GREAT BAY LIVING SHORELINE PROJECT

CHAPMAN'S LANDING - STRATHAM, NEW HAMPSHIRE
DESIGN BASIS MEMO

Prepared for: New Hampshire Fish & Game

Great Bay Living Shoreline Project Grant

Great Bay National Estuarine Research Reserve

New Hampshire Department of Environmental Services – Coastal Program

University of New Hampshire

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1.0 Introduction

The Chapman's Landing site is located on the north side of NH Route 108 (College Road) in Stratham, New Hampshire. It borders the Squamscott River and is located adjacent to the NH Route 108 bridge. The property is owned by the NH Fish and Game Department (NHF&G) and is operated as a public boat ramp. It is one of the few places in Great Bay where you can launch boats at both low and high tide. There are two dirt/gravel parking lots at the site, restrooms, and the Great Bay Community Wildlife Garden. The site is also used as fishing access point. The lower parking lot was built in the early 1990's. The upper parking lot was added in the early 2000's.

Chapman's Landing Site

In addition to the public boat launch, the site also contains a large salt marsh that provides valuable habitat for the saltmarsh sparrow (*Ammodramus caudacutus*), a state-listed species of Special Concern. The high marsh areas at Chapman's Landing provide important nesting habitat for this species.

Based on discussions with NHF&G, their goals and concerns as the landowner include:

1. Maintaining boating access and general public use – The site is funded as a boat ramp and is a popular location for both motorized and non-motorized boating. NHF&G mentioned that they receive complaints throughout the Seacoast Region that there isn't enough parking at boat ramps, so they would like to maintain the size of the existing lots at Chapman's Landing. In addition to boating, people park at the site for fishing and general access to the river and marsh.
2. Preserving saltmarsh sparrow habitat – NHF&G would like to maintain the existing high marsh at the site, so it continues to provide nesting habitat for the saltmarsh sparrow *(Ammodramus caudacutus*). Changes in water levels in the marsh would be detrimental to the species.
3. Erosion rates and causes – One of the questions asked by NHF&G is whether erosion is occurring at the site, and if it is, what are the rates and major drivers. If erosion is happening, then NHF&G would like suggestions of erosion mitigation measures that are natural and would protect the marsh. If erosion is not happening, then NHF&G would like to know if there are features of the boat launch that are helping to avoid erosion and therefore should be replicated at other sites.

The design team focused on NHF&G's goals and concerns in developing our project approach and living shoreline design. Overall, the site presented many interesting considerations and challenges. Although there is erosion occurring along the marsh edge to the north of the boat ramp, it is questionable whether this erosion is occurring at a rate that requires intervention. Further monitoring at the site is recommended to determine erosion rates and decide if and when action should be taken to stabilize the

marsh edge. To meet the deliverable goals for this project, which includes a 50% design of a living shoreline, the team developed a living shoreline design for a 190-foot segment of marsh edge north of the boat ramp with the goal of stabilizing the boat ramp area and minimizing further loss of the marsh. In addition, the team considered several other improvements that may help address some of the impairments identified at the site, as well as an "adaptive pathway" approach that could help guide long-term planning at the site. Since there is relatively extensive salt marsh at the site and the boat ramp and parking lot have a higher tolerance for flood risk, the site has potential for experimental living shoreland designs and other creative approaches.

After considering the site conditions, observed erosion, and various constraints, the design team is recommending a "no action" approach at this time for Chapman's Landing. Continued monitoring of the marsh edge erosion and long-term planning for sea level rise could help inform when a living shoreline or other actions need to be implemented to maintain the boat ramp and preserve the salt marsh habitat at the site.

Management History

It is important to note that this project will be tailored to fit into the landowner's current management goals and strategies. In order to propose a successful living shoreline design, an understanding of previous actions at the project site is necessary.

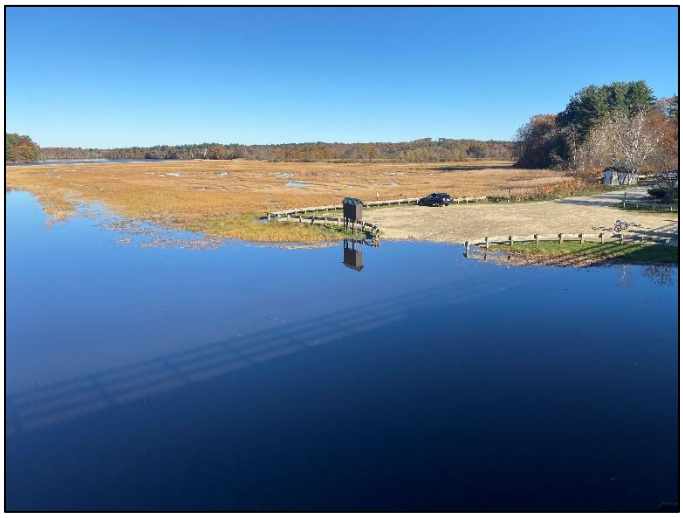
The boat access and ramp area has been updated and managed for several decades. Prior to 1991, the project site was privately owned by the Chapman family. The property at that time included a residential building and an existing bituminous concrete ramp located just north of the Route 108 bridge. In 1991, the Route 108 bridge was rebuilt. Simultaneously, NHF&G took ownership of the property and created a public boat access by developing the lower parking area along with improvements to the boat ramp with rip rap bounding the southern side of the improved boat ramp. Saltmarsh cordgrass (*Spartina alterniflora*) was installed in the area of the rip rap. In the early 2000s, the Route 108 bridge was expanded. Simultaneously, the Chapman's Landing boat ramp was replaced and an additional upper parking lot was constructed. During these updates, a total of approximately 10,000 square feet of tidal wetlands (just north of the boat ramp as well as south of the Route 108 bridge) were restored around Chapman's Landing.

2.0 Existing Conditions

2.1 Overview

The Chapman's Landing site consists of a boat ramp, two dirt/gravel parking lots, extensive salt marsh habitat, and small upland areas near Route 108. The boat ramp consists of concrete blocks that extend from the lower parking lot into the Squamscott River. Currently, the entire boat ramp is submerged during exceptionally high tide events, such as during the 2021 king tide event shown in the photograph. Small erosion channels were noted adjacent to the boat ramp during the site visits.

South of the boat ramp, the edge of the salt marsh is characterized by riprap installed in the early 2000s as part of a separate living shoreline project. Since the completion of this work, this area has been colonized by salt marsh species, predominantly cordgrass.



2021 King Tide at Chapman's Landing

Immediately north of the boat ramp, a small amount of riprap is visible at the salt marsh edge, which is undercut in some areas. Soils along the salt marsh edge consist of a thick layer of peat atop a bedrock ledge, which is visible at low tide. Where the base of the peat platform meets the riverbed, mudflats are present in some areas. A narrow strip of low marsh dominated by cordgrass exists along the river's edge, with scattered clumps of cordgrass extending into the mudflats toward the river.

The salt marsh exhibits a pronounced, elevated levee along its edge, either formed by sediment deposited by the river or constructed historically for agriculture and/or flood control. This levee is dominated by a suite of high marsh species: salt meadow hay (*Spartina patens*), salt grass (*Distichlis spicata*), black rush (*Juncus gerardii*), sea lavender (*Limonium carolinianum*), and seaside goldenrod (*Solidago sempervirens*). Further south and toward the upland, the surface of the marsh slopes downward and transitions into a low marsh community dominated by the stunted form of cordgrass. The interior of the marsh is characterized by a mosaic of megapools—large areas of standing water—dominated by short-form cordgrass and glasswort (*Salicornia depressa*).

There appear to be multiple facets causing erosion at Chapman's Landing. Erosion of sediment bounding the boat ramp is likely due to heavy rain events and subsequent runoff during heavy rain events. Within the marsh, there are several foot paths with remnants of flattened vegetation caused by anglers, birders, and others walking. Undercut banks are prevalent north of the boat ramp.

Erosion channels above boat ramp

2.2 Data Collection

The design team visited the site on September 3, 2021, and November 5, 2021. During the September visit, the site was walked, and basic observations were made regarding existing conditions. Erosion pins were installed in nine locations along the bank north of the boat ramp and several elevation measurements were made using a laser level. During the November site visit, additional survey data was collected using a total base station. The survey focused on collecting

elevation data for six transects (described in Section 2.3) as well as some additional points along the boat ramp and parking lot.

The erosion pins installed in September 2021 were measured in March 2022. The table and map in **Appendix G and H** show the erosion pin measurements and locations. These erosion pins are still in place and were re-set flush with the surface of the marsh soil after the March 2022 measurements. Over the approximate 6-month period from September to March, the extent of erosion ranged from 0 mm to 21 mm. Four of the nine pins had approximately 9-10 mm of measured erosion. If a similar rate of erosion occurs throughout the year, this data shows an erosion rate of 40 mm (1.6 in) or less per year.

The team also utilized orthoimagery, LiDAR data, and US Army Corps of Engineers bathymetry data to better understand historic/baseline erosion rates and to supplement data at cross-sections that could not be obtained via field survey at low tide. Water surface elevation data for the Squamscott River that was collected at the NH Route 108 bridge in September, October, and November 2020 were used to determine mean low, mean low low, mean tide, mean high, and mean high high water levels at the site.

2.3 Estimation of Historic / Baseline Erosion at Salt Marsh Edge

Orthoimagery (downloaded via the NH GRANIT data clearinghouse) was used to assess the dynamic shoreline adjacent to the boat ramp at the site across multiple time horizons, dating back to 1962. Orthoimagery from 13 datasets were used to compare shoreline change by georeferencing the aerial imagery to static reference points (e.g., bridge piers, parking lot edges and curbing, and permanent structures). From each image, the shoreline (edge of salt marsh) was traced in ArcGIS to allow for inter-year and multi-decade comparisons.

An overlay image comparing the shoreline edge across the 13 orthoimagery datasets along the entire base study area is provided in **Appendix B**.

Despite year-to-year fluctuations (net erosion or accretion) and mapping-based uncertainties (e.g., timing of orthoimagery not consistent with respect to seasonality, raster image resolution limitations, GIS user error in georeferencing), the project team's historic aerial imagery analysis shows that the lateral rate of shoreline change due to erosion has likely not exceeded 60 feet since 1962.

Given the history of past interventions made at this site, it is possible that past actions taken have periodically increased or decreased erosion of the marsh edge both upstream and downstream of the boat ramp. Beyond natural drivers, such as riverine flow, tidal, and winter ice processes, the site's primary use as an accessible boat ramp exposes the marsh edge to additional erosive forces and attack from boat wakes. It is also not yet clear whether shoreline erosion rates at this site are experiencing any recent acceleration attributable to sea level rise, which has been relatively minor to-date compared with future projections.

While no definitive rate or projectable trend in erosion rate could be discerned from the limited period of on-site data collection, the historic imagery makes it clear that net erosion appears to be on the order of centimeters or inches/year, rather than feet/year. As shown in the figure above, the total net shoreline change since 1962 (60 years ago) is less than 60 feet, or less than 1 foot per year.

2.4 Cross-Section Descriptions

Upstream of Boat Ramp – This cross section is located approximately 30 feet south of the boat ramp. The bank is armored with riprap but also contains salt marsh vegetation, primarily cordgrass. As mentioned above, this section of the bank was stabilized with riprap in the early 2000's and planted with cordgrass. Since then, natural vegetation became established and now stabilizes the upper part of the bank.

Boat Ramp – This cross section is located at the existing boat ramp. Elevation measurements were also taken within the lower parking lot east of the boat ramp.

Transect A – This is the first of three transects within the proposed shoreline treatment area. Transect A is located approximately 25 feet north of the boat ramp. The salt marsh edge is eroded in this area and undercut, with a bank that is approximately 4 to 5 feet tall. Bedrock is present at the river edge, below the marsh peat. This bedrock is exposed during low tide. Vegetation below the bank is sparse and consists of scattered clumps of cordgrass. High marsh characterizes the top of the bank and is dominated by black rush, saltmarsh hay, salt grass, and sea lavender. This transect continues east

toward the upland, where it crosses a worn footpath, an area of mowed high marsh, and then ends at the parking lot.

