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BACK RIVER LIVING SHORELINE
MARSH SHORELINE STABILIZATION PROJECT
OLD SAYBROOK, CONNECTICUT

March 2023 (revised May 2023)
File No. 01.0175620.00

PREPARED FOR:
Town of Old Saybrook and Connecticut CIRCA

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March 9, 2023 (revision May 22, 2023)
File No. 01.01756206.00

Town of Old Saybrook
302 Main Street
Old Saybrook, CT 06475

Attention: Mr. Carl Fortuna

Cc CIRCA

Re: Back River Living Shoreline
Shoreline Stabilization Design
Old Saybrook, Connecticut 06355

Dear Mr. Fortuna:

Please find attached GZA's report presenting the results of the 60% Design of the Back River Living Shoreline. The 60% Design Plans are presented under separate cover. This project was performed as part of the CIRCA Municipal Resilience Grant Program (MRGP) Application, “Back River Living Shoreline”.

This report was originally submitted during March 2023. At the request of CIRCA, a revised version has been prepared which incorporates CIRCA and Connecticut DEEP comments.

We are available to discuss our findings and recommendations.

Very truly yours,

GZA GEOENVIRONMENTAL, INC.

Michael Gardner
Project Manager

Stephen Lecco, A.I.C.P., C.E.P., P.W.S.
Consultant/Reviewer

Daniel C. Stapleton, P.E.
Principal

EXECUTIVE SUMMARY

The Back River Living Shoreline project includes the Conceptual Design (60% Plan Set) of proposed marsh shoreline stabilization and ecological restoration along an approximately 350-foot section along the south bank of the Back River within the Plum Bank Wildlife Marsh Area in Old Saybrook, Connecticut, using Natural and Nature-Based Features (NNBFs). This project was performed as part of the CIRCA Municipal Resilience Grant Program (MRGP) Application, "Back River Living Shoreline".

This section of the Back River riverbank has been experiencing on-going and significant shoreline erosion since 1934, the year the existing Route 154 Bridge 01386 was constructed. Back River is a natural tidal marsh channel, hydraulically connecting marsh to Long Island Sound. Upstream and downstream of Bridge 01386, Back River bends sharply to the north and continues to meander throughout the marsh. The existing bridge (and proposed bridge replacement) restrain the natural meander of the channel and also constrain flow, resulting in high velocity channel and bank flow, eddies and whirlpools. This, possibly with other factors, appears to be contributing to significant erosion of bank edges, loss of marsh area, and deep channel scour holes. Significant shoreline erosion and marsh loss has specifically occurred within the area immediately west of the bridge, including the south bank of the Back River. Scour holes are located within the channel and are deep (as deep as elevation -28 feet NAVD88). These adverse impacts to coastal resources are expected to continue in the future.

The observed shoreline erosion is expected to continue, resulting in on-going and significant loss of marsh. Therefore, shoreline stabilization is warranted. The channel flow velocities (which are artificially due to the bridge hydraulics) and associated shear stresses are too high to warrant shoreline stabilization using only natural vegetative materials.

The proposed shoreline protection alternative is a hybrid solution that integrates a rock rip-rap revetment with sand fill, planting and mixed oyster bags/clutches and mussels and revegetation with *spartina alterniflora* and *spartina patens*. The proposed construction is to be performed from the landside, requiring construction vehicle access over the existing High Marsh using timber mats. The project will require work seaward of the High Tide (HAT) line and the Coastal Jurisdiction Line (CJL). Details of the prosed project and an estimate of probable construction cost is presented in the report.

Post-construction monitoring with maintenance is recommended. The proposed shoreline stabilization utilizes natural materials and rock armor. As a nature-based system, the proposed shoreline stabilization should be considered experimental and the long-term performance is uncertain. Also, the on-going hydraulic effects of the existing bridge (and proposed bridge) will continue to create high velocity channel flow resulting in high shear stresses on the channel bank and bottom. The existing channel scour hole appears to be advancing toward the south bank of the river, destabilizing the bank sediment. Sea level rise is expected to increase this risk. The proposed shoreline stabilization includes the use of crushed stone mattresses for the purpose of minimizing bank destabilization; however, significant advancement of the scour hole may eventually cause destabilization of the improved shoreline (as well as the existing boat ramp and pile-supported docks).

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APPENDICES

1.0 PROJECT BACKGROUND AND CONTEXT

This project includes conceptual design of the proposed marsh shoreline stabilization along certain receding marsh edges along the Back River within the Plum Bank Wildlife Marsh Area, using Natural and Nature-Based Features (NNBFs), including this Technical Report; Conceptual Design (60% Plan Set); and regulatory permit pre-application meeting. This project was performed as part of the CIRCA Municipal Resilience Grant Program (MRGP) Application, "Back River Living Shoreline". **Figure 1** shows the project location.

The approximately 250-acre Plum Bank Marsh Wildlife Area (Marsh), located within Old Saybrook, Connecticut, is one of 97 Connecticut Wildlife Management Areas (WMAs). WMAs preserve habitat for many different species of animal, bird, and invertebrate and maintain critical grasslands, old fields, and coastal salt and freshwater marshes. They also provide significant public access and recreational use. At a national level, the Plum Bank Marsh Wildlife Area has been designated as Marine Protected Area since 1957.

Back River is a natural tidal marsh channel (one of two major channels within the Marsh), hydraulically connecting the Marsh to Long Island Sound. Upstream and downstream of Bridge 01386, Back River bends sharply to the north and continues to meander throughout the marsh.

Route 154, a two-lane State roadway, bisects the Marsh and connects Old Boston Post Road in the North to Cornfield Point in the South. Within the Marsh, Route 154 incorporates two bridges. Bridge 01386 spans Back River. The existing bridge is planned by the Connecticut Department of Transportation (ConnDOT) to be replaced with a similar bridge.

A residential community is located to the south of Bridge 01386, including homes, private property, and floating docks and a boat ramp along the downstream southern side of the marsh channel.

The existing (and proposed) Bridge 01386 restrains the natural meander of the channel and constrains flow, resulting in high velocity flow, eddies and whirlpools. This, possibly with other factors, appears to be contributing to significant erosion of bank edges, loss of marsh area and deep channel scour holes. Scour holes are located within the channel on either side of the bridge and are deep (as deep as elevation -28 feet NAVD88). These adverse impacts to coastal resources are expected to continue in the future and possibly increase due to the effects of sea level rise.

Back River also provides flood ingress and egress during coastal storms. Loss of marsh increases the area residential vulnerability to flooding and loss of land. The project site is located west of Rt 154 and constitutes the marsh border (edge) of a marsh peninsula (with the beach forming the Long Island Sound border). Loss of this marsh peninsula would significantly increase the flood and erosion risk of adjacent residential areas.

In addition to the hydraulically induced scour and bank erosion due to the bridge, relative sea level rise also significantly threatens the Marsh, over the long term due to submergence. CT ECO SLAMM Model results (attached) predict continued marsh loss along channel edges and trenches unless action is taken to minimize erosion. Additional marsh impacts include increased erosion along historical mosquito trenches. As discussed in **Section 3.0**, predation of marsh vegetation and weakening of the marsh substrate due to marsh crabs (*Sesarma reticulatum*) may also be a contributing factor.

Figure 2 presents the results of CT ECO SLAMM modeling for the project vicinity. **Figure 3** highlights the adverse conditions resulting from the bridge hydraulics.

2.0 PROJECT DESCRIPTION

The project includes the Conceptual Design (60% Plan Set) for stabilization of the marsh segment along the south marsh shoreline on the downstream (west) side of the bridge, along eroding marsh edges (approximately 350 to 400 lf) including marsh restoration within infill areas. Additional project components are being considered for future phases or by others, including:

- Living shoreline segment along the south marsh shoreline on the upstream (east of bridge) side of the bridge, along eroding marsh edges;
- Channel bottom stabilization using scour mats; and
- Marsh "mosquito ditches" filling and restoration.

The project goals are to utilize a Natural and Nature-Based Feature (NNBF) approach to mitigate the existing adverse impacts to the eroding marsh edge west of the bridge along the south bank of the Back River, providing both ecological and shoreline protection benefits:

- Shoreline Protection: Reduce marsh edge erosion;
- Ecological: Restore coastal habitat and mitigate future marsh loss;
- Public Resource: Reduce adverse impacts to a Connecticut WMA and Marine Protected Area;
- Innovation: Pilot project to evaluate use of NNBFs in conjunction with transportation structures; and
- Improve shoreline resilience to sea level rise at the project site.

Measurable goals include post-construction monitoring of the marsh and marsh edge, including quantitative documentation of erosion, coastal storm performance, and marsh vegetation and shellfish survivability.

3.0 PROJECT SITE EVALUATION

A Project Site Evaluation was performed to characterize the on-going marsh edge recession, including likely causes and mechanisms. The evaluation included the following:

1. GZA employed Esri's ArcGIS Desktop 10.7.1 for georeferencing and overlaying of historical aerial imagery from 1934 to current. GZA digitized the 1934 shoreline conditions for comparison to evaluate shoreline change.
2. Compilation and review of: 1) hydraulic model simulations analysis performed by the Connecticut Department of Transportation; 2) available bathymetry and topography; and 3) channel velocity measurements performed by CIRCA.
3. An erosion analysis (channel flow rates vs time vs observed shoreline change; predicted future marsh bank erosion and channel scour; sea level rise impacts).
4. A site reconnaissance to observe the site conditions.

3.1 <u>SHORELINE CHANGE AND EROSION</u>

GZA employed Esri's ArcGIS Desktop 10.7.1 for georeferencing and overlaying of historical aerial imagery from 1934 to current. GZA digitized the 1934 shoreline conditions for comparison to evaluate shoreline change. GZA also reviewed available bathymetric and topographic data relative to observed erosion.

Appendix B includes the historical aerial images with the 1934 shoreline indicated. As evident on the aerial photographs, the marsh channels are relatively stable except for specific locations where excessive shoreline erosion has occurred. The most significant marsh erosion has occurred adjacent to the Bridge 01386 (in particular, the south bank on the Back River immediately west (upstream) of the bridge. Review of historical aerial photographs from 1934 (pre-construction of the existing bridge) and post bridge construction indicate the following:

- The construction of the existing bridge also included construction of Rt 154, which included a relocation and realignment of the new roadway and bridge at the tidal channel, relative to the original bridge and road.

- The existing bridge, constructed circa 1935, included placement of significant embankment fill for roadway and bridge construction. The new embankment fill also allowed for a narrow bridge span relative to both the typical channel width and the original (pre-1935) bridge.
- The embankment fill and narrow bridge span have significantly constrained normal tidal channel flow. Specifically, the open span (between abutments) of the existing bridge is 28.0 feet. In comparison, the typical tidal channel width up and down river from the bridge is on the order of 165 to 185 feet.
- The bridge span was not placed within the roadway embankment; rather it was placed to the south of channel center redirecting high velocity flow along the southern portion of the channel immediately upstream and downstream of the bridge.
- Comparison of the 1934 aerial photograph (prior to construction of the existing bridge) to photographs after construction of the existing bridge show changes to the shorelines in the vicinity of the bridge indicative of changes in river flow conditions.
- The rate of impact has likely increased during the life of the bridge due to the approximately 0.8-foot of relative sea level rise that has occurred over that time period.

The approximate average rates of shoreline change within the immediate project area since 1934 has been about 1 to 1.5 feet per year, resulting in over 100 feet of shoreline erosion, representing about 25,000 square feet of marsh loss (an average of about 250 square feet to 300 square feet of marsh loss per year). The rate of loss appears to be increasing, likely associated with historic sea level rise. Based on a comparison of year 2000 and 2021 aerial photographs, the twenty-one year average rate of shoreline has been about 1.5 to 1.6 feet per year.

Appendix C includes the approximate topography and bathymetry within the project vicinity. Review of bathymetric data in the vicinity of the bridge is also indicative of: 1) complex and high velocity flow upstream and downstream of the bridge and channel bottom erosion:

a. A large scour hole (Elevation -28 feet NAVD88) is located downstream of the bridge. The scour hole is skewed toward the southern shoreline of the channel. The lateral extent of the scour hole is large enough to cause steep banks that extend to the boat ramp and dock, with the potential to affect the use of these facilities and also result in structural damage.

b. A large scour hole (Elevation -23 feet NAVD88) is located upstream of the bridge, also skewed to the south and resulting in steep channel banks. A second scour hole (Elevation -10 feet NAVD88) is located adjacent to and to the north of the aforementioned scour hole, upstream of the bridge. The scour hole is skewed toward the southern shoreline of the channel.

