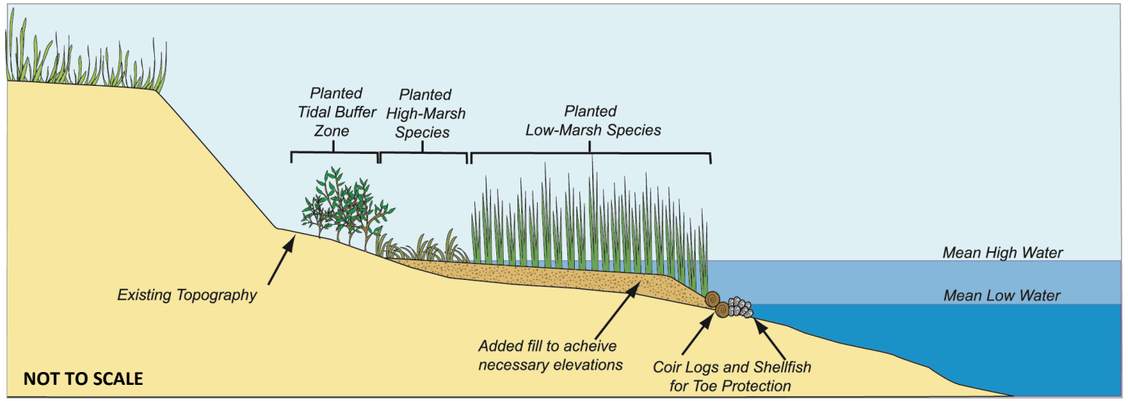
Marsh Creation/Enhancement w/Toe Protection

Marsh vegetation that is planted along the shoreline often benefits from toe protection to assist with marsh stabilization. Toe protection materials may include natural fiber rolls, shell bags or, in some cases, stone. The toe protection may also allow the design to achieve the appropriate grade in lieu of seaward fill, thereby decreasing the project footprint.

Objectives: dissipates wave energy, habitat creation, shoreline stabilization

Design Schematics



Case Study

North Mill Pond, Portsmouth, NH

This project involved restoration of low and high marsh along North Mill Pond, with about half of the area consisting of new marsh creation, and the other half of the area consisting of restoration of degraded low and high marsh through sediment addition (thin layer deposition).

North Mill Pond Marsh Restoration, Portsmouth, NH
Photo courtesy of David Burdick (UNH)

Project Proponent	City of Portsmouth, Stantec (wetlands consultant), UNH (assisted plan development)
Status	Construction complete May 2016. Beginning year two of monitoring in 2017.
Permitting Insights	NHDES and USACOE permits needed for drainage outfall into pond. Project impacted 600 sf of coastal wetland. Salt marsh restoration was compensatory mitigation.
Construction Notes	Imported fill to raise 12,060 sf to suitable elevation for salt marsh (low marsh); planted 3,055 sf of high marsh area. Created micro-topography and interior drainage channels. 12-in diameter coir logs staked at seaward edge of marsh to stabilize toe. Placed large boulders to break-up winter ice sheets.
Maintenance Issues	Long term monitoring and maintenance efforts are scheduled. Survival of low marsh plants is good; survival of high marsh salt hay is fair to poor. Survived 2016-2017 winter well.
Final Cost	$60,000 (construction, monitoring & maintenance)
Challenges	Construction did not have a provision for within plot drainage; many plants were washed out by runoff gullies in the first year. More time needed for filled sediment to settle before planting.

Design Overview

Materials	Native marsh plants appropriate for salinity and site conditions. Plugs of marsh grass can be planted to augment bare areas.[11] Sediment may be necessary if area needs to be filled to obtain appropriate elevations. Toe protection materials may include natural fiber rolls, oyster/mussel shells bags, or in some cases, stone. Filter cloth placed prior to added fill and/or sill materials.[16] Bird exclusion fence to avoid predation while plants develop.[16]
Habitat Components	Salt marsh; Tidal buffer landward of the salt marsh; Coastal beach; Mud flat.
Durability and Maintenance	Plants that are removed or die during the early stages of growth must be replaced immediately to ensure the undisturbed growth of the remaining plants. The removal of debris and selective pruning of trees is also a good maintenance practice to ensure that sunlight reaches plants. After significant growth has occurred only periodic inspections may be necessary. Protection measures, such as fencing, can keep water-fowl from eating the young plants. Toe protection materials should also be replaced or re-installed if they are moved by a storm.[6] Coir logs must be securely anchored to prevent wave and tidal current-induced movement.[11] Ongoing maintenance of invasive species and runoff issues will be important to the long-term success of the project.[10]
Design Life	It is important to recognize that design life may be shorter in the future given changes in sedimentation rates, accelerating sea-level rise and other climate change impacts.
Ecological Services Provided	Increases water infiltration, uptake of nutrients, filtration, denitrification and sediment retention.[2,3] The extensive root systems of marsh vegetation help to retain the existing soil, thus reducing erosion while plant stems attenuate wave energy.[11] Marshes provide habitat for many species of plants and animals, and maintain the aquatic/terrestrial interface.[2] Sill mitigates erosive waves and stabilizes shoreline.[10] Marine animals can access the marsh through gaps in the sill.[12] Marshes also provide better water quality, recreation and education opportunities, and carbon sequestration (blue carbon).[12]
Unique Adaptations to NE Challenges (e.g. ice, winter storms, cold temps)	Including roughened surfaces, such as logs, stones or emergent vegetation can break up ice sheets.[4,10] Fringing marsh projects will respond better to ice if designed with gentler slopes (6:1-10:1) and by incorporating shrubs.[9,13] Planting in the spring will allow vegetation to become established before it has to withstand ice.[8] Hardy, salt-tolerant shrubs are well-suited shorelines that are affected by ice.[13] Need to consider where in the tidal range oysters will be placed if they're used: too high may result in freezing.