Transect B – This transect is located approximately 80 feet north of the boat ramp. It is located near a small point in the bank and continues inland to the parking lot. Similar to Transect A, the marsh edge in this area is eroded and undercut. Small clumps of the marsh edge appear to be sloughing off into the river. Bedrock is present at the river edge, below the marsh peat. This bedrock is exposed during low tide. Low marsh vegetation occupies a narrow area along the edge of the river. The marsh above the bank is well vegetated with high marsh species including salt meadow hay and salt grass. A robust, tall variety of salt meadow hay was noted about 30 to 50 feet inland from the bank. This area abuts the parking lot and may include fill placed on the marsh during former restoration projects. At the edge of the parking lot, salt grass and sand-spurry *(Spergularia* sp.) were observed in a frequently-mowed area.

Transect C – This transect is located approximately 100 feet north of the boat ramp, just past a small point in the bank. The marsh edge is eroded and undercut. This transect is located north of the bedrock outcrop and the substrate under the marsh consists of mud interspersed with rocks and cobbles. Exposed bedrock is not apparent at this location. Cordgrass is scattered along the mudflat, where it is sparse and stunted. Above the bank, the vegetation quickly transitions to high marsh species, including salt meadow hay, salt grass, and seaside goldenrod.

Downstream Reference – Data was collected for a section of the marsh with minimal edge erosion. This transect is located northeast of the proposed shoreline treatment area, approximately 180 feet from the boat ramp. Along this area, the bank is characterized by the tall form of cordgrass. Moving west, the transect crosses an area dominated by short-form cordgrass, before transitioning to high marsh dominated by short-form cordgrass and salt meadow hay. The transect then crosses a worn footpath, where it transitions to low marsh dominated by short-form cordgrass and glasswort. Standing water is common in this area, and a megapool stands to the east of the transect.

Approximate Cross-Section Locations – Near Boat Ramp

Approximate Cross-Section Locations – North (Downstream) of Boat Ramp

2.5 Design Constraints and Considerations

Several constraints were identified during the data collection and design process. The Chapman's Landing site is unique in that it includes a public boat launch as well as a large area of existing salt marsh habitat. The boat ramp and parking lot have a higher tolerance for flood risk (compared to a house or a road) since their use can be adjusted based on tides and water levels. The salt marsh has a lower tolerance for flood risk due to the presence of the saltmarsh sparrow and its dependence on high marsh habitat for nesting. Slight increases in water levels can affect the nesting success of this species.

Some of the design constraints and considerations that were identified include:

- Boating and fishing access at the site needs to be maintained.
- A small area of common reed (*Phragmites australis*) is located adjacent to the parking lot. This invasive species is intermixed with sweetgrass (*Anthoxanthum nitens*), a native plant species protected for use by Indigenous people. Any efforts to control common reed need to avoid adverse impacts to sweetgrass at the site.
- The existing high marsh habitat is important for the saltmarsh sparrow and should be maintained. Alterations to the existing hydrology of the marsh need to be avoided.
- Japanese knotweed (*Fallopia japonica*) is present between the parking lot and the marsh edge, near the restroom facility. NH Fish and Game has started efforts to control this invasive plant species at the site.
- Aesthetics need to be considered since the site is public and easily viewed from College Road.
- Bedrock is located along approximately 100 feet of the marsh edge, on the downstream side of the boat ramp.
- Construction or other work in the marsh would need to avoid the saltmarsh sparrow breeding season (May to August).

3.0 Design Team Recommendations

Based on historic orthoimagery and monitoring data collected over the course of this study period (e.g., field survey transects, spot elevations, and measured erosion rates at installed pins), it was clear that some erosion is occurring along marsh edge on the downstream (north) side of the boat ramp. At present, however, the rate of erosion is observed to be on the order of several centimeters or inches/year, rather than feet/year.

For this reason, the consensus recommendation is that **no intervention is needed at this time** to combat erosion issues downstream of the boat ramp. It is, however, **strongly recommended that periodic site monitoring continue** at the site over the next decade, **and that NHF&G consider an Adaptive Pathways phased approach to site management.** The site monitoring effort should include – at a minimum – data collection at the installed erosion pins, water level monitoring (to discern sea level rise annual signals/decadal trend), and periodic surveys of vegetation change and salt marsh sparrow nesting numbers and success rate.

Depending on future collected site data and observed conditions, the design team has included a description of the Adaptative Pathways concept and a discussion of several alternatives explored for the Chapman's Landing site boat launch, marsh edge, and lower parking lot (refer to Section 5 and Appendix E).

While there are no immediate recommendations for intervening at the Chapman's Landing site, the design team has drafted a conceptual plan for a living shoreline treatment design along an approximate 190-foot stretch of eroding marsh and exposed banks on the downstream side of the boat ramp. It is envisioned that if there is an increase in observed erosion and/or sea level rise impacts to marsh vegetation or salt marsh sparrow habitat, reaching actionable levels as set out in the Adaptive Pathway alternatives, the conceptual design included herein could serve as the basis for design.

4.0 Proposed Site Elements

Base Design Elements (proposed):

- Primary Shoreline Treatment segment, featuring rock sill, root wads, and terraced low marsh separated by coir logs and anchored into existing marsh
- Experimental Shoreline Treatment segment, featuring coir log and oysters
- Stormwater BMPs to reduce negative impacts of erosive sheet flow runoff, including a trench drain at bottom of paved parking lot and bioretention basin(s)
- Boat ramp update (with porous paver blocks)
- Lower parking lot regrading to raise grade and add a simple drainage crown (no new paving); raising lower lot grades is likely effective only to the 2-foot sea level rise scenario (to 2050-2070)
- Educational signage about site adaptive concept and/or salt marsh sparrows

Additional future / innovative elements considered:

- Managed retreat strategy; strategically retreating lower parking lot and relocating or repurposing upper lot vegetated/lawn areas (for trailer turnaround)
- Elevated site boardwalk (with design considerations to reduce negative impacts of shade over living marsh)
- Additional oyster culture/spat at shoreline treatment (sea level rise may aid survivability)
- Thin layer placement (TLP) or dredge/sediment deposition within the high marsh to keep pace with sea level rise

5.0 'Adaptive Pathways' Concept and Approach

Given the near-term recommendation for this site is No Action (with continuing monitoring), a key question the design team wrestled with was "if/when to intervene in the future?" At the Chapman's Landing site, many different factors can impact if, how, and when to intervene. For instance, while the current observed erosion did not seem to be of significant magnitude for intervention, this condition may change in the future as sea level rise accelerates.

Among others, key factors that NHF&G may consider at the Chapman's Landing site include:

- Availability and prioritization of limited operational & capital funding
- Availability & timing of grant funding, supporting living shorelines and other adaptation/resiliency strategies
- Rate of monitored erosion at installed erosion pins and observed slumping/calving
- Rate of sea level change
- Success of critical remaining salt marsh sparrow nesting habitat
- Rate of marsh vegetation change due to sea level rise; upland migration of high marsh and long-term transitioning of salt marsh habitat to mudflat
- Impacts of an extreme event (storm surge or major riverine flooding event) that impact the boat ramp
- Frequency/extents of increased tidal flooding due to sea level rise, impacting viability and operability of the lower parking lot and trailer turn-around area
- Increases in site recreational usage, boat traffic, dog-walking within the marsh, and/or other human-centric sources of marsh impairments

Acknowledging the high tolerance for risk for built infrastructure at this site (i.e., no exposed critical infrastructure and relatively low monetary value of physical assets at risk of flooding), it is understood that other NHF&G sites may be a higher priority for near-term interventions and funding for various reasons.

For this reason, the design team considered a phased management approach, or 'Adaptive Pathways' model, to guide future decision-making. The purpose of such a planning effort was to provide NHF&G several different options, introducing data- and monitoring-informed thresholds for when to consider implementing future actions based on observable conditions. Pre-identifying specific actions and agreeing upon specific thresholds for when to take action (such as when to start applying for grant funding for a given site) can be a useful exercise, reducing the amount of uncertainty and reactive decision-making, also potentially alleviating capacity constraints which may arise later if multiple sites require attention and/or intervention concurrently.

A set of specific dynamic pathways alternatives for the Chapman's Landing site is presented in Appendix E. Four alternative options are presented (in addition to the No Action scenario), each offering differing approaches to phased management, centering sea level rise as the primary metric and actionable threshold used to trigger intervention measures.

- **Option 1** includes upfront coordination to pair the implementation of a shoreline treatment project with the boat ramp upgrade, however it may require the landowner to re-intervene

again before 2070 if sea level rise accelerates significantly

- **Option 2** separates the shoreline treatment project from the boat ramp upgrade, prioritizing the shoreline stabilization and returning to the boat ramp when funds become available (or the site become a NHF&G priority to upgrade for recreational reasons). This option has moderate site re-disturbance (several mobilizations) and potentially higher aggregate cost than Alternative 1, but offers more flexibility as all the funds don't need to be secured up-front. Like Alternative 1, the long-term acceleration in sea level rise may require the landowner to reintervene again in the future (2050-2070), as the useful life of the upgraded boat ramp may be limited to just a few decades before another intervention is required.

- **Option 3** includes implementing the majority of proposed site elements (higher cost) and doing so all at one time by pre-emptively retreating from the lower parking lot early (limiting future redesign, remobilization costs, and potential malinvestments in lower lot upgrades that have limited useful life if sea level rise accelerates).

- **Option 4** is similar to **Option 3**, but site elements are implemented independently. For instance, the shoreline treatment would be prioritized in the near term. The boat launch upgrade and lower lot regrading effort would follow at a later time, with the intent being that the lower lot is kept operational for as long as possible. A reactive retreat from the lower lot would only occur when prompted by increased flooding and impacts to lower lot viability.

- Lastly, the No Action/"Do Nothing" (**Option 0**) alternative is least intrusive and no upfront cost, but does not address any longer-term issues associated with sea level rise, potential increases in erosion, or other impairments.

It is envisioned that similar dynamic pathway alternatives could also be developed in the future using different primary metrics (e.g., salt marsh sparrow nesting numbers/success rate, low/high marsh vegetation change thresholds, an observed step change in erosion rates along the marsh edge, etc.).

6.0 Proposed Conceptual Plan for Shoreline Treatment (Living Shoreline)

A conceptual design plan for a living shoreline was developed in case NHF&G decides to take action to reduce erosion at the site and restore former marsh area. The proposed living shoreline area would extend north (downstream) from the boat ramp, along approximately 190 feet of the existing shoreline. It would consist of two separate areas adjacent to each other: (1) an area immediately north of the boat ramp which is approximately 120 ft long by 10-20 feet wide with a rock and root wad toe and (2) a minimal intervention area extending approximately 70 feet consisting of three rows of oyster shell and coir logs. See **Appendix D** for a conceptual site plan and proposed cross section profiles.