Appendix D includes representative modelled and measured Back River channel and bank velocities. Based on the information reviewed, it appears that the construction of the existing bridge significantly constrained tidal channel flow resulting in complex and high velocity flow conditions that have significantly contributed to shoreline change, scour of the tidal channel bottom and marsh loss in the vicinity of the bridge. Field velocity measurements, 1-dimensional hydraulic modeling, 2-dimensional modeling, bathymetric measurements, and historic aerial photographs appear to support that conclusion. The results indicate that the existing bridge is likely causing or contributing to adverse impacts to coastal resources (relative to the natural tidal channel conditions) due to velocity-induced stresses and resultant scour of the tidal channel bottom, marsh edges and marsh surface.

The hydraulic model output as well as the measured velocities appear to be consistent with the observed conditions, supporting the conclusion that the bridge is creating complex flow resulting in tidal channel scour and likely marsh edge erosion.

Channel and bank velocities have been estimated within the project area ranging for representative tidal conditions and for 10-year coastal flood conditions. During representative tidal conditions, channel velocities are greatest during ebb flow conditions and range from about 3 feet per second (fps) to 0.8 fps to 0.4 fps within the channel, between the channel and bank, and along the bank, respectively. During coastal flood conditions, channel velocities are also greatest during ebb flow conditions and range from about 10 feet per second (fps) to 1 to 2 fps within the channel and along the bank, respectively. The modeling also indicates that during flood conditions the High Marsh adjacent to the river floods. As discussed in the following section, the modelled flooding corresponds to High Marsh areas with vegetation loss and surface erosion. The model results appear to indicate shallow water flow velocities on the order of >0 to 1 fps within these areas.

Appendix D presents a graph indicating Critical Velocities relative to sediment particle size. The modelled velocities are (converted to centimeters per second) are also indicated. The results indicate channel velocities under both tidal and storm conditions are expected to result in excessive channel scour. Also, while not directly applicable to marsh edge erosion, they indicate that predicted velocities along the bank are capable of initiating bank sediment erosion under tidal conditions and excessive bank sediment erosion under storm conditions.

3.2 <u>OBSERVED SITE CONDITIONS</u>

GZA completed a site reconnaissance to observe and document the existing site conditions during low tide. Spot elevations were made during the site reconnaissance using a differential RTK GPS unit. Based on the spot elevations, approximate ground surface contours were developed for the project vicinity. The surface topography, along with the available bathymetric data, was used to develop representative project profiles (see **Appendix C**).

The observed conditions included:

1. The project area includes the south bank of the Back River located immediately west of the bridge. The project area includes (from east to west): a) a small rock revetment; b) a paved boat ramp; c) a fixed timber pier with boat slips; and d) the marsh riverbank area.
2. The shoreline within the project area consists of riverbank (constituting the marsh edge) and adjacent low-lying area constituting a portion of the Plum Bank Marsh.
3. The marsh adjacent to the project area consists of several feet of highly organic marsh substrate consisting of silt and fine to medium sand matrix. The marsh is primarily at or above Mean High Water and vegetated with *Spartina patens* (salt meadow) High Marsh.
4. The marsh areas immediately adjacent to the project shoreline are distinguished by lack of vegetation with indication of general surface erosion (within the intertidal zone) and likely predation. While we did not directly observe marsh crabs (*Sesarma reticulatum*), which are nocturnal, the surface evidence of burrow holes appears consistent with marsh crab activity within the de-vegetated (denuded) areas.
5. The marsh edge consists of a deep (greater than 4 feet) near-vertical face. Evidence of mass bank failure is observable at the site as well as in recent aerial photographs. The submerged bank slope is quite steep seaward of the marsh edge (ranging from 5H:1V or flatter) and appears to be influenced by the deep scour hole within the channel. Gravel, cobbles, and occasional boulders are also located along the bank.
6. Within the project area (i.e., south of the Back River), there is limited area between the marsh edge and the abutting headlands, leaving little additional space for future marsh recession.
7. Old, marsh bank-normal ditches (likely excavated in the past for water circulation and mosquito control) are also present within the project limits.

Based on the available information discussed above, it appears that the marsh and marsh edge is receding due principally to high velocity flow and associated channel bottom and bank stresses resulting, primarily, from the presence of the bridge. These hydraulic conditions have resulted in deep channel scour holes (upstream and downstream) of the bridge. Modelled bank velocities exceed the shear stresses required to result in erosion and scour of marsh and channel sediment, which appears to support the observed shoreline erosion, which since 2000 has been receding at about an average of 1.5 to 1.6 feet per year.

The instigating mechanisms of marsh edge erosion appear to be: 1) surface erosion and scour, resulting in tidal submergence; and 2) edge undercutting resulting in stability edge mass failures ("calving"). As noted above, while we did not directly observe marsh crabs (*Sesarma reticulatum*), there is surface evidence of burrow holes which appear to be consistent with marsh crab activity within the de-vegetated (denuded) areas. If so, it is likely that predation by marsh crabs is also a contributing factor. Specifically, softening of the marsh substrate (e.g., due to erosion and scour) creates a condition conducive to burrowing. Marsh crabs, which predominately eat spartina alterniflora (including root structure), have been linked to marsh de-vegetation and recession. The loss of the marsh vegetation results in oxygenation and weakening of the sediment matrix, facilitating marsh edge erosion and marsh recession.

These types of slope stability edge failures ("calving") result in aggressive loss of marshland, consistent with the high rate of observed shoreline erosion. Since the bridge-related flow velocities are related to flow volume, this condition is expected to be adversely affected by sea level rise and may deteriorate further in the future as a result. Boat wake may also be a contributing and undefined factor; however, significant shoreline change was observed prior to the construction of the existing docks.

Marsh edge reinforcement will be required to mitigate the on-going shoreline erosion within the project area.

In the project vicinity, shellfish were observed to be naturally occurring including areas of oyster settlement within the mid to lower tide and submerged and mussels with the upper tide range buried in the mud and attached to marsh grass.

4.0 PROJECT ALTERNATIVES

The project goals are to mitigate future shoreline erosion within the project limits using a NNBFs/Living Shoreline approach consistent with tidal marshes. Redevelopment of lost marsh area was also considered; however, it is expected that the presence and possible future migration of the channel scour hole would make that construction and maintenance difficult. Several alternative approaches were evaluated. Key considerations include:

1. Given the large bank flow velocities within the project limits, some bank armor will be required. The armor should be designed to resist shear stresses associated with bank river flow velocities of at least 10 fps (300 cms) (cobble to small boulder rip-rap). It is noted that 10 fps is greater than the velocities modeled for the bank; however, for conservatism and the potential for future changed conditions, selection of stone armor based on the higher velocities is recommended. The predicted bank velocities are unique to the bridge hydraulics and far exceed channel bank and bottom velocities typical of a natural marsh/tidal channel environment. Coir logs are expected to be inadequate due to the high flow velocities.

2. The use of marine organisms (oysters and mussels), while viable within in the general Plum Bank Marsh channel and bank environment, would be challenged as a primary bank protection with the expected velocities at the project site. Therefore, a hybrid shoreline stabilization approach is warranted.

3. Hard armor should be used as a component to a solution that also utilizes natural materials and vegetation to the extent practical.

4. The water quality within Plum Bank Marsh Wildlife Area is designated SA and is suitable for habitat for marine fish, other aquatic life and wildlife and shellfish harvesting for direct human consumption. Shellfish including mussels and oysters have been observed along the Back River banks within the project vicinity.

5. The existing, eroded bank edge is deep (>4 feet high). Bank stabilization will require a sloped (minimum 2.5H:1V) face.
6. The steep submerged bank slope presents stability issues that may threaten new bank construction, and channel bottom stabilization and erosion protection adjacent to the improved bank edge is warranted.
7. The marsh area adjacent to the project shoreline is de-vegetated and softening, possibly linked to predation by marsh crabs.
8. The site access is limited, which will influence what construction methods are available.

The alternatives considered included: Alternative 1: do nothing; Alternative 2: a rock rip-rap marsh edge revetment; Alternative 3: shoreline stabilization using coir logs with oyster bag/clutches, sand fill and revegetation with *spartina alterniflora* and *spartina patens*; Alternative 4: use of oyster castles as shoreline stabilization edge; and Alternative 5: a hybrid solution that integrates a rock rip-rap revetment with sand fill, planting and mixed oyster bags/clutches and mussels and revegetation with *spartina alterniflora* and *spartina patens*. As noted above, key issues include: 1) the high channel bank velocities; and 2) the presence of the adjacent scour hole which appears to be affecting the riverbank slope.

Alternative 5 is the recommended alternative. Alternative 1 is expected to result in on-gong shoreline erosion on the order of 1.5 to 2 feet per year with associated marsh loss. Alternative 2 should provide shoreline protection and mitigation of marsh loss, but with minimal habitat enhancement at the marsh edge. Alternative 3 is unlikely to resist the current and future flow stresses, with a high probability of slope failure. Alternative 4, oyster castles, was eliminated due to concern of underlying bank stability. Alternative 5 combines shoreline protection and mitigation of marsh loss with ecological enhancement of the marsh edge.

Another alternative could be to replace the existing bridge with a different bridge type (i.e., open span, high deck bridge with a wide channel) and thus reduce the flow velocities. That alternative is beyond the scope of our study and was not included.

Lastly, we note that a more minimalist approach could be employed (e.g., Alternatives 2 or 3) on an observational basis. These alternatives would have somewhat lower construction costs; however, we expect that their performance will be limited and that greater maintenance costs will be required relative to Alternative 5.

Alternative 5 is presented in **Figure 4**. Alternative 5 includes the following components:

1. A crushed stone mattress placed below MLW on the existing riverbank slope. The purpose of the mattress is to provide a stable base for the other project components.
2. An angular stone rip-rap wetland sill, backfilled (between the existing marsh face and the landside of the sill) with a well-graded gravel filter. The stone sill will be benched with an average 2.5H:1V slope and extend from the top of the crushed stone mattress to MHW (Elevation 1.3 feet NAVD88). The rip rap will be well-graded angular stone with a D_{50} (mean stone diameter) of 10 inches.
3. Oyster bags/clutches will be hand-placed within the base of the wetland sill within the lower intertidal zone. The bagged oyster clutches would not be capable of resisting the channel bank flow velocities on their own and will be stabilized by hand placement within individual large armor stones and staking.
4. A narrow, shallow bench in the marsh substrate will be constructed at the top of the wetlands sill and filled with a sand-gravel-shell hash mix, staked bags and planted *spartina alterniflora*.
5. The non-vegetated areas of upper marsh will be covered with a thin sand-gravel-shell hash mix layer (to MHW plus 6 inches = Elevation 1.9 feet NAVD88) and planted with *spartina patens*.

The success of establishing mussel and oyster beds along the marsh edge is uncertain and, therefore, the proposed shoreline stabilization is experimental; in particular, considering the potential for high flow velocities within the project area. The "Practitioner's Guide to Shellfish-Based Living Shorelines for Salt Marsh Erosion Control and Environmental Enhancement in the Mid-Atlantic", Whalen et al. provides examples where bagged oyster shell cultch was used to stabilize the foreshore immediately seaward of eroding marsh vegetation. As indicated in the guide… "Meyer et al. (1997) reported that using oyster cultch in North Carolina stabilized areas immediately upland of marsh edges and showed positive accretion of sediment, whereas non-cultched areas lost sediment. Both shell bags and coir logs produced positive stabilization and accretion in the Maurice River. Although oyster shell was primarily used to enhance stability in this project, it did attract recruitment of oyster spat. Hence, recruitment of oysters in the adjacent low intertidal and shallow subtidal areas may work in tandem with efforts to establish intertidal mussel beds along the grass margin."

Proposed Alternative 5 is expected to provide some adaptive capacity to the effects of sea level rise, in particular relative to edge stability. However, overall, sea level rise will eventually result in fundamental changes to Marsh inundation extent and depth, including tidal inundation, regular flooding of the upper marsh and associated effects on vegetation type.

Site access is limited. It is expected that construction access will be via Rt 154 and Buckingham Avenue. Construction is expected to be performed from the landside using an excavator and front-end loader. Timber or synthetic mats will be used over the existing high marsh for low pressure construction equipment access and protection of the existing marsh. Mats will be anchored because they will be located within the flood zone and susceptible to floating during inundation. Work within the water will include minor excavation (dredging) and filling (along the bank). Turbidity curtains will be used to mitigate suspended sediment. The flow velocities within the work zone during certain hours each day are quite high; completed work will be temporarily stabilized.

The project site borders several property tax parcels. Currently, access to the site as well as the eastern half of the project (122 Buckingham Avenue) is owned by community members and the western half of the project site (98 Barnes Road) is owned by the State of Connecticut. **Figure 6** displays the tax parcel locations. Discussions and decisions with each of these landowners will need to be incorporated into future project steps.

60% Design Plans:

The 60% Design Plans for Alternative 5 have been developed and are presented under separate cover.