Marsh Creation/Enhancement w/Toe Protection

A toe protection structure holds the toe of an existing, enhanced or created marsh platform in place, and provides additional protection against shoreline erosion. A gapped approach to the toe protection structure allows habitat connectivity, and greater tidal exchange. Toe protection is particularly important where there is higher wave activity or threat of boat wakes.

Marsh Enhancement w/Coir Toe, Chatham, MA
Photo courtesy of Wilkinson Ecological Design

Regulatory and Review Agencies

Maine	Municipal Shoreland Zoning, Municipal Floodplain, ME Dept. of Environmental Protection, ME Land Use Planning Commission, ME Coastal Program, ME Department of Marine Resources, ME Department of Inland Fisheries and Wildlife, ME Geological Survey, and ME Submerged Lands Program.
New Hampshire	Local Conservation Commission, NH Natural Heritage Bureau, NH Department of Environmental Services (Wetlands Bureau, Shoreland Program, and Coastal Program), and NH Fish & Game Department.
Massachusetts	Local Conservation Commission, MA Dept. of Environmental Protection (Waterways and Water Quality), MA Division of Fisheries and Wildlife (Natural Heritage and Endangered Species Program), MA Environmental Policy Act, and MA Office of Coastal Zone Management.
Rhode Island	Coastal Resources Management Program, and RI Dept. of Environmental Management.
Connecticut	Local Planning and Zoning Commission, and CT Department of Energy and Environmental Protection.
Federal (for all states)	U.S. Army Corps of Engineers, National Marine Fisheries Service, U.S. Environmental Protection Agency, and U.S. Fish and Wildlife Service.

Siting Characteristics and Design Considerations

Selection Characteristics	Detail
ES Energy State	Moderate. A sill may be necessary in medium energy sites (2-5 foot waves, moderate currents and storm surge).[3,6]
EE Existing Environmental Resources	Coastal beach; mud flat; salt marsh
SR Nearby Sensitive Resources	Endangered and threatened species. 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 for construction.[1] Shellfish beds and essential fish habitats will restrict where a marsh can be extended. Construction may produce short term habitat impacts, but in the long term, the marsh area should provide enhanced wildlife and fisheries habitat.
TR Tidal Range	Low to moderate. Sills are more suited to sites with a small to moderate tidal range, and are intended to be low-crested structures with a freeboard of between 0 and 1 ft above MHW.[7,11,16] However, shellfish sills should have a crest height at or near MLW since oysters and mussels can only remain out of the water for between 2 and 6 hours depending on the weather conditions.[7]
EL Elevation	MLW to MHW; Above MHW. For low marsh, the lowest grade should be MTL and extend up to MHW. High marsh plantings should extend between MHW and MHHW.[5] Tidal buffer should be planted above highest observable tide.
IS Intertidal Slope	Moderate. With slopes between 5:1 and 3:1 (base:height), sills should be added to the toe of the marsh.[3]
BS Bathymetric Slope	Flat to moderate
ER Erosion	Low to moderate
Other Characteristics	**Detail**
Boat Traffic	If boat wakes are expected to be the dominant force the sill should be designed accordingly.[7]
Ice Sensitivity	Gentle slopes and intermixed shrubs will handle ice the best.[8] Plant in the spring to allow plants to become established well before ice becomes a concern.[8]
Climate Vulnerability	If implemented carefully, this design can allow for inland migration. Planting higher, outside of the normal elevation range for the marsh grasses, may be useful in anticipation of sea level rise. It is important to recognize the uncertainty in future elevations. The effectiveness of a sill will be reduced over time as sea level rise gradually reduces the freeboard of the structure.[7]
Surrounding Land Use	Existing structures on site, like seawalls, may force living shoreline projects to have a steeper slope than desirable. Seawalls will limit the inland migration potential of the salt marsh in the future. Steeper slopes leave little opportunity for wave energy dissipation.[13] Marshes require sunlight to thrive; trees must be pruned or removed to allow for at least four to six hours of sunlight a day;[6,] this will increase vegetation growth.[11,15] Although it is possible to create a marsh on most shorelines, marsh creation is not recommended for sites where they are not a natural feature along comparable natural shorelines.[11]