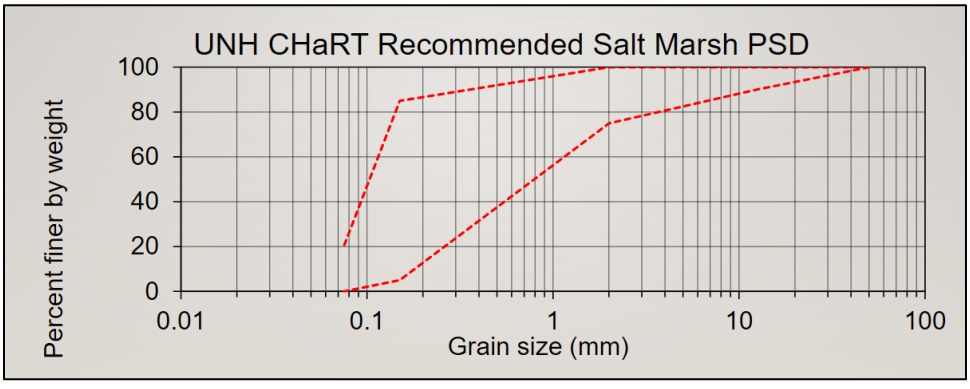
Marsh Extension with Rock and Root Wad Toe

The first treatment area extends the existing marsh surface to cover what may have been the extent of the historic marsh and is currently exposed bedrock. This would be accomplished by creating a rock sill along the edge of the bedrock area which is exposed during the mean low low tide (approximately –3.3 ft NAVD88). Root wads would be placed approximately every 5-10 feet within the rock sill, so that the roots would protrude from the rock sill and the trunk would be buried by fill, similar to that installed at the Wagon Hill Farm Living Shoreline (see photo to the right). The root wads would be held in place with cables attached to duckbill anchors, which would be anchored into the bedrock and/or the existing marsh on the uphill side. The root wads would help to add complexity to the rock sill, creating more diverse habitat and cover for wildlife.

Rock sill and roots wads at Wagon Hill Farm Living Shoreline

The rock and root wad toe treatment/sill would be built to a height of approximately 2.3 ft NAVD88, or 2 feet above the current mean tide line of 0.3 ft, and would be keyed into the existing marsh by approximately 15 ft on the south and north ends. Keying in the rock and root wad sill would help to prevent erosion and undercutting of the living shoreline treatment area, in case there is significant erosion at either end of the treatment area. A coir blanket would be placed along the uphill (marsh side) of the rock and root wad sill in order to act as a filter to hold marsh soils in place while marsh vegetation is getting established. An excess of at least ten feet of coir blanket would be left at the top of the rock and root wad sill so that it can be placed on top of the fill in order to reduce erosion at the marsh/sill interface.

Following placement of the rock and root wad sill, the area between the sill and the existing marsh would be filled with a low marsh soil mixture following the recommendations of the UNH Coastal Habitat Team (CHaRT) for particle size distribution for marsh restoration projects (see figure below).



A row of one-foot diameter coir logs would be placed along the edge of the rock and root wad sill in order to slow water and reduce erosion. Two additional rows of one-foot diameter coir logs would be placed as slope breaks between the rock sill and existing marsh, with a gain of approximately 6 inches

per row of coir logs. It is recommended that soil be built up on the downhill side of the coir logs so there is not a waterfall effect which would erode the marsh surface downhill of the coir logs.

Oyster Shells and Coir Log Treatment Area

A minimal treatment area consisting of placing rows of oyster shells and coir logs is proposed to the north of the treatment area described above. Three rows would be placed from the rock and root wad sill to the existing salt marsh edge. Each row would consist of a one-foot diameter coir log along with oyster shells in mesh bags as shown in the photo below. The coir logs and oyster shell bags would be secured to the existing mud flat using wooden stakes. This treatment area is intended to serve as a transition between the rock and root wad sill and the existing eroded marsh face. This would help to slow flows, accumulate sediment behind the rows of oyster shells and coir logs, and reduce erosion of the marsh edge.

Example of an oyster shell and coir log shoreline treatment

Planting Plan

Because proposed fill is limited to the area below the mean high water elevation, plantings should be limited to low marsh vegetation. Recommended plantings include the dominant low marsh grass species, cordgrass, on 1-foot centers in areas of exposed new fill. Following placement of fill, the site should be allowed at least two weeks to settle. If plants are grown at a nursery, it should be noted that those grown in freshwater should be hardened for several weeks with 5-10 ppt progressions of salt water to at least 2/3 expected salinity of tidal waters at Chapman's Landing.

Minimizing Disturbance

Disturbance to the intact marsh would be minimized for this project since there would be no regrading of the existing marsh. There would be a small area of disturbance where the rock sill would be keyed into the existing marsh (an approximately 15- by 5-ft area). The marsh sod would be carefully removed and set aside to place on top of where the rock sill key is constructed.

Constructing the living shoreline will require the use of heavy equipment which will either need to access the shoreline from the water or from the salt marsh. Construction access and other

implementation measures (swamp mats, long reach excavator) should be considered during final design to reduce impacts from construction. Alternatively, constructing a shorter segment of the living shoreline or using a less invasive approach that could be installed by hand (e.g., a coir log toe protection) could be considered as alternatives depending on the extent of erosion observed during future monitoring.

Another alternative to the living shoreline concept described above would be to install a rock sill at the existing marsh edge in order to prevent further erosion. This option would not protrude as far into the river channel as the above option, and so may have fewer hydraulic impacts to the channel in addition to being a less costly and simpler project to complete. This option would have fewer habitat benefits than the full living shoreline treatment described above (i.e., root wads and additional low marsh area), and would still have disturbance from the heavy equipment needed for installation.

Permitting

Construction of the proposed living shoreline would require a Wetlands Permit from NHDES and a Section 404 permit from the US Army Corps of Engineers. Section Env-Wt 609 of the NHDES Wetlands Rules discusses the permitting requirements for tidal shoreline stabilization projects. To obtain a permit, projects need to maintain or enhance the natural functions of the shoreline, provide wildlife habitat while protecting against coastal hazards, be compatible with the existing natural land cover, address the known causes of erosion, and avoid adverse impacts to the adjacent habitats and shoreline.

Under Env-Wt 609.05, living shoreline design plans must:

- Use native vegetation, sand fill, and limited stone or wood to provide shoreline stabilization and protection.
- Mimic the natural landscape and leave natural vegetation intact to the greatest extent practicable.
- Add vegetation to sand beaches or dunes or construct vegetated dunes if practicable.
- Design the sill to the lowest elevation possible that still ensures stabilization of the toe of the living shoreline.
- Maintain the shoreline's ability to absorb and mitigate storm impacts and adapt to the landward progression of the sea.
- Minimize or prevent wave reflection toward abutting properties.
- Cut back unstable banks to a flatter slope if space and soil conditions allow. Seed and replant with native, non-invasive trees and shrubs.
- Provide habitat for wildlife and aquatic species.

To qualify as a "minimum impact" project, the proposed living shoreline would need to be 200 feet in length or less, otherwise a standard permit from the NHDES Wetlands Bureau would be required. To obtain the permit, the final design of the living shoreline would need to minimize any unnecessary impacts to the existing shoreline and marsh and the need for the proposed stabilization measures would need to be demonstrated. Ongoing monitoring of erosion at the site along with future predictions of sea level rise would help inform the final design of the sill height and length to ensure that the design protects the area near the boat ramp while minimizing impacts to the abutting shoreline and marsh.

Although the area near the boat ramp appears to have been previously disturbed, potential impacts to archaeological resources should be considered. In addition, coordination with NHF&G's Nongame and

Endangered Wildlife Program would be necessary regarding potential impacts and construction considerations, such as seasonal restrictions, related to the saltmarsh sparrow and other wildlife species at the site. If the project is federally funded, review under the National Environmental Policy Act (NEPA) would likely be required.

7.0 Other Site Improvements

An existing conditions analysis (**Appendix I**) of the Chapman's Landing Boat Ramp revealed several areas of concern related to erosion, pedestrian use, and marsh habitat protection. These specific issues of concern are:

- Significant erosion of boat ramp particularly at top of slope
- Degradation of parking lot surfacing due to runoff from upper parking lot
- Uncontrolled user access on and through salt marsh
- Substandard pedestrian access from upper parking lot (safety)

Mitigation measure to address these issues are illustrated in the Conceptual Site Plan (**Appendix J**). The recommendations are:

- Extend and flatten boat ramp at the top of slope. The entrance of ramp at parking lot should also be widened to accommodate backing in of trailers that tend to miscalculate width of ramp.
- Modify lower parking lot by regrading to direct runoff away from marsh and ramp.
- Add runoff collection at base of asphalt drive with a grate drain or swale.
- Redesign existing vegetated edge of asphalt drive as rain gardens where drainage grate or swale could discharge runoff.
- Provide safe and handicap accessible walkway from upper lot to lower lot. Along marsh edge a boardwalk (timber or metal grate) is recommended to control pedestrian use off of marsh with the option to extend to a viewing platform at the river edge. The walk adjacent to the asphalt drive could be constructed with pavers or asphalt.
- Provide a vegetative barrier along marsh boundaries, parking lot and walkways to control pedestrian access to marsh habitat. Plants selected should be dense, include native species, and benefit wildlife, such as bayberry, beach plum, and beach rose (not native but naturalized).
- Increase marsh buffer about 20 feet from the existing wood guardrail. This will provide protection and allow expansion by eliminating one parking spot at the northwest edge of the existing lot.
- Improve and provide more signage. Move kiosk from behind guardrail closer to parking area. Redesign and enlarge to show more information about what NHF&G does to benefit the community and protect wildlife. Add interpretive signs about habitat and shoreline protection measures on boardwalk and walkways when constructed.

8.0 Next Steps

Continued monitoring of the Chapman's Landing site is recommended to determine if and when a living shoreline should be constructed along the marsh edge and also to help guide the level of intervention

required. This long-term monitoring could also help inform the need for the other site improvements recommended in Section 7.0. Recommended monitoring at the site includes:

- Erosion pin measurements every 6 months
- Vegetation surveys to determine changes in species and density
- Salt Marsh Sparrow nesting success monitoring
- Marsh plain elevation monitoring

Appendix A

Existing Conditions Elevation Survey

N

DS REF BOTT PEAT -0.61
DS REF TOP BANK 1.03
PIN LOWER DS REF -0.27
DS REF TOP BANK 3.33
2.99
1.07
PIN UPPER DS REF
DS EOV SHRT SP A
EROS BASE PEAT1
PIN -0.89
DS ELEV1 3.95
TR C WSE -2.07
LOWER TOP BANK1
-1.8 NEAR C 3.07
DS EOV HIGH MRSH 4.19
TR C EOV -0.04
PIN UPPER NEAR C 1.26
TR C EDGE UNDRCT 3.82
TOE SLOPE2 -0.29
-0.57 TR C EOV H MARSH
1.89
TR B WSE -2.18
TOP BANK2
TR B EOV -1.44
TR B TOP BANK 3.21
TR H MARSH VEG 4.17
TR B HI MARSH 3.64
4.4 DS TRAIL
DS LOW MARSH SP 4.32
TR B EOV PATENS 4.11
4.5 TR C ELEV1
-1.01 TOE SLOPE3
TOP BANK3 3.3
PIN LOWER DOT -0.59
PIN UPPER DOT 0.54 1.76
DOT BNCHMK 4.02
4.24 TR B ELEV PATENS
4.35 TR B EDGE MOWED
TR B PL POST 4.73
TR C ELEV2 4.53
PIN UP NEAR A
TR A WSE -2.35
TR A EOV 1.44
TR A ABOVE TRAIL 4.07 4.71
3.4 TR A EOV H MARSH
TR A BELOW TRAIL
TR A EDGE GRASS 5.34
OCC 5.44
Transect B
Transect A
Transect C
Downstream Transect
RAMP WSE 2.41
4.85 RAMP TOP BLOCK
ABOVE RAMP ELEV 5.67
Ramp Transect
ABOVE RAMP ELEV2 6.09
US REF EOV
DS EOV LO-H MRSH
US REF WSE -2.59
DS TOP RIPRAP 5.85
DS PL GRAVEL ELV
DS TOP H MRSH
DS PL FENCE
Upstream Transect
DS PL CORNER FNC 5.15
DS PL SPHALT 7.16
BNCHMK2 LIGHTPOL 6.4
DS PL CRNER FNC2 6.02
DS PL CRNER GRSS 6.57