Supplemental Construction:

The existing channel scour hole appears to be advancing toward the south bank of the river, destabilizing the bank sediment. Remediation of the scour hole is outside the scope of the proposed shoreline stabilization and is proposed here as supplemental construction by others. **Figure 5** presents a schematic plan and detail for scour hole mitigation. The currently proposed concept includes: 1) backfill of the scour hole to Elevation -10 feet NAVD88; and 2) installation of stone mattresses as scour protection. Site access will likely require work from a barge. Considering the limited draft within the tidal channel, a small specialty barge installed from the boat ramp may be required. If backfilling is not feasible, then scour protection should still be utilized.

This supplemental construction is not included in the 60% Design Plan Set.

5.0 ENVIRONMENTAL PERMITS

The work will be performed seaward of the High Tide line (HAT) and the Coastal Jurisdiction Line (CJL) and will require some in-water work. The proposed shoreline stabilization will be approximately located at the existing eroded shoreline. In consideration of the rapid rate of shoreline erosion, no habitat substitution is expected relative to recent site conditions. However, it will require replacement of submerged bank with revetment armor stone. De-vegetated, surface eroded areas of marsh are proposed to be filled in a thin lift to about Elevation 1.9 feet NAVD88 and replanted with *spartina patens* (High Marsh).

Approximate volumes and disturbed areas are summarized below:

1. Filled and re-planted De-vegetated Marsh Area:
    - Area: 17,025 square feet
    - Fill Volume: 650 cubic yards

2. Shoreline stabilization and ecological restoration:
    - Length: 350 linear feet
    - Area: 3,310 square feet
    - Fill Volume (including mattresses): 292 cubic yards

3. Supplemental Construction (scour hole remediation)
    - Scour Protection Area: 15,925 square feet
    - Backfill Volume (including mattresses): 4,185 cubic yards

Environmental permits that are expected to be required are summarized on the table in **Appendix E**. The project is expected to be consistent with Connecticut's statutory definition of a Living Shoreline.

Permitting of Living Shorelines is a key part of project development. **Appendix E** provides a summary of project permits based on GZA's current understanding of the project and a detailed summary (reference Connecticut Department of Energy and Environment) of permit requirements and guidance applicable to Living Shorelines.

Regulatory Permitting Pre-Application Meeting

In accordance with CIRCA grant award requirements, GZA held a Pre-Application Meeting with both Connecticut Department of Energy and Environmental Protection (CT DEEP) and the United States Army Corps of Engineers (USACE) on March 8, 2023. Attendees were as follows: CT DEEP – Ms. Marcy Balint; Mr. Alexander Ericson; Ms. Susan Jacobson; Mr. Kevin O'Brien; Ms. Eimy Quispe; Mr. William Sigmund; Ms. Darcy Winther; and Mr. Harry Yamalis; USACE – Mr. Kevin Kotelly; Town of Old Saybrook – Mr. Carl Fortuna; and GZA GeoEnvironmental – Ms. Bin Wang; Mr. Daniel Stapleton; Ms. Theresa Albanese; and Mr. Michael Gardner. Prior to the meeting, both the draft project report and draft 60% conceptual design plans were provided to all attendees.

The meeting opened with a site description for the Old Saybrook Back River Living Shoreline project. A presentation was given by GZA, depicting the project location, objectives, and conditions at the site. This was followed by descriptions of marsh edge stabilization and living shoreline alternative solutions with an emphasis on GZA's selected alternative. The 60% conceptual design for this alternative was presented along with proposed construction strategies, in accordance with the provided design plans.

GZA then opened the floor to questions and comments. Project design comments included considering a flow velocity reduction strategy attached to the existing docks, the benefits of filling the scour hole near the bridge, and the potential reasons for the marsh loss. A comment on the seaward slope in front of the marsh edge was made, with the belief that it may be even steeper than shown in GZA sections. GZA acknowledged this and noted that the topography/ bathymetry in the area is constantly changing and will need to be surveyed in detail prior to final design. A comment was also made about toe scour protection of the proposed design; it was discussed that it could be addressed by either 1) embedding toe stones; and/ or 2) adding another gravel mattress seaward of the proposed structure to protect the mudflat from erosion.

Following this conversation, GZA discussed permitting considerations for the proposed design alternative. USACE concerns were stated that the design may not be considered a living shoreline, as it appears more like a revetment. The proposed construction also exceeds the criteria for a USACE General Permit and a application for a 404 Individual Permit (IP) will likely be required. It was noted that the design does appear to meet the CT statutory definition for a Living Shoreline. The USACE agreed to review the design report and design plans in more detail for living shoreline feasibility.

It was also recommended that during final design the applicant follow up with CT DEEP relative to obtaining a Certificate of Permission (COP).

6.0 ESTIMATE OF PROBABLE CONSTRUCTION COST

The preliminary estimate of probable construction cost is based on an estimated unit cost of $800 to $1,000 per linear foot of shoreline stabilization. Assuming a project length of 350 linear feet, the estimated constructed cost is approximately $280,000 to $350,000. An additional 30% should be included for final design, permitting and contingency. Periodic maintenance should be expected which add supplemental project costs. Long term maintenance costs may equal or exceed construction costs.

Costs have not been estimated for the supplemental construction work including backfill of the scour hole and scour protection.

The construction costs should be re-estimated during final design, preferably with direct input for qualified contractors who have visited the site.

7.0 PERFORMANCE LIMITATIONS

The proposed shoreline stabilization utilizes natural materials and rock armor. As a nature-based system, the proposed shoreline stabilization should be considered experimental and the long-term performance is uncertain. Also, the on-going hydraulic effects of the existing bridge (and proposed bridge) will continue to create high velocity channel flow resulting in high shear stresses on the channel bank and bottom.

The existing channel scour hole appears to be advancing toward the south bank of the river, destabilizing the bank sediment. Sea level rise is expected to increase this risk. The proposed shoreline stabilization includes the use of crushed stone mattresses for the purpose of minimizing bank destabilization; however, significant advancement of the scour hole may eventually cause destabilization of the improved shoreline (as well as the existing boat ramp). Mitigation of the scour hole should include backfill of the hole with a coarse-grained material and extensive covering of the filled channel bottom with scour protection. That mitigation would be costly and is beyond the scope of this project.

Supplemental bathymetric and topographic survey should be performed during final design.

8.0 TECHNOLOGY TRANSFER

Erosion and scour resulting in adverse impacts to coastal resources is a common challenge with transportation bridges and culverts. Innovative use of a Natural and Nature-Based approach to mitigate impacts associated with transportation projects is needed and this project, when constructed and monitored, could contribute to that technology and experience as a pilot project. While the State of Connecticut is using Living Shorelines for coastal shoreline protection, this project introduces the use of this approach for tidal marsh channel stabilization.

9.0 REFERENCES

Technical data developed by others was relied upon for this report, in particular studies performed for ConnDOT for design of the proposed bridge replacement, including:

1. "Final Assessment Report; CTDOT Bridges No.01386 and No. 02708; CTDOT Project Number 105-209", prepared by RACE Coastal Engineering, prepared for GM2 Associates, Inc., dated January 2020 (RACE 2020);

2. DRAFT "Connecticut Department of Energy and Environmental Protection License; Structures, Dredging & Fill and Tidal Wetlands Permit; Section 401 Water Quality Certification; Flood Management Certification Approval", Licensee(s): Connecticut Department of Transportation, c/o Kimberly Lesay, including draft plans; and
3. Four images of 2-dimensional Hydrologic Modeling, (SMS SRH 2D) representing the existing bridge and three bridge alternatives. Note that the report presenting these results was just received and will be reviewed for testimony. However, summary presented here does not include review of this report.
4. "2018 Old Saybrook Coastal Resilience and Adaptation Report" by GZA GeoEnvironmental, Inc.

10.0 ACKNOWLEDGEMENTS

GZA utilized several references and tools that are developed and maintained by CIRCA and the University of Connecticut, including:

- Historical Aerial Photographs dated 1934 to 2004, and current: Aerial Photography Indexes: 1934-2010 http://magic.lib.uconn.edu/connecticut_data.html#apindex1934 Recent imagery: CT ECO Imagery (uconn.edu).
- Ct ECO SLAMM Model.
- Channel velocity measurements performed by CIRCA/University of Connecticut for this project.
- CT ECO 2016 Lidar topographic data.

