biodegradable materials. Natural fiber blankets are mats made of natural fibers, such as straw, burlap, and coconut husk, which is also called coir. Some natural fiber blankets are made of loosely woven coir twine and others are made of straw, coconut, or a mix of fibers held together with netting made from coir or other materials. The blankets are used to help reduce erosion of exposed soil, sand, and other sediments from wind, waves, and overland runoff.

No shoreline stabilization option permanently stops all erosion or storm damage. The level of protection provided depends on the option chosen, project design, and site-specific conditions such as the exposure to storms. All options require maintenance, and many also require steps to address adverse impacts to the shoreline system, called mitigation. Some options, such as seawalls and other hard structures, are only allowed in very limited situations because of their impacts to the shoreline system. When evaluating alternatives, property owners must first determine which options are allowable under state, federal, and local regulations and then evaluate their expected level of protection, predicted lifespan, impacts, and costs of project design, installation, mitigation, and long-term maintenance.

Vegetation growing up through a natural fiber blanket. **(Photo: Wilkinson Ecological Design)**

Woven coir blanket.

Stitched fiber blanket.

(Photos: Coir Green "Environmentally Friendly")

In this bank stabilization project, a natural fiber blanket was installed on the face of the bank and vegetation was planted through it. A coir roll was also installed at the base of the bank. (Photo: CZM)

For important instructions on using plants in bioengineering projects, see the *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage*. This fact sheet includes specific information on how vegetation reduces erosion and storm damage, tips on maximizing the effectiveness of vegetation projects and minimizing impacts, specifics on project design and implementation, and instructions on selecting, properly planting, and caring for appropriate species.

Natural fiber blankets are frequently used with other techniques for erosion management, such as coir rolls (cylindrical rolls packed with coconut husk fibers) and runoff control projects. See the following StormSmart Properties fact sheets: *Controlling Overland Runoff to Reduce Coastal Erosion* and *Bioengineering - Coir Rolls on Coastal Banks*.

How Natural Fiber Blankets Stabilize Slopes and Help Reduce Erosion

Natural fiber blankets are used on non-vegetated portions of banks to prevent erosion while native salt-tolerant vegetation with extensive root systems becomes established on the site. A salt-tolerant seed mix is spread across the area before the natural fiber blanket is secured, and then live vegetation is planted through the blanket. The blanket helps hold sand, soil, and other sediments in place by protecting the surface from erosion caused by wind, salt spray, and flowing water. The seeds grow quickly and also help secure the soil surface while the larger live plants become established and begin to spread. The blanket also retains moisture to promote seed growth and protect the roots of the live plants. As the natural fibers in the blanket disintegrate over 6 to 24 months, depending on the density and type of fiber blanket selected, the dense root systems of the plants take over the job of stabilizing the site.

A natural fiber blanket was installed on this bank and vegetation was planted through the blanket while the plants were dormant. (Photo: CZM)

Relative Benefits and Impacts Compared to Other Shoreline Stabilization Options

Natural fiber blankets and vegetation provide direct, physical protection to reduce erosion of bare soils. Because they are made from natural, biodegradable materials and are planted with vegetation, natural fiber blankets absorb much more wave energy than seawalls, rock revetments, or other "hard" shoreline stabilization structures, which reflect significantly more of the wave energy that hits them onto beaches or neighboring properties. The design of a hard structure affects how much wave energy is reflected, for example vertical walls reflect more wave energy than

Under the Massachusetts Wetlands Protection Act, new hard structures are typically prohibited on all beaches and dunes. On coastal banks, hard structures are only allowed when necessary to protect buildings permitted before August 10, 1978, and only if no other alternative is feasible. In many cases, natural fiber blanket projects and other non-structural alternatives are therefore the only options available for reducing erosion and storm damage on coastal properties.

sloping rock revetments. These reflected waves erode beaches in front of and next to a hard structure, eventually undermining and reducing the effectiveness of the structure and leading to costly repairs. This erosion also lowers the elevation of the beach in front of the structure, ultimately leading to a loss of dry beach at high tide and reducing the beach's value for storm damage protection, recreation, and wildlife habitat. Natural fiber blanket projects also allow some natural erosion from the site while hard structures impede virtually all natural erosion of sediment. Without this sediment supply, down-current areas of the beach system are subject to increased erosion. In addition, natural fiber blankets can often be installed without the use of mechanized equipment that can significantly impact the site. Because they are made with natural fibers and planted with vegetation, natural fiber blankets also help preserve the natural character and habitat value of the coastal environment.

Bioengineering projects using natural fiber blankets can cause minor impacts that may be effectively minimized through appropriate project design (see Design Considerations below). However, projects using blankets made of synthetic materials, which do not degrade readily in the coastal environment, can cause significant impacts. For example, synthetic materials washed into the ocean during storms or exposed at the ground surface can entangle wildlife, and unlike natural fiber blanket materials, the synthetic materials will remain in the environment for long periods of time. Therefore, the use of blankets made with synthetic fibers is strongly discouraged for coastal projects.

Design Considerations for Natural Fiber Blanket Projects

This section covers a variety of factors that should be considered to minimize adverse impacts and ensure successful design, permitting, construction, and maintenance of natural fiber blanket bioengineering projects.

Appropriate Locations

Natural fiber blankets can be installed on almost any coastal bank to help stabilize soils while plants become established. However, they are most effective in areas with higher beach elevations with some dry beach at high tide, where the toe of the bank is not constantly subject to erosion from tides and waves. Blankets are typically installed over the entire surface of a non-vegetated bank, but they may also be placed in specific areas where a bank is devoid of vegetation. Blankets will not prevent erosion on unstable slopes or in areas subject to erosion from high tides or storm waves.

On banks where the toe is subject to erosion from tides or storm waves, it may be appropriate to combine natural fiber blankets and vegetation with other shoreline stabilization options. Coir rolls can be installed to protect the base of the bank (see *StormSmart Properties Fact Sheet 4: Bioengineering - Coir Rolls on Coastal Banks*). Sediments can also be brought in from off-site sources to increase beach width and dune volume to help dissipate wave energy before it reaches the bank (see *StormSmart Properties Fact Sheet 1: Artificial Dunes and Dune Nourishment* and *StormSmart Properties Fact Sheet 8: Beach Nourishment*).

Establishing a Stable Slope

On banks, a stable slope is essential for project success. If the bottom of the bank has eroded and its slope is steeper than the upper portion of the bank, the bank is likely unstable. Even when heavily planted with erosion-control vegetation, banks with unstable slopes are extremely vulnerable to slumping or collapse, which can endanger property landward of the bank. Before planting vegetation, therefore, the bank slope should be stabilized.

Ideally, any existing invasive vegetation is removed and soil of a similar type to that on the bank or beach is brought in as fill and added to the lower part of the bank to create a lower slope that matches or is less steep than the upper slope. However, if adding fill brings the toe of the bank within the reach of high tides, the fill will erode quickly and undermine the rest of the bank. In these cases, regrading the bank slope by removing sediment from the top of the bank is a better option. While removing part of the upper portion of the bank does reduce the land area of the property, it can be done in a controlled fashion that improves the overall stability and storm damage prevention capacity of the bank. And if the slope is not stabilized by either adding fill at the bank toe or regrading the top of the bank, bank collapse during a storm could cause substantially more loss of land area to the sea. In addition, any investment in natural fiber blankets, vegetation, and other site stabilization methods will be lost if the bank collapses. On sites where the top of the bank is well vegetated with mature, salt-tolerant species with extensive roots, the appropriate approach to stabilize the bank should be carefully developed by a professional with extensive experience successfully stabilizing similar sites.

Removing/Replacing Invasive Plants

Invasive plants (i.e., introduced species that thrive at the expense of native plants) should be removed and replaced with appropriate native plants if they are preventing establishment of erosion-control vegetation on a bank. This effort is particularly warranted when bank stability is severely compromised by invasive plants. Because of their tenacity, successful control of invasive plants can take years to accomplish and may require perpetual monitoring and management. Effective ways to manage invasive species on the bank should therefore be incorporated into project design. See *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage* for more information.

Protecting Vegetation

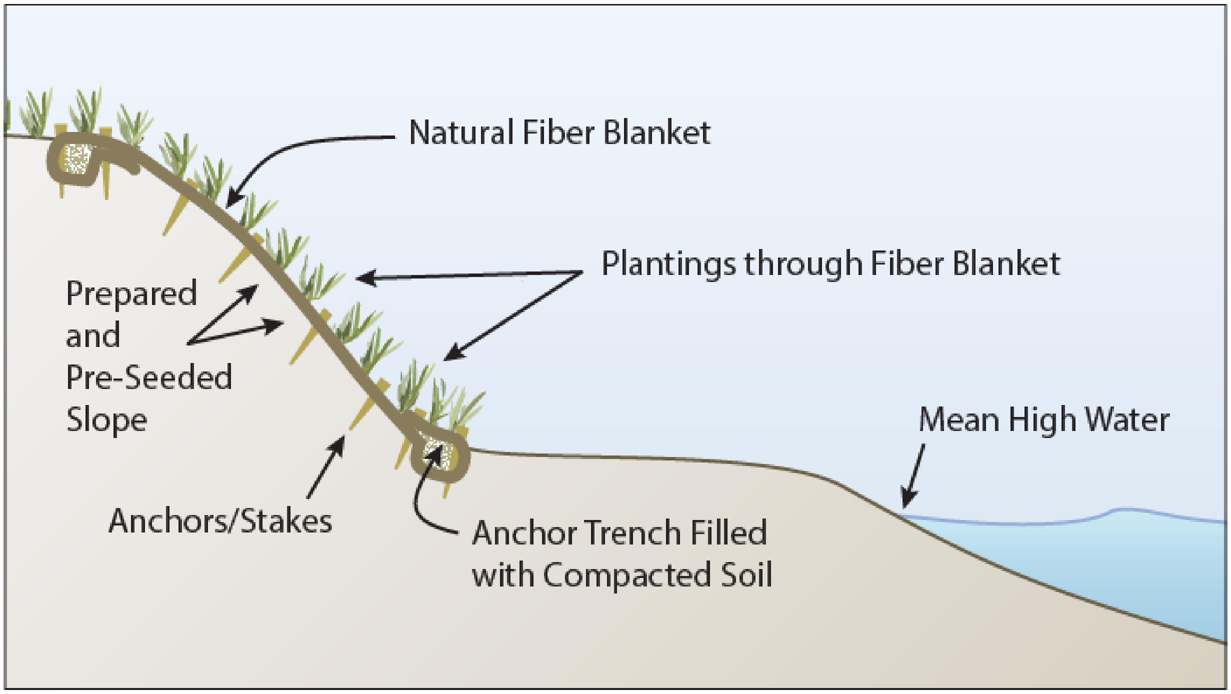
To help ensure the success of newly planted vegetation, sources of erosion on the site, including upland runoff and waves, should be identified and addressed as part of the site evaluation and design process. If surface runoff is causing erosion, it should be reduced and/or redirected to give newly planted vegetation the best chance of survival (see *StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion* for more detail). In addition, exposed areas should not be planted during the winter when the plants are dormant because wind or waves are likely to pull them out before they can get established. See *Storm Smart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage* for more planting tips. To further protect the bank, pedestrian access to the shoreline should be restricted to designated access paths or walkways and the number of access points should be limited as much as possible. Often, multiple properties can use a common access point. To limit shading impacts to vegetation, access structures should be elevated on open pilings and their size should be minimized as much as possible.

Preparation of the Site Surface

Natural fiber blankets are most effective when vegetation, rocks, twigs, and other debris have been removed to create a smooth surface so that the blankets are placed in close contact with the soil or sediments. If the blanket is not in close contact with the ground surface, vegetation shoots may push the blanket up instead of growing through it, causing a “tent” effect. Such tenting allows overland runoff to flow under the blanket and across the ground surface, causing erosion. Plants growing under the blanket will also have difficulty getting established at the site.

Project Installation and Blanket Anchoring

To best protect the site from surface runoff, the rolls of natural fiber blanket should be installed from the top to the bottom of the bank rather than horizontally across the bank. Blankets should be placed so that they overlap by 6 to 12 inches to prevent exposure of the ground surface if the blanket edges curl. To ensure close contact is maintained between the natural fiber blanket and the ground surface, the blanket must be anchored down. Stakes or staples are hammered through the blanket and into the ground to hold the blanket in place. These stakes or staples range from 6 to 24 inches in length and are made of metal, wood, or a biodegradable corn/gluten mix. In coastal settings, anchors made of biodegradable materials should be used to minimize environmental impacts in case they are dislodged from the site. In addition, staples should be installed and maintained so that they stay flush to the ground. In sandy soils, longer staples or stakes will be required to anchor the natural fiber blankets.



This figure shows a natural fiber blanket that has been installed using anchor trenches and planted with live plants. To promote project success, the bank surface was seeded with a mix of salt-tolerant grasses and stakes were installed throughout the blanket to ensure close contact with the ground surface.

Oak stakes are used to anchor the natural fiber blanket installed on this bank. A notch in the stake is used as a stop to hold biodegradable coir twine to secure the blanket to the ground surface. Vegetation was planted through the blanket.
(Photo: Cape Organics, Inc.)

When natural fiber blankets are used to cover the entire slope of a bank, anchor trenches are often used. Anchor trenches are small depressions, typically 6-12 inches deep by 6 -8 inches wide that are dug parallel to the shoreline. In this approach, the blankets run from an anchor trench at the top of the bank, down the bank face to another anchor trench at the bottom of the slope. The trenches are backfilled with sediments similar to those found on the bank or beach and compacted so water will flow evenly over the blanket and not under it.

Blanket Types and Density

Erosion-control blankets are manufactured with a variety of different materials intended for a range of uses, including linings for stormwater impoundments and slope stabilization adjacent to highways. Only blankets composed of natural fibers held together with mesh made of natural fibers are recommended for coastal stabilization projects. Photodegradable mesh is not recommended because the plants used to stabilize the site will shade the blanket, preventing sunlight from helping to break down the mesh.

