Nature-Based Approaches to Control Erosion in high wave energy environments within Massachusetts

Communities around Massachusetts have designed and implemented resilient, nature-based solutions to enhance coastal resilience and protect infrastructure. Nature-based solutions offer increased coastal resiliency where more traditional coastal protection structures cannot be implemented due to environmental regulations. The nature-based alternatives are intrinsically sustainable, enhance environmental resource areas, and offer regulatory options for communities to address climate change, erosion, and coastal resiliency, while often providing recreational, ecological, and community benefits. Below is a summary of a nature-based project constructed in Massachusetts that utilizes the same nature-based techniques proposed for Forty Steps Beach.

Dynamic Cobble Beaches and Berms in Massachusetts

The use of cobble berms for shore protection dates back to the early 1970s when an artificial gravel beach was created along the entrance to Rotterdam Harbor in the Netherlands, primarily to dissipate the energy of ship wakes. Historically, coastal scientists and engineers referred to this method of coastal protection as a dynamic revetment, as it consists of gravel and cobbles that can be easily moved by waves, unlike conventional stone revetments made of larger quarry stones (Ahrens, 1990). The term cobble nourishment/berm, artificial dune, and nature-based approach are now commonly used to refer to this stabilization measure. This may be more acceptable for management purposes when engineered revetments or seawalls are discouraged or explicitly prohibited by regulations.

There are several advantages in using a cobble nourishment/berm for shore protection rather than a rock revetment or seawall. Stone sizes are significantly smaller than the armor stone required for a rock revetment, which makes construction more straightforward relative to a conventional revetment, in which each massive stone must be individually placed for the structure to be stable. The mixed sediment that is required is readily available and often easier to source than armor stone, and less expensive. The mixed sediment is usually sourced from quarries as “pit run” material or other natural sources, such as creating and managing cranberry bogs.

Another advantage is that by nourishing the beach and constructing a cobble berm, it has the same appearance and morphologic details of the natural cobble beach. The design and construction of the cobble berm enhance the width and height of the existing berm to buffer the landward infrastructure and provide a buffer from storm surge and waves. The design of the berm can also accommodate sea level rise, by introducing measured increases in height and volume during re-nourishment cycles, which allows

communities to scale the level of protection based on the observed changes, as opposed to relying on projections.

Cobble berms have been used across Massachusetts with great success. The use of cobble berms has improved the coastal resilience along the coastlines where other solutions are not permitted or appropriate. The Town of Nahant's proposed use of a cobble berm will offer the community an effective and sustainable solution to address coastal erosion and storm damage, while preventing damage to critical infrastructure and private property, thus benefiting both the community and the environment. The use of cobble berms has also been shown to provide:

- effective solution for coastal protection ;
- address ongoing erosion;
- cost-effective approach;
- preservation of natural habitat, visual aesthetics, and recreational benefits associated with a natural shoreline;
- conservation of biodiversity within the coastal resource areas;
- adaptable solution to address ongoing changing conditions, climate change, and sea level rise; and,
- minimize flood risks and storm damage for the community.

Here are examples of cobble nourishment and berms that have been used across Massachusetts:

Egypt Beach, Scituate, MA

The Mann Hill/Egypt Beach cobble berm was engineered and installed by the Town of Scituate in 1979 following the Blizzard of '78. The cobble berm was originally a naturally occurring "shingle" dunes created by erosion and littoral transport of regional glacial materials. After 1957, the Town began to monitor beach elevations along this stretch of shoreline and repair the dune system to maintain foreshore protection. The engineered cobble berm/dune was placed in 1979, and repaired by the Town in 1992, 2008, 2018, and 2020. The most notable storms to impact the dune system since the late 1950s are the Blizzard of '78, the Halloween Storm of 1991, the December Nor'easter of 1992, Winter Storm Nemo in 2013, and Winter Storm Riley in 2018. During Winter Storm Riley, earth-moving equipment was needed throughout the storm to repair various "breaches" that formed through the berm over during the storm.

The Town’s repairs have consisted of restoring the cobble berm to its 1979 design height. Restoring the dune's height and supplementing the volume adds stability and restores the dunes' ability to withstand moderate nor'easter storm impacts and protect the landward infrastructure. During significant storms, the engineered berm is designed to gradually shift landward in response to storm wave energy, similar to a natural dune

system. Due to the town's ongoing maintenance and monitoring, funding for the latest repairs was obtained from FEMA, which covered 75% of the construction costs.