Figures

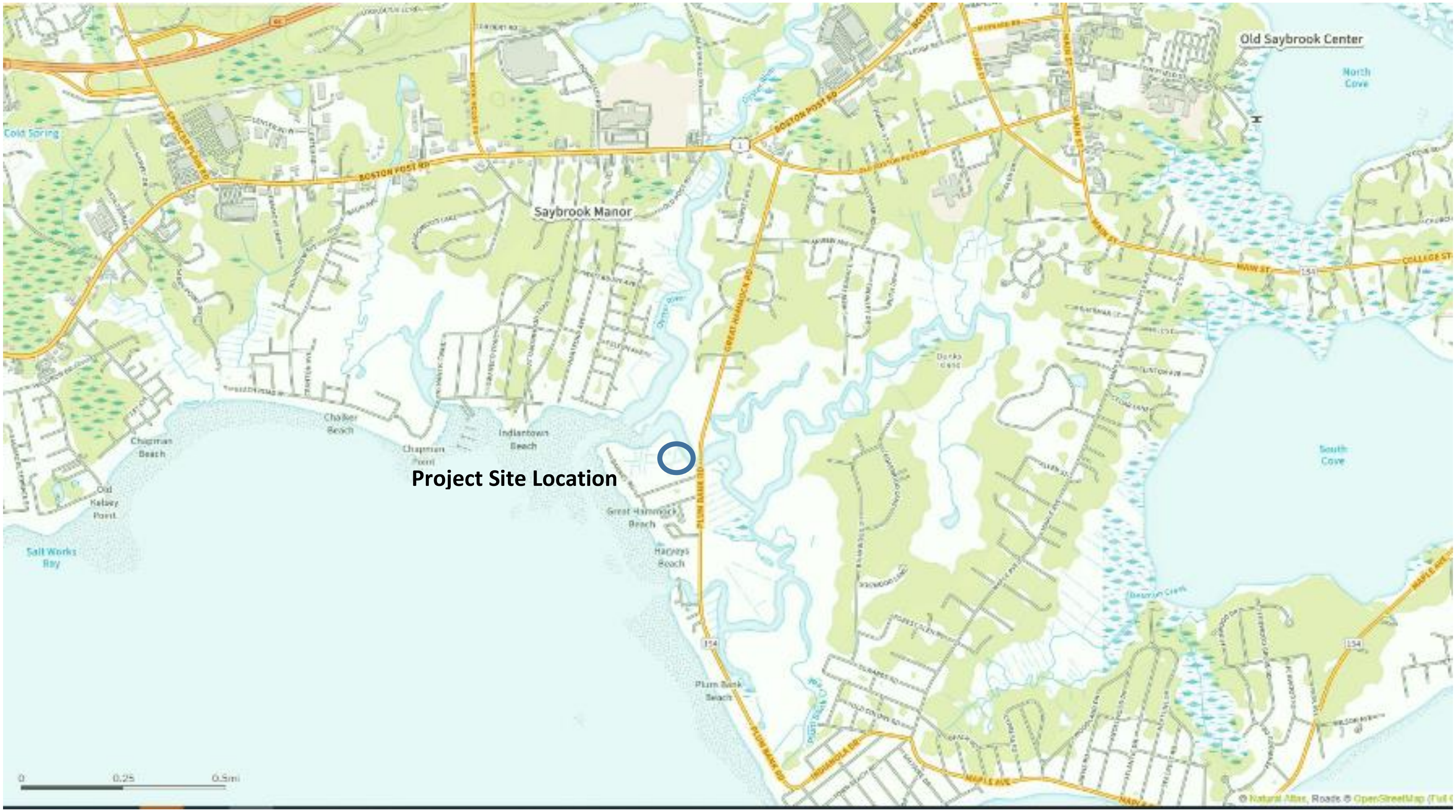


Figure 1: Back River Living Shoreline Project Location

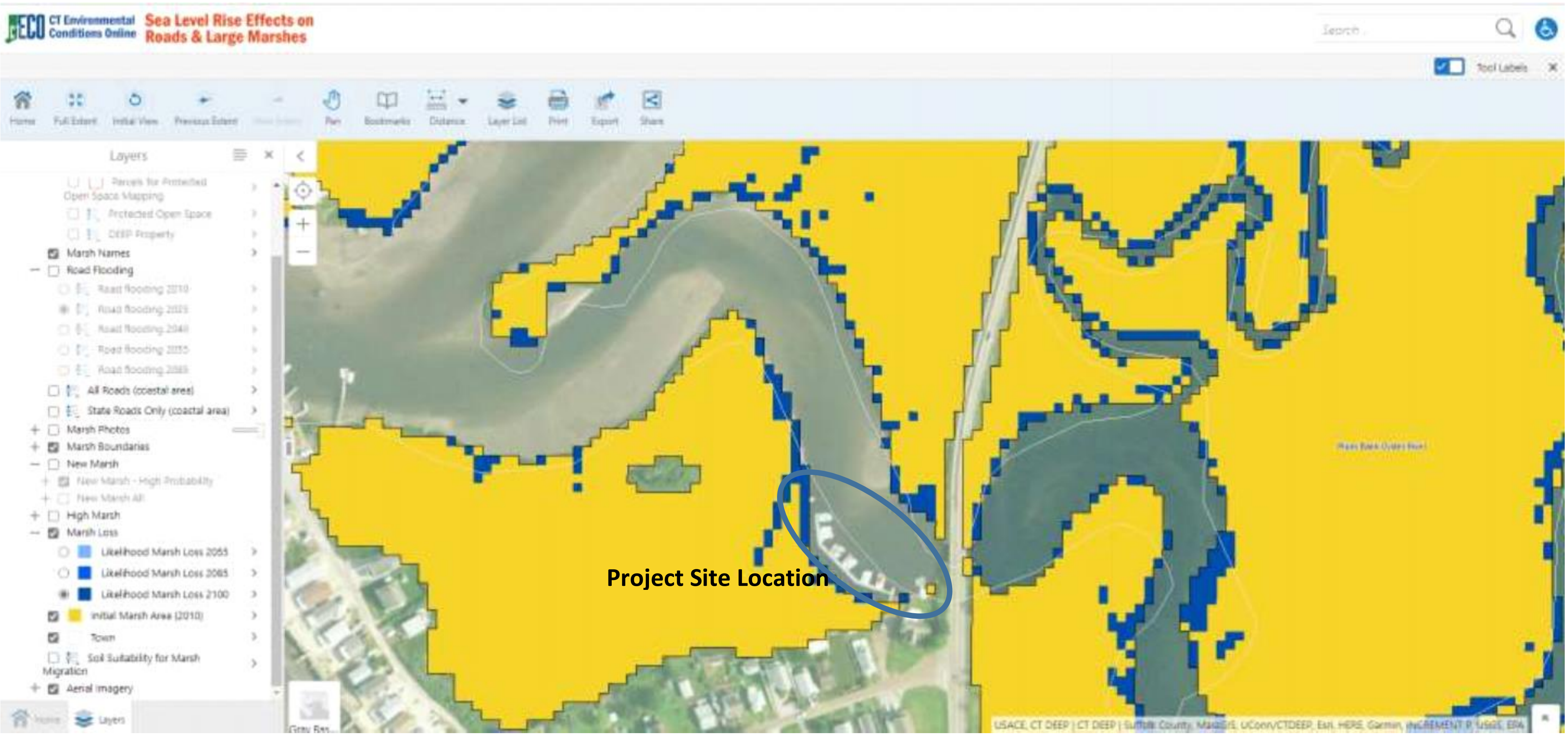
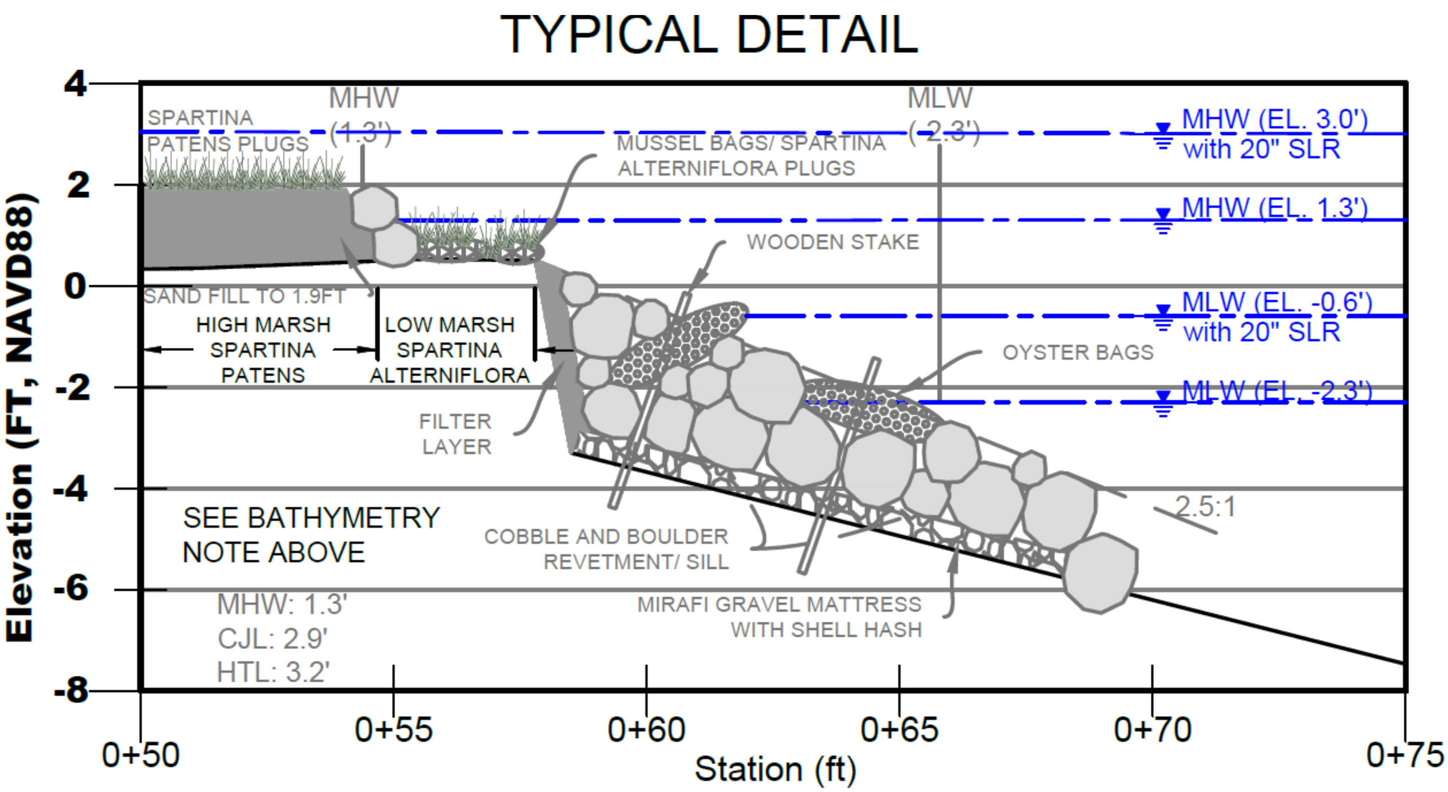


Figure 2: Connecticut SLAMM Model

Figure 3: Back River On-Going Adverse Impacts

Modeled Flow Vectors (above); High velocity flow (below left) and whirlpools (below right)

Marsh edge erosion



Note: The submerged bank slope and bathymetry is unconfirmed and highly dynamic. Supplemental bathymetric survey is required for final design.

Figure 4: Proposed Shoreline Stabilization/Ecological Restoration Detail

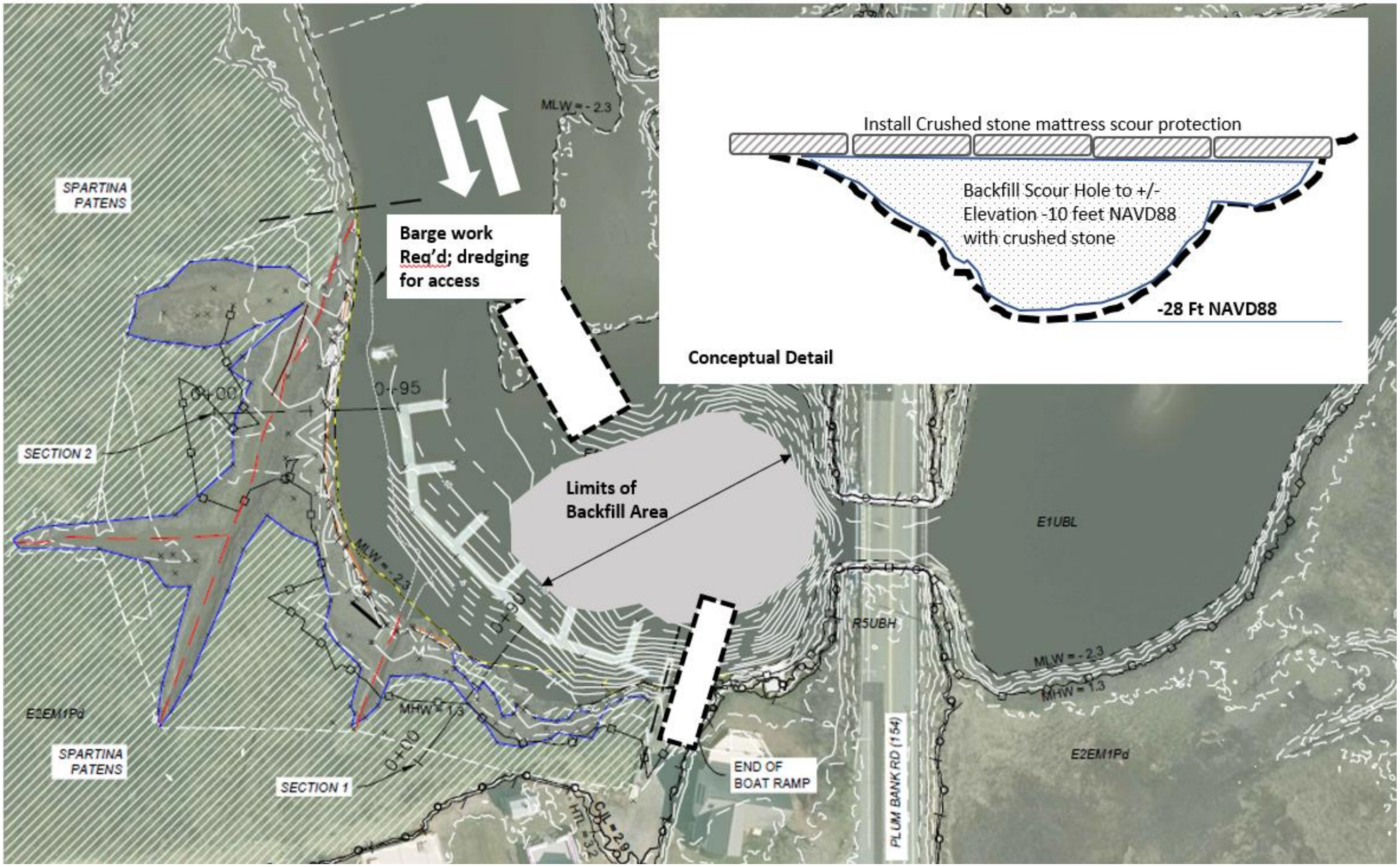


Figure 5: Supplemental Construction Conceptual Detail – Backfill and Scour Protection of Existing Scour Hole

Figure 6: Project Site Land Ownership. Parcel 98 – Owned by The State of Connecticut. Parcel 122 Owned by Local Community Members

Appendix A – Limitations

Use of Report

1. GeoEnvironmental, Inc. (GZA) prepared this report on behalf of, and for the exclusive use of the Client (Town of Old Saybrook, Connecticut) for the stated purpose(s) and location(s) identified in the Report. Use of this Report, in whole or in part, at other locations, or for other purposes, may lead to inappropriate conclusions and we do not accept any responsibility for the consequences of such use(s). Further, reliance by any party not identified in the agreement, for any use, without our prior written permission, shall be at that party's sole risk, and without any liability to GZA.

Standard of Care

2. Our findings and conclusions are based on the work conducted as part of the Scope of Services set forth in the Report and/or proposal and reflect our professional judgment. These findings and conclusions must be considered not as scientific or engineering certainties, but rather as our professional opinions concerning the limited data gathered during the course of our work. Conditions other than described in this report may be found at the subject location(s).
3. The interpretations and conclusions presented in the Report were based solely upon the services described therein, and not on scientific tasks or procedures beyond the scope of the described services. The work described in this report was carried out in accordance with the agreed upon Terms and Conditions of Engagement.
4. GZA's flood and wave evaluation was performed in accordance with generally accepted practices of qualified professionals performing the same type of services at the same time, under similar conditions, at the same or a similar property. No warranty, expressed or implied, is made.
5. The study included development of flood frequency curves. These curves were developed for: 1) the stillwater flood evaluation (exclusive of wind-generated wave effects, including wave height, run-up or setup), and 2) for the current climate and sea level conditions. The development of flood-frequency curves relied on readably available historical storm data as well as data developed by others. Future storms that impact the project area may result in changes to the flood-frequency curves.
6. Unless specifically stated otherwise, the flood evaluations performed by GZA and associated results and conclusions are based upon evaluation of historic data, trends, references, and guidance with respect to the current climate and sea level conditions. Future climate change may result in alterations to inputs which influence flooding at the site (*e.g.*, rainfall totals, storm intensities, mean sea level, *etc*.). Such changes may have implications on the estimated flood elevations, wave heights, flood frequencies and/or other parameters contained in this report.
7. Basis of Opinion of Cost Unless otherwise stated, our opinions of cost are only for comparative and general planning purposes. These opinions are based on the limited data and the conditions and assumptions described in the Report. The cost estimates may involve approximate quantity evaluations and are not intended to be sufficiently accurate to develop construction bids, or to predict the actual cost of work addressed in the Report. Further, since we have no control over when the work will take place nor the labor and material costs required to plan and execute the anticipated work, our cost opinions were made by relying on our experience, the experience of others, and other sources of readily available information. Actual costs may vary over time and could be significantly more, or less, than stated in the Report.
8. Cost opinions presented in the Report are based on a combination of sources and may include published RS Means Cost Data; past bid documents; cost data from federal, state or local transportation agency web sites; discussions with local experienced contractors; and GZA's experience with costs for similar projects at similar locations. GZA did not attempt to independently verify the accuracy or completeness of all information reviewed or received during the course of this evaluation. Actual costs will likely vary depending on the quality of materials and installation; manufacturer of the materials or equipment; field conditions; geographic location; access restrictions; phasing of the

work; subcontractors mark-ups; quality of the contractor(s); project management exercised; and the availability of time to thoroughly solicit competitive pricing. In view of these limitations, the costs presented in the Report should be considered "order of magnitude" and used for budgeting and comparison purposes only. Detailed quantity and cost estimating should be performed by experienced professional cost estimators to evaluate actual costs. The opinions of cost in the Report should not be interpreted as a bid or offer to perform the work. Unless stated otherwise, all costs are based on present value.