The blanket material, its thickness, and the density of the weave should be based on a variety of project conditions, such as the steepness of the bank slope and exposure to wind and waves. Coconut and jute are stronger and more durable, so they are typically used on areas with the most significant erosion issues, such as steep slopes in more exposed areas, while straw may be used in areas with lower erosion potential. Typical blanket weights are 400, 700, and 900 grams per square meter. The thicker the blanket and the denser the weave, the stronger and more durable it is. For most coastal projects, the 900 weight blanket will be the most durable and provide the longest bank protection.

Heavy Equipment

If heavy equipment is needed for a natural fiber blanket project, equipment access must be carefully planned to avoid destruction of existing vegetation; creation of ruts; destabilization of banks, beaches, or other landforms; impacts to wildlife and nesting habitat for protected shorebird and turtle species (i.e., species that are considered endangered, threatened, or of special concern in Massachusetts); and related impacts. When mechanical equipment is being used, contractors should keep hazardous material spill containment kits on-site at all times in case there is a release of oil, gasoline, or other toxic substances.

Wildlife and Fisheries Protection

If the project is proposed in or adjacent to habitat for protected wildlife species or horseshoe crab spawning areas, there may be limitations on the time of year that the project can be constructed. Information about the location of these resources and special permitting requirements can be obtained from the Natural Heritage and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife (for protected wildlife species) and the Massachusetts Division of Marine Fisheries (for horseshoe crabs). (Please note this fact sheet focuses on banks. Natural fiber blankets are typically not appropriate for use on dunes, particularly in habitat for protected shorebirds and turtles.)

Permits and Regulations

Most options for addressing coastal erosion, storm damage, and flooding are likely to require a permit under the Massachusetts Wetlands Protection Act through the local Conservation Commission. Additional permits may be needed from the Massachusetts Department of Environmental Protection (MassDEP) Waterways Program and the U.S. Army Corps of Engineers if the project footprint extends below the mean high water line or seaward of the reach of the highest high tide of the year, respectively. Permits or approvals may also be required from other state agencies and local departments, depending on the location and the work involved. Often, Conservation Commission staff are available to meet with applicants early in the design process to go over the important factors that need to be considered.

Generally, regulatory programs are supportive of projects that involve non-structural approaches to managing coastal erosion, such as bioengineering projects with natural fiber blankets and vegetation, as opposed to hard structures. To obtain a permit, projects need to be designed to comply with regulatory requirements, including minimizing or avoiding impacts to sensitive resource areas (e.g., horseshoe crab spawning habitat and endangered species habitat), which are protected by the various regulatory programs.

Professional Services Required

A landscape architect, biologist, engineer, or other environmental professional with experience designing, permitting, implementing, and successfully maintaining bioengineering projects in coastal areas should be consulted to: 1) identify regulatory requirements that must be addressed and ensure the project fully conforms with those requirements; 2) determine the conditions at the site, such as the history of erosion, exposure to wind and waves, soil types, and runoff patterns that will affect the choice of materials for the site; 3) identify any existing conditions including over-steepened slopes and the presence of invasive species that must be considered as part of the design; 4) identify the appropriate natural fiber blanket and vegetation for the site conditions; 5) identify the volume and composition of fill, if needed; 6) identify the best time of year to install the various components of the project; 7) develop an access plan if any heavy equipment is needed; 8) prepare plans for and oversee permitting; and 9) prepare design specifications for and oversee construction. It is also recommended that the consultant be involved in the monitoring and maintenance of these projects.

Project Timeline

It may take as little as two to six months to have a bioengineering project with natural fiber blankets and vegetation designed, permitted, and installed, assuming only a Massachusetts Wetlands Protection Act permit is required. It can take longer, however, depending on the factors involved. Factors influencing this timeline include the contractor's experience with designing and permitting similar projects, completeness of permit applications, special considerations in the permitting process (such as objections by abutters, sensitive resources to be protected, and availability of access for construction), the need for special timing to avoid impacts (e.g., a prohibition on construction during endangered species nesting season), special timing needed for planting vegetation, and/or weather conditions during construction.

Maintenance Requirements

Bioengineering projects with natural fiber blankets and vegetation require ongoing maintenance to ensure their success. Maintenance requirements will vary greatly depending on site conditions. As with all bioengineering projects, maintenance is initially required to ensure that the vegetation that has been planted becomes successfully established (such as watering and replacing dead plants). Blankets and plantings should also be inspected frequently and areas of erosion, areas where the blanket is no longer in contact with the soil, and stakes or staples that are not flush with the ground should be addressed immediately to avoid further deterioration. Other maintenance activities include replacing eroded fill, re-establishing a smooth surface under the blanket, re-anchoring or replacing blankets as needed, and reseeding and replanting vegetation at the appropriate time of year. The frequency of maintenance needed will largely depend on the proximity of the bank to the reach of high tide and the frequency and severity of rain events and coastal storms. Because the replacement of sediment and plants removed by storms is typically necessary, the original permit application should include a maintenance plan. This plan should specify any replacement materials and activities that may be used on the site and how the site will be accessed so that maintenance can be conducted without additional permitting.

Project Costs

With bioengineering projects, a range of options are available that give increasing levels of protection with increased construction costs. In addition, whenever you hire a professional to conduct work on your property, total costs will vary significantly based on site-specific considerations. The considerations that most influence costs of natural fiber blanket projects are the severity of erosion, condition of the existing site (e.g., proximity of the eroded area to the high tide line), density of the blanket selected, type and size of plants selected (plugs are less expensive than plants in containers), need for regrading, amount of fill required, presence of invasive species, and complexity of project design and permitting. For comparison with other shoreline stabilization options, bioengineering projects with natural fiber blankets have relatively low design and permitting costs, low construction costs, and low maintenance costs. See the StormSmart Properties chart, *Relative Costs of Shoreline Stabilization Options* (PDF, 99 KB), for a full comparison.

Additional Information

Bioengineering projects with natural fiber blankets can be used in conjunction with many other techniques for erosion management. See the following CZM StormSmart Properties fact sheets for additional information:

- *StormSmart Properties Fact Sheet 1: Artificial Dunes and Dune Nourishment*
- *StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion*
- *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage*
- *StormSmart Properties Fact Sheet 4: Bioengineering - Coir Rolls on Coastal Banks*
- *StormSmart Properties Fact Sheet 8: Beach Nourishment*

The following publications and websites also provide valuable information on bioengineering with natural fiber blankets and vegetation:

- CZM's [Coastal Landscaping website] includes information on landscaping coastal areas with salt-tolerant vegetation to reduce storm damage and erosion.
- CZM's *Landscaping to Protect Your Coastal Property from Storm Damage and Flooding fact sheet* (PDF, 962 KB) gives specific information for homeowners on appropriate plants for erosion control in coastal areas.
- CZM's *Environmental Permitting in Massachusetts* briefly describes major environmental permits required for projects proposed in Massachusetts.
- *Guidelines for Barrier Beach Management in Massachusetts* (PDF, 12 MB), which was produced by the Massachusetts Barrier Beach Task Force in 1994, provides an overview of the Massachusetts Wetlands Protection Act Regulations and the function of beaches, dunes, and other resource areas (in Chapter 2). It also gives information on various erosion management techniques, their potential impacts, and measures to minimize those impacts (Chapter 5).
- Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00) cover work in wetland resource areas and buffer zones.
- The Natural Heritage and Endangered Species Program website provides information on protected species in Massachusetts, habitat maps, and regulatory review for projects in or adjacent to these habitats.
- The Massachusetts Division of Marine Fisheries can provide information on horseshoe crab protection and other fisheries resources.
- The Massachusetts Ocean Resource Information System, or MORIS, is a web-based mapping tool for interactively viewing coastal data. MORIS data layers, such as endangered species habitat and shellfish, can help identify sensitive resource areas within or near the project site.

Commonwealth of Massachusetts
Charlie Baker, Governor

Executive Office of Energy and Environmental Affairs
Matthew A. Beaton, Secretary

Massachusetts Office of Coastal Zone Management
Bruce K. Carlisle, Director

Massachusetts Office of Coastal Zone Management | 251 Causeway Street, Suite 800 | Boston, MA 02114 | (617) 626-1200
CZM Information Line: (617) 626-1212 | **CZM Website**: www.mass.gov/czm

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StormSmart Properties Fact Sheet 6: Sand Fencing

The coast is a very dynamic environment and coastal shorelines—especially beaches, dunes, and banks—change constantly in response to wind, waves, tides, and other factors such as seasonal variation, sea level rise, and human alterations to the shoreline system. Consequently, many coastal properties are at risk from storm damage, erosion, and flooding. Inappropriate shoreline stabilization methods can actually do more harm than good by exacerbating beach erosion, damaging neighboring properties, impacting marine habitats, and diminishing the capacity of beaches, dunes, and other natural landforms to protect inland areas from storm damage and flooding. StormSmart Properties—part of the Massachusetts Office of Coastal Zone Management's (CZM) StormSmart Coasts Program—provides coastal property owners with important information on a range of shoreline stabilization techniques that can effectively reduce erosion and storm damage while minimizing impacts to shoreline systems. This information is intended to help property owners work with consultants and other design professionals to select the best option for their circumstances.

What Is Sand Fencing?

Sand fencing, also called snow fencing, is designed to help capture sand to build dunes. It is typically made of thin, wooden slats that are connected with twisted wire to wooden or metal stakes. While other fence materials such as plastic, polyethylene, and metal are sometimes used to trap sand, they are not recommended for coastal use because of the impacts they can cause. See Design Considerations below for details on impacts of other materials.

No shoreline stabilization option permanently stops all erosion or storm damage. The level of protection provided depends on the option chosen, project design, and site-specific conditions such as the exposure to storms. All options require maintenance, and many also require steps to address adverse impacts to the shoreline system, called mitigation. Some options, such as seawalls and other hard structures, are only allowed in very limited situations because of their impacts to the shoreline system. When evaluating alternatives, property owners must first determine which options are allowable under state, federal, and local regulations and then evaluate their expected level of protection, predicted lifespan, impacts, and costs of project design, installation, mitigation, and long-term maintenance.

Sand fencing was installed along the base of and perpendicular to this eroded dune to trap windblown sand and help rebuild the dune. **(Photo: CZM)**

How Sand Fencing Reduces Storm Damage

Sand fencing reduces storm damage on coastal properties by helping to build up dunes. As wind blows through the sand fencing, the fencing creates a drag that reduces the wind speed. At lower speeds, the wind can no longer carry sand, which is deposited at the base of or behind the fence. The resulting accumulation of sand and other sediment helps build the dune. Because larger dunes provide greater levels of protection from storm waves and storm surge (the rise in sea level above the average tide level caused by onshore winds), the sediment trapped by sand fencing increases the dune's capacity to protect landward areas. In addition, sand fencing is often used to keep people off the dunes and direct them toward boardwalks and other designated beach access paths to prevent damage to both the dune and erosion-control vegetation.

Sand fencing can be used in conjunction with many other techniques for erosion management. See the following StormSmart Properties fact sheets on related techniques: *Artificial Dunes and Dune Nourishment*, *Planting Vegetation to Reduce Erosion and Storm Damage*, *Bioengineering - Coir Rolls on Coastal Banks*, *Bioengineering - Natural Fiber Blankets on Coastal Banks*, and *Beach Nourishment*.

Relative Benefits and Impacts Compared to Other Options

Under the Massachusetts Wetlands Protection Act, new hard structures are typically prohibited on all beaches and dunes. On coastal banks, hard structures are only allowed when necessary to protect buildings permitted before August 10, 1978, and only if no other alternative is feasible. In many cases, sand fencing projects and other non-structural alternatives are therefore the only options available for reducing erosion and storm damage on coastal properties.

Sand fencing provides a low-cost, easy-to-install, and effective way to help build up dunes and protect inland areas from storm damage. Unlike seawalls, rock revetments, or other "hard" shoreline stabilization structures, properly designed sand fencing projects do not reflect or redirect waves onto beaches or neighboring properties. The design of a hard structure affects how much wave energy is reflected, for example vertical walls reflect more wave energy than sloping rock revetments. These reflected waves erode beaches in front of and next to a hard structure, eventually undermining and reducing the effectiveness of the structure and leading to costly repairs. This erosion also results in a loss of dry beach at high tide, reducing the beach's value for storm damage protection, recreation, and wildlife habitat. Hard structures also impede the natural flow of sand, which can cause erosion in down-current areas of the beach system. Sand fencing projects, however, increase protection to landward areas while allowing the system's natural process of erosion and accretion to continue.

In general, the impacts of sand fencing projects are relatively minor compared to other options. The most significant factor is the proximity of the fencing to sensitive habitats, particularly nesting habitat for protected shorebird and turtle species (i.e., species that are considered endangered, threatened, or of special concern in Massachusetts). Sand fencing traps lighter, fine-grained sand, creates steeper slopes, and otherwise physically alters the area in a way that impedes shorebird nesting. These birds prefer relatively flat dune areas with coarser sand. The fencing also is a physical barrier that can block unfledged chicks from getting from their nests to their food source, and the posts or stakes can serve as perches for hawks and other predators that feed on the chicks. Another negative impact occurs when fencing destroyed during a storm becomes marine debris. Slats, posts, and wire littered on the beach or floating in the water are not only unsightly, they can harm people and wildlife. For example, wire can entangle wildlife and broken slats can puncture the bare feet of recreational beach users. Certain sand fencing designs and materials, such as sturdy drift fencing and plastic fencing, have additional impacts. See the Design Considerations section for details.

Design Considerations for Sand Fencing Projects

This section covers a variety of factors that should be considered to minimize adverse impacts and ensure successful design, permitting, construction, and maintenance of sand fencing.

Appropriate Locations

Because of its relatively low cost and minor impacts, sand fencing is appropriate at almost any site (except where it may impact protected shorebird and turtle species)—as long as the fencing is not reached by daily high tides and waves from minor storms. Sand fencing can be installed to build up an existing dune, build a dune at the base of an existing bank, or build a dune in low-lying areas where there is blowing sand. Sand fencing can also be strategically placed to direct pedestrian traffic to a designated access point to minimize dune impacts from foot traffic.

