81 Technology Park Dr., East Falmouth, MA 02536
Direct Extension: (508) 495-6221
Main Telephone: (508) 540-8080
FAX: (508) 540-1001
e-mail:lweishar@whgrp.com
www.woodsholegroup.com

MEMORANDUM

Date: June 9, 2016
To: Mr. Arthur Leventis
From: Lee Weishar, Ph.D.; PWS
Re: Technical Memorandum: Alternatives Analysis & Agency Coordination Meeting

The following memorandum provides an alternatives analysis that examines potential shoreline erosion mitigation alternatives that could be considered to mitigate the shoreline erosion at Coughlin Park in Winthrop, MA. This task also required that an interagency be conducted to solicit comments from agency partners concerning the preferred alternative.

Introduction & Background

There are many options to choose from when considering mitigating shoreline erosion. However, not all options will be considered coastal resilient or green infrastructure. There are two broad categories of coastal resilient projects. They are soft engineering alternatives and hybrid alternatives. In general, soft engineering alternatives do not incorporate hard infrastructure into the design. The soft engineering alternatives would include alternatives such as bank grading, planting, and coir fiber rolls. A hybrid alternative incorporates a hard coastal engineering component into the engineering design. Examples of a hybrid alternatives would include an offshore sill with marsh planting and low profile revetment at the toe of the coastal bank. The hybrid alternatives are usually used where the incident coastal processes are too high to support a totally soft engineering alternative. The Massachusetts Office of Coastal Zone Management's Green Infrastructure for Coastal Resilience Grant Program specifically requires that green infrastructure designs be considered for implementation on this project. The grant solicitation specified the following broad categories that a potential shoreline mitigation design must fall into:

- Beach, berm, dune building, enhancement or restoration with compatible native sediment
- Bio-engineering with coir rolls, natural fiber blankets, and/or other biodegradable materials with planting/re-vegetation
- Natural oyster or mussel creation or restoration
- Fringe marsh creation or restoration

Therefore, after careful consideration and consultation with CZM the following potential design options have been selected for consideration. This memorandum will outline the advantages and disadvantages of each potential mitigation alternative and then each alternative will be evaluated with its viability in light of the storm surge and wave energy that will occur along the shoreline.

The following green infrastructure design alternatives will be evaluated for the Coughlin park shoreline:

Beach, berm, dune building, enhancement or restoration with compatible native sediment

- Beach Nourishment
- Bank nourishment with cobble/gravel mix
- Cobble berm
- Re-grading and planting of the coastal bank
- Expand/enhance existing rocky intertidal area on the intertidal beach

Bio-engineering with coir rolls, natural fiber blankets, and/or other biodegradable materials with planting/re-vegetation:

- Fiber rolls at the toe of bank
- Fiber matting with planting on face of bank

Natural oyster or mussel habitat creation or restoration

- Sill/offshore low crested reef composed of:
    - Oyster or mussel shell bags
    - Cobble or rock (rocky intertidal enhancement) to enhance substrate for mussels

Fringe marsh creation or restoration

- Fringe marsh creation with fiber rolls

The following is a discussion of the advantages and disadvantages of each of the green infrastructure design alternatives listed above.

Beach, berm, dune building, enhancement or restoration with compatible native sediment

<u>Beach Nourishment</u>

Beach nourishment is a green infrastructure alternative that is widely accepted as a shoreline erosion mitigation alternative. Beach nourishment is a process in which sediment that is of similar grain size that has been lost by erosion and longshore drift are replaced on the beach. The sediment size is selected to be similar in size to the sediment that is naturally found on the beach. While many beach nourishment projects use sand as the primary sediment, the beach sediment along the Winthrop Beach are a mix of sand and cobble with cobble making up the majority of the sediment. Sediment from an outside source of the similar grain size as the natural beach is placed on the eroded beach to replace the lost sediment. Often a dune building component is incorporated into the beach nourishment project to increase the volume of sand placed on the beach, to raise the elevation of the back beach. One of the advantages of a beach nourishment project is that the project adds sediment to the littoral system replacing sediment that has been lost due to coastal erosion and longshore transport.