Figure 1. Mann Hill/Egypt Beach nourished by the Town of Scituate in Winter of 2020 (Photo: Sustainable Coastal Solutions).

Winthrop Beach, Winthrop, MA

The Department of Conservation and Recreation (DCR) protected 4,200 linear feet of Winthrop Shore Drive by designing and building a cobble berm. The nourishment contained mixed cobble, gravel, and sand sediments, naturally sorting into a cobble berm as designed. Once the project was completed in late 2014, the high tide shoreline was pushed more than 150 feet from the seawall, with a gradual slope extending approximately 350 feet offshore. Although shoreline change modeling indicated a design life of approximately 10 years, the coarse fraction of sediment naturally sorted in response to wave action, enhancing the gravel/cobble berm along the upper portion of the beach. This has resulted in reduced erosion rates. The ongoing monitoring of the beach and berm shows the project still protects the Winthrop shoreline 20 years later.

Figure 2. Winthrop Beach with a mixed sediment nourishment constructed by DCR (Photo: Sustainable Coastal Solutions).

Plymouth Long Beach, Plymouth, MA

Plymouth Long Beach is a barrier beach that provides flood control and storm protection for Plymouth Harbor and the downtown waterfront area. Long Beach is also a popular recreational area and an important breeding and staging area for several species of protected coastal waterbirds.

Severe storms had caused significant erosion along the barrier beach between the Day Parking Area and the Crossover. The erosion lowered the beach and dune elevations, reducing the volume of the dune, making it more susceptible to regular storm damage from lower energy storm events. The erosion caused the loss of vegetation and bird nesting habitat and damaged the road, parking area, and nearby private properties. The continued degradation of the dune negatively impacted the beach's ability to function as an effective barrier to provide flood and storm protection for the mainland shoreline.

The Town of Plymouth successfully enhanced the resilience of the barrier beach to withstand severe storms and rising sea levels with a nature-based solution. Environmental regulations prevented the use of typical coastal engineering structures, however, the nature-based solution provided the same level of protection for the Town.

The nourishment of the upper beach and dune system involved approximately 35,030 cubic yards of nourishment comprised of a mix of sand, gravel and cobble along a 2,000 foot long project area. The project restored the dune crest's height and bolstered the dune's volume and extent. The project's construction was completed in the winter of 2023 and has provided the Town with a stable barrier beach that has weathered numerous coastal storms. The use of mixed sediment solution provided the Town of Plymouth with a practical and effective solution to protect the Town's infrastructure while managing erosion and mitigating environmental impacts. Funding and technical assistance for this project were provided by the Massachusetts Office of Coastal Zone Management through the Coastal Resilience Grant Program.

Figure 3. Plymouth Long Beach in 2018 and 2023 after the mixed sediment nourishment (Photo: Town of Plymouth).

Duxbury Beach Erosion Control Cobble Berm, Duxbury, MA

Duxbury Beach Reservation addressed erosion and storm damage along the back of Duxbury Beach at Powder Point Bridge by enhancing the cobble berm. Wetland regulations prevented the use of traditional coastal engineering structures to combat the ongoing erosion. By enhancing the cobble berm, Duxbury Beach Reservation has protected the beach and the bridge abutment while preserving the natural habitat and wetland resources. The project continues to be monitored and continues to provide a successful solution. Additionally, funding for design, regulatory permitting, and construction was obtained from available state grants.

Figure 4. Bayside berm in Duxbury Beach (Photo: Duxbury Beach Reservation).