Fence Placement

Sand fencing should be installed as far landward as possible, well behind the high tide line, to minimize potential impacts to beachgoers and wildlife and to protect the fencing from storm waves. If waves and tides regularly reach the sand fencing, there will be erosion around the fencing and it will likely be destroyed during a storm. Sand fencing can be installed using a variety of designs, including a single line of fencing parallel to the shoreline, double rows of fencing, a zigzag configuration, and a line of fencing with attached spurs running perpendicular to the dominant wind direction.

In this project, an artificial dune was built at the base of an eroding bank and heavily planted with erosion-control vegetation. Sand fencing was installed to help trap sand to build the artificial dune. **(Photo: CZM)**

Fence Posts

Post material and size should be carefully considered in project design. As for material, only untreated wooden posts are recommended for use on coastal beaches and dunes. Metal posts rust and become a hazard to public safety and marine life, fiberglass posts often shatter when they break and leave dangerous shards on the beach, and wooden posts treated with preservatives do not break down very quickly and remain a marine debris hazard for much longer than untreated wood if lost in a storm. The larger the posts, the more potential for erosion around the base from wind and water, so smaller posts are recommended to minimize scour (i.e., the erosion of sediment around a stationary object). The recommended post size is no larger than 2x4 inches for rectangular posts and 3 inches in diameter for circular posts.

Space Between Slats

Based on a review of available information, sand fencing with 50% open space and 50% slats optimizes sand deposition. If wider slats are used, more erosion is likely to occur around the fencing from wind and waves. Wider gaps between slats promote scour of the sand rather than sand deposition.

Fence Installation

The number of fence posts should be limited as much as possible to avoid excessive erosion from scour. Posts should be spaced at least 4 feet apart and should be buried several feet into the sediment to withstand erosion and waves. A minimum depth of 4 feet below the surface is optimal.

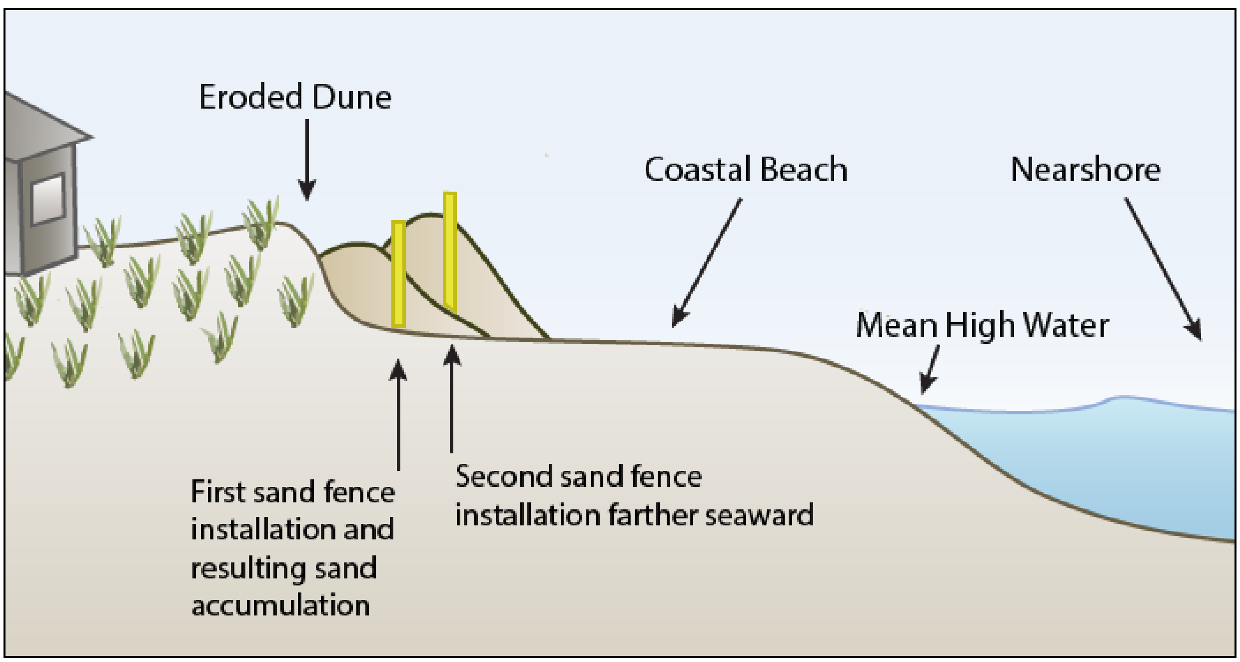
If waves and tides are routinely damaging the sand fencing, it has likely been installed too close to the high tide line. If there is no room at the site to move the fencing landward, additional or alternative shoreline stabilization strategies are likely warranted. Dune nourishment, construction of artificial dunes, and beach nourishment are often combined with sand fencing and vegetation to provide a wider beach and greater level of storm damage protection (see the following StormSmart Properties fact sheets: *Artificial Dunes and Dune Nourishment*, *Planting Vegetation to Reduce Erosion and Storm Damage*, and *Beach Nourishment*).

Vegetation

Whenever possible, native plants that are salt-tolerant and have extensive root systems should be planted as part of a sand fencing project, generally on the landward side of the fencing. These plants are extremely effective at holding sediments in place and help to stabilize windblown sand accumulated by sand fencing. For more information, see *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage*. Please note that planting may be restricted in nesting habitat for protected shorebird species and only live vegetation should be used. Christmas trees are not recommended for trapping sand because a large section of the dune is disturbed when they are removed by waves, increasing dune erosion. Putting brush and other dead plant material on banks or dunes can prevent living plants from becoming established, further destabilizing the area. Christmas trees and brush can also degrade nesting habitat for protected shorebird species by physically occupying otherwise suitable nesting habitat and impeding chick movement.

Additional Rows of Fencing

As shown in the figure below, when sand builds up and buries the fencing (i.e., when the fence is approximately two-thirds buried by sand), an additional row of sand fencing may be installed to continue to help the dune grow (if there is sufficient space available above the high tide line).



This diagram shows where a second row of sand fencing was installed to trap sand after the initial row became partially buried.

Wildlife Protection

Sand fencing may be prohibited in or adjacent to nesting habitat for protected bird and turtle species. At some sites, the location, linear extent, size of the openings, time of year for construction, and other design details may need to be modified so that birds can successfully nest. The Natural Heritage and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife can provide information on the species listed as endangered, threatened, and of special concern in Massachusetts, including their location and any special design or permitting requirements under state regulations.

Marine Debris

To minimize impacts if fencing is washed out in a storm and becomes marine debris, only fencing made of thin slats of untreated wood connected with twisted wire should be used in coastal areas. These materials break down relatively quickly in the marine environment and consequently have fewer impacts than plastic fencing or other fencing made of non-degradable materials. The posts/stakes, slats, and other fencing materials can be labeled to facilitate identification, recovery, and disposal of any components that are damaged and washed off site in a storm.

Heavy Equipment Use

Access for heavy equipment to deliver fence components, vegetation, or sediment to the site must be carefully planned to avoid destruction of existing vegetation; creation of ruts; destabilization of banks, beaches, or other landforms; impacts to wildlife, particularly protected species; and related impacts. When mechanical equipment is being used, contractors should keep hazardous material spill containment kits on-site at all times in case there is a release of oil, gasoline, or other toxic substances.

Sturdy Drift Fencing

This sturdy drift fencing is constructed in a zigzag pattern parallel to the shoreline with 2x3-inch vertical and horizontal cross-members attached to 6- to 8-inch posts. As described above, this type of fencing is not recommended because of its adverse impacts. **(Photo: CZM)**

Sturdy drift fencing is a type of sand fencing constructed with more robust structural elements than standard wire and slat fencing (see photograph below). The components are nailed together and the fence is constructed in a zigzag pattern. Typically used in areas subject to strong waves, this fencing option is intended to break some of the wave energy before it reaches the bank or dune landward of it, rather than to capture blowing sand. This type of structural fencing can increase erosion issues because: 1) the larger the posts used in a sand fencing project, the greater the level of erosion around the posts; 2) the fence acts as a physical barrier that interferes with the natural flow of sediment along the shoreline, particularly when this fencing is installed on narrow beaches and/or in close proximity to the water; and 3) the fence can cause a wind-tunnel effect, increasing erosion of non-vegetated sediments landward of the fence. Sturdy drift fencing also uses significantly more wood and nails than traditional sand fencing, and the wood is thicker and takes longer to break down in the marine environment. This fencing therefore increases marine debris impacts and threatens public safety when significant numbers of nails are left on the beach after the fencing is damaged during storms. Like traditional sand fencing, sturdy drift fencing negatively impacts nesting areas for protected shorebird and turtle species. In most cases, therefore, thin wooden slat and twisted wire sand fencing is recommended over sturdy drift fence to trap sand. If the fence will be reached by daily high tides and waves from minor storms, additional alternative shoreline stabilization strategies are likely warranted. Dune nourishment, construction of artificial dunes, and beach nourishment are often combined with sand fencing and vegetation to provide a wider beach and greater level of storm damage protection (see the following StormSmart Properties fact sheets: *Artificial Dunes and Dune Nourishment*, *Planting Vegetation to Reduce Erosion and Storm Damage*, and *Beach Nourishment*).

If sturdy drift fencing is used, ways to reduce the potential impacts and increase the longevity and effectiveness of the project include: 1) installing the fencing far enough landward so that it will not be reached by tides or typical storm waves (i.e., these projects will be affected by severe storms but should not be impacted by regularly occurring storms); 2) adding sediment with a similar or slightly coarser grain size to the existing beach and/or dune (called beach and dune nourishment) when the fencing is installed to minimize impacts to natural sediment flow and enhance the longevity of the fencing; 3) periodically adding additional sediment to "renourish" the beach system; 4) labeling fence components and actively retrieving any debris generated by storm damage; 5) cutting notches in the boards at the bottom of the fence for animal access; and 6) avoiding use in nesting habitat for protected shorebirds and turtles.

Other Types of Fencing Are Not Recommended in Dunes

Sand fencing is the only type of fencing that should be used in dunes. In some cases, rows of closely spaced posts have been installed as anchors for sand bags or as part of a shoreline stabilization project. Although these closely spaced posts have been referred to as fencing, they act as a solid wall, reflecting wave energy and increasing erosion of the beach. Because of their adverse impacts, rows of posts are strongly discouraged.

The row of posts installed at the base of this bank is acting like a solid wall, reflecting wave energy and exacerbating beach erosion and erosion of neighboring properties. **(Photo: Greg Berman, Woods Hole Oceanographic Institution Sea Grant Program)**

There are many other types of fencing that have been inappropriately used in dunes, including chain link and solid privacy fences. Chain link fences rust and become a marine debris and public safety hazard when damaged and/or torn out in a storm. Solid privacy fences interfere with the natural movement of the dune and therefore impede the dune's ability to provide storm damage protection. These two types of fencing are typically used for establishing property lines or for stopping sand from blowing onto parking areas. As an alternative, native vegetation can help trap blowing sand and stabilize dunes while serving as a privacy buffer. For more information on the use of vegetation in dunes, see *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage*.

A solid fence prevents the natural movement of this dune. **(Photo: CZM)**

Permitting and Regulatory Standards

Most options for addressing coastal erosion, storm damage, and flooding are likely to require a permit under the Massachusetts Wetlands Protection Act through the local Conservation Commission. Permits or approvals may also be required from other state and federal agencies and local departments, depending on the location and the work involved. Generally, regulatory programs are supportive of projects that work to trap windblown sand and build dunes, so permits are not always required for sand fencing. To obtain a permit, sand fencing projects need to be designed to avoid adverse impacts to habitat for protected species and sited landward of the reach of daily tides and regular storms.

Professional Services Required

Simple fencing projects may be done by the property owner after permits have been obtained if needed. Projects in or adjacent to protected shorebird and turtle habitat and in areas with very narrow dry beach may require professional services. A professional with expertise in designing fencing projects can be consulted to: 1) identify regulatory requirements and ensure the project fully conforms with those requirements; 2) determine the conditions at the site that will affect the project (such as the width of dry beach above high tide, wave exposure, and predicted flood elevations); 3) select plant species and develop a planting and plant maintenance plan; 4) identify the best time of year for installation; 5) prepare plans for permitting; 6) develop an access plan if heavy equipment is needed; and 7) prepare design specifications for construction. The consultant can also oversee permitting, construction, monitoring, and maintenance of the project.

Project Timeline

It may take as little as two to three months to complete a sand fencing project, assuming that only a Massachusetts Wetlands Protection Act permit is required, but it can take longer depending on the factors involved. Factors that affect how long it takes to design, permit, and install a sand fencing project include the contractor's experience with designing and permitting similar projects, completeness of permit applications, special considerations in the permitting process (such as objections by abutters, sensitive resources to be protected, and availability of access for construction), the need for special timing to avoid impacts (e.g., restrictions on construction during nesting season for protected species), and/or weather conditions during construction. Often, Conservation Commission staff are available to meet with applicants to go over the important factors that need to be considered early in the design process.

Maintenance Requirements

Regular maintenance of fencing projects will include retrieving damaged fencing components and replacing deteriorated or storm-damaged fence sections. Maintenance needs will depend, in part, on the proximity of the fencing to the reach of high tide and the frequency and severity of storms. A schedule and plan for replacing fencing should be included in the original permit application so that maintenance can be conducted without additional permitting.

Project Costs

The costs of sand fencing projects are most influenced by the type of fencing and posts selected, the length of the area to be fenced, and the complexity of project design and permitting. In addition, the size and location of the fence will affect construction and maintenance costs, as well as the level of protection provided by the project. Fences that are too close to the high tide line will likely require more frequent maintenance. In comparison with other shoreline stabilization options, sand fencing projects typically have relatively low design and permitting costs, low construction costs, and low maintenance costs. See the StormSmart Properties chart, *Relative Costs of Shoreline Stabilization Options* (PDF, 99 KB), for a full comparison.