Additionally, the restored beach and/or dune acts as a wave buffer between the nearshore and the coastal bank dissipating wave energy before it reaches the coastal bank or the upland. When coupled with a dune building project it increases the elevation of the back beach and helps improve the beaches ability to provide storm damage protection to the adjoining upland. A beach nourishment is flexible and the design can easily be readjusted or modified during the re-nourishment phase to compensate for sea level rise. Additionally, a beach nourishment project expands the usable beach area and in general has a lower impact on the environment than hard coastal engineering structures. The newly nourished beach and dune creates or re-establishes habitat for birds and other animals that inhabit the beach and/or dune ecosystem.

The disadvantages of a beach and dune project is that it requires periodic re-nourishment. This can often be expensive and can potentially disrupt the offshore if an offshore borrow site is used as a source of sand. The height of protection from storm surge is limited to the height of the beach or the dune system. Additionally, the addition of large quantities of sediment may adversely impact intertidal and/or nearshore resources such as saltmarsh and subaquatic vegetation such as eelgrass.

<u>Bank nourishment with cobble/gravel</u>

This design alternative is similar to beach nourishment in that it adds sediment to the system and is often combined with other design alternatives to provide protection to the coastal bank (Figure 1). The eroding face of the coastal bank is covered with suitable sediment and the face of the bank is built seaward. The new face of the coastal bank can be vegetated depending on the sediment size that is selected for the bank grading materials. This reduces the vertical slope of the erosion scarp and allows waves to break on a gentler slope. The sediment selected should closely resemble the native sediments of the beach and nearshore regions. The sediment eroded from the nourished bank will provide sediment to the beach and intertidal area. Selecting sediment grain size should be guided by the sediments that are in the nearshore area and on the beach.

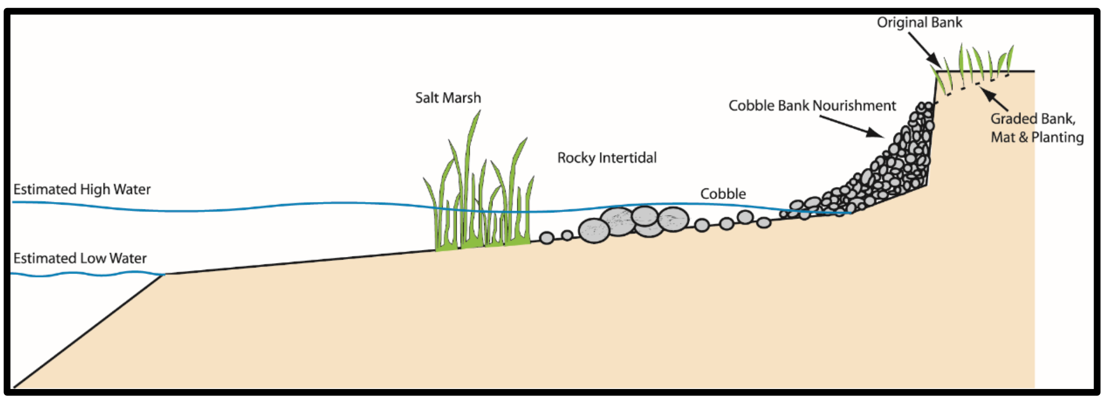


Figure 1. Bank nourishment with cobble and gravel

The advantage of this design alternative is that the top of the bank does not need to be cut back landward to reduce the vertical or near vertical slope of the eroding coastal bank. Additionally, the cobbles on the newly shaped slope will attenuate wave and help prevent the waves from breaking directly on the bank and reflecting energy back onto the beach. This alternative will also provide a source of sediment to the adjacent beach.