9. The opinion of costs are based only on the quantity and/or cost items identified in the Report, and should not be assumed to include other costs such as legal, administrative, permitting or others. The estimate also does not include any costs with respect to third-party claims, fines, penalties, or other charges which may be assessed against any responsible party because of either the existence of present conditions or the future existence or discovery of any such conditions.

10. In the event that any changes in the nature, design or location of the proposed construction are planned, the conclusions and recommendations contained in this report shall not be considered valid unless the changes are reviewed and conclusions of this report modified or verified in writing by GZA GeoEnvironmental, Inc. (GZA). It is recommended that this firm be provided the opportunity for a general review of final design and specifications in order that earthwork and foundation recommendations may be properly interpreted and implemented in the design and specifications.

Reliance on Information from Others

11. In conducting our work, GZA has relied upon certain information made available by public agencies, Client and/or others. GZA did not attempt to independently verify the accuracy or completeness of that information. Any inconsistencies in this information which we have noted are discussed in the Report.

Compliance with Codes and Regulations

12. We used reasonable care in identifying and interpreting applicable codes and regulations necessary to execute our scope of work. These codes and regulations are subject to various, and possibly contradictory, interpretations. Interpretations with codes and regulations by other parties are beyond our control.

Additional Information

13. In the event that the Client or others authorized to use this report obtain information on conditions at the site(s) not contained in this report, such information shall be brought to GZA's attention forthwith. GZA will evaluate such information and, on the basis of this evaluation, may modify the opinions stated in this report.

Additional Services

14. GZA recommends that we be retained to provide services during any future investigations, design, implementation activities, construction, and/or property development/ redevelopment at the Site. This will allow us the opportunity to: i) observe conditions and compliance with our design concepts and opinions; ii) allow for changes in the event that conditions are other than anticipated; iii) provide modifications to our design; and iv) assess the consequences of changes in technologies and/or regulations.

Appendix B – Observed Shoreline Change

Figure B-1: 1934 Shoreline in Project Vicinity

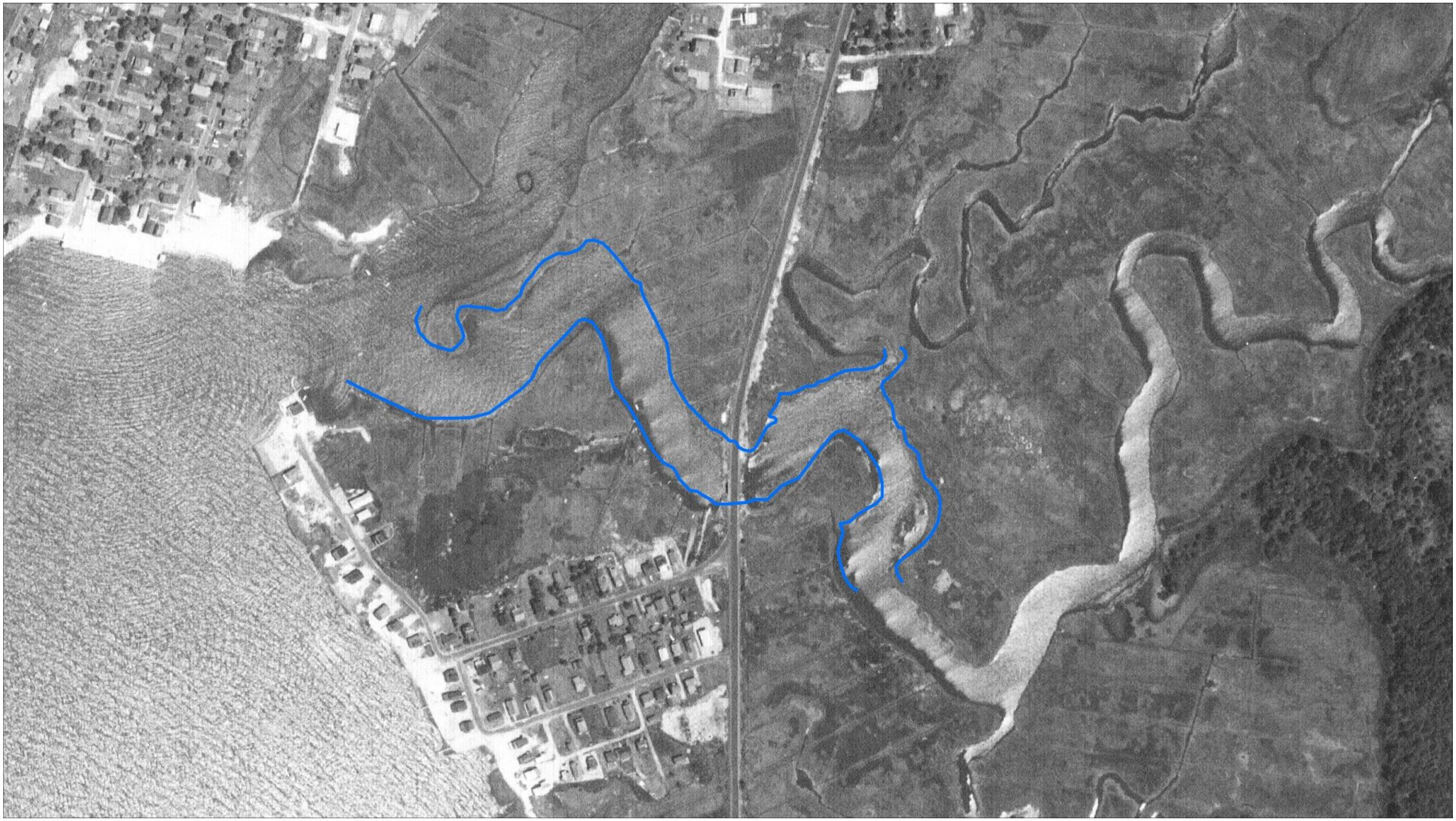


Figure B-2: 1957 Shoreline in Project Vicinity relative to 1934 Shoreline in blue

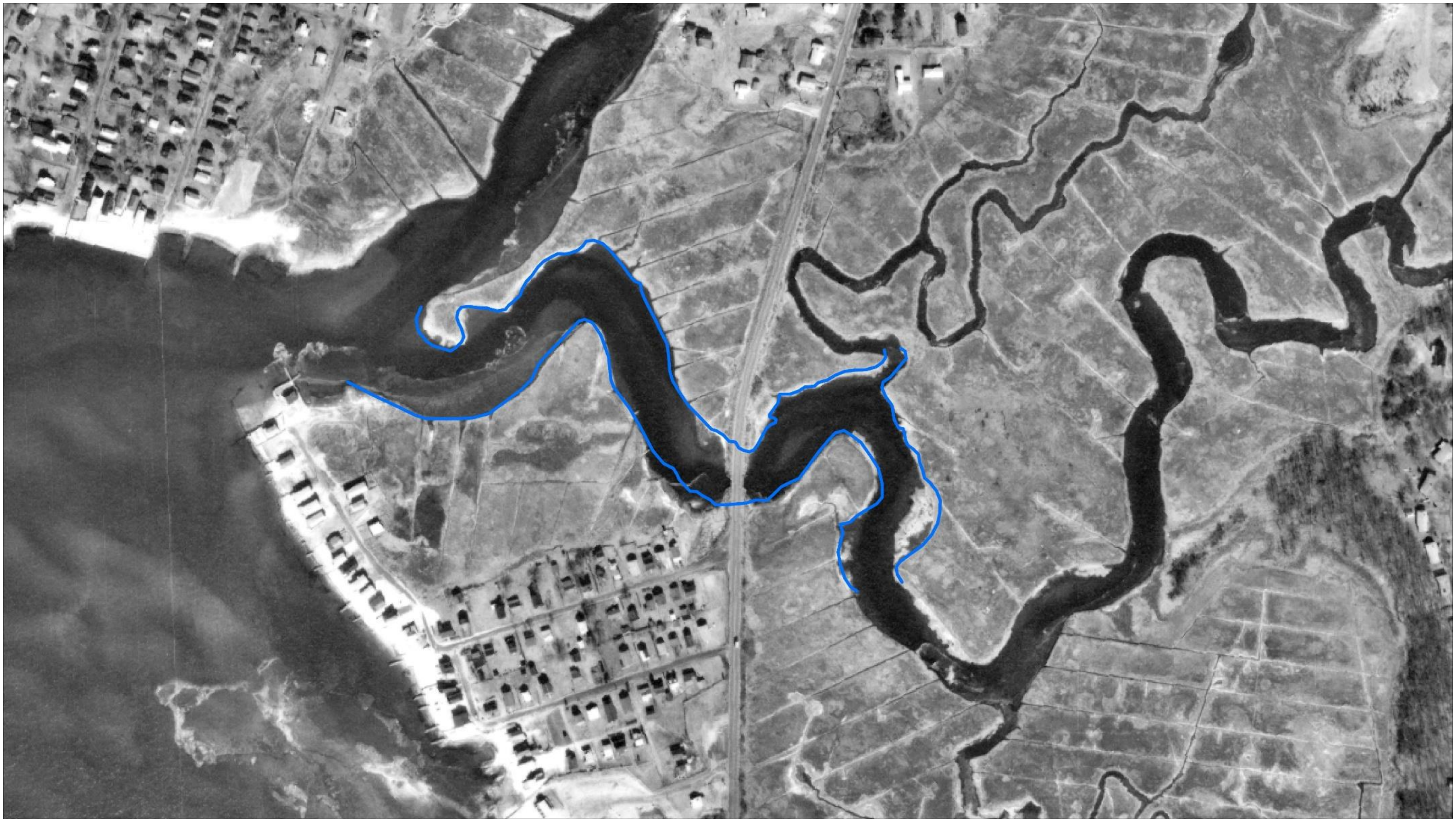


Figure B-3: 1970 Shoreline in Project Vicinity relative to 1934 Shoreline in blue