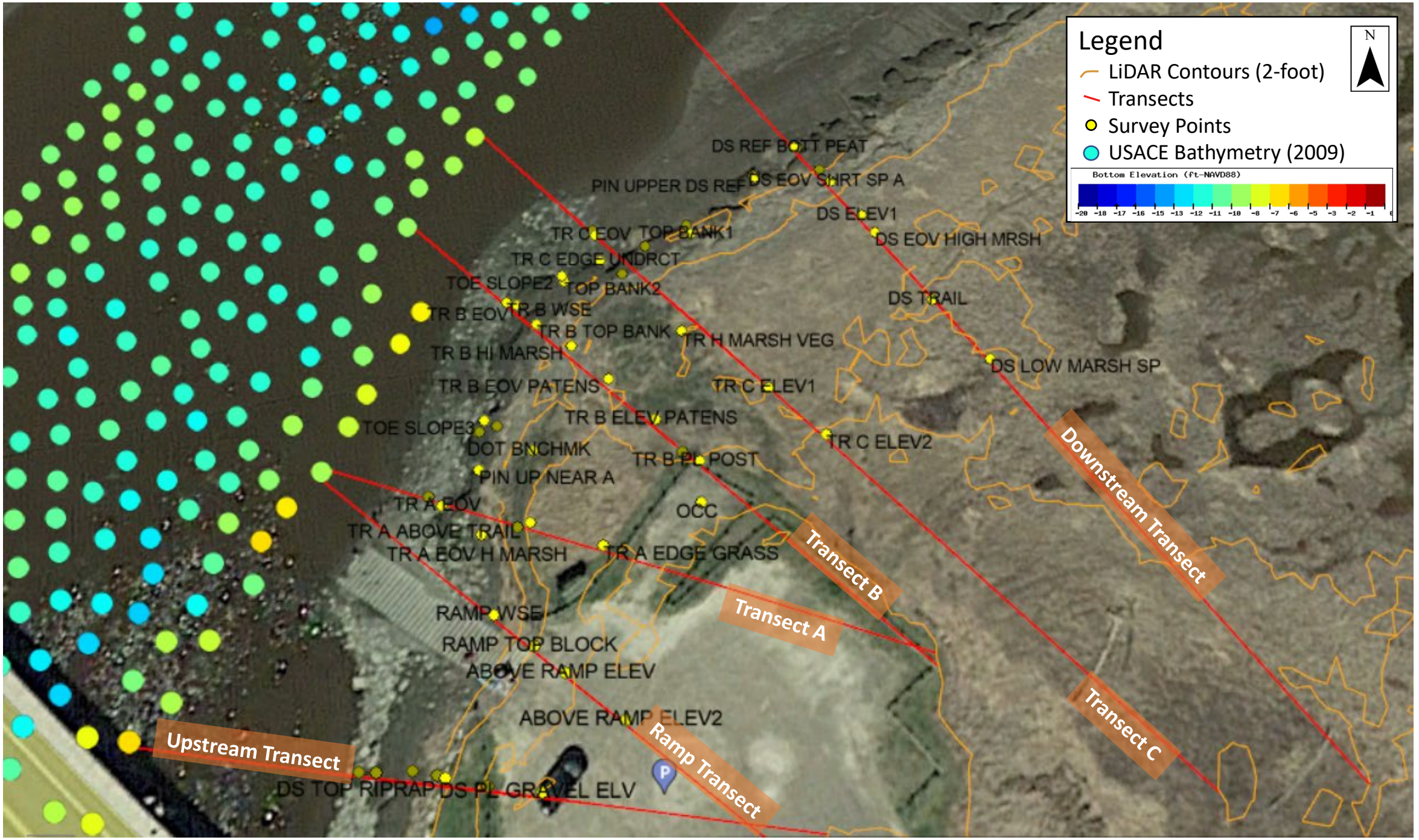
2 4 6 8 10 12 14 16 18

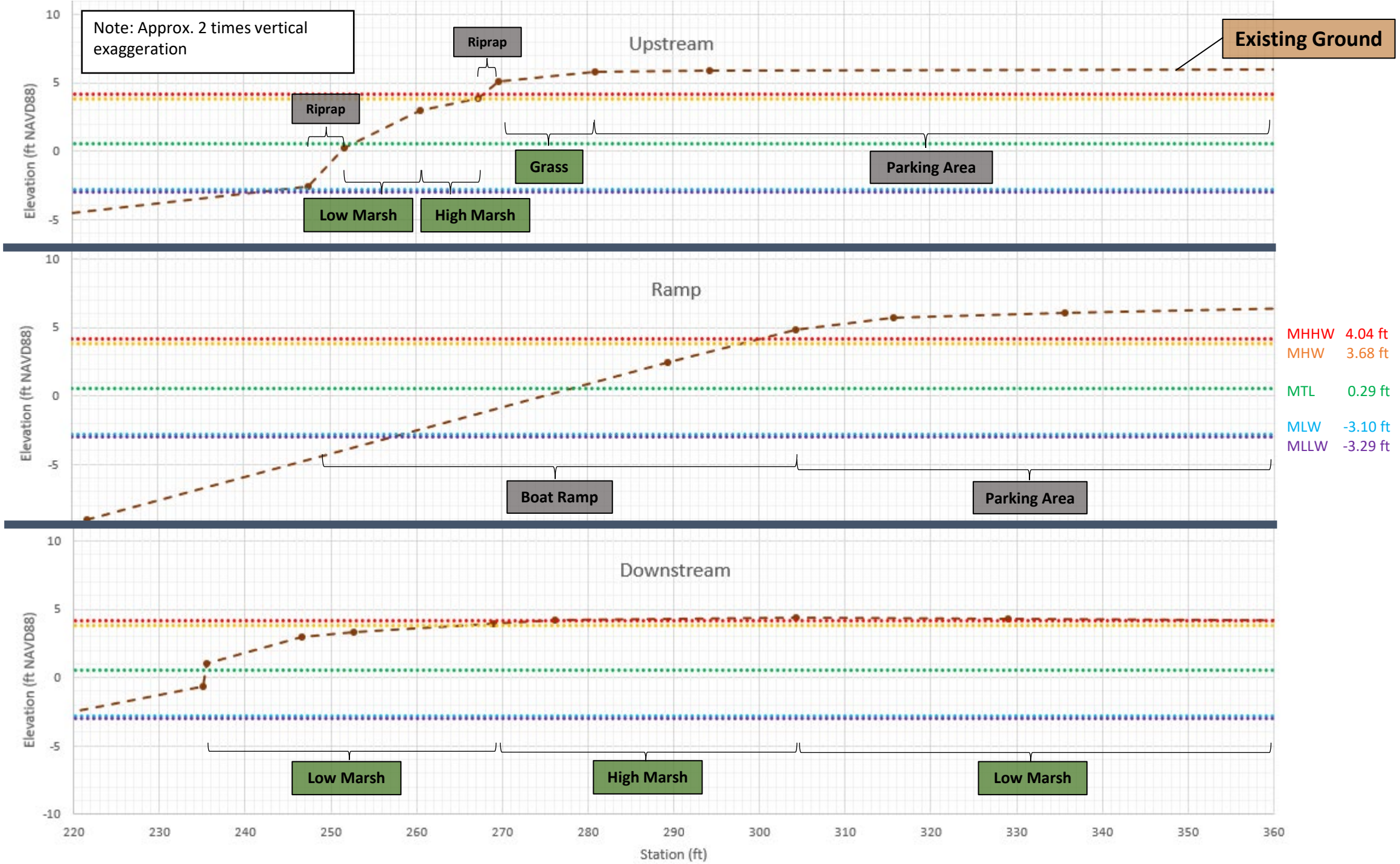
0 30 60 Feet

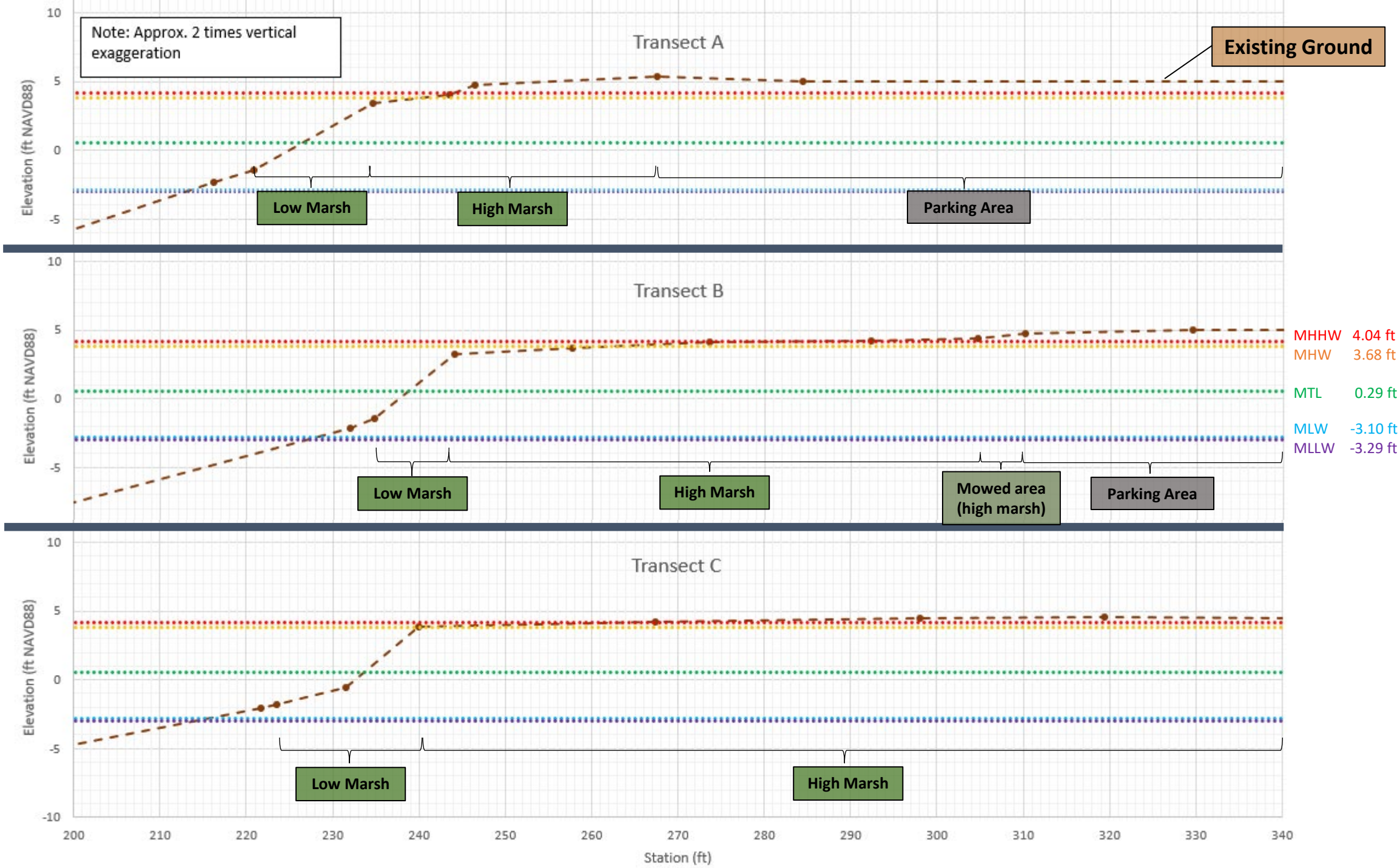
2015 Aerial Photo and 2-ft contours downloaded from GRANIT.
Field survey was completed on 11/5/2021.
Survey points are in US Survey Feet units.
Vertical datum is NAVD88.