Additional Information

Sand fencing can be installed in conjunction with many other techniques for erosion management. See the following CZM StormSmart Properties fact sheets for additional information:

- *StormSmart Properties Fact Sheet 1: Artificial Dunes and Dune Nourishment*
- *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage*
- *StormSmart Properties Fact Sheet 4: Bioengineering - Coir Rolls on Coastal Banks*

- *StormSmart Properties Fact Sheet 5: Bioengineering - Natural Fiber Blankets on Coastal Banks*
- *StormSmart Properties Fact Sheet 8: Beach Nourishment*

The following publications and websites also provide valuable information:

- CZM's Coastal Landscaping website includes information on landscaping coastal areas with salt-tolerant vegetation to reduce storm damage and erosion.
- CZM's *Landscaping to Protect Your Coastal Property from Storm Damage and Flooding fact sheet* (PDF, 962 KB) gives specific information for homeowners on appropriate plants for erosion control in coastal areas.
- *Coastal Dune Protection and Restoration—Using 'Cape' American Beachgrass and Fencing* (PDF, 3 MB) by the Woods Hole Sea Grant and Cape Cod Cooperative Extension Program includes case studies and tips on dune restoration, along with information on preserving shorebird habitat and understanding the permit process.
- CZM's *Environmental Permitting in Massachusetts* briefly describes major environmental permits required for projects proposed in Massachusetts.
- *Guidelines for Barrier Beach Management in Massachusetts* (PDF, 12 MB), which was produced by the Massachusetts Barrier Beach Task Force in 1994, provides an overview of the Massachusetts Wetlands Protection Act Regulations and resource areas, along with information on various erosion management techniques, their potential impacts, and measures to minimize those impacts.
- *Salisbury Beach Dune Walkover Access Design Standards* (PDF, 14 KB) gives general design standards for walkways over coastal dunes that minimize potential adverse effects. These standards are widely applicable.
- *The Ballston Beach Barrier Dune Restoration Project* (PDF, 1 MB) documents innovative sand fencing techniques used to restore a dune on a barrier beach in Truro.
- Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00) cover work in wetland resource areas and buffer zones.
- The Natural Heritage and Endangered Species Program website provides information on protected species in Massachusetts, habitat maps, and regulatory review for projects in or adjacent to these habitats.
- The Massachusetts Ocean Resource Information System, or MORIS, is a web-based mapping tool for interactively viewing coastal data. MORIS data layers, such as endangered species habitat and shellfish, can help identify sensitive resource areas within or near the project site.

www.mass.gov/stormsmart-coasts-program

Commonwealth of Massachusetts
Charlie Baker, Governor

Executive Office of Energy and Environmental Affairs
Matthew A. Beaton, Secretary

Massachusetts Office of Coastal Zone Management
Bruce K. Carlisle, Director

Massachusetts Office of Coastal Zone Management | 251 Causeway Street, Suite 800 | Boston, MA 02114 | (617) 626-1200
CZM Information Line: (617) 626-1212 | **CZM Website**: www.mass.gov/czm

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StormSmart Coasts

StormSmart Properties Fact Sheet 7: Repair and Reconstruction of Seawalls and Revetments

The coast is a very dynamic environment and coastal shorelines—especially beaches, dunes, and banks—change constantly in response to wind, waves, tides, and other factors such as seasonal variation, sea level rise, and human alterations to the shoreline system. Consequently, many coastal properties are at risk from storm damage, erosion, and flooding. Inappropriate shoreline stabilization methods can actually do more harm than good by exacerbating beach erosion, damaging neighboring properties, impacting marine habitats, and diminishing the capacity of beaches, dunes, and other natural landforms to protect inland areas from storm damage and flooding. StormSmart Properties—part of the Massachusetts Office of Coastal Zone Management's (CZM) Stormsmart Coasts Program—provides coastal property owners with important information on a range of shoreline stabilization techniques that can effectively reduce erosion and storm damage while minimizing impacts to shoreline systems. This information is intended to help property owners work with consultants and other design professionals to select the best option for their circumstances.

What Are Seawalls and Revetments?

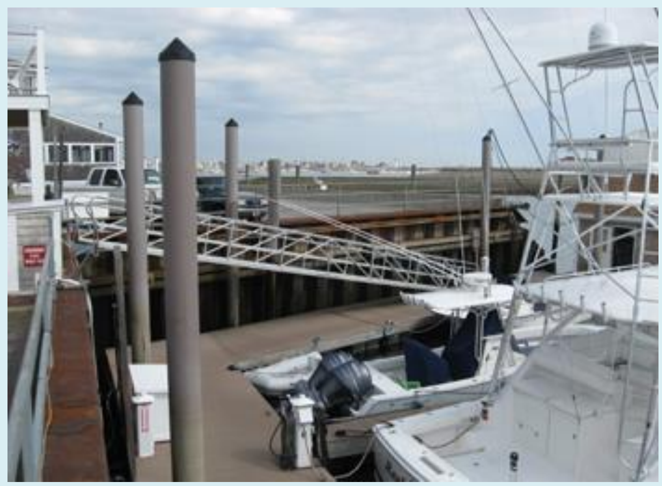
Seawalls and revetments are types of coastal engineering structures that run parallel to the shoreline. Also known as "armoring" or "hard structures," coastal engineering structures provide a physical barrier that directly protects inland areas. Seawalls are vertical walls that are typically constructed of concrete or stone, while revetments are sloping structures typically composed of rock (also called "rip rap"). Seawalls and revetments provide storm damage protection and erosion control from waves, tides, currents, and storm surge (water build up above the average tide level). They can be used in both exposed areas with high wave energy, as well as in areas with more sheltered conditions (e.g., relatively low wave energy). As discussed below, seawalls and revetments can significantly alter the coastal system and may have adverse impacts on the project site and neighboring properties. Because these effects are now well understood, *new construction* of these hard structures is only allowed in very limited circumstances. This fact sheet addresses the more common practice of repair and reconstruction of *existing* seawalls and revetments. Given the technical and permitting issues involved with seawall and revetment repair and reconstruction projects, a coastal engineer should be consulted for site-specific advice.

No shoreline stabilization option permanently stops all erosion or storm damage. The level of protection provided depends on the option chosen, project design, and site-specific conditions such as the exposure to storms. All options require maintenance, and many also require steps to address adverse impacts to the shoreline system, called mitigation. Some options, such as seawalls and other hard structures, are only allowed in very limited situations because of their impacts to the shoreline system. When evaluating alternatives, property owners must first determine which options are allowable under state, federal, and local regulations and then evaluate their expected level of protection, predicted lifespan, impacts, and costs of project design, installation, mitigation, and long-term maintenance.

This concrete seawall was built to protect the homes and infrastructure behind it. This seawall has a curved face built into the top of the wall, which redirects some of the reflected water and waves away from the wall. (Photo: CZM)

This rock revetment was installed on the lower part of a coastal bank, while salt-tolerant vegetation was planted to protect the upper bank. (Photo: CZM)

Bulkheads - Also a type of hard structure constructed parallel to the shoreline, bulkheads are vertical walls designed to hold soil in place and prevent it from sliding or slumping into the water. Although they may also provide some protection from waves and tides, bulkheads are not typically appropriate to address coastal erosion. They are typically made of wood, steel or vinyl sheeting, granite blocks, or concrete and are primarily used around developed harbors and marinas. Their vertical structure allows them to provide docking space for vessels in sheltered areas where wave action is relatively limited. The design considerations for bulkheads are similar to those recommended for seawalls (see below). A coastal engineer should be consulted for site-specific advice when bulkhead repairs are needed.



This steel bulkhead is built to hold the soil under this parking lot in place. (Photo: CZM)

Hard Structures - Their Role, History, and Impacts

Coastal engineering structures were originally utilized to prevent erosion and protect development and infrastructure from waves and storm surge. The unintended effects of hard structures on the shoreline system were not initially well understood, however, and significant long-term impacts have been documented in areas where these structures were constructed. While seawalls and revetments can help protect landward property and infrastructure from waves and tides, they do not stop (and may exacerbate) erosion. As natural erosive forces continue to remove sediment over time, beaches in front of the hard structures are diminished and can eventually be completely lost. Seawalls and revetments themselves can also exacerbate erosion problems by reflecting waves onto the beach in front of them or onto neighboring properties. As these sources of erosion continue, more of the hard structure is exposed, causing more wave reflection and erosion. Over time, the structure can become undermined, reducing its shoreline protection capacity, increasing maintenance costs, and ultimately leading to total structure failure. When used on coastal banks (also known as bluffs), seawalls and revetments prevent erosion of these landforms, which halts the natural supply of sand and other sediment to the shoreline system. The result is that beaches and dunes in downdrift (i.e., down current) areas experience increased erosion rates. Therefore, these structures not only affect the property owner, they also affect the natural resources necessary for storm damage prevention, recreation, and wildlife habitat.

The beach in front of this concrete seawall eroded, undermining the structure. (Photo: CZM)

Erosion of the beach in front of this revetment created a depression at the base of the structure. (Photo: CZM)

Alternatives to Revetments in Front of Seawalls - To address seawall undermining, small rock revetments have often been installed in front of seawalls to protect the structure from collapse. As erosion continues, however, the small revetment may also be undermined—leading to designs that consider a larger revetment. A larger revetment will extend farther seaward, increasing the frequency and intensity of interactions between the structure and tides, waves, and currents and further worsening beach erosion. The result can be a succession of larger structures, increased wave reflection and erosion, and loss of beach, with the beach being permanently replaced by the hard structures. Erosion-control options that add sediments in front of the structure, like beach nourishment and cobble berms, can be used instead to effectively protect upland development and infrastructure, reducing impacts to neighboring properties, and maintaining beach resources and habitat. In addition, adding a revetment does not effectively stop waves and water from overtopping the seawall during storms. In many cases, overtopping and storm damage are more effectively reduced by adding sediment seaward of the wall to dissipate wave energy before it reaches the structure. This practice is referred to as beach nourishment (see *StormSmart Properties Fact Sheet 8: Beach Nourishment* for additional information).

Repair and Reconstruction - An Opportunity to Improve Performance and Reduce Impacts

As the impacts of hard structures have become better understood over the last 50 years, recommended design practices for seawalls and revetments have advanced significantly. Any repair or reconstruction project—whether minor repairs or complete reconstruction—should therefore include design improvements based on the best available techniques to reduce impacts, improve structure longevity, and minimize maintenance costs. Typically, the more work the structure needs, the greater the opportunity for incorporating improvements into the redesign. Investing in significant improvements and best management practices can cost more in the short term, but such improvements reduce costs associated with mitigating for adverse effects of the structure and can significantly improve the protection provided in a major coastal storm. In addition, if minor repairs are simply patches that make the structure look better, they may not do enough to prevent the structure from failing in a storm, which would result in significant damage to the property and infrastructure landward of it.

Design Considerations for Repair or Reconstruction of Seawalls and Revetments

This section covers a variety of options that should be considered as part of seawall and revetment repair and reconstruction projects to minimize adverse impacts, maximize structure longevity, reduce maintenance costs, and ensure successful design, permitting, and construction of the project.

This bulkhead has deteriorated and erosion has occurred landward of it. When reconstructed, the bulkhead should be replaced with a sloping rock revetment to dissipate energy more effectively and reduce wave reflection. In addition, the toe of the revetment should be constructed at the base of the eroding bank to minimize regular interaction with waves and tides. This improved placement will reduce impacts to the beach and extend the life of the structure. **(Photo: CZM)**

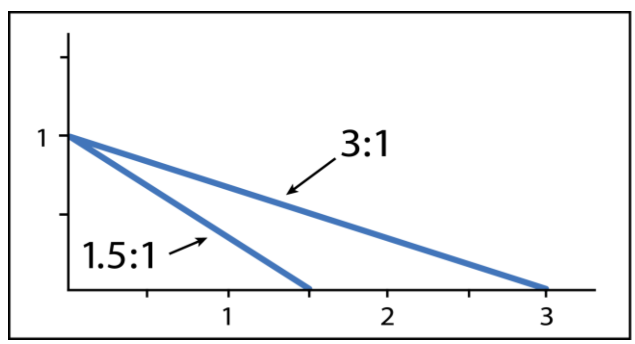
Placement

To minimize interaction with waves and tides and therefore reduce erosion to the fronting beach and adjacent areas, seawalls and revetments should be located as far landward as possible. When repairing or replacing an existing seawall or revetment, therefore, the structure should not be extended farther seaward. In addition, if erosion is occurring behind an existing structure, to minimize impacts, the structure should be pulled back to the base of the landward landform to prevent continued erosion from undermining the structure. Leaving the structure in place and using fill to reclaim land will likely continue the cycle of erosion. Seawalls and revetments should also conform to the natural shape of the shoreline without any segments extending seaward from the main structure, which would focus wave energy on the parts of the structure closer to the sea. This focused wave energy exacerbates erosion of the beach and reduces the longevity of the structure. In addition, the structure should not extend farther seaward than those on adjacent properties and every effort should be made to align the ends of the structure with adjacent structures.

Slope

Sloping structures dissipate wave energy (i.e., reduce wave strength) more effectively than vertical structures. Therefore, when seawalls need significant repairs or reconstruction, replacing them with sloping rock revetments that do not extend farther seaward should be considered.