The disadvantage of this alternative is that it will require maintenance and periodic replacement of sediment of the appropriate size. Additionally, as with any soft engineering solution it will be subject to damage from a severe storm and will most likely need to be repaired after a severe event. The height of protection from storm surge is limited to the height of the coastal bank which may result in overtopping depending on the severity of the storm and the height of the storm surge.

Cobble Berm

A cobble berm is similar to a cobble dune. The primary difference is where they are located. They both are a mound of sediment (cobble in this alternative). A dune in usually constructed on the beach face and not necessarily at the toe of the coastal bank. A berm is normally constructed at the toe of the coastal bank and is specifically designed to reinforce and protect the toe of the coastal bank. The size of the cobble varies depending on the size of the cobbles and gravel on the beach. This alternative is often used in conjunction with another alternative designed to stabilize the coastal bank face.

The advantage of this alternative is that it utilizes cobbles that are near or slightly larger than occur on the beach. The cobble berm is slightly mobile and will move around on the upper beach area during large storms. Normal beach geomorphic formations such as beach ridges often form in the cobble as the result of waves breaking on the cobble berm. However, the loose nature of cobble berm will absorb wave energy and reduce wave runup.

The disadvantage of this alterative is that it will require periodic maintenance and re-nourishment. Additionally, as with any soft engineering solution it will be subject to damage from a severe storm and will most likely need to be repaired after a severe event. The repair may be as simple as using a front end-loader to reposition the berm or it may require the placing of additional cobble on the berm to rebuild its height and width. Additionally, the height of protection from storm surge is limited to the height of the coastal bank which may result in overtopping depending on the severity of the storm and the height of the storm surge.

Re-grading and planting of the coastal bank

This design alternative reshapes a vertical or near vertical coastal bank and plants native vegetation on the face of the coastal bank. The bank top of the bank is cut back (landward) to reduce the angle of the bank to more closely approach an angle of repose. Once the gentler slope is achieved, the face of the coastal bank is planted using native vegetation. Ideally the plants selected will have a deep root system with a relative small over-story. This design alternative is generally most suitable for low wave energy environments because there is no protection provided to the toe of the coastal bank.

The advantage of this design alternative is that it is generally less intrusive and will have less impact on natural community and ecosystem services. The affects from project construction and project implementation will normally be less than other potential design alternatives. If the project includes planting of the back beach area then, the project will help maintain the connectivity between the aquatic and terrestrial habitats.

The disadvantages of planting alone is that it does not provide protection from storm surge or increase the beaches and nearshore height and/or width to reduce the impacts of storm surge. This design alternative will have applications in relatively few locations because of its potential vulnerability to storms. Additionally, growing plants on the beach and on the face of the coastal bank is difficult because of poor soil conditions, limited nutrients, and limited availability of water when the juvenile plants are most vulnerable.

Expand/enhance existing rocky intertidal area on the intertidal beach

This alternative will place additional boulders on the intertidal beach to enhance and expand the existing rocky intertidal area. The boulders will range in size from 10 – 15 inches in diameter to 1-2 feet in diameter.

The advantage of this alternative is that it will enhance the rocky intertidal habitat presently on the inter-tidal beach. If placed carefully the rocks can also break waves during small storm events and reduce runup. Additionally, it is unlikely that the newly placed rocks will be moved by normal storms if the rocks placed on the intertidal beach match the larger sizes of rocks that make up the rocky intertidal resource area.

The disadvantage of this design alternative is that during large storms with high storm surge the enhanced rocky intertidal area will not provide protection to the coastal bank toe. The waves and storm surge will simply overtop and inundate the rocky intertidal area.

Bio-engineering with coir rolls, natural fiber blankets, and/or other biodegradable materials with planting/re-vegetation:

Fiber rolls at the toe of bank

This alternative anchors fiber rolls at the toe of the coastal bank. A fiber roll is a densely packed tube of coconut fiber (coir) that can be wrapped in either biodegradable and /or non-biodegradable cordage that holds the coir filling in the tube (Figure 2). The fiber rolls are usually covered with bank compatible sediment to reduce degradation from ultraviolet light.

