

Beverly Harbor/Waterfront Plan

Review Draft March 2019

Appendix B

Report from GEI Consultants

Prepared for the City of Beverly
Prepared by Harriman
FXM Associates • GEI Consultants



Consulting
Engineers and
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Waterfront Elements Beverly Harbor/Waterfront Plan

Beverly, Massachusetts

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Table of Contents

Executive Summary	iii
1. Waterfront Infrastructure	1
1.1 General Findings	2
1.2 Existing Uses	2
1.3 Commercial Uses	2
1.4 Recreational Facilities	3
1.5 Shoreline Structures	4
1.5.1 Private Shoreline Structures	4
1.5.2 Public Shoreline Structures	4
1.6 Impacts of Existing Vessel Drafts and Dredging Needs	5
1.6.1 Bass River	5
1.6.2 Danvers River	6
1.7 Potential Improvements	6
1.7.1 Dredging	6
1.7.2 Public Access Points (Boat Ramps and Landings)	6
1.7.3 Boating Slips	7
1.7.4 Passenger Vessels	7
2. Regulatory Approaches to Sea Level Rise and Storm Surge in Beverly	9
2.1 Incentive-Based Overlay District	9
2.2 Flood-Fringe Overlay District	10
2.3 Additional Considerations	10
3. Community Comments on Waterfront Infrastructure, Dredging, Moorings, and Vessel Issues	12
3.1 Comments and Additional Information on Draft Illustrative Plans	12
3.1.1 Bass River North	12
3.1.2 Bass River South	13
3.1.3 Danvers River	13
3.1.4 Beverly Harbor	14
3.2 Comments and Additional Information on Draft Conceptual Plans	15
3.2.1 Bass River North	15
3.2.2 Bass River South	15
3.2.3 Danvers River	15
3.2.4 Beverly Harbor	15
3.3 General Comments and Additional Information	16
4. Comments Sea Level Rise, Flooding Frequency, and Plan Revisions	17
4.1 Landside Conditions	17
4.2 Waterside Conditions	18

4.3	Connecting with Earlier Planning Efforts	21
5.	Recommendations	24
6.	Literature Cited	27

Figures

1.	Map of Area - Bing Maps	1
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Appendices

- A. Beverly Waterfront Assessment Photos
- B. Maps Showing Proposed Dredge Limits

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Executive Summary

In 2018, GEI Consultants, Inc. contributed to Harriman Associates' efforts to develop a Beverly Harbor/Waterfront Plan for the City of Beverly (City). GEI participated in meetings with Harriman and City officials; conducted site visits and reviewed the condition of waterfront infrastructure; commented on several draft maps and planning documents regarding potential future uses of the harbor and development of lands around the harbor; and evaluated planning documents and potential future development, all from the perspective of vulnerability to the combined threats of sea level rise and storm surge.

Considerations and recommendations address possible categories of activity regarding moorings, boat launches, commercial fishing, recreational boating, boardwalks, permitting, dredging, flood frequency, building standards in areas of future development, zoning, and other elements relevant to development of the Beverly Harbor/Waterfront Plan.

1. Waterfront Infrastructure

GEI Consultants performed a general evaluation of the public waterfront for the City of Beverly. The evaluation extended from the northern waterfront limit of Bass Haven Yacht Club on the Bass River to Tuck Point on Beverly Harbor. The portion of the Bass River evaluation was limited to the eastern shoreline and water sheet. The evaluation included the following:

- General evaluation of the public and commercial marine infrastructure for this segment of the harbor and Bass River
- Evaluation of the impacts of the proposed dredging of the Bass River on the water sheet
- Review and assessment of water sheet uses and waterside access
- Documentation of existing conditions to identify access issues and opportunities

Goals of the evaluation were also to provide an assessment of impacts and requirements of regulations and to provide guidance on the viability of waterfront structures and potential uses for development. Photographs of shoreline features are included in Appendix A.



Fig. 1. Map of Area - Bing Maps

1.1 General Findings

Shoreline structures along the Beverly waterfront were generally in satisfactory condition at the time of GEI's observation performed for this study (comments on structure condition and findings indicated in this study relate to observations made during this study unless otherwise noted). City-owned structures of newer construction, including the floating docks near the Beverly Harbor Management Authority (BHMA) and Beverly Harbormaster's Office (BHMO), as well as the recently renovated parking area under the Route 1A Bridge adjacent to the BHMA, were generally in good condition, with a few exceptions including the Ventron Site Seawall. There are also some private (commercial) facilities that are either in need of investment to maintain current uses (e.g., Beverly Port Marina, Hills Yacht Yard, and the commercial fishing dock between Tuck Point Marina and Beverly Port Marina) or are in poor condition (e.g., Rowand's Pier). Examples of needed repairs include:

- The commercial fishing pier has pilings that will require replacement or repairs to maintain current uses.
- Hills Yacht Yard needs repairs to the bulkheads and requires dredging to maintain water dependent operations.

A more complete list of marine structures and their conditions is provided in Section 1.5.

1.2 Existing Uses

Beverly Harbor and the Bass River area have a multitude of uses from private industry to weekend recreational boaters, large commercial fishing boats to small kayaks and stand up paddleboards.

1.3 Commercial Uses

Along the Bass River south of the Bridge Street swing bridge (Hall-Whitaker Bridge), the majority of use is commercial with some non-water dependent uses. The eastern shoreline supports a lumberyard, a yacht yard, a power company, and two commercial fishing vessel docking facilities.

Along the north side of Beverly Harbor, commercial properties line the majority of the shoreline east of the Route 1A Bridge. Most of this portion of the waterfront includes marina facilities with slips for varying sized commercial and recreational vessels. This includes the twelve main access floats that provide the main private commercial/recreational marine services of the Beverly Harbor waterfront. There are several commercial fishing vessel support facilities mixed within the marinas plus the City owned/maintained dockage supporting the commercial lobster fishing fleet to the west of the City Pier.

1.4 Recreational Facilities

Along the waterfront study area there are a number of facilities that support recreational boating, including:

- North of Bridge Street is the Bass River's Bass Haven Yacht Club (BHYC) which provides floating docks and moorings as well as a boat ramp for access to the Bass River. The current waterway has silted-in and now has a very restrictive draft and is only mainly navigable in higher tides. South of Bridge Street, BHYC also supports several mooring locations for larger boats that cannot transit past the bridge.
- Just north of Bridge Street there is a private pier and boat ramp providing public access to Bass River for a fee. The pier, ramp, and float at the Bowl-o-Mat are in marginal condition and the ramp is only usable at high tides.
- Pleasant View Beach at the end of Porter Street Extension is adjacent to a public park and includes paved access to the water. This area appeared to be in good condition.
- East and adjacent to the Route 1A Bridge, the City has a public facility that includes floating docks, a timber pile supported pier, and a recreational marina managed by the BHMA.
- East of the City's commercial vessel area, Beverly Port Marina supports approximately 200 recreational slips and a few commercial vessels. This facility includes its own travel lifts (2) for vessel launching and retrieval.
- Adjacent and associated with the Tuck Point Condos is a private marina consisting of four main dock access systems providing slips for about 50 recreational boats.
- At the eastern end of the main waterfront is the Jubilee Yacht Club (JYC), a private recreational boating facility with water access for members. JYC has a travel lift facility to support boat launching and retrieval.
- The eastern limit of the waterfront evaluation area, at the end of Water Street, includes a deteriorated boat ramp that has historically been used primarily for small crafts such as kayaks and Stand-up Paddle boards. Because this area is an extension of Water Street, it provides public access to this beach area.

1.5 Shoreline Structures

Beverly Harbor has a significant number of shoreline structures. Most of the shoreline is owned by private entities responsible for maintenance. Remaining sections of the shoreline are owned and maintained by the City. The City also owns and maintains revetments, groins, and seawalls.

1.5.1 Private Shoreline Structures

The privately-owned shoreline structures vary in condition and purpose. Most of the commercial private structures are better maintained and consist of seawalls and piers. The non-commercial private structures are typically revetments, vegetated slopes or concrete seawalls. The commercial structures vary in condition and are situated between stacked stone walls, steel bulkheads, revetments, concrete walls, and vegetated shoreline slopes.

A few commercial facilities on the shoreline are in need of improvements, including Rowand's Pier. Home to a commercial fish market, the pier collapsed in 2018. Beverly Port Marina supports a large volume of recreational and commercial boaters. The Marina is in satisfactory condition, but the travel lifts are in need of maintenance (one or more are non-functional) and some floats have tripping hazards.