Chapman's Landing
Stratham, NH

Existing Conditions Survey


Legend
LiDAR Contours (2-foot)
Transects
Survey Points
USACE Bathymetry (2009)
Bottom Elevation (ft-NAVD88)
N
DS REF BOTT PEAT
PIN UPPER DS REF
DS EOV SHRT SP A
DS ELEV1
DS EOV HIGH MRSH
TR C EOV TOP BANK1
TR C EDGE UNDRCT
TOE SLOPE2
TOP BANK2
DS TRAIL
TR B EOV
TR B WSE
TR B TOP BANK
TR H MARSH VEG
TR B HI MARSH
DS LOW MARSH SP
TR B EOV PATENS
TR C ELEV1
TR B ELEV PATENS
TOE SLOPE3
TR C ELEV2
DOT BNCHMK
TR B PL POST
PIN UP NEAR A
TR A EOV
OCC
TR A ABOVE TRAIL
TR A EOV H MARSH
TR A EDGE GRASS
RAMP WSE
RAMP TOP BLOCK
ABOVE RAMP ELEV
ABOVE RAMP ELEV2
DS TOP RIPRAP
DS PL GRAVEL ELV
Upstream Transect
Ramp Transect
Transect A
Transect B
Transect C
Downstream Transect
P

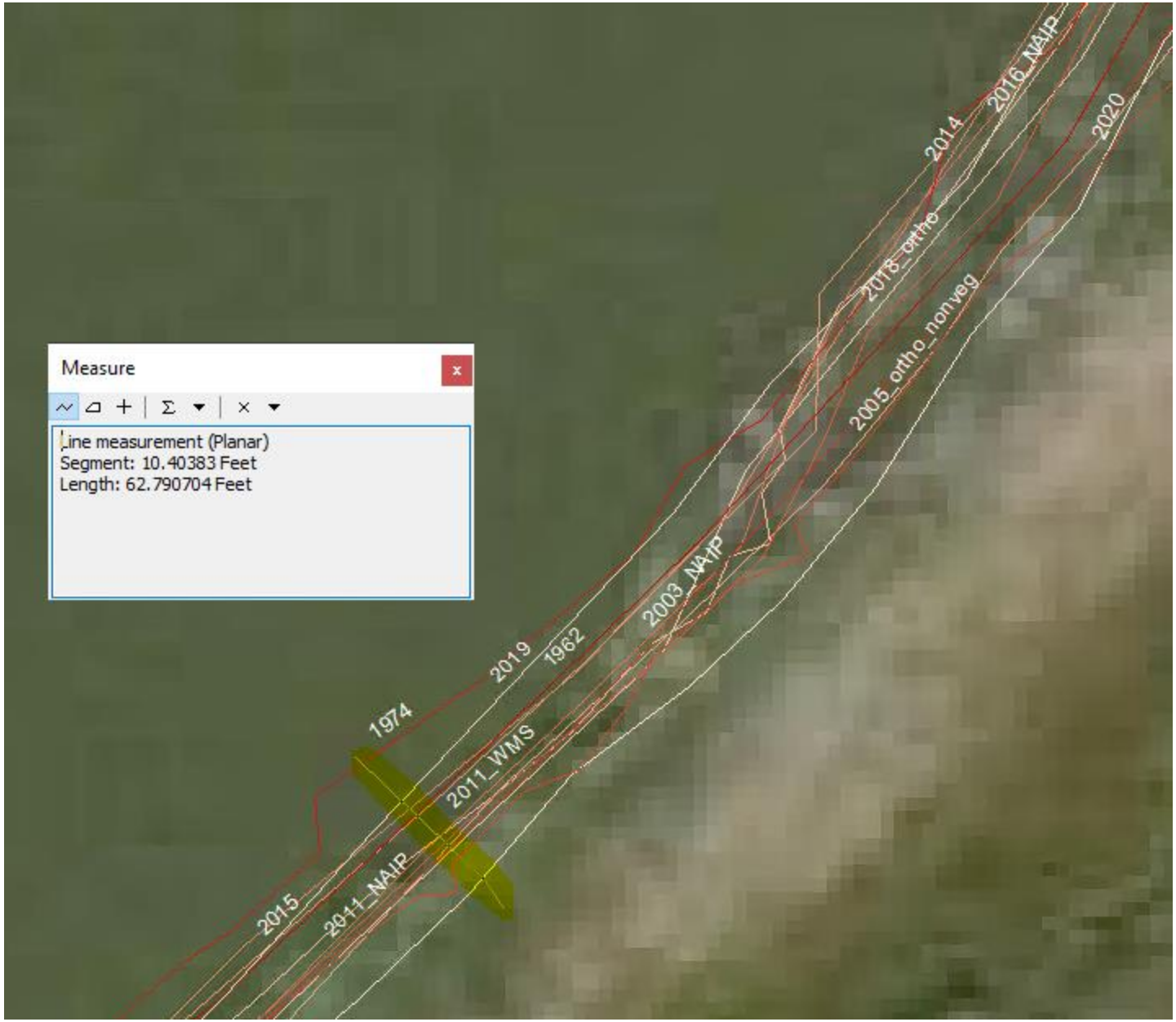

Note: Approx. 2 times vertical exaggeration
Upstream
Riprap
Riprap
Existing Ground
Grass
Parking Area
Low Marsh
High Marsh
Ramp
Boat Ramp
Parking Area
Downstream
Low Marsh
High Marsh
Low Marsh
Elevation (ft NAVD88)
Station (ft)
MHHW 4.04 ft
MHW 3.68 ft
MTL 0.29 ft
MLW -3.10 ft
MLLW -3.29 ft


Note: Approx. 2 times vertical exaggeration
Transect A
Existing Ground
Low Marsh
High Marsh
Parking Area
Transect B
Low Marsh
High Marsh
Mowed area (high marsh)
Parking Area
Transect C
Low Marsh
High Marsh
Elevation (ft NAVD88)
Station (ft)
MHHW 4.04 ft
MHW 3.68 ft
MTL 0.29 ft
MLW -3.10 ft
MLLW -3.29 ft

Appendix B

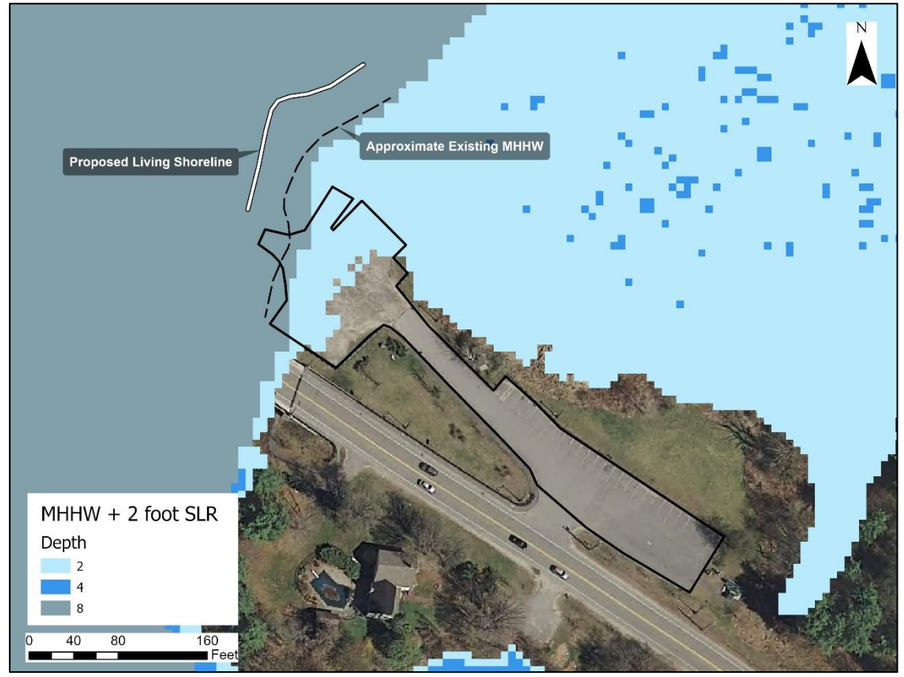
Orthoimagery & Shoreline Edge Overlays

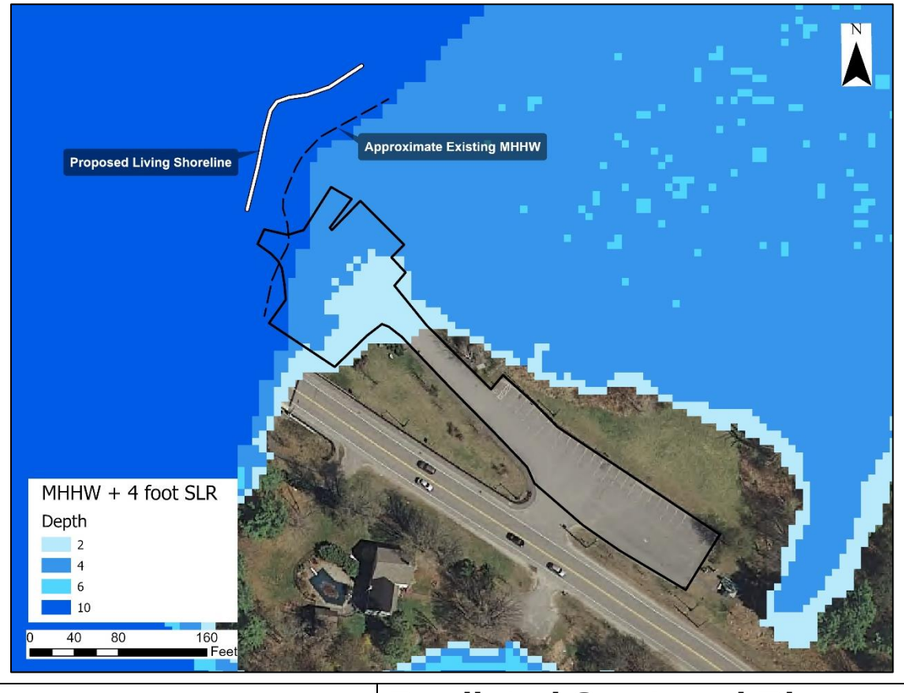

Edge of Salt Marsh
ORTHO IMAGE YEAR
2020
2019
2018_ortho
2016_NAIP
2015_ortho_nonveg
2015
2014
2011_WMS
2011_NAIP
2005_ortho_nonveg
2003_NAIP
1974
1962
Newmarket Rd
College Rd
1962_2016_NAIP_2011_NAIP
1974_2020_2019
2015
2018_ortho
2014
2015_ortho_nonveg
2005_NAIP

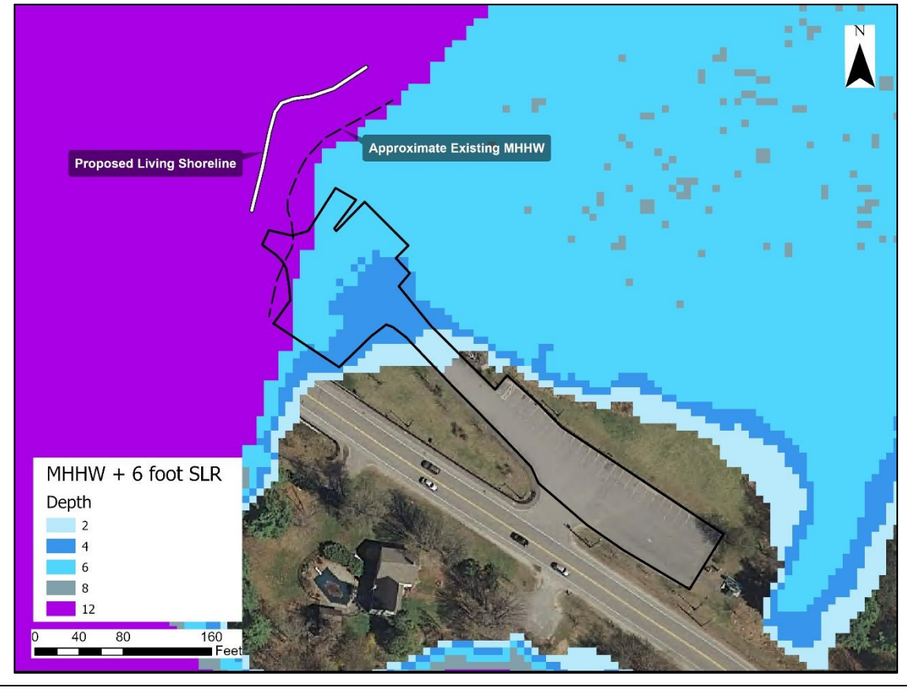

Measure
Line measurement (Planar)
Segment: 10.40383 Feet
Length: 62.790704 Feet
2016_NAIP
2014
2020
2018_ortho
2005_ortho_nonveg
2003_NAIP
2019
1962
1974
2011_WMS
2015
2011_NAIP

Appendix C

Sea Level Rise Projections – Site Overlay Visualizations







Chapman's Landing
Stratham, NH

Predicted Sea Level Rise

(Source: Earth Systems Research Center, UNH - GIS data downloaded from NH GRANIT)

Appendix D

Plan and Cross Sections at Proposed Edge Treatment

SEE DESIGN PLANS LINK ON WEBPAGE

Appendix E

Adaptive Pathways – Dynamic Pathway Scenario Schematics

STEP 3

STEP 3 TABLE A. RECOMMENDED DECADAL RSLR ESTIMATES (IN FEET ABOVE 2000 LEVELS) BASED ON RCP 4.5, PROJECT TIMEFRAME, AND TOLERANCE FOR FLOOD RISK.