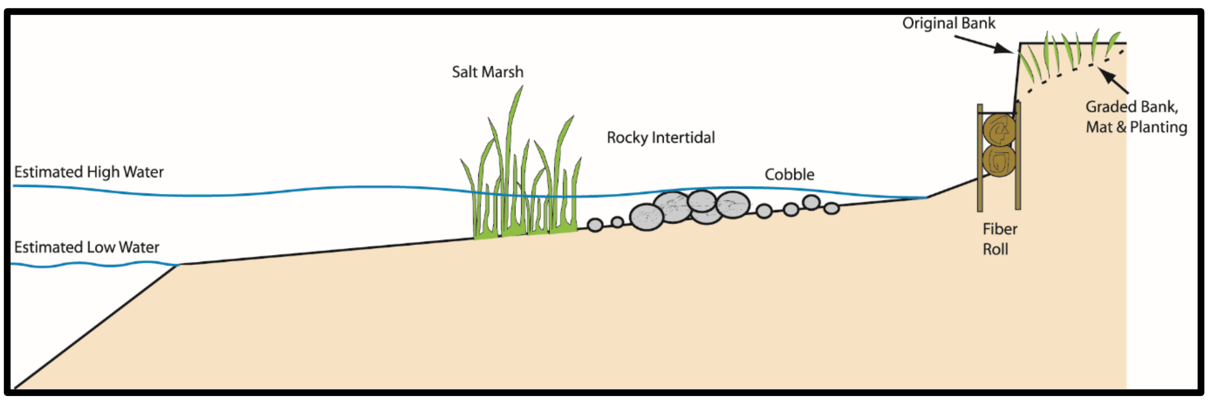


Figure 2. Fiber rolls installed at the base of the coastal bank.

This design alternative is often used in conjunction with other alternatives such as bank grading and/or planting to increase the stability of the coastal bank.

The advantage of this alternative is that the fiber roll acts as a buffer between the toe of the coastal bank and the incident wave and/or storm surge. Protecting the toe of the coastal bank allows the face of the bank to stabilize and results in an environment that is conducive to grow vegetation which helps stabilize the coastal bank.

The disadvantage of this alternative is that the fiber rolls are biodegradable and have a design life that is dependent on the incident wave energy, the length of exposure to ultraviolet rays. The average design life is between 5 – 8 years. The fiber rolls are difficult to stake in place if the wave environment is too great. Usually the fiber rolls can be used to protect the toe of the coastal bank if the wave height impacting the bank is less than 3 ft. Ideally, the fiber rolls are placed high on the beach where they are exposed to runup only. The average design life for the fiber rolls is between 5 to 8 years. During this period, it will be necessary to keep the fiber rolls covered with sediment. Therefore, if a storm uncovers the fiber rolls it will be necessary to replace the sediment covering the fiber rolls. Additionally, if the fiber rolls become displaced during a storm it will be necessary to reset and/or re-stake them at the base of the coastal bank.

Fiber matting with planting on face of bank

This design alternative places biodegradable mat on the face of the coastal bank. Once the mat is staked and/or secured to the bank face, the bank face is planted with vegetation. The mat provides a stable surface so that vegetation can root into the bank face. Ideally the plants selected with have a large root area and a relatively small overstory because the plant roots stabilize the coastal bank face. The alternative is often used in conjunction with other alternatives.

The advantages of this alternative is that it composed entirely of biodegradable materials and uses indigenous plants to stabilize the bank.

The disadvantage of this alternative is that it depends on plantings to stabilize the coastal bank. Additionally, if the toe of the coastal bank is not stabilized then the erosion scarp will undermine the root system and destabilize the bank face.

Natural oyster or mussel habitat creation or restoration

Sill/offshore low crested reef composed of oyster or mussel shell bags

This alternative constructs a sill on the intertidal beach by placing bagged oyster or mussel shells in the intertidal area. The exposed shell in the bags create a favorable location for new shellfish spat to set. Normally the shellfish are packaged into a jute or coir bags and anchored on the intertidal beach. The bags containing the shell act as a substrate for the shell spat to set and if located in a low energy environment can break small waves or boat wakes before they reach the toe of the coastal bank.