1.5.2 Public Shoreline Structures

- **Water Street Groin:** The Water Street Groin is a quarry stone groin over a sewer outfall and appeared to be in satisfactory condition and functioning adequately. A few smaller stones were observed to be dislodged along the crest of the groin.
- **Cabot Street Bulkhead:** The Cabot Street bulkhead at 11 Cabot St. consists of a steel sheet pile bulkhead. The bulkhead was recently replaced between 2007 and 2013. The bulkhead was noted as being in excellent condition in the 2013 Coastal Hazards Inventory Study (MA DCR, 2013). The bulkhead supports the recently reconstructed shoreline walkway between the BHMO and the BHMA.
- **Cabot Street Seawall:** The Cabot Street Seawall is a stacked stone seawall with an estimated length of 246 ft. The seawall abuts the recently replaced steel bulkhead and extends east. The seawall was noted as being in excellent condition in the 2013 Coastal Hazards Inventory Study, with a few small blocks out of place (MA DCR, 2013).
- **Cabot Street Pier:** The Cabot Street Pier is a timber pile supported pier. The Pier is approximately 260 ft long and 20 ft wide. The Pier has an overall "L" shape at the end extending approximately 40 ft to the west. The Pier is in excellent condition with concrete floats on either side and no floats on the outshore end.

- Ventron Site Seawall: The seawall at the Ventron Site consists of a stacked stone wall. Several portions of the wall have collapsed, and fill has washed into the harbor leaving the site exposed to wave action.
- Porter Street Seawall: The Porter Street seawall is located at Pleasant View Beach and supports a playground above it. The seawall is a stacked stone wall and is located above the high tide elevation. The wall was in fair condition in the 2013 inspection, with localized cracking and mortar missing (MA DCR, 2013). The wall showed no signs of additional change in our 2018 observations.
- Innocenti Park Seawall: The seawall at Innocenti Park is a stacked stone wall. It is generally in satisfactory condition with minor stone movement and voids present between some stones. There were visual signs of settlement along the top edge in our 2018 observations.

1.6 Impacts of Existing Vessel Drafts and Dredging Needs

1.6.1 Bass River

Uses along the Bass River are restricted by water depths, although the river is currently permitted for dredging and awaits funding. The authorized river channel is approximately 100 ft wide south of Bridge Street and 75 ft wide north of Bridge Street, but has a limited operational width and a variable depth. With the proposed dredging, the channel north of Bridge Street would be restored to approximately 7 ft deep and the channel south of Bridge Street would provide be approximately 10 ft deep. The increased depths would allow larger boats to use the boat yard along the Bass River, and BHYC would have a larger area to allow boats on moorings without encroaching the channel.

North of Bridge Street, the functional water sheet is only about one acre, but the proposed dredging would expand the functional area of the water sheet to over seven acres. South of Bridge Street, the channel is proposed to be widened and deepened to allow commercial traffic to have adequate clearance and allow vessel mooring along the edge of the river. This would allow as much as 2,500 linear ft on each side of the channel for bow/stern mooring configurations.

If it is feasible to redesign and replace the swing bridge, the BHYC could service sailboats and other vessels with higher air-drafts within the mooring field north of the bridge.

South of the bridge, the increased draft of the channel would allow the boat yard to work on larger boats throughout the tidal cycle. Dredging would also allow boats moored along existing docks to not rest on the mud a tow tide, as most of them currently do. It would additionally support the two commercial fishing docks, which currently do not have suitable dockage at low water.

1.6.2 Danvers River

The Danvers River provides access to much of the Beverly Waterfront. The existing channel appears suitable for passage within Beverly even at low tide. While there are many shoals along the edges, the channel is well-marked and can accommodate existing uses. Improvements to the channel could include increasing the width to accommodate larger vessels or narrowing the channel along the waterfront to accommodate more slips on existing docks. However, this would restrict uses by larger vessels.

Given the presence of ledge east of the railroad bridge, expansion of the Danvers River would likely be costly and may not be economically feasible. The Danvers River could potentially benefit from limited dredging to accommodate more mooring areas across from the waterfront, however in-depth review of this potential is not included in this memorandum.

1.7 Potential Improvements

1.7.1 Dredging

Dredging within Bass River to restore its historic authorized width and depth would provide a significant increase to the economic potential of the river and a large calm area for vessels to moor.

Dredging the Beverly Harbor beyond its historic approved limits would provide access for larger vessels including passenger vessels. With greater depth and width, an increase in boater traffic and dockage could be realized – but, as above, may not be economically feasible.

1.7.2 Public Access Points (Boat Ramps and Landings)

The City has two publicly owned boat ramps. The eastern ramp, at the end of Water Street, is not usable at most tides, and no parking is available. It provides public access and is used by kayaks and other small boats. The City should consider reconstructing or modifying the ramp to be functional during all tides. The second City-owned ramp is outside the project scope area.

The Pleasant View Beach site could be well-suited for increasing paddle board and kayak landings. The site has beach access and currents are minimal, providing a better launch area than the deteriorated Water Street ramp.

Two additional public ramps are available within 1.5 mi of Beverly Harbor, although both are within the City of Salem.

A privately-owned ramp is on the Bass River off Margin Street. The ramp is not suitable for use at low tide and the access gangway is closed, having been determined to be unsafe.

1.7.3 Boating Slips

There are several commercial entities in Beverly that provide several hundred recreational boating slips along the waterfront. The City provides their own slips around the City Pier. We are unaware of inefficiencies of the publicly owned vessel slips. It is presumed that vessel demands will change over time and that marina reconfiguration may be desirable. At present, the layout appears to meet industry design standards with no need for changes.

The current channel is federal and has an approximately 200 ft width, larger than a typical channel for the size of vessels that currently use the waterway. The City could thus limit the channel width to allow additional mooring capacity. However, modification of a federal channel or state harbor line requires legislative action, represents a significant commitment of effort, and should be reviewed carefully relative to currents and vessel maneuvering requirements within the harbor. Narrowing of the channel would also negatively impact larger commercial vessels accessing Bass River.

1.7.4 Passenger Vessels

While current infrastructure provides ADA access for marina activities, it does not meet requirements for passenger vessels due to the more stringent requirements for this use. Ramp requirements for different levels of waterfront use are as follows:

< 25 vessel slips	Min Total Gangway Length	30 ft
> 25 vessel slips	Min Total Gangway Length	80 ft
Passenger Vessels	Min Total Gangway Length	120 ft

The City could create berthing to accommodate passenger vessels around the existing City Pier near the BHMO. To facilitate a passenger vessel service, the facility would also need to be ADA compliant. Examples of compliant infrastructure include ADA-tailored ramping systems, berthing accommodations, ticket booths, and passenger staging areas.

Water Taxis. Water taxi services tend to be provided by vessels less than 50 ft in length with capacity of less than 30 passengers. An example is the City of Salem, which shares a taxi service with Marblehead and has Boston Harbor Cruises as the operator. The water taxi has seen an increase in riders since its inception in 2017.

Small Passenger Vessels (<50 Passengers): Small passenger vessels can be an opportunity for excursion or charter. These include fishing charters, sight-seeing tours, and other small cruises. These types of vessels are typically very maneuverable, can be high speed, and do not occupy large areas or need special channel accommodations.

Medium size – up to 149 passengers – high speed catamarans (generally <100 ft):

Medium sized vessels are similar to commuter ferries that operate between Boston and Salem. Similar vessels could be used to provide tours, whale watches, or similar trips. These vessels are highly maneuverable and typically do not require modifications to existing channels.

Large Vessels / Small Cruise Ships – up to 400 ft: Large Vessels and small cruise ships (such as those that enter Salem Harbor) require substantial operating area and special dockage, and typically would not be able to be accommodated with the existing channel in Beverly. The City could consider a partnership with neighboring towns to accommodate vessels of this type and the potential for mooring them outside the channel (ferrying passengers to the City).

Cruise Ships – >500 ft: Cruise Ships require significant area for mooring and special dockage, and typically would not be able to be accommodated by the existing channel. The City could evaluate mooring the vessels outside the harbor to ferry passengers into the City. This is typically done to accommodate cruise ships where terminal access cannot be provided. Economic feasibility would need to be carefully evaluated.

2. Regulatory Approaches to Sea Level Rise and Storm Surge in Beverly

As the City of Beverly takes next steps in adapting to the combined threats of sea level rise and storm surge, regulatory approaches may need to be developed. An overview of regulatory opportunities and considerations is below.