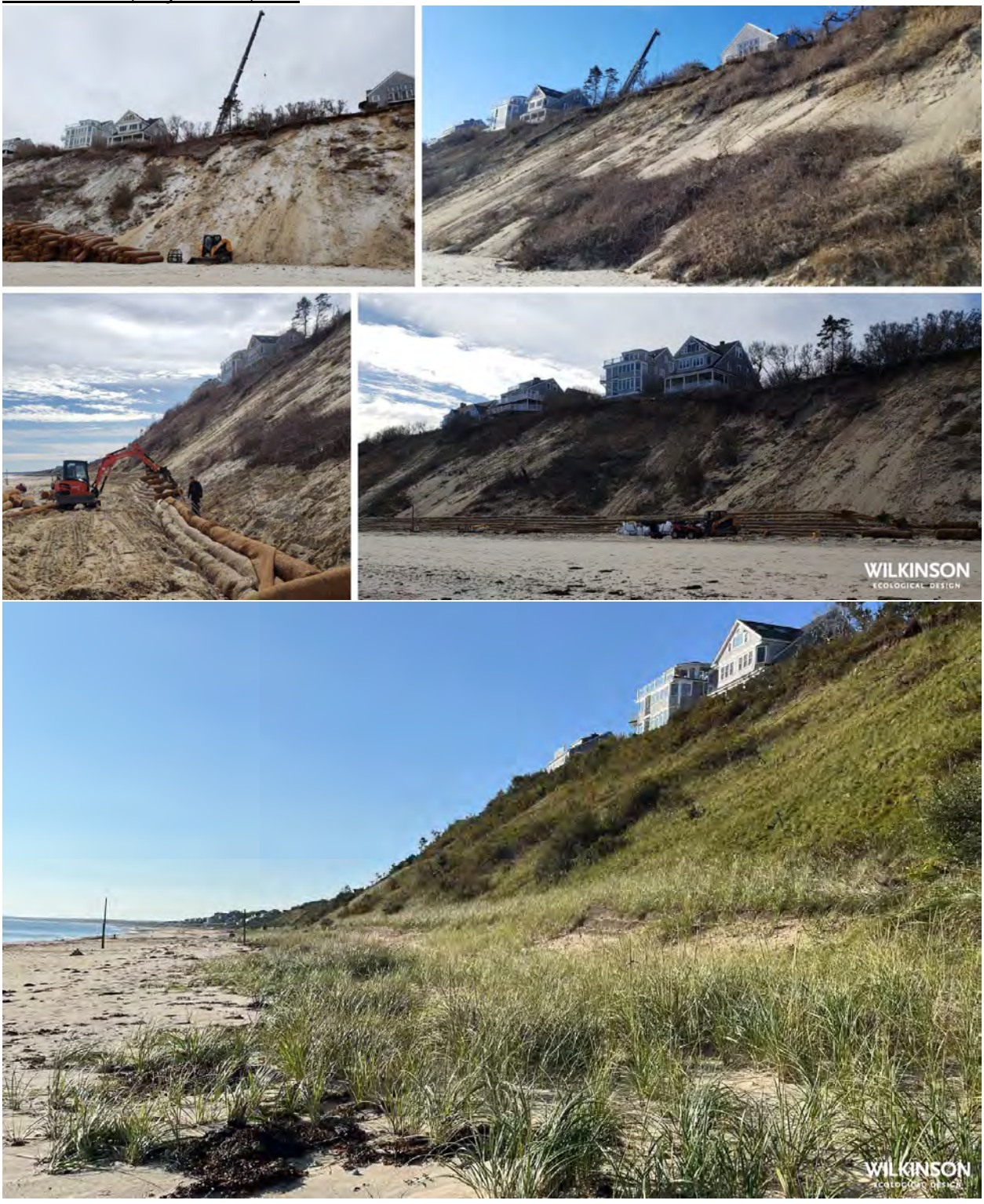
Coughlin Park, Winthrop, MA

The Coughlin Park shoreline was eroding ~1.5 feet/year, threatening the public park and the community tennis courts. The Town of Winthrop permitted and implemented a nature-based stabilization of the shoreline, which mitigated the severe erosion and increased the park's coastal resiliency by enhancing and nourishing the cobble berm along the shoreline. The project design also utilized fiber rolls and regrading to stabilize the eroding undercut coastal bank. The completed cobble berm has and continues to dissipate wave energy and mitigate shoreline erosion for the community while maintaining the salt marsh along the park's edge and rocky bottom habitat immediately offshore.

Nature Based Stabilization Systems for Higher Energy Shorelines

Nature-based or bio-engineered systems provide viable solutions for stabilizing and protecting eroding coastal banks, dunes, and shorelines. The systems utilize a variety of natural materials, fabrics, and components, along with engineering design, to stabilize, anchor, and protect eroding shoreline features. For eroding coastal banks, engineered soil lifts are utilized to restore the bank face and support over steepened slopes. Seaward of the lifts, high-density coir fiber rolls are utilized to protect the face of the bank from wave attack and runup. The envelopes and core fiber rolls are anchored into the coastal bank using earth anchors and cabling to keep the system in place and prevent movement during moderate to significant storm events. The outward face of the system is often wrapped in coir matting, with an outer layer of nourishment that can be vegetated to enhance the coastal bank's ability to withstand wave runup and minimize scour from runoff along the upper elevations of the coastal bank. Here are a few examples of how these systems have been implemented.

White Cliffs, Plymouth, MA



Pleasant Bay, Chatham, MA