The advantage of this alternative is that it enhances the nearshore area by increasing biodiversity. Additionally, the mussels or oysters filter water that will remove particulates, pollutants, and nitrogen from the water. Additionally, the mussels or oysters can be harvested as a cash crop. If the waters are clean then the shellfish can be harvested and directly marketed. If the shellfish are in close waters, they can be relayed to a clean location and allowed to clean themselves. Once they have been cleaned, they can be harvested.

The disadvantage of this alternative is that the oyster/mussel shells need to be anchored to the bottom so that there is a stable substrate for the shellfish. If the bags are not anchored securely to the bottom small waves and boat wakes will move the bags and the coir or jute netting will tear releasing the shellfish from the bag. When this happens the shellfish will be distributed across the nearshore area resulting in a degradation of the shellfish habitat and the loss of the potential for the sill to reduce wave energy.

Sill/offshore low crested reef with cobble or rock (rocky intertidal enhancement) to enhance substrate for mussels

The alternative would increase the rocky intertidal area by adding additional boulders in an unorganized /randomly placed manner. The intent would be not to create a structure but to increase the rocky intertidal area. This would create additional intertidal area for the shellfish spat to set.

The advantage of this alternative is that it improves the nearshore bio-diversity of the habitat by providing additional area for shellfish and other marine flora and fauna to live. Additionally, the increased rocky intertidal area will increase the roughness of the nearshore area and will help break small waves, boat wakes, and reduce runup during small storms or during lower water levels.

The disadvantage of this alternative is that it will only reduce wave energy for relatively minor storms. While this alternative will increase the biodiversity of the nearshore area, it will not significantly reduce wave energy at the toe of the coastal bank.

Fringe marsh creation or restoration

Fringe marsh creation with fiber rolls

This design alternative will lay a series of fiber rolls across the intertidal beach to create a sill. The sill can be allowed to fill naturally with sediment or can be filled with sediments suitable for growing marsh species such as *Spartina alterniflora* of *Spartina patens*. This alternative would most likely require filling the sill because sedimentation rates in New England are on the orders of millimeters per year and would require a long time the accrete sediment to reach an elevation that would be suitable for growing marsh species.

The advantage of this alternative is that it increases the diversity of the nearshore habitat. Raising the elevation of the marsh will act as a natural buffer between the high tide beach and the nearshore area. Marshes act as nursery areas, help filter pollutants and sediments from runoff, and if the sill is high enough it can help break boat wakes and/or waves during small storms.

The disadvantage of this alternative is it will only provide limited wave dissipation during a large storm. Additionally, the fiber rolls used to contain the sediment can only be used in relatively low energy environments. Medium size waves will dislodge the fiber rolls resulting in a loss of sediment behind the fiber rolls. When this occurs elevation behind the fiber rolls will be reduced and the marsh plants will be dispersed into the nearshore area. Additionally, the fiber rolls may be removed from the restoration site and become flotsam.

Preferred Alternative

The preferred alternative of a combination of fiber rolls, bank grading and planting, cobble bank nourishment, and cobble berm was selected based on the following criteria:

- Consultation with representatives of the DPW and Conservation Commission from the Town of Winthrop.
- Evaluation of the incident energy at the site
- Examination of the Massachusetts Wetlands Regulations
- Consultation with CZM
- Feed-back from the regulatory interagency meeting

The preferred alternative will begin by installing a row of three fiber rolls at the base of the bank (Figure 3).