2.1 Incentive-Based Overlay District

Some municipalities have implemented overlay zones superimposed on existing zoning to provide an alternative set of uses and development standards. For example, the Nantasket Beach Overlay District in Hull, MA provides incentives to encourage mixed use redevelopment for commercial and multi-family property at scales and densities appropriate for the type of community, capable of revitalizing local economic development and able to protect people, property and resources (Schechtman and Brady 2013, Hull, Town of, 2014).

The District incentivizes flood-resilient measures that could be considered in Beverly, including:

- A rebate of \$500 on building permit fees for inclusion of increased building floor elevation in the building design.
- Taller buildings may be permitted by the Planning Board to be elevated beyond the prescribed height limit.

To receive the incentives, candidate projects must include flood-resilient features such as:

- The lowest floor or story does not contain habitable space.
- Mechanical, electrical, and HVAC equipment is not located on the lowest floor.
- Generators are located on the roof or upper stories.
- Projects include "green building" components to the greatest extent possible such as energy-efficient design, use of alternative energy sources such as solar, onsite stormwater retention, layouts that promote walking, and connections to public transport.
- Projects include underground utilities and floodproof electrical transformers.

2.2 Flood-Fringe Overlay District

Other municipalities use overlay districts to establish minimum design standards for construction in flood-prone areas. Districts of this type could additionally be considered for implementation throughout appropriate areas in Beverly. For example, Woodstock, NY has a Flood-Fringe Overlay District (Woodstock, Town of, 2014) where all land in the 100-yr flood zone as mapped by FEMA plus additional lands designated by the Town Board (lands in the “fringe” of the flood zone) are subject to construction standards, including that structures:

- Are anchored and designed to prevent flotation, collapse, or lateral movement due to floodwater-related forces.
- Use flood-resistant construction materials and utility equipment.
- Provide adequate drainage to reduce flood hazard exposure.
- Locate and construct public utilities and facilities to minimize or eliminate potential flood damage.
- Design all water supply and sanitary sewage systems to minimize or eliminate floodwater infiltration or discharges into floodwaters.
- Locate on-site sewage systems (e.g., septic tanks) to avoid damage to or contamination from them during flooding.
- Elevate the lowest floor of new residential construction (or during substantial improvement to existing construction) to at least 1 ft above BFE.
- Elevate or floodproof the lowest floor of all non-residential construction (or during substantial improvement to existing construction) to at least 1 ft above BFE, including utilities and sanitary facilities.

2.3 Additional Considerations

Although other regulatory approaches could be used to help manage future development in areas vulnerable to impacts of sea level rise and storm surge (such as rolling development restrictions that move landward as the tide line moves landward, or simply strengthening building codes by requiring additional adaptation strategies; Titus, 2011, EPA, 2017), we believe the zoning ordinance is the best tool for the current planning context.

In developing overlay districts of the types described, consideration should be given to types of exposure in different parts of the district. For example, some areas adjacent to the shore

may have no sea walls and be more vulnerable to moderate levels of flooding, while other areas may have substantial sea walls and be less vulnerable to the same levels of flooding. It may also be necessary to conduct hydrologic modeling in addition to what was conducted for the Beverly Coastal Resiliency Plan (CRP; Beverly, City of, 2017), such as evaluations of likely inland flooding from rain events and upland runoff. This could provide useful information about where flood waters are likely to go in areas intended for future development and help refine spatial distinctions within the district(s). Additional detail on suggested structure of overlay districts tailored to the impacts of sea level rise can be found in an Expert Review Report on the topic from the Georgetown Climate Center (2011). Among other elements, it provides language for a model zone that distinguishes between land with sensitive natural resources and land that could continue to be developed, and includes sub-districts with differential setbacks, structure elevations, and sizes.

Political acceptability of each of these possible regulations should also be considered. Outreach to private landowners in proposed future development areas may be appropriate or necessary as part of developing the overlay district.

3. Community Comments on Waterfront Infrastructure, Dredging, Moorings, and Vessel Issues

3.1 Comments and Additional Information on Draft Illustrative Plans

GEI was asked to respond to questions regarding 9/28/18 draft illustrative plans for the Beverly Harbor Plan. Responses are below. Maps showing proposed dredge limits are in Appendix A.

3.1.1 Bass River North

1. *Can there be access to a kayak launch at low tide?*

The issue will be about whether the intertidal area is walkable. The area is not likely to be walkable, because the substrate is typically very soft. Low profile floats could be added, but regulatory conditions will restrict floats resting on mudflats at low tide.

2. *Need to move kayak launch away from salt marsh?*

Yes, if there is room to keep it out of the salt marsh. Putting the launch and access within the salt marsh will require it to meet environmental regulatory conditions for resource protection.

3. *Need to move kayak launch away from eelgrass? If so, possibly shift onto BHYC?*

Relocation of the kayak launch may be possible if acceptable to BHYC. It may be better to locate it at former boat ramp at the South East end of the BHYC property.

4. *Location of former boat launch?*

The former boat launch may be better used as a carry-down kayak/canoe launch area because of shallow depths at low tides.

5. *How should people access current and future moorings? From Bowl-o-mat, BHYC?*

Most moorings were held by former BHYC members that could no longer use them because of inadequate draft. It is understood that the City owns the moorings of concern; a managed approach to the moorings could be employed, where a third party gains control of the layout and process of mooring assignments, coordinates a launch service from the Bowl-o-mat boat ramp, BHYC, or another location, and ensures dinghy docks and parking support for users. This could be a private entity like BHYC.

BHYC expansion to include additional slips could also be considered.

6. *Can additional moorings be added on the west side, too? Would this create too much traffic? Are there safety issues?*

Having moorings on the west side should not be a problem but needs to be part of the managed layout and oversight.

The proposed dredge footprint would accommodate a significant increase in additional moorings and available space. However, if along the channel, double bow/stern mooring would be needed (and could be easily removed for future dredging). This may be an issue with USACE approval.

7. *Specify the proposed dredging area.*

The proposed dredge footprint should be overlaid on the plan to illustrate the changes, available mooring, marina expansion, and channel. Refer to appendix B for limits of the proposed dredging footprints.

3.1.2 Bass River South

1. *Can additional moorings be added on the west side, too? Would this create too much traffic? Are there environmental or safety issues?*

Having moorings on the west side should not be a problem but needs to be part of the managed layout and oversight.

The dredge footprint would accommodate a significant increase in additional moorings and available space.

2. *Wire above bridge is too low for sailboats; safety issue?*

The existing bridge no longer functions as a swing bridge. Sailboats operate seasonally south of Bridge Street and are required to de-mast to allow access under bridge for winter removal and storage. It would appear that the existing powerline would be too low for larger sailboats if the swing bridge were made operational.

3. *Will dredging on the Bass River reduce allowable area for slips or floats or can these structures be pushed further into the River?*

Slips and floats cannot project into the dredge footprint.

Slips and floats would need separate permitting from the dredging project. Abutters should be able to expand the dredge footprint if no resource impacts exist (e.g., inter-tidal, saltmarsh, or eelgrass areas).

3.1.3 Danvers River

1. *Specify the proposed dredging area.*

The proposed dredge footprint should be overlaid on the plan to illustrate the changes, available mooring, marina expansion, and channel. Refer to Appendix B for limits of the proposed dredging footprints.

2. *Are slips possible? Or is it too rocky or too much of a mudflat?*

The question may be how far out low tide goes. All such expansion would need to be outshore of the mean low water line and bottom conditions would need to be verified. This may be impacted by any proposal to narrow the river channel.

3.1.4 Beverly Harbor

1. *Is it possible to add a float at the end of the City's pier?*

- Provided the floats do not extend into the channel, expansion should be possible. It appears that the existing City pier is within the USACE channel “buffer” and that federal approval would have been required. If the City wishes to extend floats into this area, federal approvals will be required.

2. *How would a storm impact additional slips?*

- Beverly Harbor is relatively protected and should not see a significant increase in exposure of the vessels located further outshore. Marina construction may require some wave attenuation and greater design loading on outshore floats and mooring piles.

3. *Would narrowing the federal channel be more difficult for boat traffic, especially west of the rail bridge?*

- The federal channel does not extend west of the Railway Bridge; it ends East of the City Pier.
- The railway bridge is the restriction point for all traffic west of the bridge, because the bridge only has a 40 ft width for each direction (which restricts use to a single line of vessels in either direction).
- Narrowing the federal channel is not expected to make navigation more difficult provided that recommended channel widths are maintained. Channel limits would also need to be reviewed based on proposed uses.
- The existing channel is not suitable for turning vessels larger than 100 ft.