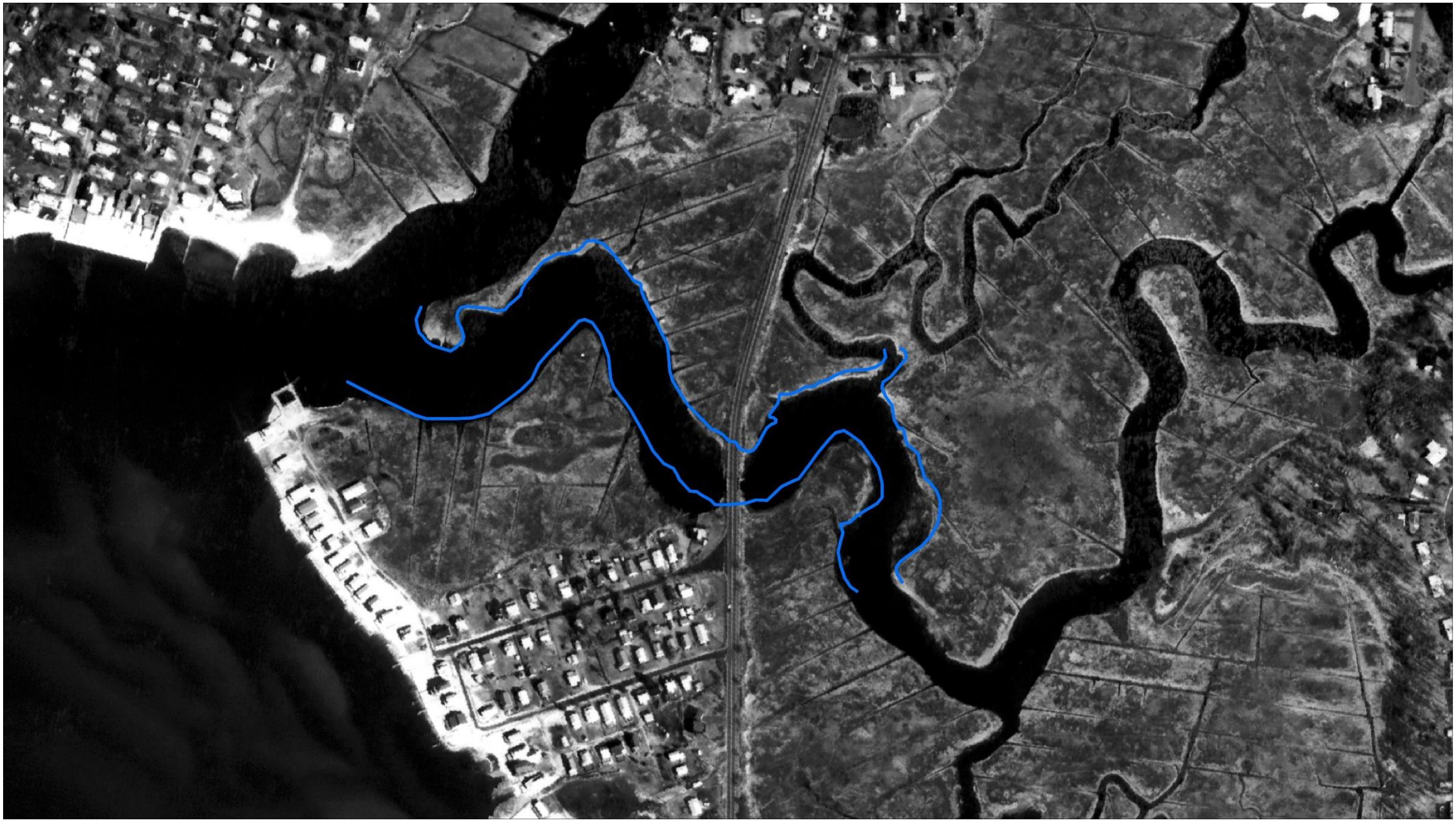


Figure B-4: 1986 Shoreline in Project Vicinity relative to 1934 Shoreline in blue

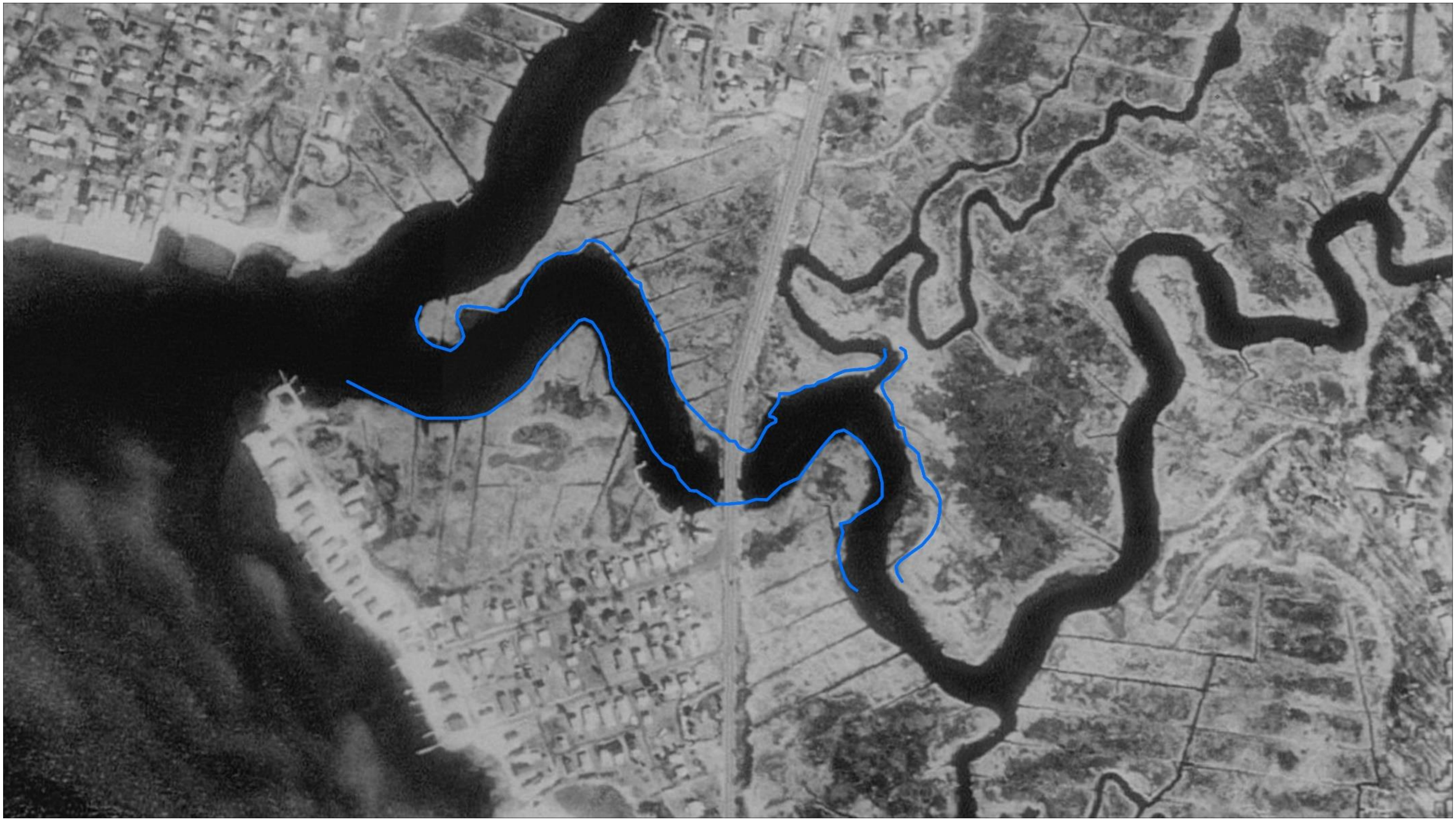
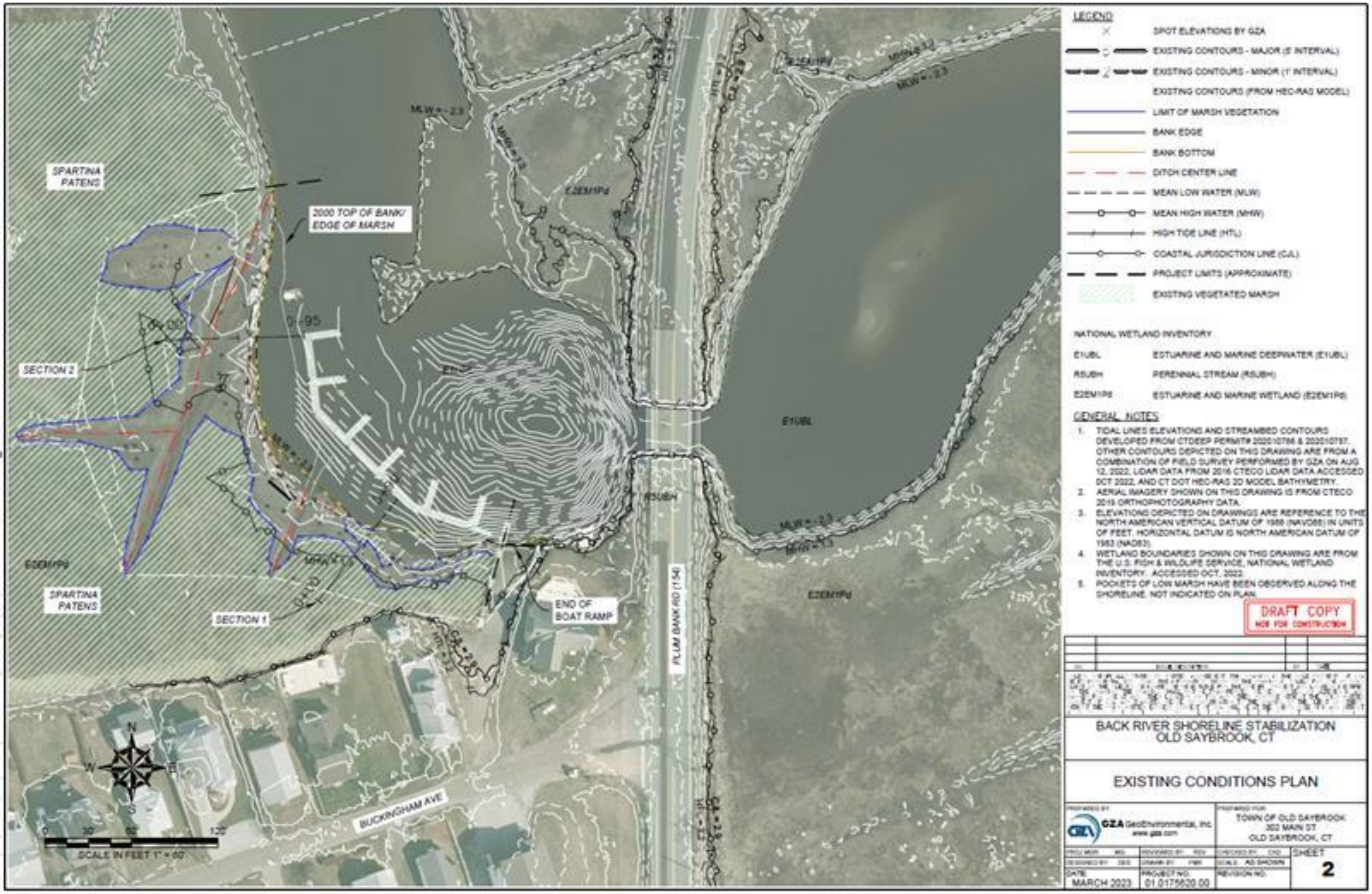


Figure B-5: 1990 Shoreline in Project Vicinity relative to 1934 Shoreline in blue

Figure B-6: 2008 Shoreline in Project Vicinity relative to 1934 Shoreline in blue

Figure B-7: 2021 Shoreline in Project Vicinity relative to 1934 Shoreline in blue

Appendix C– Bathymetry and Topography; Site Photographs


SPARTINA PATENS
2000 TOP OF BANK/ EDGE OF MARSH
SECTION 2
SECTION 1
E2EM1Pd
E1UBL
R5UBH
MLW = -2.3
MHW = 1.3
END OF BOAT RAMP
PLUM BANK RD (154)
BUCKINGHAM AVE
SCALE IN FEET 1" = 60'
LEGEND
SPOT ELEVATIONS BY GZA
EXISTING CONTOURS - MAJOR (5' INTERVAL)
EXISTING CONTOURS - MINOR (1' INTERVAL)
EXISTING CONTOURS (FROM HEC-RAS MODEL)
LIMIT OF MARSH VEGETATION
BANK EDGE
BANK BOTTOM
DITCH CENTER LINE
MEAN LOW WATER (MLW)
MEAN HIGH WATER (MHW)
HIGH TIDE LINE (HTL)
COASTAL JURISDICTION LINE (CJL)
PROJECT LIMITS (APPROXIMATE)
EXISTING VEGETATED MARSH
NATIONAL WETLAND INVENTORY
E1UBL ESTUARINE AND MARINE DEEPWATER (E1UBL)
R5UBH PERENNIAL STREAM (R5UBH)
E2EM1Pd ESTUARINE AND MARINE WETLAND (E2EM1Pd)
GENERAL NOTES
1. TIDAL LINES ELEVATIONS AND STREAMBED CONTOURS DEVELOPED FROM CTDEEP PERMIT# 202010786 & 202010787. OTHER CONTOURS DEPICTED ON THIS DRAWING ARE FROM A COMBINATION OF FIELD SURVEY PERFORMED BY GZA ON AUG 12, 2022, LIDAR DATA FROM 2016 CTECO LIDAR DATA ACCESSED OCT 2022, AND CT DOT HEC-RAS 2D MODEL BATHYMETRY.
2. AERIAL IMAGERY SHOWN ON THIS DRAWING IS FROM CTECO 2019 ORTHOPHOTOGRAPHY DATA.
3. ELEVATIONS DEPICTED ON DRAWINGS ARE REFERENCE TO THE NORTH AMERICAN VERTICAL DATUM OF 1988 (NAVD88) IN UNITS OF FEET. HORIZONTAL DATUM IS NORTH AMERICAN DATUM OF 1983 (NAD83).
4. WETLAND BOUNDARIES SHOWN ON THIS DRAWING ARE FROM THE U.S. FISH & WILDLIFE SERVICE, NATIONAL WETLAND INVENTORY. ACCESSED OCT, 2022.
5. POCKETS OF LOW MARSH HAVE BEEN OBSERVED ALONG THE SHORELINE. NOT INDICATED ON PLAN.
DRAFT COPY
NOT FOR CONSTRUCTION
BACK RIVER SHORELINE STABILIZATION
OLD SAYBROOK, CT
EXISTING CONDITIONS PLAN
GZA GeoEnvironmental, Inc.
www.gza.com
TOWN OF OLD SAYBROOK
302 MAIN ST
OLD SAYBROOK, CT
SCALE AS SHOWN
DATE MARCH 2023
PROJECT NO. 01.0175620.00
SHEET 2

Looking west at the project site during near low tide.