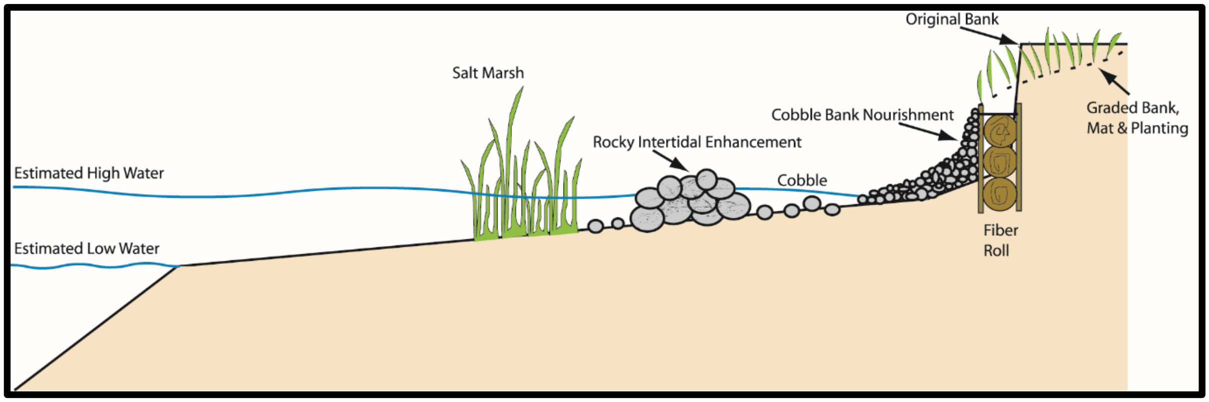


Figure 3. Preferred alternative of fiber rolls, bank grading, planting, cobble bank nourishment, cobble berm.

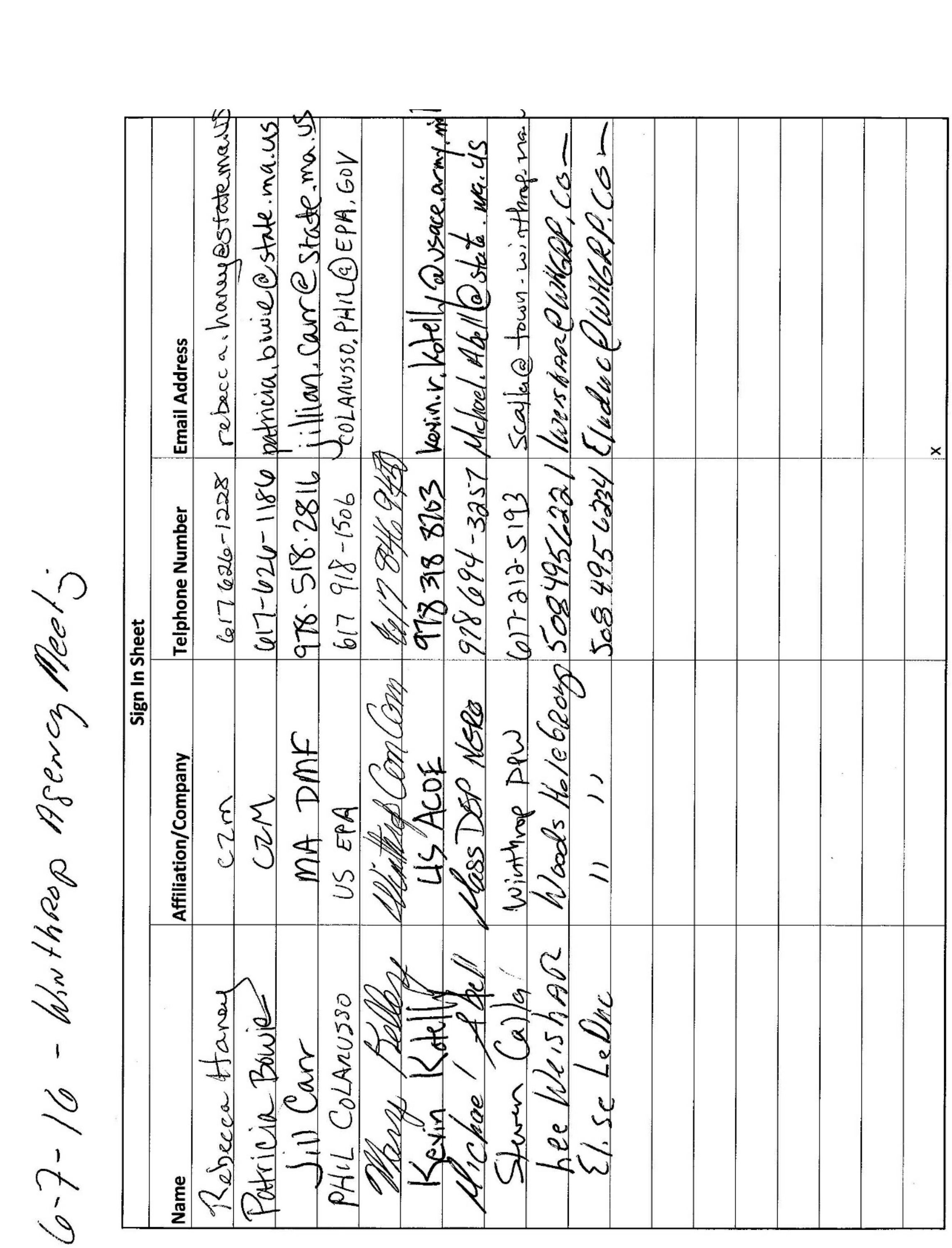
The lowest fiber roll will be excavated into the beach and then an additional two rows of fiber roll will be stacked vertically on top of the lowest fiber roll. The fiber rolls will be anchored into the coastal bank using a duckbill anchor system. The top of the coastal bank will be cut back to a stable slope and then planted with native grass species. The fiber roles will be covered with cobble that mimics (3 to 6 inches in diameter) the size of the cobble on the beach. The cobbles will help protect the fiber rolls from UV degradation. The last step in the mitigation will be the installation of a cobble berm at the toe of the coastal bank. The elevation of the berm will be approximately 3- 4 feet and will have a relatively shallow 1 on 10 to 1 on 15 slope. The cobble berm will help absorb wave energy and protect the fiber rolls during severe storms.