3.2 Comments and Additional Information on Draft Conceptual Plans

3.2.1 *Bass River North*

1. Walkways over saltmarshes will require elevated boardwalks.
2. Dredge limits have been defined – see Appendix B for proposed limits.
3. Greater space for slips and moorings will be available after dredging. The mooring field should be managed by an entity approved by City.
4. Vessel storage rearrangement will need cooperation by an entity approved by the City.

3.2.2 *Bass River South*

1. Vessel storage rearrangement will need cooperation by an entity approved by the City.
2. Dredge limits have been defined – see Appendix B for proposed limits.
3. Boat launch reference signs.
 - a. Signs need to differentiate between kayak/canoe launch, boat launch, and boat lift systems.
 - b. Pathways through active marinas should be coordinated where lift systems are being utilized (on account of heavy machinery in use).

3.2.3 *Danvers River*

1. Boat launch reference signs.
 - a. Signs need to differentiate between kayak/canoe launch, boat launch, and boat lift systems.
 - b. Pathways through active marinas should be coordinated where lift systems are being utilized (on account of heavy machinery in use).

3.2.4 *Beverly Harbor*

1. Boat launch reference signs
 - a. Signs need to differentiate between kayak/canoe launch, boat launch, and boat lift systems.
 - b. Pathways through active marinas should be coordinated where lift systems are being utilized (on account of heavy machinery in use).

3.3 General Comments and Additional Information

1. Structures can be permitted where there are salt marsh grasses, however gaining permitting approvals and construction may be difficult and alternative locations may need to be investigated further. Anticipated regulatory approvals include the following, at a minimum:
 - a. US Army Corps of Engineers (USACE)
 - b. MA Department of Waterways
 - c. MA Department of Environmental Protection
 - d. MA Coastal Zone Management
 - e. Beverly Conservation Commission
2. The best means of access to moored boats is via dinghies or a launch service run by an entity approved by the City.
3. Final quantity of moored vessels will depend on vessel sizes. Regardless of quantity, the layout will also have to allow for minimum widths of navigational channels for boats of those sizes.
4. Moorings could be installed along the Bass River's western shoreline of the dredge area (see Appendix B). Bow/stern moorings should be used where possible to minimize impacts. Oversight and use of moorings should also be coordinated by an entity designated by the City.
5. Additional floats and slips could be installed provided they do not impact the federal dredging project and they are approved by National Grid (which has rights to the area in front of their waterfront). Federal project approvals will also need to be obtained to ensure the area could be dredged again. Also see other responses above under Bass River North. Access and management would need to be coordinated with National Grid and the coordinating entity determined by the City.
6. Narrowing the federal channel is not expected to impact boat traffic west of the rail bridge, because the rail bridge is the narrowest section and only allows single-lane traffic through the fender system.
7. Dredging north of Bridge Street would have a larger impact if the bridge is replaced, because the area north of the bridge would then be accessible to sailboats and taller motor boats.
8. Access to the harbor via the Ventron Site is limited because water depths in front of it are not sufficient at low tide. A ramp could be provided but would only be accessible at higher tides. Dredging could be proposed for the site, but we understand it may have chemical contamination, both on and off shore, which could make permits difficult to obtain.

4. Comments Sea Level Rise, Flooding Frequency, and Plan Revisions

As the City of Beverly takes next steps in adapting to the combined threats of sea level rise and storm surge, numerous issues regarding land-based infrastructure merit careful consideration. These include flood frequency on the waterfront, impacts to land- and water-based infrastructure and how best to incorporate lessons from previous planning efforts. An overview of these issues is below.

4.1 Landside Conditions

Beverly's 2017 CRP represents a recent and comprehensive evaluation of adaptation options on land that may increase resiliency in the City regarding the combined threats of sea level rise and storm surge. Importantly, for such evaluations to have strong utility they often need to rely on sound underlying analysis of likely future hydrodynamic conditions to which the jurisdiction wishes to adapt. The CRP relied on the Boston Harbor Flood Risk Model (BH-FRM) developed by the Massachusetts Department of Transportation and the Federal Highway Administration (Massachusetts Department of Transportation, 2015). The research team for that project made probabilistic estimates for risk of flooding events of various sizes, taking into account riverine flows, tides, waves, wind, storm surge, and wave set-up, and under several sea level rise scenarios. The CRP report used the BH-FRM results to examine the likely spatial extent and elevation of inundation resulting from the scenarios and identified portions of Beverly that may warrant consideration for protection from future inundation through adaptation. It described four candidate interventions (below) at areas of constriction along the pathway of predicted flooding, each of which could receive additional site-specific evaluation for potential appropriateness. Numerous additional infrastructure-specific projects in Beverly could be identified using the BH-FRM data, but this would require further hydrodynamic analysis and was beyond the scope of the current project.

1. Hall-Whittaker Bridge Street Adaptation. Recommended actions included installation of tidal control measures (likely to be tide gates) below the bridge superstructure. The measures would remain open during most conditions but could be closed prior to impending storms. Measures also included installing tide gates along the length of the bridge and raising adjacent roads. Recommendations did not include an environmental impact study or other analysis, although it may be appropriate to conduct such work if the measures are to be implemented.
2. Elliot Street Adaptation. The report recommended a culvert assessment be conducted for the culvert and piping system in this location, to support decisions that would minimize salt water intrusion and maximize stormwater drainage. It also

recommended a naturalized berm along the southern side of Elliott Street and a living shoreline along the marsh abutting the street, to provide a more nature-based solution for inhibiting flooding paths through the Cummings Center.

3. Federal Street Adaptation. The report recommended a deployable flood barrier (e.g., AquaFence or similar product), a strategy that could be installed in advance of potential future storm events to protect this area.
4. Chubb Creek Marshes Adaptation. The report recommended that the railroad overpass crossing the small inlet that is part of the Chubb Creek Marsh system be redesigned with a tide control structure to protect the large residential area adjacent to the Marsh from elevated coastal tide levels.

The CRP additionally described how to conduct adaptation in Beverly in a manner that simultaneously protects natural resources and recreational spaces, enhances resilience of Beverly's utility sector (as in Section 2.2), connects with forward-looking development incentives (as in Section 2.1), addresses issues of social equity and cohesion, and positively engages the public. GEI recommends that each of these categories of issues to consider be carefully integrated into preparation of Beverly's Harbor/Waterfront Plan, also taking into account the below considerations about Beverly's suite of historical planning documents.

4.2 Waterside Conditions

What happens to slips, docks, and moorings as the sea rises over time?

The impacts of sea level rise on floating structures, while still present, may be seen as less severe than upland fixed shoreline structures. In general, primary land-based infrastructure typically needs to be improved for resiliency against coastal storms based on sea level rise impacts and the associated potential impacts of waves superimposed on sea level rise and storm surge. For floating marinas and moorings, the primary floating infrastructure will rise, provided there is sufficient pile height and/or chain length, for example, and may not be directly impacted by increases in water levels. These facilities are likely to require the following assessments and improvements to ensure their sustainability:

- Mooring systems may be required that allow for greater range of water depth. This would include increased mooring pile height and longer mooring chain lengths for systems that are bottom moored. Individual vessel moorings would also need to accommodate greater water depth from larger storms and increased surge size. This transition would not be dramatic because most improvements would be incorporated into normal maintenance cycles for mooring systems, which are assumed in this report to undergo annual inspections.

- Vessel berthing and mooring areas are likely to experience impacts from larger storms and areas that are marginal today may require some wave protection at higher elevations or have their use restricted or even abandoned if conditions become too severe. For marinas, upgrades may involve wave attenuation systems adapted to higher water surface elevations and potentially higher waves. In areas with severe conditions, float systems may additionally require seasonal removal.
- Landside access improvements are likely to be required including increased gangway connection elevations and possible systems to suspend gangways so that they are disconnected from float systems during major storm events.
- A secondary impact in higher water surface elevation scenarios may be a reduction in the frequency of required dredging. This would be a relatively small benefit, but for marinas that infrequently dredge it could even further reduce the need to dredge by a number of years.

What does Beverly need to consider in terms of the position of infrastructure for water access, commercial fishing, and recreational boating?