TIMEFRAME	HIGH TOLERANCE FOR FLOOD RISK	MEDIUM TOLERANCE FOR FLOOD RISK	LOW TOLERANCE FOR FLOOD RISK	VERY LOW TOLERANCE FOR FLOOD RISK
	Plan for the following RSLR estimate (ft)* *compared to sea level in the year 2000*			
	Lower magnitude, Higher probability	←	→	Higher magnitude, Lower probability
2030	0.7	0.9	1.0	1.1
2040	1.0	1.2	1.5	1.6
2050	1.3	1.6	2.0	
2060	1.6	2.1	2.6	
2070	2.0	2.5	3.3	
2080		3.0	3.9	4.5
2090		3.4	4.6	5.3
2100	2.9	3.8	5.3	6.2
2110	3.3	4.4	6.1	7.3
2120	3.6	4.9	7.0	8.3
2130	3.9	5.4	7.9	9.3
2140	4.3	5.9	8.9	10.5
2150	4.6	6.4	9.9	11.7

Low tolerance for marsh itself / salt marsh sparrow use; boat ramp upgrade

Higher tolerance and later timeframe for parking lot

*The colors (blue, red, purple, green) in Step 3 Table A correspond with the colors of the graph depicted in Figure 2 (see also Figure 4.5 in *Part I: Science*[17]). The RSLR estimates for High tolerance for flood risk projects correspond with K14, upper end of "likely" estimates for RCP4.5 (83% chance RSLR will not exceed this value). The RSLR estimates for Medium tolerance for flood risk projects correspond with K14, 1-in-20 chance estimates for RCP 4.5. The RSLR estimates for Low tolerance for flood risk projects correspond with K14, 1-in-100 chance estimates for RCP 4.5. The RSLR estimates for Very Low tolerance for flood risk projects correspond with K14, 1-in-200 chance estimates for RCP4.5. For K14, 1-in-1000 chance estimates, see Table 4.2 in *Part I: Science*.[17] Note that while the Bayesian probabilities associated with RSLR projections are useful, they have some limitations as described in Box 4.3 in *Part I: Science*.[17]

Adaptation Pathways for Chapman's Landing
(Option 0 --- DO NOTHING)

Observe erosion rate, vegetation change rate, SLR, SM sparrow nesting site success (i.e., assess erosion pins quarterly, vegetation, SLR and nesting success annually)

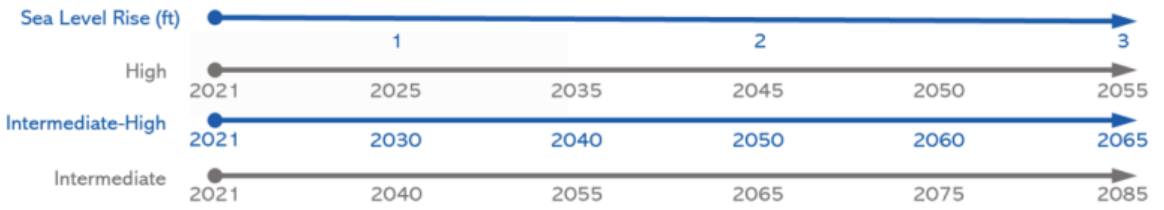
DO NOTHING (no action for shoreline)

Upgrade boat ramp
(keep lower lot, add simple drainage crown)

Wait to install new boat ramp until F&G recreation priority

Abandon lower lot/ramp only after frequent inundation

Metric #1 >>

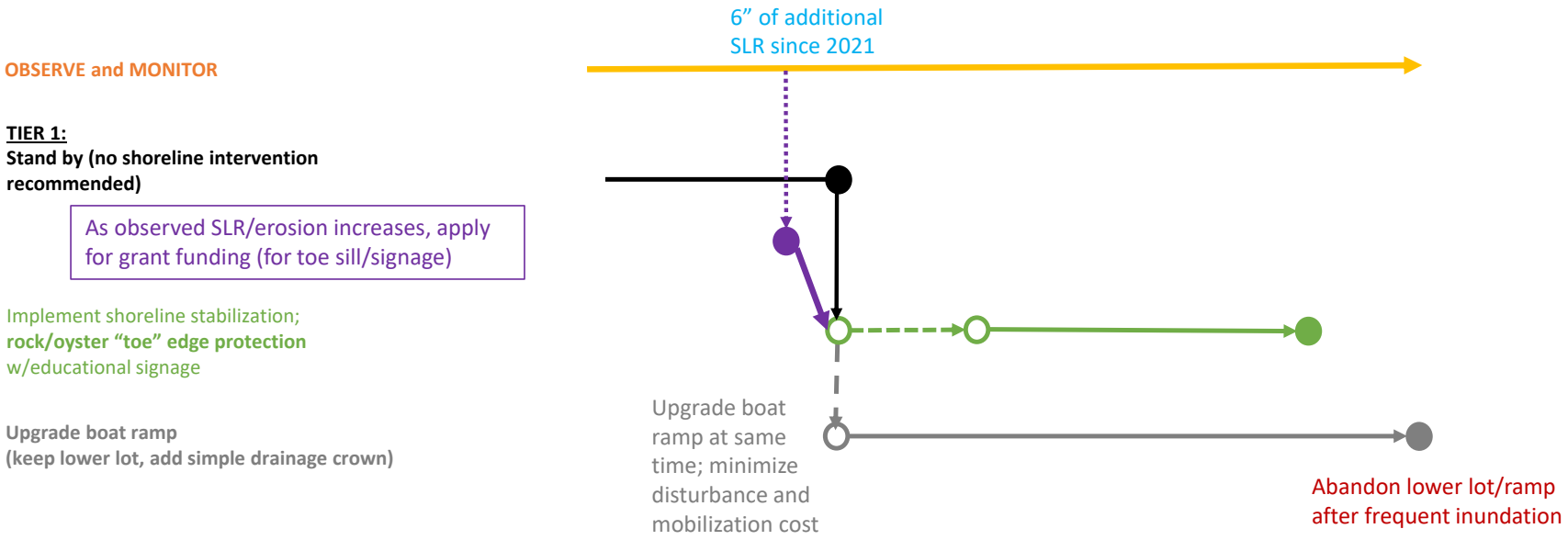


Observed sea level rise (depth above 2021 baseline)

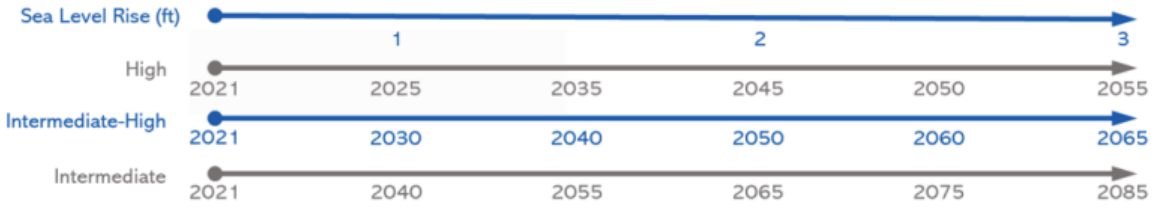
Legend

- Design choice/transition opportunity
- End/abandon action
- Action taken
- Transition to new action or adapt current action

Adaptation Pathways for Chapman's Landing (Option 1)



Metric #1 >>

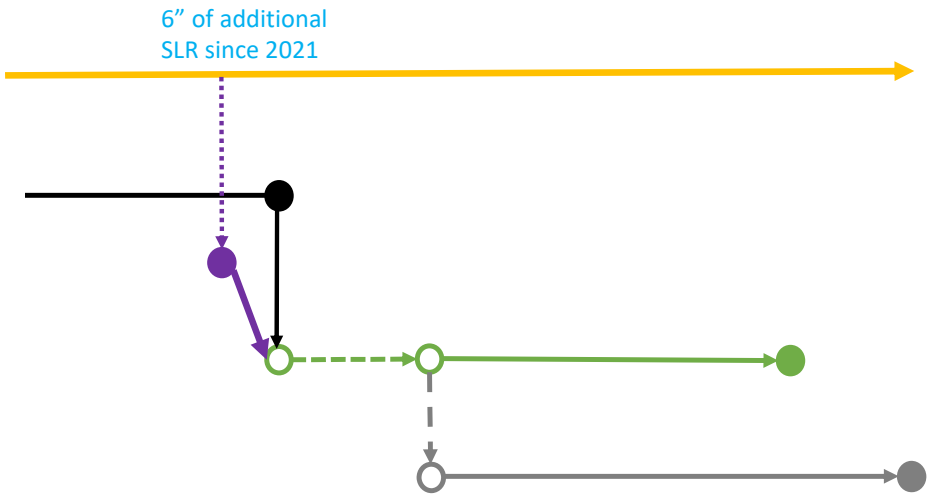


Observed sea level rise (depth above 2021 baseline)

Legend

- Design choice/transition opportunity
- End/abandon action
- Action taken
- Transition to new action or adapt current action

Adaptation Pathways for Chapman's Landing (Option 2)



OBSERVE and MONITOR

TIER 1:
Stand by (no shoreline intervention recommended)

As observed SLR/erosion increases, apply for grant funding (for toe sill/signage)

Implement shoreline stabilization;
rock/oyster "toe" edge protection
w/educational signage

WAIT…. then upgrade boat ramp (TIER 2)
(keep lower lot and add bioretention stormwater BMPs)

Wait to install new boat ramp until F&G recreation priority (i.e., "it's okay if lower lot floods somewhat regularly in meantime")