Interagency Coordination Meeting

An interagency meeting was help at Coughlin Park on June 7, 2016 to discuss the project with the following agencies:

- Coastal Zone Management
- Massachusetts Department of Marine Fisheries
- Winthrop Conservation Commission
- US Army Corps of Engineers
- Massachusetts Department of Environmental Protection
- Winthrop Department of Public Works
- Woodard & Curran
- Woods Hole Group, Inc.

The meeting was held at low tide and the preferred alternative was presented. After the project components were discussed the wetland resource areas at the site were examined and potential impacts of the project were discussed. While there were no major objections to the project, the agency representatives were careful to say they would reserve formal comment when a filing was filed. The sign in sheet from the meeting is attached below (Figure 4).



6-7-16 - Winthrop Agency Meeting

Sign In Sheet			
Name	Affiliation/Company	Telphone Number	Email Address
Rebecca Haney	CZM	617 626-1228	rebecca.haney@state.ma.us
Patricia Bowie	CZM	617-626-1186	patricia.bowie@state.ma.us
Jill Carr	MA DMF	978.518.2816	jillian.carr@state.ma.us
PHIL COLARUSSO	US EPA	617 918-1506	COLARUSSO.PHIL@EPA.GOV
Mary Kelley	Winthrop ConCom	617 846 9450	
Kevin Kotelly	US ACOE	978 318 8703	kevin.r.kotelly@usace.army.mil
Michael Abell	Mass DEP NERO	978 694-3257	Michael.Abell@state.ma.us
Steven Calla	Winthrop DPW	617-212-5193	scalla@town-winthrop.ma.us
Lee Weishar	Woods Hole Group	508 495 6221	lweishar@WHGRP.com
Elise LeDuc	" "	508 495 6234	eleduc@WHGRP.com
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Figure 4. Sign in sheet from the interagency meeting held at Winthrop on June 7, 2016.