For development of water dependent usage, protection against major storm events is paramount. For most infrastructure, optimal siting would be in protected harbors where exposure to wave conditions during extreme weather events is reduced. The level of exposure a structure can tolerate is dependent on its type and usage. Considerations for various structures and uses include:

- Solid bulkheads and seawalls incorporated into the design need to be able to withstand major wave exposure without damage.
- Fixed open pile supported structures need to be designed with deck systems with sufficient freeboard above peak wave crests especially when superimposed on predicted sea level rise and storm surge elevations. Where this is not possible, systems for wave pressure release should be incorporated into infrastructure upgrade designs. Pile systems need to be able to withstand the wave loading of design storms. Timber deck structures are very susceptible to wave damage when deck surfaces begin to become submerged, and special care should be taken in considering wave exposure.
- Public access ramp systems should be located in protected waters with limited wave or wake impacts, to allow users to launch and retrieve systems without risk of injury. Launch areas should be usable for all water levels and have a shallow

slope that is stable for walking and from erosion. Configuration of these spatial needs could shift over time as sea levels rise.

- Commercial boat marinas are typically designed to withstand greater wave conditions but also tend to represent year-round users. The float systems need to be of commercial grade and moorings need to be designed for these higher loading conditions. Commercial fishermen also need space for loading and unloading catch. Configuration of these spatial needs could shift over time as sea levels continue to rise.
- Recreational marinas need relatively calm water on a normal day, with less than 1 ft of swell. This often results in the need for a perimeter wave attenuation system to provide the level of performance that recreational boaters typically demand.
- Landside access to coastal water should be available to accommodate all types of users, ensuring ADA conformity and ample room for parking, boat trailers, and bikes as well as linkage to trail systems.

How often will the public walkway on the waterfront be flooded?

At present, this type of question is best addressed through reference to regional modeling of coastal inundation that has been conducted in the last few years. For example, the research team for the BH-FRM made probabilistic estimates for risk of flooding events of various sizes under several sea level rise scenarios. This included calculating exceedance probabilities for water surface elevations from the various storm events both in the present and under sea level rise scenarios modeled in the years 2030 and 2070. In Beverly's 2017 CRP, these data were interpreted for the local context to provide numerous observations for critical infrastructure in the City. For example, for the Margin Street Stormwater Pump Station, the CRP analysis suggested the following:

- For Present conditions, there is an approximately 5% chance that flood water levels would exceed the estimated Margin Street Stormwater Pump Station critical elevation of 7.91 ft North American Vertical Datum of 1988 (NAVD88) in any given year.
- For the 2030 planning horizon, there is an approximately 50% chance that flood water levels would exceed the estimated Margin Street Stormwater Pump Station critical elevation of 7.91 ft NAVD88 in any given year. At the 1% chance (100-yr annual recurrence interval), the water level would be approximately 2.4 ft above the asset's critical elevation of 7.91 ft NAVD88.
- For the 2070 planning horizon, there is an approximately 1% chance that flood water levels would exceed the estimated Margin Street Stormwater Pump Station

critical elevation of 7.91 ft NAVD88 in any given year. At the 1% chance (100-yr annual recurrence interval) the water level would be approximately 4.8 ft above the asset's critical elevation of 7.91 ft NAVD88.

Although these risks do not correspond exactly with the public walkway along the waterfront, further analysis of the elevation of each building, section of walkway, or piece of land- or water-based infrastructure (in relation to the probabilistic threats identified in the BH-FRM) could help evaluate flooding frequency for each asset of concern. Additional efforts of this type were conducted for the Beverly CRP and include City-owned facilities such as the BHMA, the BHMO, the Sewer Pump Station near Marsh Avenue, the bulkhead/seawall near Woodbury Street, and numerous sections of vulnerable road.

Further analysis of this type could also be conducted using readily available online tools such as the Surging Seas Risk Viewer (Climate Central, 2018). Using recent data from NOAA and other sources, the tool can provide estimates of the number of flooding days per decade that have been experienced in Beverly since 1955; single-year risk and multi-year risk of flooding above 5 ft. in Beverly, in terms of percent likelihood; and water levels (in ft) in Beverly when considering sea level rise alone and with mild, moderate, as well as major flood levels.

4.3 Connecting with Earlier Planning Efforts

The City's recent CRP report along with the analysis based on developing technologies, mentioned above, are focused on adaptation action and developed independently from, and not necessarily in full reference to, the large volume of planning initiatives conducted by and for the City of Beverly in the last 20 years. Because both the recent works and the earlier efforts make recommendations regarding physical distribution of assets in the City and their intended uses, there is a risk that fully implementing the recent recommendations could create conflicts with objectives of some of the earlier planning initiatives. This report aims to mitigate that risk to some extent.

At the same time, possible changes in the environment – including geometry of the coastline and frequency and intensity of storm surge events – suggest that ongoing benefit from the earlier planning initiatives would be enhanced by revisiting some earlier recommendations with these threats in mind. This is an additional intent of the below commentary, so that upgrades to the Beverly Harbor/Waterfront Plan can integrate both the historic context and the recent innovations on behalf of enhancing resiliency in Beverly (e.g., Beverly, City of, 2017).

Some questions the Beverly Harbor/Waterfront Plan will address are focused on relatively short-term outcomes, such as specifying locations for proposed dredging areas, additional moorings, a kayak launch site, etc. These still need to be addressed, but we suggest the Plan

will benefit from also considering longer-term changes and needs, particularly regarding possible changes in high tide levels and flood frequency and intensity.

Making revisions to the Harbor Plan to address the aforementioned concerns would be a change from how many planning efforts have developed in the last 20 years. That is, the planning disciplines in general are only recently beginning to incorporate concerns about a changing climate. An example is an early planning document in the City's relatively recent history, the Public Waterfront Usage Plan (Fort Point Associates, 1999). It provided detailed discussion about zoning, setbacks, dimensional requirements, and other elements of the regulatory context at the time but did not address sea level rise or storm surge. Collective understanding about these threats has evolved since then, such that for planning recommendations going forward, it is advisable that setbacks and other requirements be structured in a flexible manner that allows evolution over time if high tide levels change markedly. Similarly, the 2003 Beverly Harbor Management Plan (Beverly, City of, 2003) has a detailed discussion of shoreline access issues but does not reference a changing coastline over time and whether this might negatively impact public access to the waterfront at some of the sites discussed. The Beverly Harbor Waterfront Development Plan (Vine Associates, 2004) also made no mention of sea level rise or storm surge. Nor did the Beverly Master Plan use these terms (Beverly, City of, 2002), even though sustainability-related goals such as "Maintain public buildings and facilities on an on-going basis" are articulated throughout, however the City's ability to achieve these goals may be influenced by a changing environment.

Over the decades following these documents, three economically oriented documents cited the critical importance of certain economic assets in Beverly (e.g., the Cummings Center) and made growth projections that assumed a stationary environment during the planning period. These were the Downtown Beverly Strategic Plan (CLUE Group, 2010), the Market Analysis for Potential Transportation-Oriented Development at the Beverly Depot MBTA Station (RKG Associates, 2013), and the Beverly Economic Snapshot (AKRF, 2016). In making no reference to a changing environment, it is as if the documents assume these economic assets will retain their economic productivity and other characteristics when high tide levels may rise around them. The MBTA report by RKG did discuss issues related to FEMA classifications, but the AE flood zones and base flood elevations used by FEMA are retrospective, not prospective, so threats from environmental change in the future may be underestimated. Because the threats of sea level rise and storm surge are not mentioned, these three documents also do not discuss adaptation actions that may become necessary to preserve the desired economic characteristics of these assets. This is also the case with the Beverly Bass River District Vision and Action Plan (MAPC, 2014), which details many types of intended development in what are now or may soon become flood prone areas.

Finally, numerous additional planning documents with specific references to waterfront infrastructure in Beverly similarly do not reference these threats, even though they address

assets directly on the waterfront. These include the Ferry Landing Waterfront Usage Plan with design guidelines (Fort Point Associates, 2000) and products from several class projects by students from Harvard's School of Design in 2013. Each Harvard project designated intended new uses along Beverly's shores, and none referenced that some of the sites may be underwater at high tide within the next several decades (if not on a daily basis, then possibly on a semi-annual basis when astronomical high tides occur) or what might be done to protect the potential developments.

Although not entirely reflected in these documents, the anticipated impacts of environmental change are serious. It is difficult to overstate the importance of integrating analysis of these changes into future planning documents in Beverly. This could be accomplished by providing adequate requirements for floodproofing, elevation adjustments, structural support, etc. The CRP report has a section on possible new zoning and overlay zones and other planning reforms that could be implemented in this manner, and additional recommendations are provided in this report.