Abandon lower lot/ramp after frequent inundation

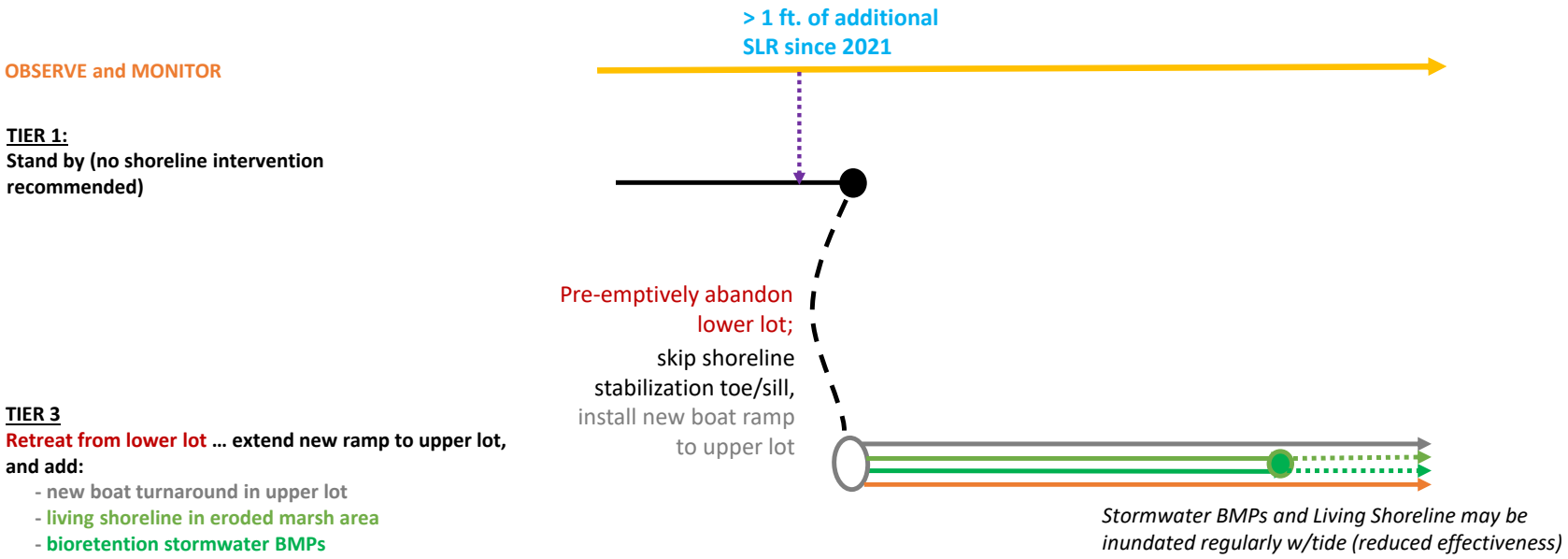
Metric #1 >>

Observed sea level rise (depth above 2021 baseline)

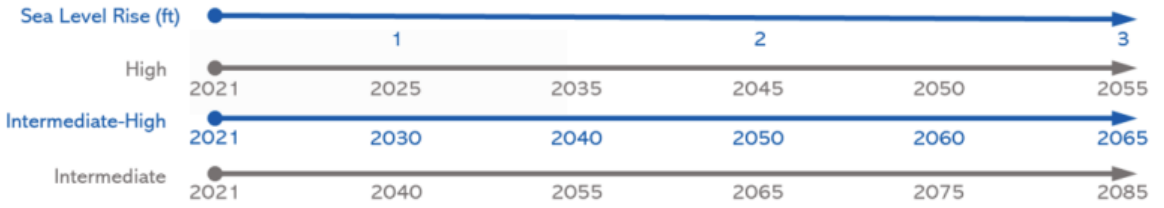
Legend

- Design choice/transition opportunity
- End/abandon action
- Action taken
- Transition to new action or adapt current action

Adaptation Pathways for Chapman's Landing (Option 3)



Metric #1 >>

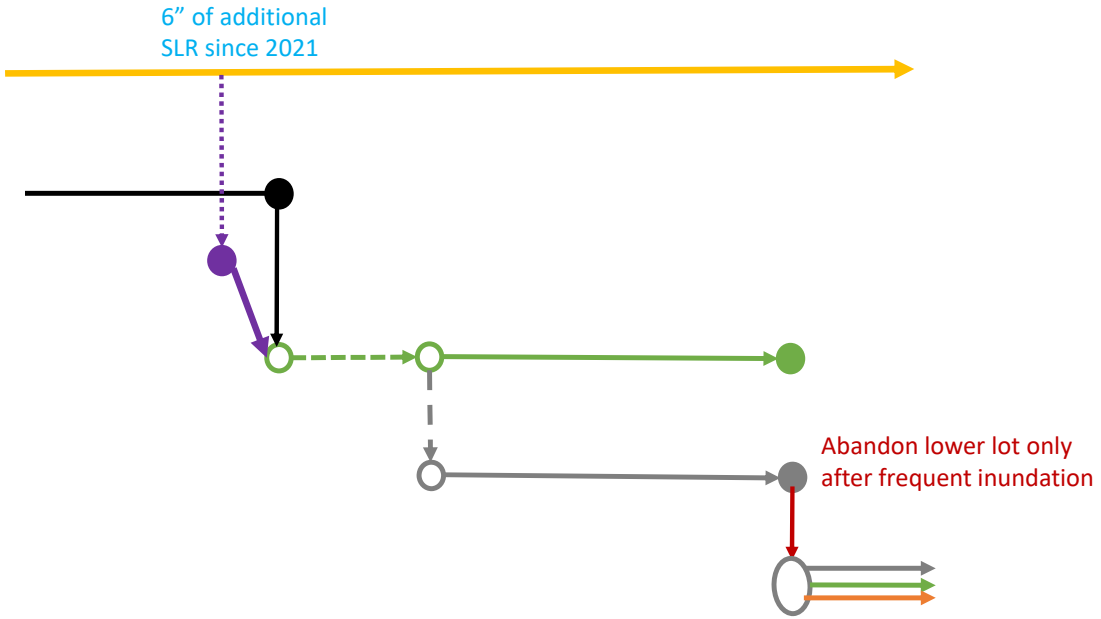


Observed sea level rise (depth above 2021 baseline)

Legend

- Design choice/transition opportunity
- End/abandon action
- Action taken
- Transition to new action or adapt current action

Adaptation Pathways for Chapman's Landing (Option 4)



OBSERVE and MONITOR

TIER 1:
Stand by (no shoreline intervention recommended)

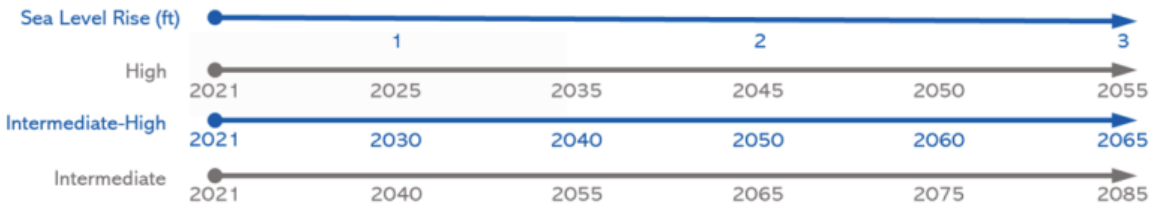
As observed SLR/erosion increases, apply for grant funding (for toe sill/signage)

Implement shoreline stabilization;
rock/oyster "toe" edge protection
w/educational signage

WAIT…. then regrade/upgrade boat ramp (TIER 2)

WAIT…. then retreat from lower lot and add (TIER 3):
- new ramp; new boat turnaround in upper lot
- **living shoreline in eroded marsh area**
- **boardwalk/overlook amenity?**

Metric #1 >>



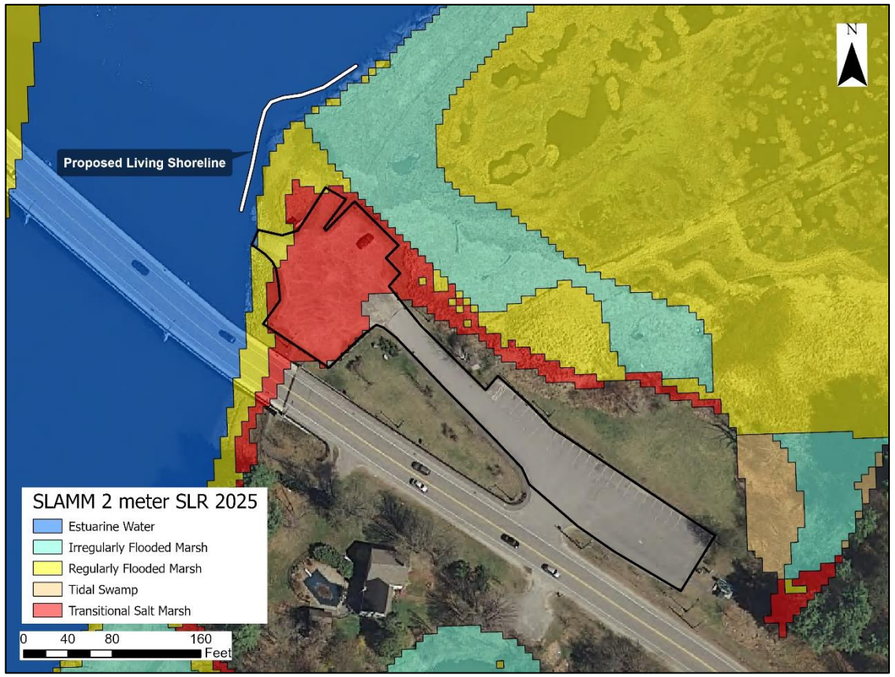
Observed sea level rise (depth above 2021 baseline)

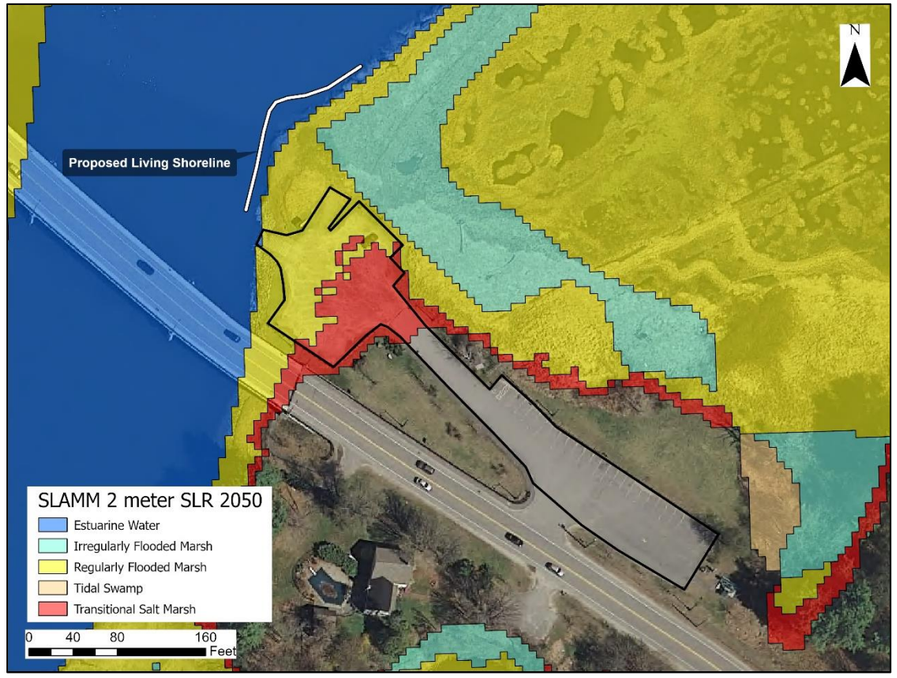
Legend

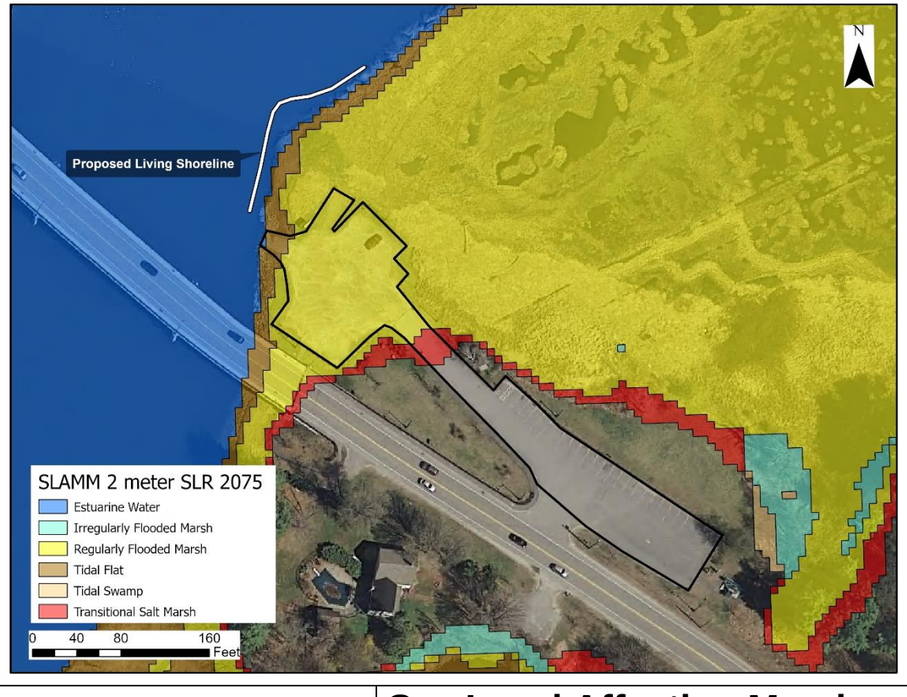
- Design choice/transition opportunity
- End/abandon action
- Action taken
- Transition to new action or adapt current action