Looking west at the project site during near high tide.

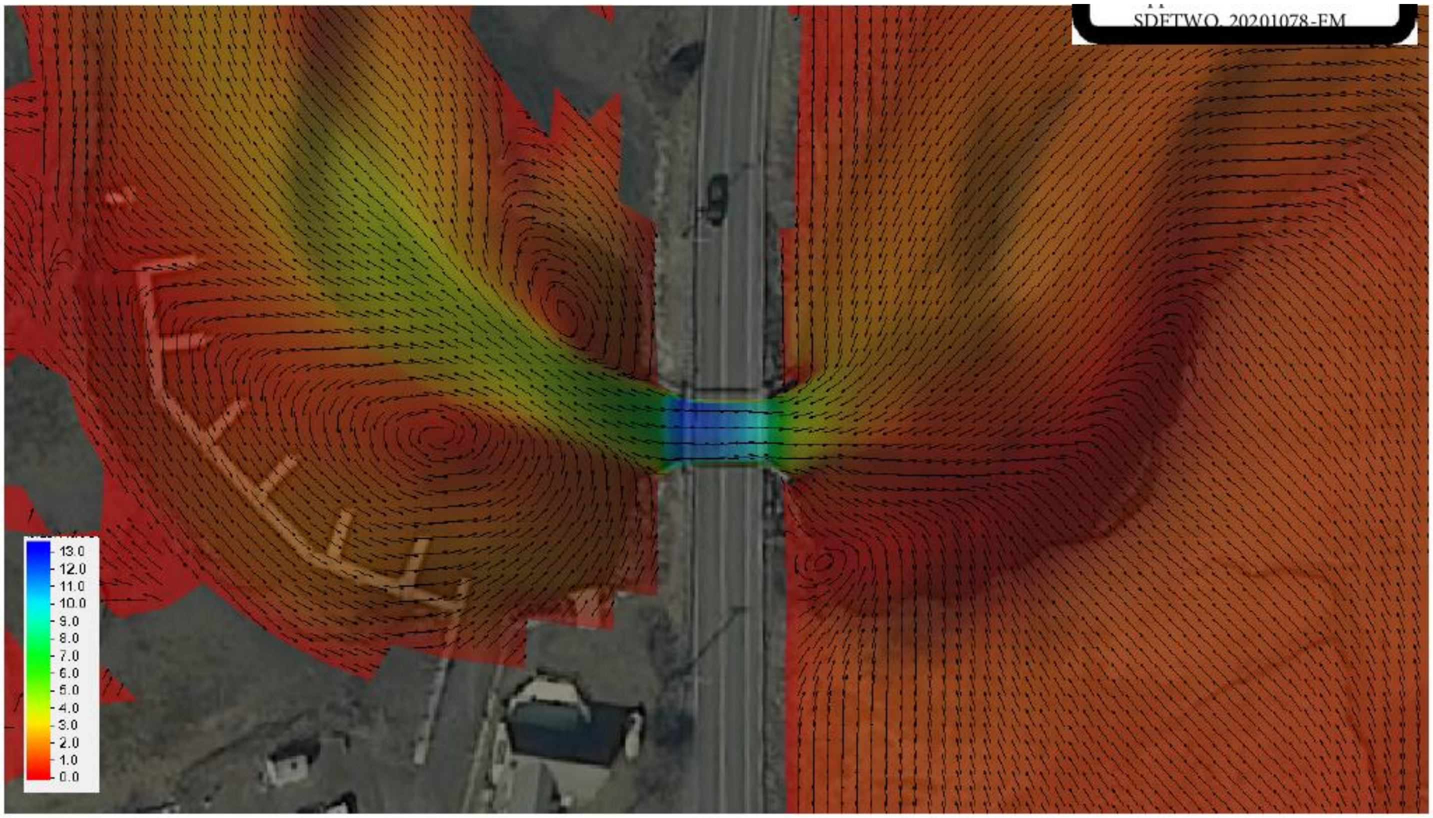
Looking west at the project site during near low tide. Example of sloughing (mass wasting) of marsh edge.


Examples of sloughing (mass wasting) of marsh edge. Clams and mussels present.

Examples of existing oyster settlement with lower tide and submerged zone.

Examples of sloughing (mass wasting) of marsh edge. Clams and mussels present.

Appendix D – Modelled and Measured Back River Channel and Bank Velocities

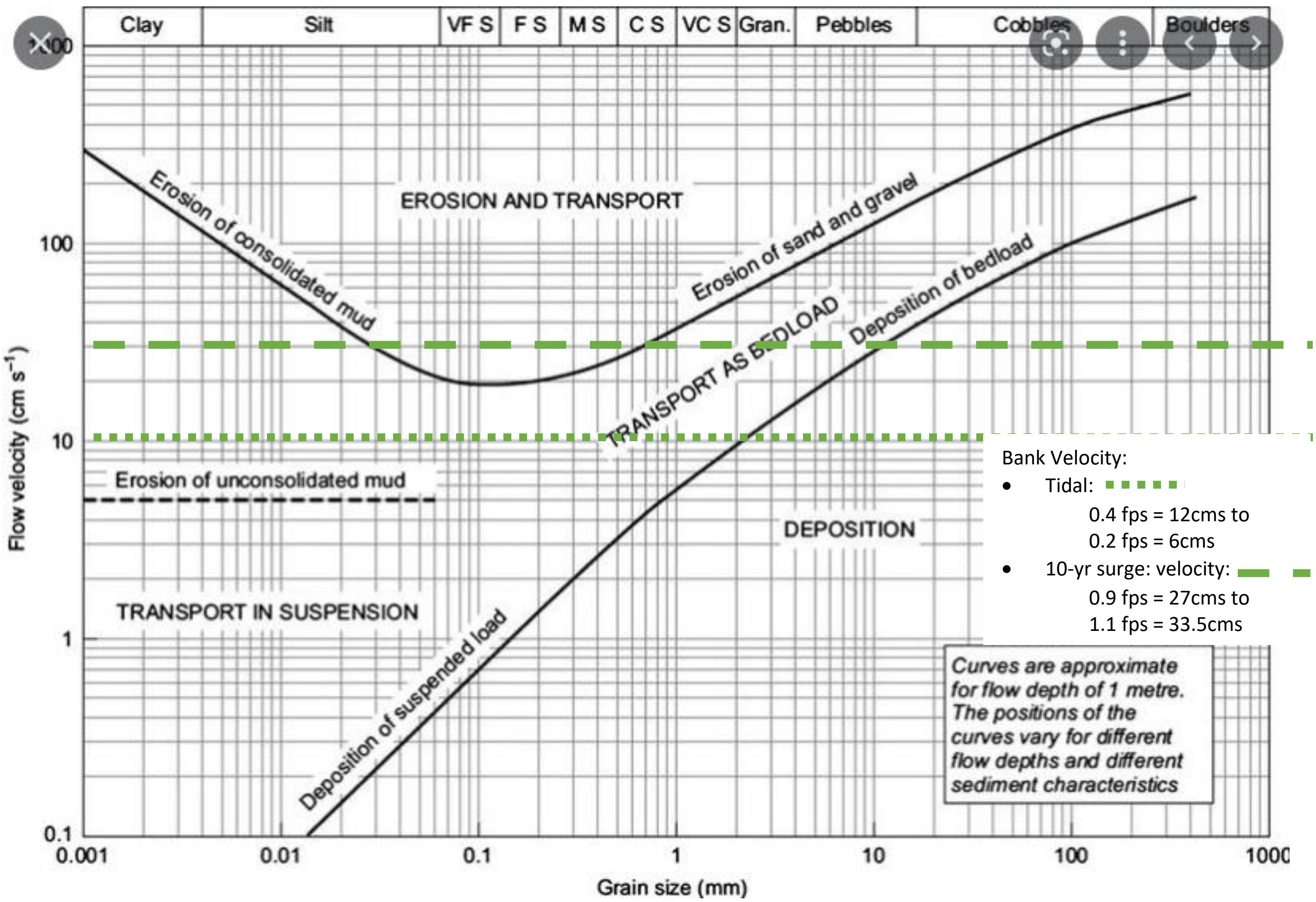


Existing Bridge 10-Year Surge with 100-Year Riverine
(Not to Scale)

Table 5 – Maximum Flow and Velocity through Bridge No. 01386

Route 154 over Plum Bank Creek	Flood						Ebb					
	Existing			Proposed			Existing			Proposed		
	Time (hours)	Flow (cfs)	Velocity (fps)	*Time (hours)*	Flow (cfs)	Velocity (fps)	*Time (hours)*	Flow (cfs)	Velocity (fps)	*Time (hours)*	Flow (cfs)	Velocity (fps)
Astronomical Tide (High Tide @ *25.00 hours*)												
Maximum Flow	*23.75*	338	1.5	*23.75*	338	1.5	*26.75*	342	2.1	*26.75*	342	2.1
Maximum Velocity	*23.75*	338	1.5	*23.75*	338	1.5	*26.75*	342	2.1	*26.75*	342	2.1
10-Year Storm Surge (Peak Surge Elevation @ 24.00 *hours*)												
Maximum Flow	*22.75*	2100	8.9	*22.75*	2196	7.8	*27.75*	1889	9.5	*28.25*	1898	9.4
Maximum Velocity	*22.50*	2082	9.0	*22.00*	2037	8.2	*29.00*	1728	10.7	*29.25*	1730	10.2
Astronomical Tide and 100-Year Riverine Runoff (High Tide @ 25.00 *hours*)												
Maximum Flow	-	-	-	-	-	-	*27.25*	910	5.9	*27.25*	910	5.9
Maximum Velocity	-	-	-	-	-	-	*28.00*	827	6.1	*28.00*	827	6.1
10-Year Storm Surge and 100-Year Riverine Runoff (Peak Surge @ 24.00 *hours*)												
Maximum Flow	-	-	-	-	-	-	*28.25*	2012	11.1	*28.50*	2018	10.4
Maximum Velocity	-	-	-	-	-	-	*29.25*	1879	11.8	*29.75*	1838	11.3
10-Year Storm Surge and 500-Year Riverine Runoff (Peak Surge @ 24.00 *hours*)												
Maximum Flow	-	-	-	-	-	-	*28.25*	2076	11.5	*28.75*	2078	11.1
Maximum Velocity	-	-	-	-	-	-	*29.25*	1958	12.2	*29.75*	1938	11.7

		HEC-RAS 1D			SMS SRH 2D			
Alternatives		Max Ebb Flow (CFS)	Avg. Velocity (FPS)	Avg. Velocity in Channel outside Bridge (FPS)	Max Ebb Flow (CFS)	Velocity (FPS)	Velocity along bank outside Bridge (FPS)	Shear Stress (PSF)
Existing	Surge	2100	9.6	1.1	1890	9.6	0.9	0.012
	Tide	670	3.3	0.4	340	2	0.2	0.001
1	Surge	2080	9.5	1.1	1890	9.2	1.1	0.019
	Tide	670	3.3	0.4	350	1.9	0.2	0.001
2	Surge	3180	7.2	1.7	2200	5.3	1	0.016
	Tide	790	2	0.5	330	1	0.2	0.001



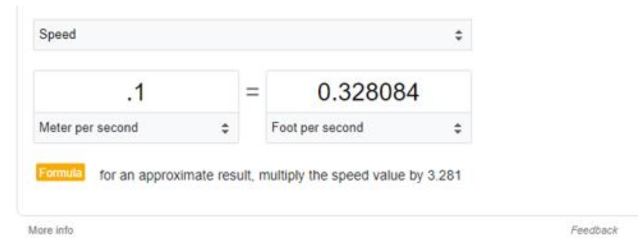
The graph presented above is based on Shields Critical Velocities for different gradation sediment and indicates the critical velocities that are predicted to result in erosion, transport and/or deposition. The lines indicate the predicted flow velocities outside the channel including the riverbank area (in green). The heavy dash lines represent flows associated with a current 10-year recurrence interval coastal flood. The smaller dashed lines indicate representative tidal flow conditions. The velocities presented above have been converted from feet per second to cm per second.