Taking the steps identified in this report will provide a chance to 1) ensure that earlier recommendations are not lost when environmental conditions change, and new planning frameworks are required or initiated, and 2) bridge the gap between sustainability-oriented intentions of master planning documents and implementation-oriented intentions of documents that direct economic or waterfront development. These observations suggest there is great opportunity for the Beverly Harbor/Waterfront Plan to responsibly address a changing environmental future.

5. Recommendations

The Beverly Harbor/Waterfront Plan presents the City with an opportunity to incorporate short- and long-term approaches that would address anticipated changes to the physical environment. As a start, Sections 2.1 and 2.2 of this report describe numerous requirements of Incentive-based and Flood Fringe Ordinances. Passing such ordinances could be viewed as a long-term strategy, but even without such regulatory mechanisms in place the City of Beverly could take many of the itemized steps in the short term, with public buildings and infrastructure in flood prone areas. For example, items in the Flood Fringe Ordinance that could be implemented in the short term include:

- Ensuring that public buildings and infrastructure such as gas or liquid storage tanks, equipment servicing buildings, and pedestrian elements such as park benches and pagodas:
 - Are anchored and designed to prevent flotation, collapse or lateral movement due to floodwater-related forces.
 - Use flood-resistant construction materials and utility equipment in any new construction or substantial modification.
 - Provide adequate drainage to reduce flood hazard exposure.
- Locating and constructing public utilities and facilities to minimize or eliminate potential flood damage. This includes use of wet and dry floodproofing techniques, both for new construction and for retrofits of existing structures.
- Designing all water supply and sanitary sewage systems to minimize or eliminate floodwater infiltration or discharges into floodwaters.

As in Section 2.3, implementation of an overlay district is another possible long-term strategy. An effective zone could distinguish between land with sensitive natural resources and land that could continue to be developed. It could also include sub-districts with differential setbacks, structure elevations, and sizes.

Besides overlay districts, long-term strategies could also include creation of rolling development restrictions that move landward as the tide line moves landward (Titus, 2011) and strengthening building codes to require additional adaptation strategies (EPA, 2017). For all these actions, outreach to private landowners in currently developed areas and especially in proposed future development areas may be appropriate or necessary.

Additional long-term actions could include ongoing evaluations of likely inland flooding from rain events and upland runoff. This could provide useful information about where flood waters are likely to go in areas intended for future development. In combination, these strategies will help the City of Beverly become more resilient in the face of the combined threats of sea level rise and storm surge.

Other recommendations made throughout this report are summarized below:

- Dredge the Bass River to restore its historic authorized width and depth. This would provide the ability to add moorings north of the Bridge Street swing bridge, restore functionality to the Margin Street Boat Ramp, address the ability of Hill's Yacht Yard to work on larger boats throughout the tidal cycle, and add potential for additional slips.
- Investigate rearrangement of vessels within Bass Haven Yacht Club to allow public access along the water. Vessel storage rearrangement would need cooperation by an entity approved by the City.
- Add moorings, as appropriate, throughout the area north of the swing bridge. The additional moorings can be accommodated through the proposed dredge footprint. Bow/stern moorings should be used where possible to minimize impacts. The control of the layout and process of mooring assignments, coordination of a launch service, and dinghy docks and parking support for users could be managed by an entity approved by the City.
- Add moorings, as appropriate, along the Bass River's western shoreline area (see Appendix B). Bow/stern moorings should be used where possible to minimize impacts. Oversight and use of moorings should also be coordinated by an entity designated by the City. Additional floats and slips could also be installed provided they do not impact the federal dredging project and they are approved by National Grid (which has rights to the area in front of their waterfront). Federal project approvals will also need to be obtained to ensure the area could be dredged again, and access and management would need to be coordinated with National Grid and the coordinating entity determined by the City.
- Consider limiting the channel width to allow additional mooring capacity, recognizing that modification of a federal channel or state harbor line requires legislative action, represents a significant commitment of effort, and should be reviewed carefully relative to currents and vessel maneuvering requirements within the harbor. Narrowing of the channel would also negatively impact larger commercial vessels accessing Bass River.

- Review potential for limited dredging in the Danvers River to accommodate more mooring areas across from the waterfront.
- Consider reconstruction of the eastern public boat ramp at the end of Water St., which is not usable at all tides, and developing the Pleasant View Beach site into a launch area for paddle board and kayak landings.
- Examine creation of ADA-compliant berthing to accommodate passenger vessels around the existing City Pier near the BHMO.
- Evaluate partnerships with neighboring towns to accommodate small and large cruise vessels and the potential for mooring them outside the channel and ferrying passengers to the City.
- Provide elevated boardwalks over the saltmarshes along Bass River North.
- Provide boat launch reference signs on Bass River South, Danvers River, and in Beverly Harbor. Signs should differentiate between kayak/canoe launches, boat launches, and boat lifts. Coordinate pathways through active marinas where lift systems are being utilized.
- Evaluate installation of tidal control measures below the superstructure of the Hall-Whittaker Bridge. Consider an environmental impact study as part of this.
- Conduct an assessment of the culvert and piping system along Elliot Street, install a naturalized berm along the southern side of Elliott Street, and construct a living shoreline along the marsh abutting the street.
- Consider a deployable flood barrier in the vulnerable portion of Federal Street.
- Consider evaluating the railroad overpass crossing the inlet that is part of the Chubb Creek Marsh system and evaluate whether to implement a tide control structure to protect the large residential area adjacent to the Marsh.
- Make gradual adjustments to mooring systems to accommodate for rising sea levels, including increased mooring pile height and longer mooring chains for systems that are bottom moored.
- Develop wave attenuation systems to provide marina protection from storm surge.
- Increase gangway connection elevations and, as appropriate, develop systems to suspend gangways so that they are disconnected from float systems during major storm events.

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Appendix A

Beverly Waterfront Assessment Photos

Beverly Harbor Waterfront Assessment



Bass Haven Yacht Club



Bass Haven Yacht Club



Margin Street Ramp (Private)



Margin Street Ramp (Private)

Beverly Harbor Waterfront Assessment



Hall/ Whitaker Bridge, Bridge Street



Hills Yacht Yard



Hills Yacht Yard



Commercial Fishing Pier (Private) on Bass River

Beverly Harbor Waterfront Assessment



Commercial Fishing Pier (Private) on Bass River



Commercial Fishing Pier (Private) on Bass River



Pleasant View Beach



Pleasant View Beach

Beverly Harbor Waterfront Assessment



Paved Path to Pleasant View Beach



Open Land (West of Beverly/Salem Bridge)



Collapsed Fish Market Pier @ 4 Cabot Street - Next to Beverly/ Salem Bridge Abutments