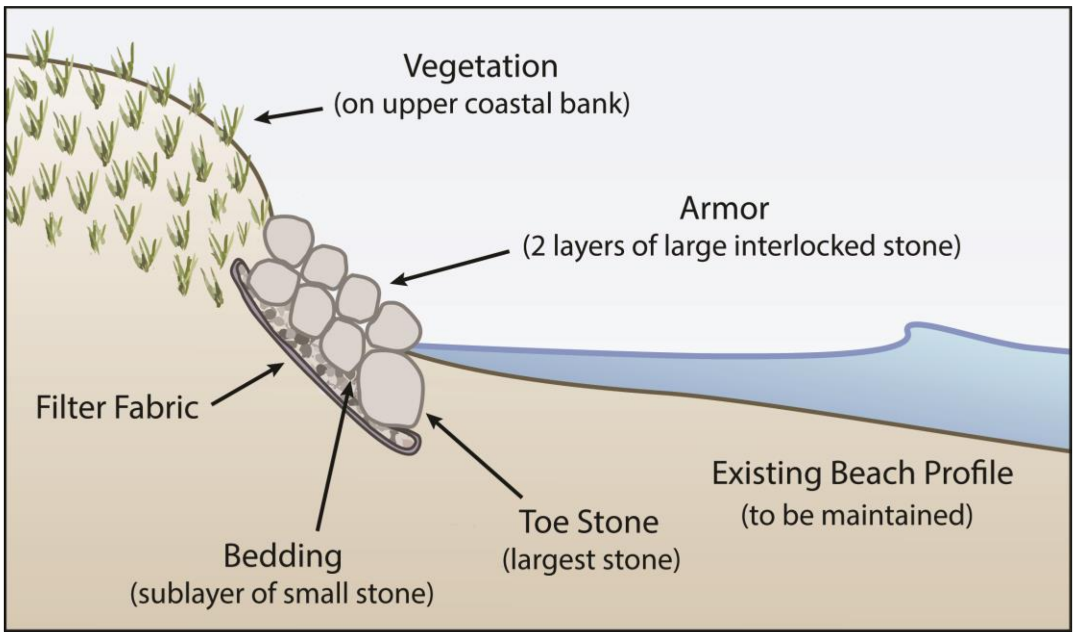
In addition, shallow slopes minimize wave reflection that causes erosion. Revetments should ideally have a slope no steeper than 1.5:1 to limit erosion of fronting beaches and adjacent properties. A coastal engineer can recommend an appropriate slope based on site-specific conditions, including beach width and elevation, bank height, erosion rate, wave energy, and integrity of the structure.



The slope is typically expressed as a ratio of the width of a structure's base to its height, or horizontal to vertical. This figure shows two examples of different slopes.

Reconstruction offers an excellent opportunity to reduce the steepness of a revetment. To achieve a shallower slope without extending the structure farther seaward, the bank or other landform behind the revetment can be regraded and the top of the structure moved landward. Though this landward extension results in a loss of ground surface between the revetment and the development or infrastructure behind it, the property will be better protected through the increased longevity of the structure and reduced erosion rates.

The vertical seawall at this site has been undermined and is failing. In this case, there is room on the site to replace the vertical wall with a sloping rock revetment that does not extend farther seaward onto the beach. **(Photo: CZM)**



Schematic of a typical revetment on a coastal bank.

Curved Face for the Top of the Seawall

Vertical seawalls reflect water straight down and straight up. The wave energy that is reflected downward erodes the beach, while the wave energy that goes up into the air can overtop the structure and cause erosion behind the wall, potentially damaging the development or infrastructure being protected. If the seawall cannot be replaced with a revetment, a curved face can be added to the top of a vertical concrete seawall to help direct some of the reflected water and waves out and away from the wall. A coastal engineer will need to evaluate the applicability and potential effectiveness of this approach for each site.

Waves are reflected by this vertical seawall, causing energy to be deflected straight down on the beach and straight up and over the wall, damaging the building behind it. **(Photo: CZM)**

Beach and Dune Nourishment

Beaches and dunes naturally dissipate energy associated with waves, tides, and currents. Therefore, the best way to reduce the wave energy that hits seawalls and revetments is to maintain the beach in front of these structures. In areas where there is a wide enough beach, dunes can provide additional protection. With an older seawall or revetment, the beach in front of the structure has often eroded over time. Replacing and maintaining these natural buffers can prolong the structure's longevity and minimize its adverse impacts—and can also provide a recreational beach. To build up beaches (and dunes where appropriate), "compatible" material (i.e., sediment of a similar size) is brought in from an offsite source and added to the beach. After the initial nourishment project is completed, sediment is added to maintain the desired beach and/or dune volume according to a monitoring and maintenance plan that includes details for determining when, how much, and what type of sediment should be added. Depending on erosion rates and storm impacts, sediment could be required on an annual basis, and will likely be necessary after coastal storms. See the following StormSmart Properties fact sheets for more information on where beach and dune nourishment are appropriate: *Artificial Dunes and Dune Nourishment* and *Beach Nourishment*, as well as the guidance document, *Beach Nourishment: MassDEP's Guide to Best Management Practices for Projects in Massachusetts* (PDF, 2 MB).

In most cases, the sediment added to the beach or dune is not permanent. How long it remains in front of the seawall or revetment will vary depending on many factors, including: the initial width of the dry beach, the length of beach where sediment is added, wave energy, erosion rate, grain size and volume of sediment added, and storm frequency and intensity. A coastal geologist or coastal engineer with experience designing beach and dune nourishment projects can make recommendations for the grain size and volume of sediment needed. When this added sediment erodes, it is not "lost" to the system—it moves into nearshore areas and/or alongshore to the adjacent shoreline where it dissipates wave energy, protects the shoreline, and improves wildlife habitat. And in many cases, this eroded sediment moves back onshore during the summer and after storms. See these StormSmart Properties fact sheets for design considerations to help reduce erosion of added sediment: *Artificial Dunes* and *Dune Nourishment* and *Beach Nourishment*.

On coastal banks, when a seawall or revetment is undergoing significant repairs or reconstruction, the project should also specifically include provisions to add sediment to compensate for the fact that the bank is no longer acting as a source of sediment to the beach system. Adding this sediment will also help maintain the beach volume in front of the structure, increasing its longevity. The minimum volume of sediment required should be based on the historic shoreline erosion rate, the height of the bank, and the length of the project. A professional with experience designing beach nourishment projects can make recommendations regarding the volume of sediment that will be needed. A monitoring plan should be implemented to document the change in beach elevation in front of the structure, along with beach and bank erosion adjacent to the structure. This plan should include requirements for adding sediment when beach elevation falls to a certain level. In addition, any sediment excavated from the beach as part of the repair or reconstruction project should be placed on the beach after construction to maintain the volume of sediment in the beach system.

Surface Texture and Chinking in Revetments

Rough surfaces dissipate more wave energy than smooth surfaces. Therefore, when individual rocks in revetments are replaced or repositioned, or when the structure is reconstructed, the seaward face should be rough instead of flat and smooth. The coastal engineer designing the project can specify the type of rock to use and how to build the structure to maximize dissipation of wave energy.

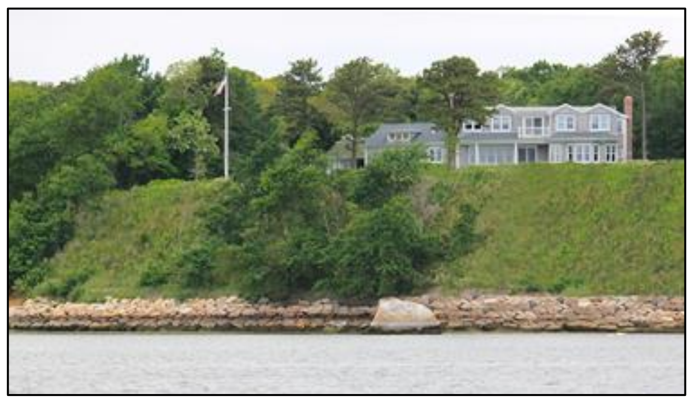
The surface of the rocks in this sloping revetment is relatively smooth and the spaces between the rocks have been filled with cement, further smoothing the structure. Smoother surfaces such as this reflect wave energy outward onto the beach and upward toward the house rather than dissipating the energy. The results are increased overtopping of the wall by waves, resulting in erosion and storm damage. **(Photo: CZM)**

In addition, no grout (e.g., cement) should be used in between the rocks in revetments because it smoothes the surface. Chinking (filling gaps with stones) should also only be done to the extent needed to structurally stabilize the revetment. Filling every void with small stones should be avoided because it reduces wave dissipation, and the small stones can become projectiles in a storm. Adequate void space between rocks also provides better habitat for marine species. Marine animals cannot hide or attach to flat, high energy surfaces. Rough surfaces with spaces in between rocks also reduce wave energy and provide spaces for encrusting organisms, like shellfish and anemones, and hiding spots for small fish. Through this approach, the area will be more diverse and biologically productivity, resulting in a more environmentally friendly seawall.

Structure Height

The higher the seawall or revetment, the more surface area there is to reflect wave energy. Therefore, projects that raise the height of an existing seawall or revetment must be considered carefully in light of the additional erosion that may be caused by wave energy reflected downward. The design height of seawalls and revetments is typically determined by balancing the desired level of protection to landward areas with construction costs and the need to minimize erosion of the fronting beach, which can compromise the structure in the future.

For sites with high banks, the bank itself also serves as a vertical buffer to waves and storm surge. Rather than increasing the height of the structure in these areas, efforts can be made to stabilize the upper bank using vegetation, natural fiber blankets, and/or coir rolls. See the following StormSmart Properties fact sheets for information on these techniques: *Planting Vegetation to Reduce Erosion and Storm Damage*, *Bioengineering - Coir Rolls on Coastal Banks*, and *Bioengineering - Natural Fiber Blankets on Coastal Banks*.



The bank above this revetment was stabilized with natural fiber blankets and native, salt-tolerant vegetation. **(Photo: Wilkinson Ecological Design)**

Water overtopping this seawall in a storm eroded the lawn and sediments behind it. Replacing the sediment and planting salt-tolerant vegetation may help to reduce erosion in future storms. **(Photo: CZM)**

For sites without high banks, raising the height of the structure may be appropriate to provide protection from overtopping waves during large storm events. However, the increased wave reflection will likely result in greater beach erosion. Where appropriate, an alternative approach would be to add sediment to the beach and/or dune seaward of the structure to dissipate wave energy before it reaches the structure. Salt-tolerant vegetation with deep roots can also be used in conjunction with natural fiber blankets to address erosion behind seawalls and revetments. See the following StormSmart Properties fact sheets for more information: *Artificial Dunes and Dune Nourishment*, *Planting Vegetation to Reduce Erosion and Storm Damage*, and *Beach Nourishment*.

Transition to Adjacent Properties

During repair and reconstruction, it may be necessary to consider changes to reduce "end effects"—the increased erosion and storm damage to adjacent properties caused by the seawall or revetment. Unless the structure connects to an existing structure on an adjacent property, it should be shortened so that it ends approximately 15 to 20 feet from the property line (where feasible and where adequately protective of the building on the site). The ends of the structure should also be tapered so that both its elevation and slope are gradually reduced to further minimize end effects.

Natural fiber blankets, coir rolls, artificial dunes, beach nourishment, and vegetation should also be considered for use at the end of the structure to both reduce end effects and provide the needed protection to the property. See the following StormSmart Properties fact sheets: *Artificial Dunes and Dune Nourishment*, *Planting Vegetation to Reduce Erosion and Storm Damage*, *Bioengineering - Coir Rolls on Coastal Banks*, *Bioengineering - Natural Fiber Blankets on Coastal Banks*, and *Beach Nourishment*.

The end effects of this concrete seawall are causing erosion of the bank and damage to the parking area on a neighboring property. **(Photo: CZM)**

Coir rolls, natural fiber blankets, and fill were installed to prevent erosion at the end of this bulkhead. **(Photo: Wilkinson Ecological Design)**

Controlling Erosion from Overland Runoff and Other Sources

To help ensure the success and longevity of a repaired or reconstructed structure, all sources of erosion on the site—including upland runoff and waves—should be identified and addressed as part of the site evaluation and design process. Signs that overland runoff or wave overtopping has caused erosion around seawalls and revetments include erosion of sediment behind seawalls or under revetments and sinkholes behind structures. If overland runoff is causing erosion, this runoff should be reduced or redirected (see *StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion* for details).

Seawall repair or reconstruction projects should include improvements to the drainage system to prevent pressure from building up behind the wall due to wave overtopping or ponding of rainwater. This pressure is one potential cause for structural failure.

To minimize soil erosion behind seawalls and under revetments—which can compromise the integrity of the structure and potentially cause it to fail—woven filter fabric should be placed between the structure and the ground surface during construction (see figure above of a cross section of a revetment). The fabric holds the sediment in place, while the water drains.

Beach Access

According to the requirements of the Massachusetts Public Waterfront Act, coastal property owners are required to maintain public access along the shore for the purposes of "fishing, fowling, and navigation." With hard structures, the best way to protect shoreline public access is to keep the structure as far landward as possible and maintain the height of the beach in front of the structure. When erosion results in no fronting beach at mean high tide, then the reconstruction or repair of the structure will require a license from the Massachusetts Department of Environmental Protection (MassDEP) Waterways Program that specifies how the property owner will maintain required public access. For additional details on these requirements, see the MassDEP Waterways Program web page.

Protecting Existing Vegetation

Vegetation plays an important role in erosion prevention and shoreline protection. Therefore, any destroyed or damaged vegetation should be replaced after project completion. If damaged vegetation consisted of invasive species, large trees that may have been destabilizing the top of the coastal bank or dune, or plants with shallow root structures, the vegetation may be replaced with native grasses and/or shrubs that are more appropriate for erosion control. See *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage* for more information on the use of native, salt-tolerant species for erosion control, as well as information on how to protect newly planted vegetation while it gets established.

Minimizing Impacts to Habitat, Wildlife, and Fisheries

During repair or reconstruction, changes should be incorporated into a hard structure's design to reduce impacts to sensitive habitats. These changes include reducing the amount of wave reflection and erosion caused by the structure, as well as addressing the impact of the structure on sediment levels in the beach system. Any loss of sediment caused by the hard structure can result in erosion to and eventual loss of habitat for shorebirds and other species. In addition, redesigning seawalls to include shelves and crevices within the intertidal and subtidal areas provides more habitat for marine animals, including shellfish.

Restrictions on the time of year when repair or reconstruction can be conducted may also be required to avoid impacts to protected species. The Natural Heritage and Endangered Species Program of the Massachusetts Division of Fisheries and Wildlife can provide information on the species listed as endangered, threatened, and of special concern in Massachusetts, including their location and any special design or permitting requirements under the Massachusetts Endangered Species Act and the rare wildlife sections of the Wetlands Protection Act. The Massachusetts Division of Marine Fisheries Habitat Program can provide information on fish and shellfish species and locations that may have special design or permitting requirements.