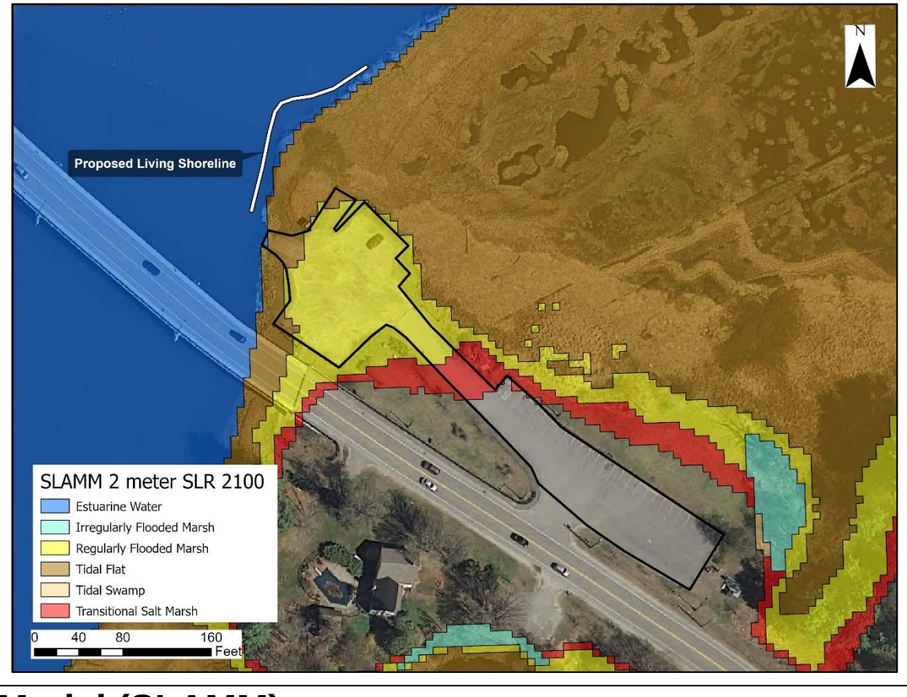
Appendix F

Site-specific SLAMM Maps









Chapman's Landing
Stratham, NH

Sea Level Affecting Marshes Model (SLAMM)

(Source: NH Fish and Game Department - GIS data downloaded from NH GRANIT)

Appendix G

Installed Erosion Pin Reference Schematic

0 25 50 100 Feet

Chapman's Landing
Erosion Pin Locations

N

Appendix H

Erosion Pin Data Table

Chapman's Landing
Erosion Pin Data

	Extent of Erosion Measured (mm)
	3/18/2022
Calving-2021-1	0
Ledge-upper	9
Ledge-lower	9
NearC-upper	1
NearC-lower	21
EdgeofMudFlat-upper	4
EdgeofMudFlat-lower	10
DS-upper	10
DS-lower	4

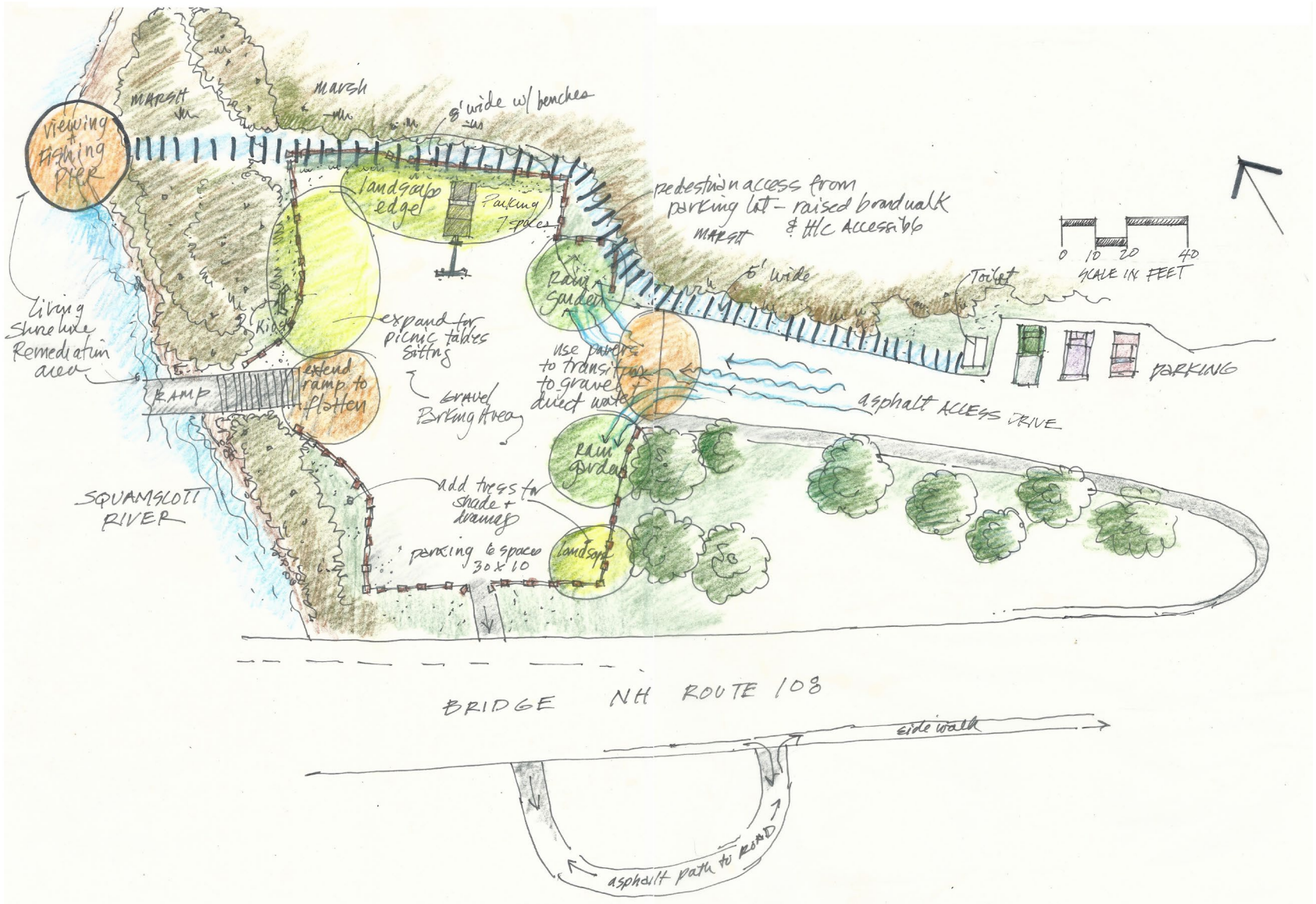
Notes:

1. Erosion pins were installed on 9/3/2021 along the marsh edge downstream (north) of the boat ramp.
2. After the measurements on 3/18/2022, the erosion pins were re-set flush with the soil surface.

Appendix I

Conceptual Site Analysis

Conceptual Site Analysis



Appendix J

Site Recommendations

Conceptual Site Plan

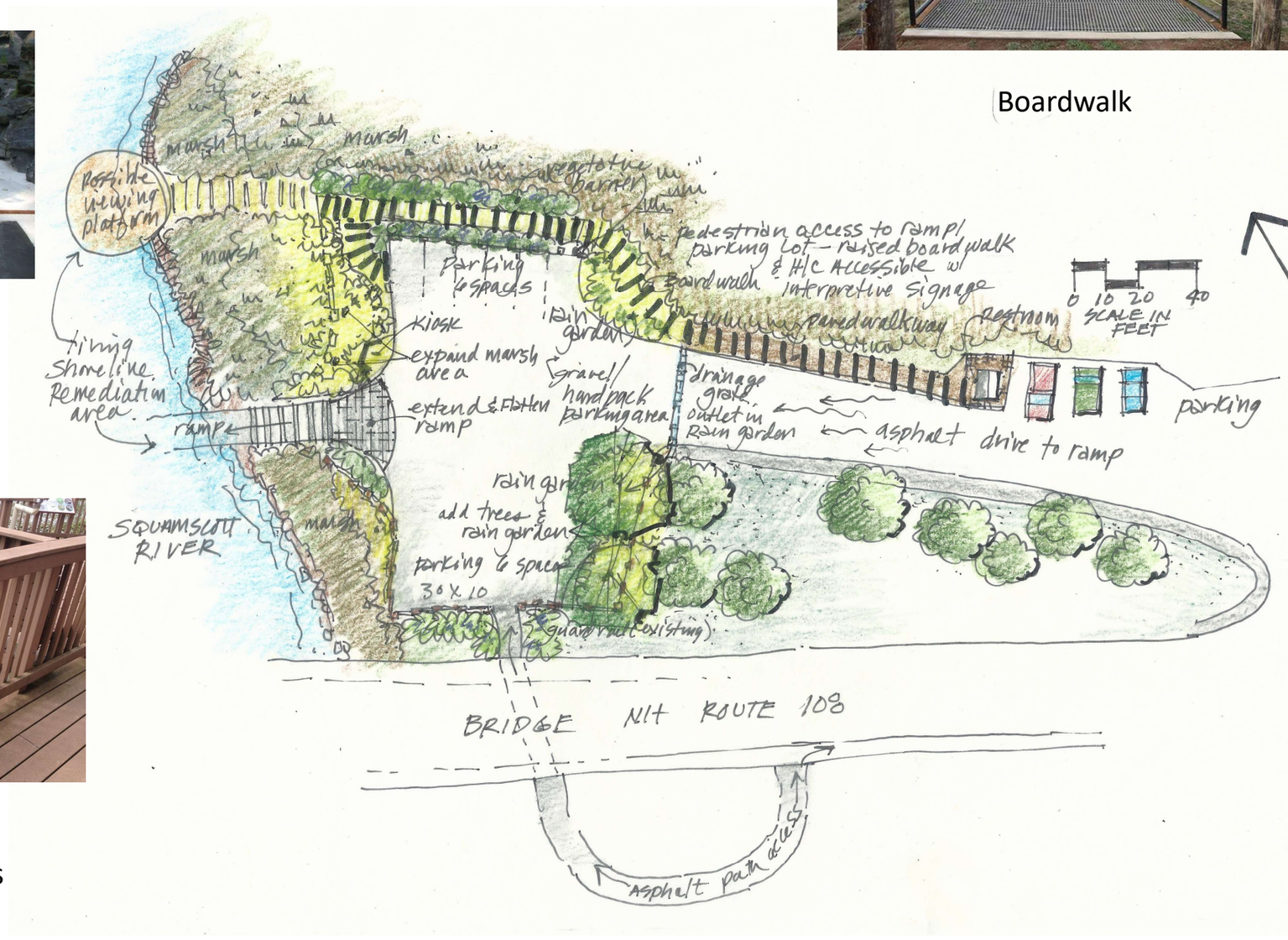
Trench Grate

Boardwalk

Beach Plum

Bayberry

Boardwalk
Interpretive Signs



Rain Garden