City Public Area - City's Harborwalk Beneath Beverly/ Salem Bridge

Beverly Harbor Waterfront Assessment



City Marina



City Marina



City Pier



City Floats and Gangway

Beverly Harbor Waterfront Assessment



City Floats and Gangway at Harbor



City Floats and Gangway at Harbor



Beverly Port Marina



Beverly Port Marina

Beverly Harbor Waterfront Assessment



Beverly Port Marina



Beverly Port Marina



Beverly Port Marina



Commercial Fishing Access at Harbor

Beverly Harbor Waterfront Assessment



Commercial Fishing Access, Beverly Harbor



Commercial Fishing Access, Beverly Harbor



Commercial Fishing Access, Beverly Harbor



Tuck Point Condo Marina

Beverly Harbor Waterfront Assessment



Tuck Point Condo Marina



Tuck Point Condo Marina



Tuck Point Condo Marina



Tuck Point Condo Marina

Beverly Harbor Waterfront Assessment



Jubilee Yacht Club



Jubilee Yacht Club



Jubilee Yacht Club



Jubilee Yacht Club

Beverly Harbor Waterfront Assessment



Jubilee Yacht Club



Water Street Ramp



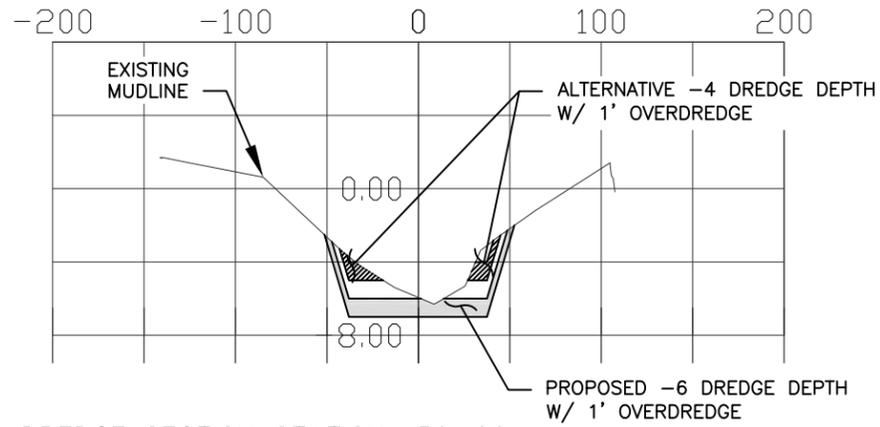
Water Street Ramp

Appendix B

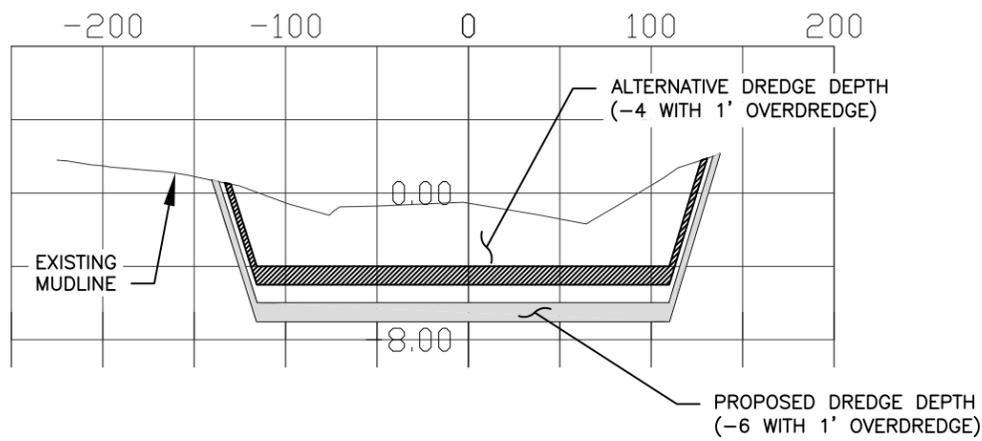
Maps Showing Proposed Dredge Limits

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DREDGE SECTION STATION: 40+00



DREDGE SECTION STATION: 50+00



LEGEND:

- TOTAL IMPACT AREA - CHANNEL AND SIDE SLOPES
- AREA ABOVE MLW
- 1955 HISTORIC BASIN MA DPW CONTRACT 1455
- HISTORIC CHANNEL 1904 HLC LIC. (2854)
- 1934 HISTORIC BASIN MA DPW CONTRACT 414

PROPOSED DREDGE LIMITS (-6)

PHASE I: STATION 36+00 - 53+88	
-6 DREDGE	43,664CY
-7 OVERDREDGE	10,076CY
TOTAL:	53,740CY

ALTERNATE DREDGE LIMITS (-4)

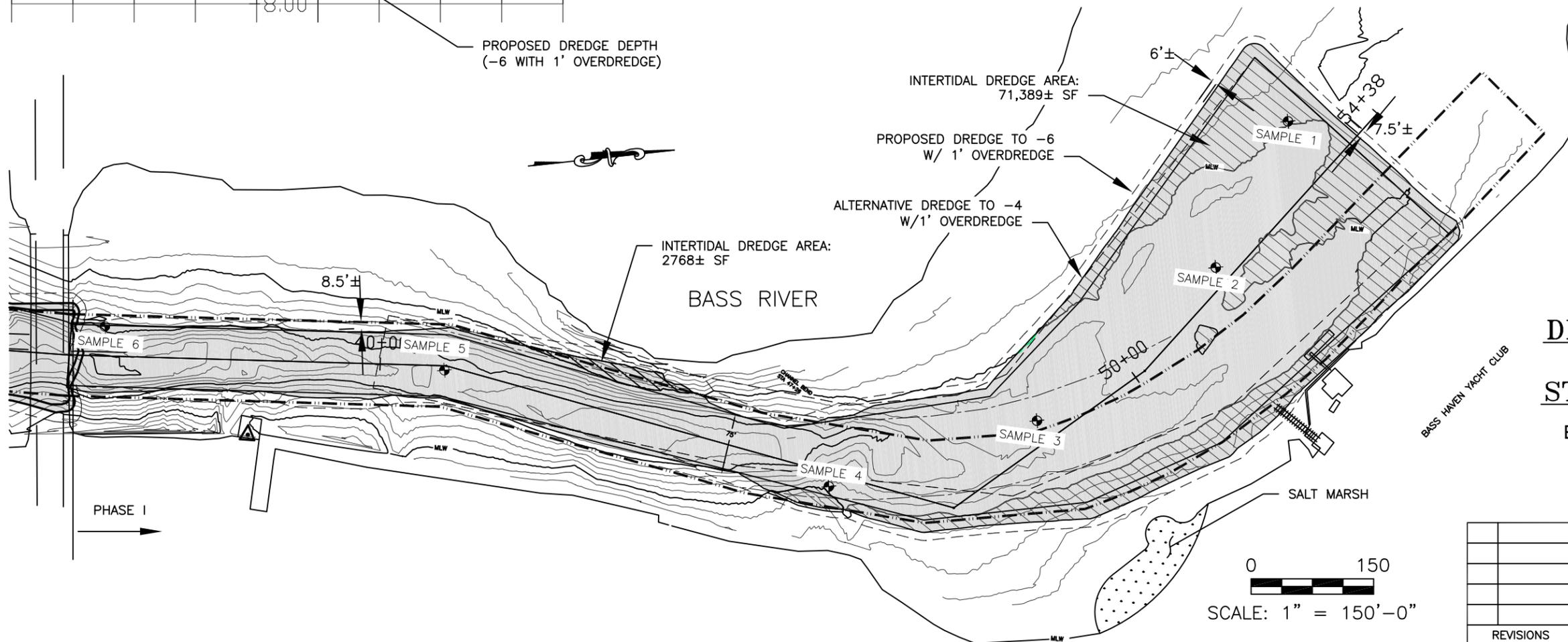
PHASE I: STATION 36+00 - 53+88	
-4 DREDGE	25,063CY
-5 OVERDREDGE	8,219CY
TOTAL:	33,282CY

PHASE I DREDGE AREA: 315,005 SF

INTERTIDAL IMPACT: 94,105 SF

PHASE I DREDGE AREA: 282,312 SF

INTERTIDAL IMPACT: 74,156 SF

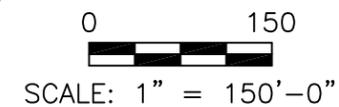


DATUM

100 YR. FLOOD	+14.5
HTL	+11.37
MHW	+9.03
NGVD	+4.50
MLW	0.0

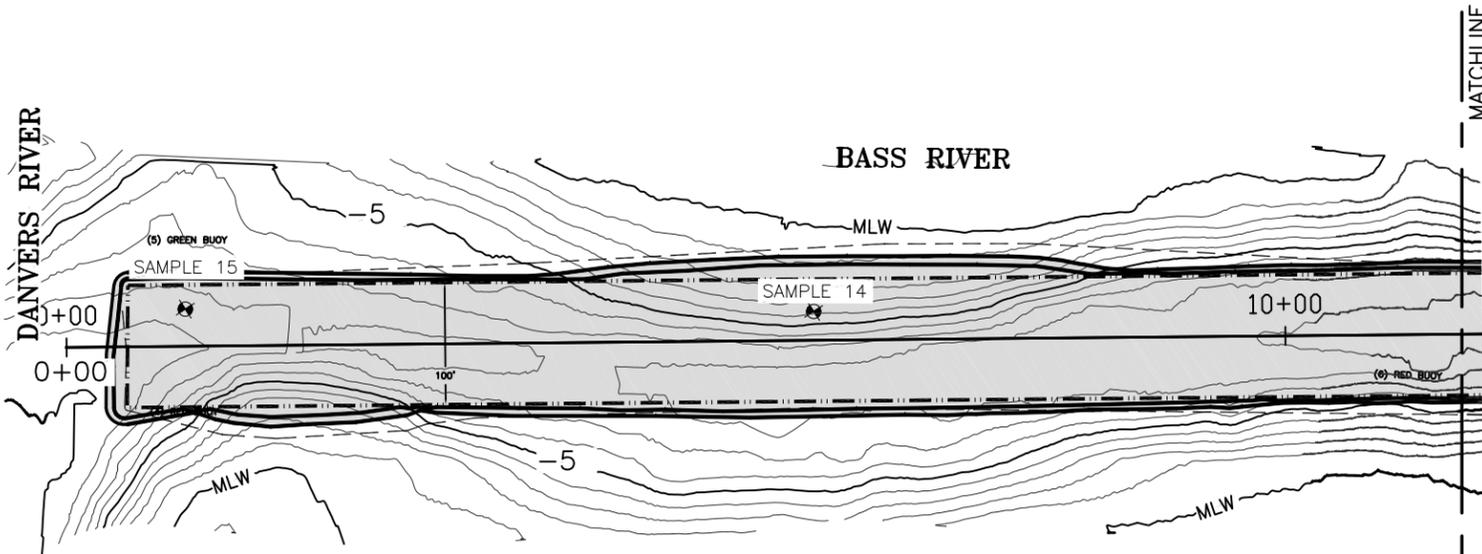
**DREDGE ALTERNATIVE
PHASE I
STA 36+00 TO 53+88**