Heavy Equipment Use

Access for heavy equipment must be carefully planned to avoid destruction of existing vegetation; creation of ruts; destabilization of banks, dunes, or other landforms; impacts to wildlife and nesting habitat for protected shorebird and turtle species; and related impacts. To the extent possible, heavy equipment operators should avoid running over beaches multiple times, which can compact sediments and prevent them from moving and shifting to effectively dissipate wave energy. When mechanical equipment is being used, contractors should keep hazardous material spill containment kits on-site at all times in case there is a release of oil, gasoline, or other toxic substances.

Permitting and Regulatory Standards

Most seawall and revetment repair and reconstruction projects are likely to require a permit under the Massachusetts Wetlands Protection Act through the local Conservation Commission. Additional licenses and permits may be needed from MassDEP and the U.S. Army Corps of Engineers if the project footprint extends below the mean high water line or seaward of the reach of the highest high tide of the year, respectively. Depending on the project location and the work involved, permits or approvals may also be required from other state agencies and local departments, particularly for larger projects. Massachusetts Environmental Policy Act (MEPA), Massachusetts Endangered Species Act, and CZM federal consistency review requirements may apply. Often, Conservation Commission staff, as well as state and federal agencies as applicable, are available to meet with applicants early in the design process to go over the important factors that need to be considered during the design and permitting.

Permitting requirements are typically more stringent for hard structures than for non-structural alternatives, such as beach and dune nourishment. However, regulatory programs are generally supportive of repair and reconstruction projects that are designed to reduce the adverse impacts being caused by the structure. Projects that have been designed so that the repaired or reconstructed structure is within the same general footprint as the existing structure (i.e., does not extending farther seaward) and include mitigation for any impacts to the fronting, adjacent, and downdrift beaches and banks and dunes generally have fewer issues during permit review and authorization.

Professional Services Required

A coastal engineer with expertise in designing, repairing, and reconstructing coastal engineering structures should be consulted to: 1) identify regulatory requirements and ensure the project fully conforms with those requirements; 2) determine the conditions at the site that will affect the project (such as the width of dry beach above high tide, wave exposure, and predicted flood elevations); 3) assess the condition of the structure and the level of protection it is providing; 4) determine what design changes are needed to reduce the impacts of the structure and increase its longevity; 5) develop a monitoring and mitigation plan to address sediment loss to the beach system (i.e., the loss of sediment from armoring of sediment-source banks and increased erosion of the fronting beach); 6) determine if other shoreline stabilization techniques are needed in addition to the structure; 7) identify the best time of year to install the various components of the project; 8) prepare design plans for permitting; 9) develop an access plan for heavy equipment; and 10) prepare design specifications for construction. The consultant can also oversee permitting, construction, monitoring, mitigation, and maintenance of the project. As with hiring any contractor, consider meeting with multiple engineers to compare how they would address site-specific design issues.

Project Timeline

It may take six to eight months or more to have a repair or reconstruction project designed, permitted, and completed, assuming that only a Massachusetts Wetlands Protection Act permit is required—but it can take longer, depending on the factors involved. Factors influencing this timeline include the extent of the proposed repairs or reconstruction, whether the proposed work mitigates for adverse impacts of the existing structure, the contractor’s experience with designing and permitting similar projects, completeness of permit applications, special considerations in the permitting process (such as objections by abutters, sensitive resources to be protected, and availability of access for construction), the need for special timing to avoid impacts (e.g., a prohibition on construction during endangered species nesting season), and/or weather conditions during construction.

Monitoring, Mitigation, and Maintenance Requirements

As described in the design considerations section, regular maintenance of coastal engineering structures will likely include adding sediment to maintain the fronting beach. The amount of sediment that should be added and how frequently it is needed will depend, in part, on the proximity of the structure to the reach of high tide, the frequency and severity of storms, and the type and design of the structure (e.g., rough-faced sloping rock revetment vs. vertical wall). Pulling the structure back from the high tide line and reducing its steepness helps to minimize the need for maintenance and mitigation. A monitoring plan developed during the permitting process should specify the volume and grain size of sediment that should be placed on the beach, how the beach elevation will be monitored, who the monitoring reports will be submitted to, and when additional sediment may be needed to mitigate for beach erosion.

Other maintenance activities can include resetting rocks if they have moved or shifted significantly, re-chinking, adding soil behind the structure to replace eroded material, re-vegetating eroded areas behind the structure, filling cracks in concrete seawalls, and replacing rotted wood or metal components. For projects that include planting vegetation, the plants should be replaced (at the appropriate time of year) if they are removed by storms or die (until the plants become fully established, such losses are more common). See *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage* for more information. A schedule and plan for replacing sediments and plants should be included in the original permit application and approved as ongoing conditions of the permit so that maintenance can be conducted without additional permitting.

Project Costs

With projects involving repair or reconstruction of coastal engineering structures, permitting, design, and construction costs will vary depending on the extent of repairs needed and site-specific considerations. Maintenance costs will depend, in part, on the amount of sediment needed to maintain beach levels, as well as factors such as storm damage and erosion levels. Adding this sediment, however, can lower the costs of maintaining the structure itself. The considerations that most influence the costs of repair or reconstruction projects are the condition of the structure, severity of erosion, width and elevation of the beach, complexity of project design and permitting, and size and location of the proposed structure. For comparison with other shoreline stabilization options, reconstruction projects typically have relatively high design and permitting costs and high construction costs. Repair projects will vary depending on the amount of work to be done, but they typically are also relatively high. While yearly maintenance costs for repair and construction projects are relatively low, long-term maintenance costs (i.e., future major repairs or reconstruction) are high and costs to mitigate for adverse impacts are medium. For a full comparison, see the StormSmart Properties chart, *Relative Costs of Shoreline Stabilization Options* (PDF, 99 KB).

Additional Information

Many other erosion management techniques can be used in conjunction with repair and reconstruction projects to minimize the adverse impacts of these structures and increase their longevity. See the following CZM StormSmart Properties fact sheets for additional information:

- *StormSmart Properties Fact Sheet 1: Artificial Dunes and Dune Nourishment*
- *StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion*
- *StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage*
- *StormSmart Properties Fact Sheet 4: Bioengineering - Coir Rolls on Coastal Banks*
- *StormSmart Properties Fact Sheet 5: Bioengineering - Natural Fiber Blankets on Coastal Banks*
- *StormSmart Properties Fact Sheet 8: Beach Nourishment*

The following publications and websites also provide valuable information on repair or reconstruction of seawalls and revetments:

- *Maintaining Shoreline Erosion Control Structures* (PDF, 2 MB) by the New York Sea Grant Program includes information on how to determine if coastal engineering structures need maintenance.
- CZM's Inventories of Seawalls and Other Coastal Structures web page includes information on the cost of repairs and reconstruction of seawalls.
- *Beach Nourishment: MassDEP's Guide to Best Management Practices for Projects in Massachusetts* (PDF, 2 MB) describes the steps for beach nourishment projects. The *Technical Attachments* (PDF, 1 MB) give detailed information on sampling beach sediments, evaluating offsite source material, and monitoring project performance.
- The U.S. Army Corps of Engineers *Coastal Engineering Manual* provides detailed guidance on the importance of using site-specific information on coastal erosion and other processes, as well as planning and design considerations.
- Massachusetts Wetlands Protection Act Regulations (310 CMR 10.00) cover work in wetland resource areas and buffer zones.
- Massachusetts Public Waterfront Act (Chapter 91) covers requirements for protecting public trust rights in tideland areas, such as with projects seaward of the current mean high tide line.
- CZM's *Environmental Permitting in Massachusetts* gives brief descriptions of major environmental permits required for projects proposed in Massachusetts.
- CZM's Public Rights Along the Shoreline web page explains the ownership of tidelands in Massachusetts and describes the scope of public and private rights under the Public Trust Doctrine.
- *Guidelines for Barrier Beach Management in Massachusetts* (PDF, 12 MB), which was produced by the Massachusetts Barrier Beach Task Force in 1994, provides an overview of the Wetlands Protection Act Regulations and the function of resource areas, along with information on various erosion management techniques.
- CZM's Coastal Landscaping website focuses on landscaping coastal beaches, dunes, and banks with salt-tolerant vegetation to reduce storm damage and erosion.
- CZM's *Landscaping to Protect Your Coastal Property from Storm Damage and Flooding fact sheet* (PDF, 962 KB) gives specific information for homeowners on appropriate plants for erosion control in coastal areas.
- The Natural Heritage and Endangered Species Program website provides information on threatened and endangered species in Massachusetts, maps of Estimated and Priority Habitats, and details on regulatory review for projects in or adjacent to these habitats.
- The Massachusetts Division of Marine Fisheries can provide information on protection of fisheries resources.
- The Massachusetts Ocean Resource Information System, or MORIS, is a user-friendly, web-based mapping tool for interactively viewing coastal data. It includes shoreline change data, which should be considered when evaluating and designing erosion-control or shoreline-stabilization projects. Other data layers in MORIS, such as endangered species habitat, shellfish, and eelgrass, can be used to help identify sensitive resource areas within or near the project site.

www.mass.gov/stormsmart-coasts-program

Commonwealth of Massachusetts
Charlie Baker, Governor

Executive Office of Energy and Environmental Affairs
Matthew A. Beaton, Secretary

Massachusetts Office of Coastal Zone Management
Bruce K. Carlisle, Director

Massachusetts Office of Coastal Zone Management | 251 Causeway Street, Suite 800 | Boston, MA 02114 | (617) 626-1200
CZM Information Line: (617) 626-1212 | **CZM Website**: www.mass.gov/czm

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Publication Date: December 2013, with updates in 2018

StormSmart Properties Comparison Chart - Relative Costs of Shoreline Stabilization Options

With shoreline stabilization projects, there are typically a range of options available that give increasing levels of protection with increased costs. In addition, whenever you hire a professional to conduct work on your property, total costs are expected to vary significantly based on site-specific considerations. These considerations include the severity of erosion, condition of the existing site (e.g., proximity of the eroded area to the high tide line), exposure to wind and waves, frequency of storm events, proximity to endangered or threatened species habitat, and complexity of project design and permitting. The following table provides relative costs for permitting, construction, maintenance, and mitigation for various shoreline stabilization techniques to reduce erosion, flooding, and storm damage.

Technique	Relative Costs				
	Design and Permitting	**Construction**	**Expected Maintenance Frequency[1]**	**Average Annual Maintenance Costs[2]**	**Average Annual Mitigation Costs[3]**
Artificial Dunes & Dune Nourishment	Low	Low	1-5 years	Low	None
Controlling Overland Runoff	Low	Low	5-20 years	Low	None
Planting Vegetation	Low	Low	1-3 years	Low	None
Bioengineering - Coir Rolls on Coastal Banks	Low-Medium	Medium-High	1-3 years	Low-Medium	Low
Bioengineering - Natural Fiber Blankets on Coastal Banks	Low	Low	1-3 years	Low	None
Sand Fencing	Low	Low	3-5 years	Low	None
Beach Nourishment	Medium	Low-Medium	5-10 years	Low	Low
Rock Revetments - Toe Protection	High	High	10-20 years	Low	Low- Medium
Rock Revetments - Full Height (up to predicted flood zone elevation)	Very High	Very High	20-25 years	Low	Medium
Seawall	High-Very High	Very High	25-40 years	Low	Medium-High

COST ESTIMATES *(average cost per linear foot of shoreline)*
Low: <$200
Medium: $200-500
High: >$500-1,000
Very High: >$1,000

[1]The frequency of required maintenance is highly dependent on storm severity and frequency and shoreline exposure. See StormSmart Properties fact sheets for details on maximizing longevity.
[2]Estimated, annual costs averaged over the life of the project to maintain project components, assuming the project is designed and installed properly.
[3]Estimated, annual costs averaged over the life of the project to compensate for the technique's adverse effects.

Source: CZ-Tip - Basics of Building Beach Access Structures that Protect Dunes and Banks | Mass.gov

CZ-Tip - Basics of Building Beach Access Structures that Protect Dunes and Banks

Find ways to get to, protect, and enjoy the coast with tips from the Massachusetts Office of Coastal Zone Management (CZM).

Boardwalks, walkways, stairways, and other structures that provide beach access over dunes and banks can cause erosion and increase storm damage if not properly designed. Potential problems include limiting the growth of plants that stabilize the shoreline and creating wind and water channels that lead to scour, erosion, and flooding of landward properties. Properly designed access structures not only minimize these impacts, but actually provide significant benefits—they help to define and maintain pedestrian access in one location, discourage widespread trampling of vegetation, allow for the natural movement of sand and other sediment, and stabilize dunes and banks to help protect coastal properties from waves, wind, erosion, storm surge, and flooding.

This tip covers the importance of vegetation for dune and bank stability, the benefits of elevated access structures, permitting requirements, and recommended design and construction methods for access structures.

Vegetation and Dune and Bank Stability

Salt-tolerant plants with extensive root systems help stabilize dunes and banks—roots hold sediments in place and leaves and stems absorb water, break the impact of raindrops or wave splash, and slow and diffuse the flow of overland runoff. Plants can also help trap windblown sand, which is particularly important for building dunes and buffering inland areas from storm waves, erosion, and flooding. For more information on the benefits of coastal plants on dunes and banks, see the Massachusetts Office of Coastal Zone Management's (CZM) StormSmart Properties Fact Sheet 3: Planting Vegetation to Reduce Erosion and Storm Damage.

American beachgrass is particularly useful for stabilizing dunes because it is extremely hardy and grows readily on the coast. In addition, its fast-growing rhizomes (underground stems) effectively stabilize sediments and allow for quick establishment of new plants. (For more on the benefits of beachgrass for dune stability, see CZ-Tip - Dune Building with Beachgrass.)

Elevated Structures

Pathways at ground level do not define and designate pedestrian access to the beach as clearly as elevated structures and can lead to the trampling of nearby beachgrass and other stabilizing vegetation. In addition, since low pathways are not always clearly visible, pedestrians often inadvertently create additional pathways to get to the beach. Dune plants, including beachgrass, are vulnerable to being trampled—walking directly over or through a dune can kill dune plants and create landslides, bare spots, and the potential for dune blowouts (i.e., areas where strong winds “blow out" sand and form a depression), as well as lower the overall height and stability of the dune. Walking over banks can also kill vegetation, leading to landslides, erosion, and reduced bank stability.

Boardwalks, walkways, and stairways are therefore preferable to at-grade pathways. Not only are they clearly visible and defined, they also allow for the growth of stabilizing vegetation and the natural movement of sand and sediments beneath them. (In some circumstances, however, at-grade rollout structures used on a seasonal basis are a good option—see “**Sectional, Adjustable, and Temporary Design Elements**” below for more information.)

Permits First!

Because activities on the coast can easily impact natural resources and neighboring properties, they are strictly regulated. The construction or replacement of a boardwalk, walkway, or stairway on or near a dune, bank, or beach will require a permit under the Massachusetts State Building Code, as well as a permit through your local Conservation Commission and the Massachusetts Department of Environmental Protection's (MassDEP) Wetlands and Waterways Program. (Contact your city or town for local permit applications and requirements.) Though a permit is required, the Wetland Protection Act Regulations allow and encourage pedestrian walkways on dunes, provided that they are designed to minimize the disturbance to vegetation and promote the ability of dunes to move, shift, and migrate. Construction of structural accessways may also warrant review by the Natural Heritage and Endangered Species Program (NHESP) to ensure there are no conflicts with bird nesting habitat or other species requirements. Depending on project location and the work involved, other permits or approvals may also be required, such as under the state’s Chapter 91: Public Waterfront Act and its Waterways Regulations (310 CMR 9.00) and the federal Rivers and Harbors Act and Program Regulations.

Design and Construction Tips

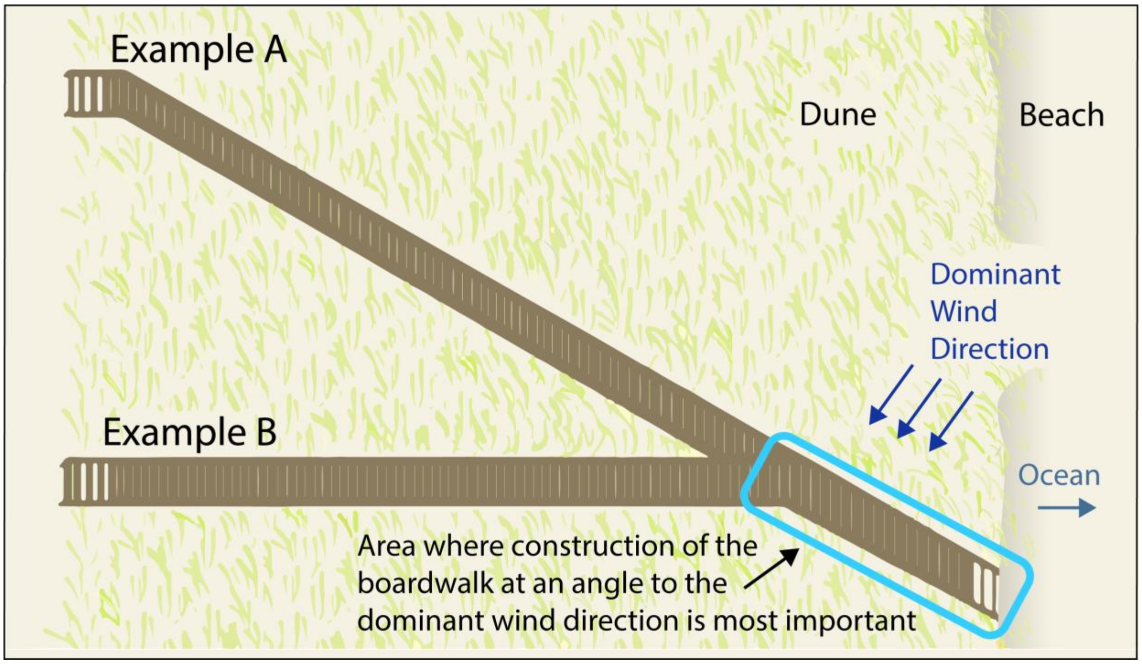
To rebuild pedestrian accessways in a way that minimizes impacts to coastal dunes and banks, follow these design and construction guidelines:

- **Size** - Overly large structures on coastal dunes and banks limit growth of beachgrass or other salt-tolerant vegetation. In general, boardwalks, walkways, and stairways should be no wider than 4 feet (and preferably narrower) and extend no longer than necessary to provide access to the beach (see “**Orientation**” below for more details).
- **Elevation** - Sufficient elevation is important for plant growth and to allow the natural movement of sand and other sediments under and around the structure. For dunes, elevating the structure on posts or pilings without footings—and at least 2 feet above the grade of the surrounding dune—will allow for easy movement of sand or sediments, dune growth, and enough sunlight to penetrate under the structure for plant growth. It is important to elevate the access structure 2 feet above the grade of the surrounding dunes (and not just 2 feet above the dune directly below the structure) to ensure elevation is maintained after the dune builds back up. For banks, elevating the structure at least 2 feet above grade allows for the growth of stabilizing vegetation and the natural movement of bank sediments to feed area beaches.

This boardwalk is elevated 2 feet above the surrounding grade to allow sunlight to penetrate, plants to grow, and sediments to move.

- **Additional Options for Increasing Sunlight** - The elevated structure can be built with additional elements that help reduce shading impacts on plants. Sections of metal grate with openings can be used for the walkway’s surface, or planks can be spaced 1 inch apart (enough space to allow sunlight to penetrate under the structure, but not enough to impede safe access on the walkway). For stairways, using treads without risers will also reduce shading effects on plants.

- **Orientation** - Avoid the creation of damaging wind or wave tunnels by properly orienting the boardwalk, walkway, or stairway across the dune. The recommended approach is to construct the structure at an angle away from the dominant wind and wave direction (see Example A in the figure below). As long as the walkway section closest to the beach is oriented in this manner, a break in the angle can be constructed in the more sheltered area further inland to reduce the length of the walkway (see Example B).



Boardwalks correctly constructed at an angle to the dominant wind direction.

Roll-out, sectional, at-grade boardwalk

- **Sectional, Adjustable, and Temporary Design Elements** - Access structures can be built with elements to reduce impacts over time, such as the use of breakaway sections to minimize impacts to the stability of the underlying dune or bank if a section is destroyed. An alternative to permanent elevated structures on dunes is the seasonal use of roll-out, at-grade, sectional boardwalks. These temporary structures can be removed during the off-season to reduce the potential for storm debris and to allow the dune to function unimpeded when wind-driven sediment transport is generally higher and the demand for beach access is reduced.

- **Reducing Overland Runoff Issues** - Another consideration, particularly on coastal banks, is overland runoff (rainwater, snowmelt, and water from irrigation systems and other sources that does not soak into the ground or evaporate, but instead flows over the ground surface). Generally, runoff should be redirected away from the top of the bank, particularly at the access point of the structure, to avoid creating a gully and erosion of the bank face. The area under the walkway can also be planted to stabilize the soils and sediments. See CZM's StormSmart Properties Fact Sheet 2: Controlling Overland Runoff to Reduce Coastal Erosion for more information.
- **Time of construction** - Construction activities should be timed to minimize or avoid impacts if they are in or adjacent to endangered or threatened species habitat (contact NHESP for additional information). In addition, construction that will remove plant cover and expose areas to erosion during the storm season (winter) is not recommended. When planting, allow enough time for beachgrass to grow in the spring or fall to be able to provide protection and stability to the underlying landform.
- **Materials** - When deciding the type of construction material to use for your structure, consider materials that will resist rot and other deterioration. Though pressure treated wood is effective, it contains arsenic, which poses health risks to you and the environment. See MassDEP's Q&A: Pressure Treated Wood page for information on the health risks associated with this product. Other options include non-arsenic-containing hardwoods (such as cedar and redwood), wood composites, and non-wood alternatives such as metals and plastics.
- **Maintenance** - General maintenance is typically required to ensure the longevity of the structure, such as repairing and replacing sections. Any components of the structure that are damaged or broken should be removed to ensure public safety and natural sediment movement.

ATTACHMENT C

MA NHESP Rare Species Fact Sheet

Natural Heritage & Endangered Species Program

www.mass.gov/nhesp

Massachusetts Division of Fisheries & Wildlife

Piping Plover
Charadrius melodus

State Status: **Threatened**
Federal Status: **Threatened**

GENERAL DESCRIPTION: The Piping Plover is a small, stocky shorebird with pale brownish gray or sandy-colored plumage on its backside, with a white breast, forehead, cheeks, and throat, a black streak on the forecrown extending from eye to eye, and a black breastband which may not always form a complete circle. Its coloration gives it excellent camouflage in sandy areas. The average Piping Plover is 15 to 17 cm (6 to 7 in.) long, with a wingspan of 35 to 40 cm (14 to 16 in.). The tail is white at the base and tip, but dark in the middle. It has yellow-orange legs and its short bill is yellow-orange with a black tip in the summer, but turns completely black during the winter. In general, females have darker bills and lighter plumage than males. The Piping Plover runs in a pattern of brief starts and stops; in flight, it displays a pair of prominent white wing stripes. Its call is a series of piping whistles.

SIMILAR SPECIES: The Piping Plover is similar to the Semipalmated Plover (*Charadrius semipalmatus*) in size, shape, and coloration. However, the Semipalmated Plover is a darker brown in color, and has much more black on its head than the Piping Plover. The Semipalmated Plover does not breed in Massachusetts but is present on sandy beaches and intertidal flats from late July to early September during its southward migration.

HABITAT: Piping Plovers in Massachusetts nest on sandy coastal beaches and dunes, which are relatively flat and free of vegetation. Piping Plovers often build their nests in a narrow area of land between the high tide line and the foot of the coastal dunes; they also nest in Least Tern colonies. Nesting may also occur on vegetated dunes and in eroded areas behind dunes.

RANGE: During spring and summer, the Atlantic Coast population of Piping Plovers nests from the Newfoundland south to North Carolina. In winter they migrate farther south, from North Carolina to Florida, the Gulf of Mexico, and the Caribbean. Other populations of Piping Plovers nest along rivers on the Northern Great Plains and along the shores of the Great Lakes, migrating to the Gulf of Mexico in the winter.

POPULATION STATUS IN MASSACHUSETTS: The Atlantic Coast population of Piping Plovers is listed as Threatened at both the state and federal levels. In 2005, 475 breeding pairs nested at about 100 sites.

Massachusetts has the largest breeding population of Piping Plovers along the Atlantic Coast.

LIFE CYCLE / BEHAVIOR: As soon as Piping Plovers return to their breeding grounds in Massachusetts in late March or April, the males begin to set up territories and attract mates. Territorial rivalry between males is very strong; adjacent male Piping Plovers mark off their territories by running side by side down to the waterline. Each bird takes turns, one running forward a few feet, then waiting for the other to do likewise. Nests are usually at least 200 feet apart; the nesting pair will confront any intruding Piping Plover which approaches the nest. Male Piping Plovers also defend feeding territories encompassing beach front adjacent to the nesting territory.

Courtship consists of a ritualized display by the male, who flies in ovals or figure-eights around a female, then displays on the ground by bowing his head, dropping his wings, and walking in circles around the female. The male also scrapes shallow depressions in the sand at potential nest sites. The female then chooses one of these nesting sites, usually in a flat, sandy area. The nest itself is a shallow depression which is often lined with shell fragments and small pebbles, which may aid in camouflaging the eggs. Female Piping Plovers typically lay four eggs per clutch, one egg every other day over a week's time. The eggs are sandy gray in color with dark brown or black spots, and all hatch within 4 to 8 hours of each other. Both parents take part in incubating the eggs until they hatch 26-28 days later.

The young chicks leave the nest within hours after hatching and may wander hundreds of meters before they become capable of flight. When threatened by predators or human intruders, the young run or lie motionless on the sand while their parents often pretend to have broken wings in an effort to attract the intruder's attention away from the chicks. Young Piping Plovers are brooded by their parents for 3 to 4 weeks and finally fledge 4 to 5 weeks after hatching, at which time they leave the nesting area.

Piping Plovers feed on marine worms, mollusks, insects, and crustaceans. They forage along the waterline, on mudflats at low tide, and in wrack (seaweed, marsh vegetations and other organic debris deposited by the tides) along the beach. Foraging behavior consists of running a short distance, then staring at the ground with the head tilted to one side, often standing on one foot while vibrating the other foot on the ground, and finally pecking at the food item it has detected in the sand.

Piping Plovers begin to migrate southward between late July and early September, although occasional stragglers remain behind until late October. Adult birds often return to the same nesting area every spring, although they usually change mates from year to year. Young birds may nest anywhere from a few hundred feet to many miles from where they were hatched.