BASS RIVER DREDGE PROJECT
CITY OF BEVERLY
BEVERLY, MA
JULY 2011

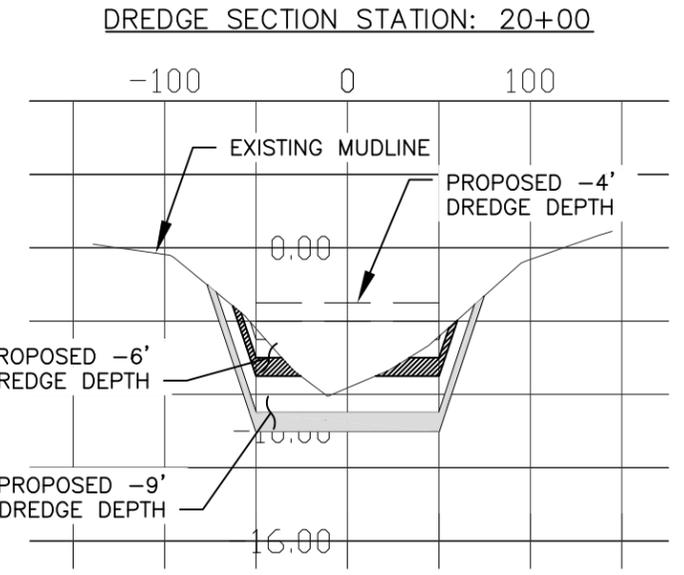
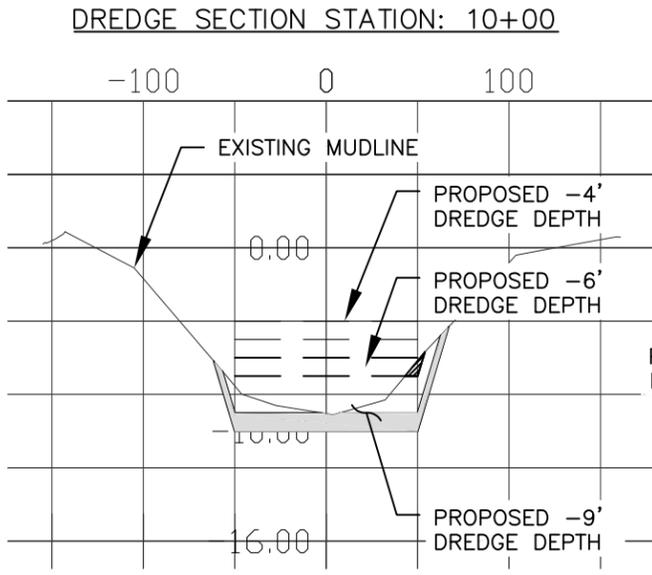


REVISIONS		Bourne Consulting Engineering	
		3 Bent Street Franklin, MA 01930 PH. (508) 533-0000 FAX. (508) 533-0000	
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		CHECKED: RRB	SHEET 1 OF 7
		APPROVED: RRB	
		DATE: 07/12/11	

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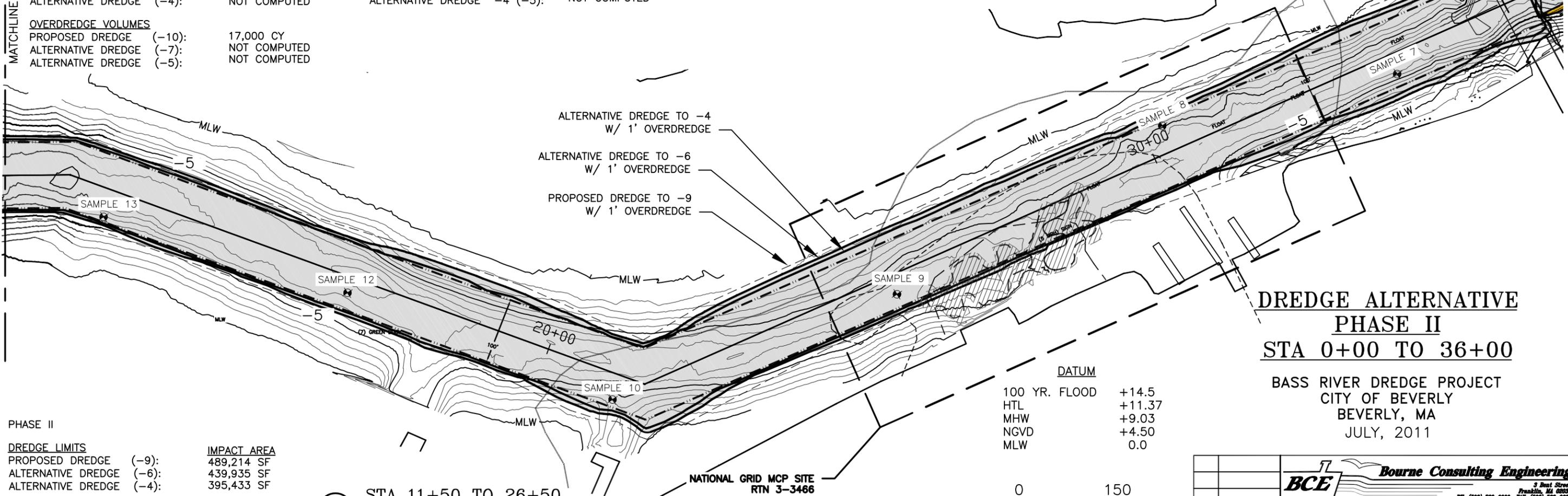


A
2
STA 0+00 TO 11+50
SCALE: 1" = 150'



PHASE II

DREDGE VOLUMES		DREDGE VOLUMES TOTALS	
PROPOSED DREDGE (-9):	39,000 CY	PROPOSED DREDGE -9 (-10):	56,000 CY
ALTERNATIVE DREDGE (-6):	NOT COMPUTED	ALTERNATIVE DREDGE -6 (-7):	NOT COMPUTED
ALTERNATIVE DREDGE (-4):	NOT COMPUTED	ALTERNATIVE DREDGE -4 (-5):	NOT COMPUTED
OVERDREDGE VOLUMES			
PROPOSED DREDGE (-10):	17,000 CY		
ALTERNATIVE DREDGE (-7):	NOT COMPUTED		
ALTERNATIVE DREDGE (-5):	NOT COMPUTED		



B
2
STA 11+50 TO 26+50
SCALE: 1" = 150'

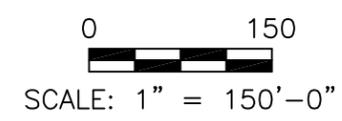
ALTERNATIVE DREDGE TO -4
W/ 1' OVERDREDGE

ALTERNATIVE DREDGE TO -6
W/ 1' OVERDREDGE

PROPOSED DREDGE TO -9
W/ 1' OVERDREDGE

DATUM

100 YR. FLOOD	+14.5
HTL	+11.37
MHW	+9.03
NGVD	+4.50
MLW	0.0



**DREDGE ALTERNATIVE
PHASE II
STA 0+00 TO 36+00**

BASS RIVER DREDGE PROJECT
CITY OF BEVERLY
BEVERLY, MA
JULY, 2011

REVISIONS	BCE Bourne Consulting Engineering 3 Bent Street Franklin, MA 02038 PH. (508) 533-0000 FAX. (508) 533-0000	DRAWING NO. 30800-10-02 SHEET 2 OF 7
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