Updated 2015

A Species of Greatest Conservation Need in the Massachusetts State Wildlife Action Plan

ATTACHMENT D

Shoreline Stabilization Infrastructure Information:

Table 1. Shoreline Stabilization Infrastructure
Segments and Owners

Shoreline Stabilization Structures Overview and Detail Figures

Table 1. Shoreline Stabilization Infrastructure Segments and Owners

Shoreline Stabilization Segment Information*							Owner Information**				
Structure ID	**Shoreline Stabilization Type**	**Primary Material**	**Map-Block-Parcel ID**	**Ownership**	**Site Address**	**Zoning**	**Owner**	**Address**	**City**	**State**	**Zip Code**
248-013-192N-005-001	Revetment	Stone	13-192N-4	Private	26 PINES RD	RA	PETER A CERBONE FAM IRREVOCABL	26 PINES RD	REVERE	MA	02151
			13-192N-5	Private	32 PINES RD	RA	CERBONE MERYL	26 PINES RD	REVERE	MA	02151
248-013-192N-008-002	Bulkhead/Seawall	Stone	13-192N-8	Private	33 PINES RD	RA	TRANIELLO RALPH E	33 PINES RD	REVERE	MA	02151
248-013-192N-008-003	Bulkhead/Seawall	Stone	13-192N-8	Private	33 PINES RD	RA	TRANIELLO RALPH E	33 PINES RD	REVERE	MA	02151
248-013-192N-008-004	Bulkhead/Seawall	Stone	13-192N-8	Private	33 PINES RD	RA	TRANIELLO RALPH E	33 PINES RD	REVERE	MA	02151
248-013-192O-001-001	Bulkhead/Seawall	Concrete/Stone	13-192O-1	Private	0 RICE OPPOSITE AVE	RA	JOANN BERTOLINO REVOCABLE TRUST	415 RICE AVE	Revere	MA	02151
			13-192N-4	Private	26 PINES RD	RA	PETER A CERBONE FAM IRREVOCABL	26 PINES RD	REVERE	MA	02151
248-013-192O-UNK-001	Bulkhead/Seawall	Concrete	13-192O-7	Private	0 RICE OPPOSITE AVE	RA	JIANG LIMEI	369 RICE AVE	REVERE	MA	02151
			14-0-UNK	Unknown							
			14-192O-9	Private	0 RICE AVE	RA	ZINGARIELLO CARMINE	76 DELANO AVE	REVERE	MA	02151
			13-192O-3	Private	0 RICE OPPOSITE AVE	RA	ODONNELL JAMES F	40 HARRINGTON AVE	REVERE	MA	02151
			13-192O-5	Private	0 GOODWIN (OPPOSIT AVE	RA	CURRTELLI FAMILY TRUST	53 GOODWIN AVE	REVERE	MA	02151
			13-192O-8	Private	0 RICE AVE	RA	345 RICE AVE LLC	11 FERNCROFT WAY	MALDEN	MA	02148
			13-192O-4	Private	0 RICE OPPOSITE AVE	RA	LIBERATORE SUZANNE	391 RICE AVE	REVERE	MA	02151
			14-0-UNK	Unknown							
			13-192O-6	Private	0 RICE OPPOSITE AVE	RA	RICCIO DAVID	375 RICE AVE	REVERE	MA	02151
			13-192O-UNK	Unknown							
248-014-192O-023-001	Bulkhead/Seawall	Concrete	14-192O-23	Private	0 RICE AVE	RB	POINT OF PINES BEACH ASSOC INC	24 DELANO AVE	REVERE	MA	02151
248-014-192O-023-002	Bulkhead/Seawall	Concrete	14-192O-23	Private	0 RICE AVE	RB	POINT OF PINES BEACH ASSOC INC	24 DELANO AVE	REVERE	MA	02151
248-009-192R-001-001	Bulkhead/Seawall	Stone	9-192R-1	State	0 REVERE BEACH BLVD	RC	COMMONWEALTH OF MASSACHUSETTS	20 SOMERSET ST	BOSTON	MA	02108
			13-192N-8	Private	33 PINES RD	RA	TRANIELLO RALPH E	33 PINES RD	REVERE	MA	02151
248-013-192N-008-001	Revetment	Stone	9-192R-1	State	0 REVERE BEACH BLVD	RC	COMMONWEALTH OF MASSACHUSETTS	20 SOMERSET ST	BOSTON	MA	02108
			13-192N-8	Private	33 PINES RD	RA	TRANIELLO RALPH E	33 PINES RD	REVERE	MA	02151
			13-192N-7	Private	35 PINES RD	RA	WUNDERLICH KENNETH	35 PINES RD	REVERE	MA	02151
			13-192N-6	City	0 PINES REAR RD	RA	CITY OF REVERE	281 BROADWAY	REVERE	MA	02151

*Source: MORIS - CZM's Online Mapping Tool (http://maps.massgis.state.ma.us/map_ol/moris.php)

**Source: MassGIS (http://maps.massgis.state.ma.us/map_ol/oliver.php)

POINT OF PINES
BEACH MANAGEMENT PLAN AREA

SHORELINE STABILIZATION STRUCTURES - OVERVIEW
Revere, Massachusetts

Legend

Seawall - Private

Beach Management Plan Area

1 inch = 400 feet

0 400 Feet

AECOM

Date: 1/15/2021

FIGURE 1.

POINT OF PINES
BEACH MANAGEMENT PLAN AREA

SHORELINE STABILIZATION STRUCTURES - DETAIL 1
Revere, Massachusetts

Legend

Seawall - Private

Beach Management Plan Area

Parcels with Private Seawall

1 inch = 60 feet

0 30 60 Feet

AECOM

Date: 1/15/2021

C:\Work\60646341\REV\Maps\BeachManagementPlan_Seawall_grid.mxd

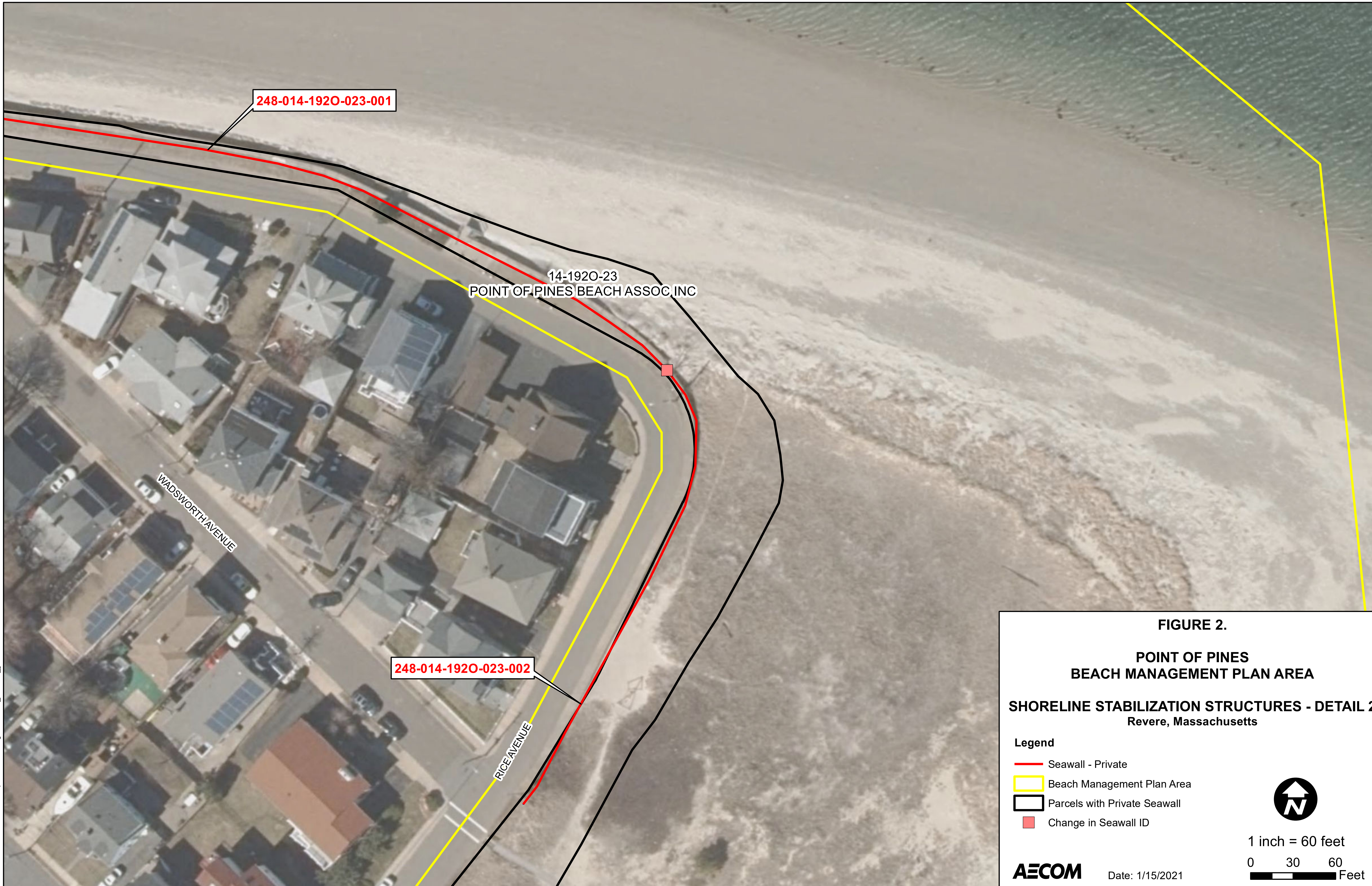


FIGURE 2.

POINT OF PINES
BEACH MANAGEMENT PLAN AREA

SHORELINE STABILIZATION STRUCTURES - DETAIL 2
Revere, Massachusetts

Legend

- Seawall - Private
- Beach Management Plan Area
- Parcels with Private Seawall
- Change in Seawall ID

1 inch = 60 feet

0 30 60 Feet

AECOM

Date: 1/15/2021

C:\Work\60646341\REV\Maps\BeachManagementPlan_Seawall_grid.mxd

FIGURE 3.

POINT OF PINES
BEACH MANAGEMENT PLAN AREA

SHORELINE STABILIZATION STRUCTURES - DETAIL 3
Revere, Massachusetts

Legend

- Seawall - Private
- Beach Management Plan Area
- Parcels with Private Seawall

1 inch = 60 feet

0 30 60 Feet

AECOM

Date: 1/15/2021

FIGURE 4.

POINT OF PINES
BEACH MANAGEMENT PLAN AREA

SHORELINE STABILIZATION STRUCTURES - DETAIL 4
Revere, Massachusetts

Legend

- Seawall - Private
- Beach Management Plan Area
- Parcels with Private Seawall

1 inch = 60 feet

0 30 60 Feet

AECOM

Date: 1/15/2021

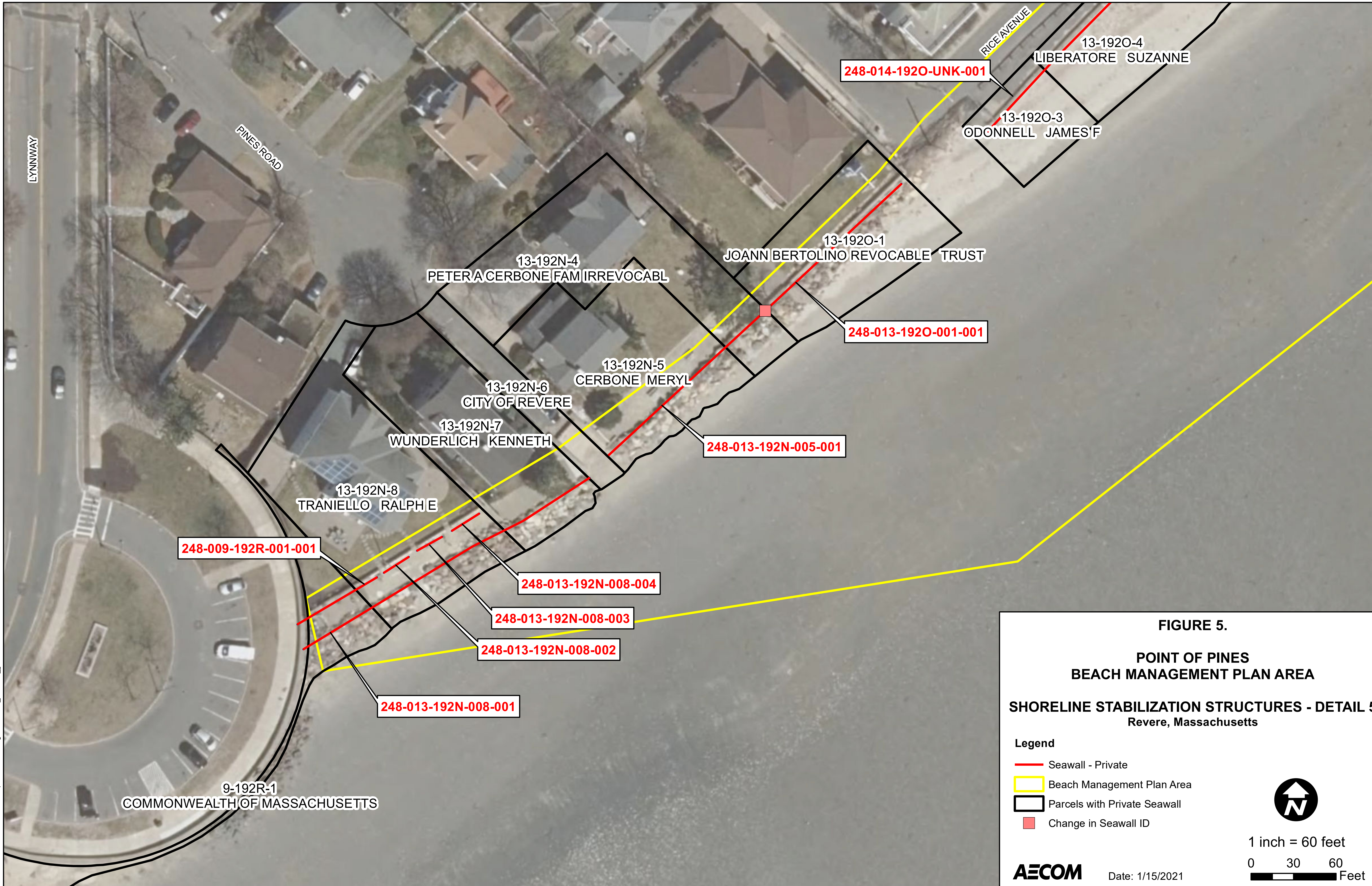


FIGURE 5.

POINT OF PINES BEACH MANAGEMENT PLAN AREA

SHORELINE STABILIZATION STRUCTURES - DETAIL 5
Revere, Massachusetts

Legend

- Seawall - Private
- Beach Management Plan Area
- Parcels with Private Seawall
- Change in Seawall ID

1 inch = 60 feet

0 30 60 Feet

AECOM

Date: 1/15/2021