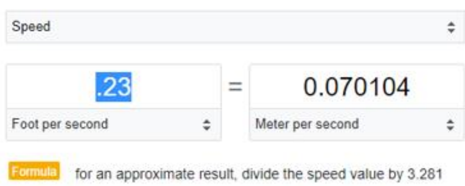
The following images show the results of flow velocity measurements obtained by CIRCA/UCONN as part of this project during representative tidal conditions. The measurements were obtained off the dock in depths of about 20 feet relative to high tide. The observed velocities were greatest during ebb flow (consistent with the models) and were on the order of 0.25 meters (0.8 fps; 25 cms). The measuring location was about midway between the channel and the bank. The measured velocities appear to be generally consistent with the modelled velocities.

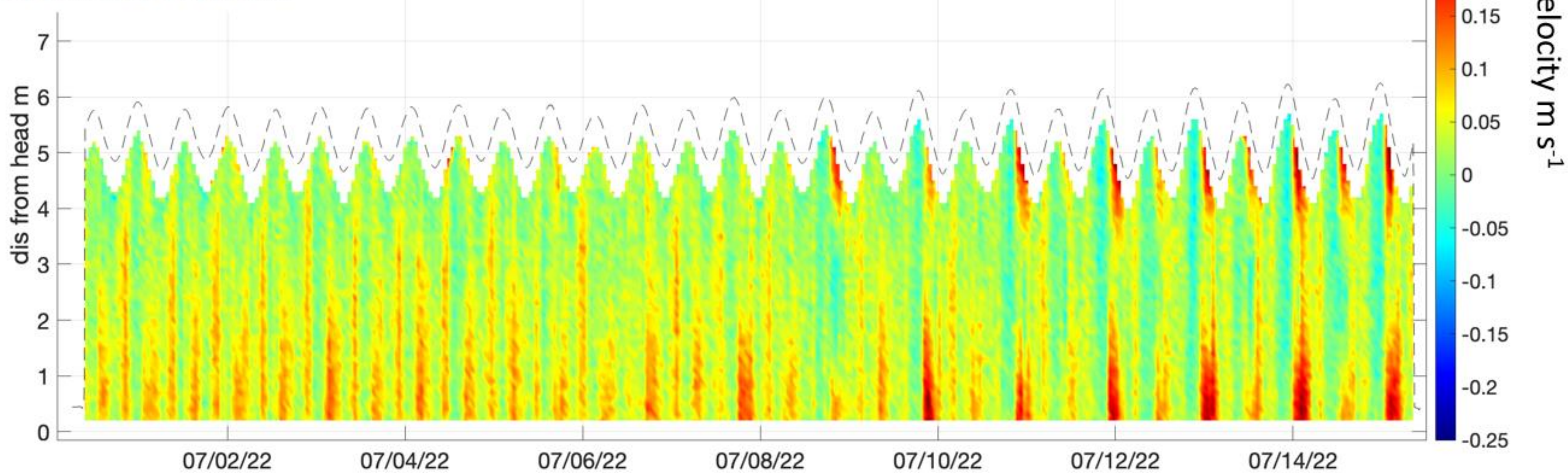
The diagram was used to review currents on the channel bottom, marsh edge, and the top of marsh. Although not a perfect indicator for erosion properties on a marsh edge slope, the diagram gives an idea of forces that could be expected, assisting in sediment and stone sizing for erosion protection.

Bottom Velocity Data from CIRCA

Dock Deployment (BR_dck)

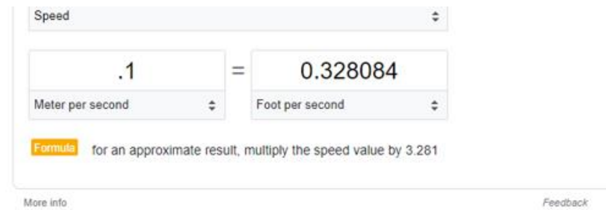




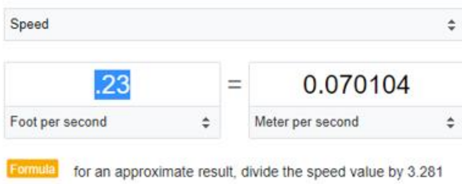


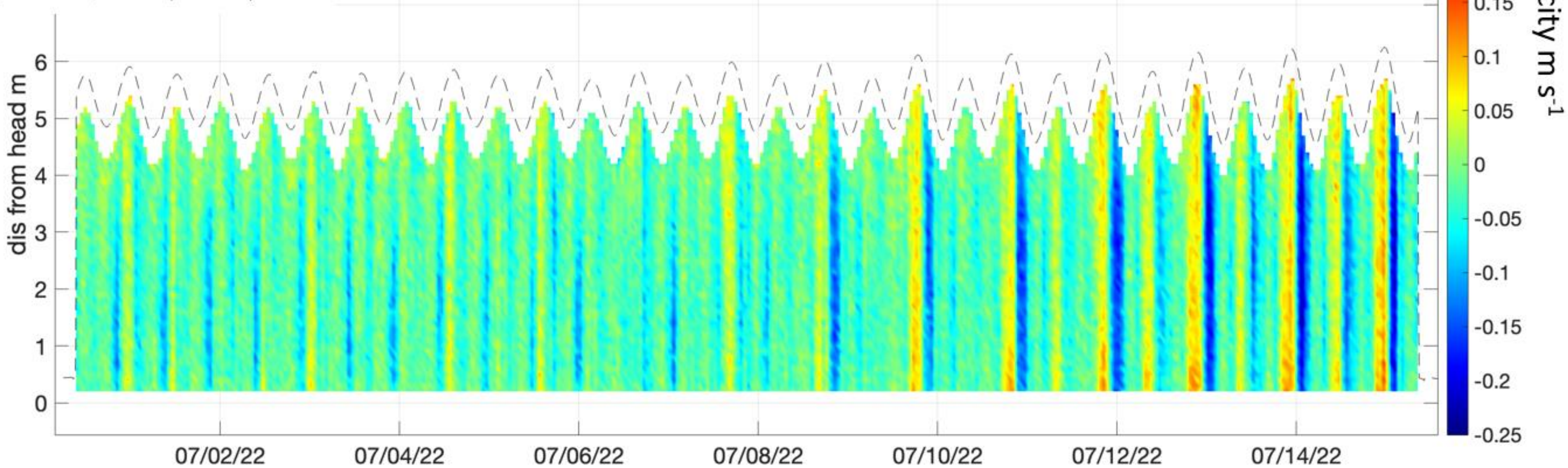
Distance from head of the instrument. The ADCP sits ~ 10 cm above the bed. Surface is marked in dashed black.

Bottom Velocity Data from CIRCA



Dock Deployment (BR_dck)





Distance from head of the instrument. The ADCP sits ~ 10 cm above the bed. Surface is marked in dashed black.

Appendix E – Environmental Permits

Permits	Agency	Jurisdiction	Permit Review Time
Structures & Dredging[1]	CT DEEP	Work below the Coastal Jurisdiction Line (El. 2.0 ft NAVD88)	6 months
Flood Management Certification	CT DEEP	Use of State funds requires this Certification because the project is in a FEMA Flood Zone	3 months
Tidal Wetlands Permit	CT DEEP	Work within vegetated tidal wetlands	6 months
401 Water Quality Certificate	CT DEEP	Work below MHHW that is also subject to Section 404	6 – 12 months
Section 404 Permit[2]	USACE	Work below MHHW	12 months
Section 10 Permit	USACE	Work within navigable waters that could affect navigation	12 months (issued concurrently with Section 404)
Navigation Safety Marker Permit	CT DEEP Navigation/Boating Safety Access Unit	Structures placed in navigable waters that could affect navigation (commercial or recreational) may require markers	2 months
USCG Notification	USCG	Letter notification for work in navigable waters	1 month
Coastal Site Plan Review	Stonington	Site is within Coastal Zone; therefore approval from the Stonington Planning & Zoning Commission is required.	2 months
Natural Diversity Data[3] Base Review	CT DEEP	Work within a NDDB Area requires submittal of a Review Request Form	2 days
Essential Fish Habitat Analysis	NOAA National Marine Fisheries Service (NMFS)	Site is within an EFH area and requires an analysis to be submitted to NOAA	60 days
State Fisheries Review	CT DEEP Marine Fisheries Division	Triggered by the need for a Structures & Dredging Permit or COP	30 days
iPAC Review	U.S. Fish & Wildlife Service	Section 404 permit triggers the need for this review	2 days (online)
Section 106[4]	State Historic Preservation Office; and Tribal Historic Preservation Office	Section 404 and Structures & Dredging Permits trigger the need for consultation which includes submission of a Project Notification Form	60 days
Harbor Management Commission Review	Harbor Management Commission	Structures & Dredging permit requires this consultation	30 days
Shellfish Commission Review	Shellfish Commission (or designated representative)	Structures & Dredging permit requires this consultation	30 days

[1] The project may qualify for a Certificate of Permission (COP) in lieu of a Structures & Dredging Permit. A request to DEEP is required for this determination. This would reduce review time to 45-90 days.
[2] An Individual Permit (IP) will likely be required; however, depending on the final impacts, it may qualify under the General Permit which would reduce the review time to 4-6 months.
[3] If CT DEEP determines that biological surveys are needed, additional review time will be needed.
[4] If SHPO determines that site-specific archaeological or historic investigations are required, additional review time will be needed.

Notes: Additional permits not listed here may be required: 1) for shellfish restoration activities; and 2) for work within a Connecticut Wildlife Management Areas (WMAs).

Table: Summary of Project Permits

Connecticut DEEP Permitting Guidance

Connecticut's Coastal Management Act (CCMA) establishes goals and policies to preserve and manage navigation, water-dependent uses, and coastal resources. CCMA also includes a policy for coastal planning that considers the potential impact of flooding and erosion patterns on coastal development and a policy for areas within the coastal boundary to maintain the natural relationship between eroding and depositional coastal landforms and promote nonstructural mitigation measures to minimize the adverse impacts of erosion and sedimentation. Accordingly, CCMA policy identifies several criteria that must be met in order for structural solutions to be permissible "where there is no feasible, less environmentally damaging alternative and where all reasonable mitigation measures and techniques have been provided to minimize adverse environmental impacts."

CCMA was amended in 2012 by P.A.12-101, "An Act Concerning the Coastal Management Act and Shoreline Flood and Erosion Control Structures," which introduced the implementation of living shorelines in coastal management. The act includes living shorelines techniques that maintain or restore costal resources and habitat as a "feasible, less environmentally damaging alternative" for sedimentation and erosion control, and it excludes any activity, including living shorelines projects, for which the primary purpose or effect is restoration or enhancement of tidal wetlands, beaches, dunes, or intertidal flats, from the definition of a shoreline flood and erosion control structure.

Living shorelines are also identified as an innovative and low-impact approach to shoreline protection and adaptation to sea level rise in Connecticut General Statutes (CGS) section 22a-363h, which was established by this act. Permit Process CCMA specifies that to be considered a less environmentally damaging alternative, living shoreline techniques must maintain or restore coastal resources and habitat in addition to providing shoreline protection. Consistent with the goals and policies of CCMA, review of proposed living shoreline projects requires consideration of their effect on:

- Naturally eroding shorelands;
- Longshore sediment transport;
- Patterns of shoreline erosion and accretion;
- Intertidal flats;
- Existing tidal wetlands;
- Wildlife, finfish & shellfish habitat;
- Public access;
- Navigation.

Therefore, the permit process for living shorelines varies, depending on circumstances of the site, since all projects and potential sites are unique. Pre-application coordination with DEEP Land & Water Resources Division (LWRD) staff is still strongly recommended.

Certificate of Permission (COP):

Living shoreline projects that are proposed waterward of the Coastal Jurisdiction Line (CJL) or within tidal wetlands in Connecticut require authorization from LWRD. New living shoreline projects that provide shoreline protection and maintain or restore coastal resources and habitat, including their functions and process, or are proposed to replace existing "hard" shoreline structures that were either previously authorized or completed prior to January 1, 1995, may be eligible for expedited approval through the Certificate of Permission (COP) authorization process pursuant to CGS sections 22a-363b and 22a-363h. A COP application is processed within 90 days or less, and the process does not include public notice or hearing requirements.

Structures, Dredging and Fill and Tidal Wetlands:

A Structures, Dredging and Fill and Tidal Wetlands (SDF/TWSD) permit process pursuant to CGS sections 22a-361 and 22a-32 may be warranted in cases where a living shoreline is proposed by multiple property owners or the potential for adverse impacts to coastal resources, navigation, or aquaculture requires more extensive evaluation. The SDF/TWSD application is more comprehensive than the COP application; thus, it requires more time to process than a COP. Processing times and level of coordination are contingent on the size, complexity and scope of the intended project. Coordination & Review Any activity proposed within an SDF/TWSD application, including living shorelines, requires consultation with the Bureau of Aquaculture within the Department of Agriculture and several local commissions, including Harbor, Shellfish, and Conservation commissions, prior to submission of the application to DEEP. The application process also requires certification of a public notice of the application from the applicant upon submission to DEEP and a subsequent public notice of tentative determination from DEEP, which includes a public comment period. If the primary purpose or effect of a proposed living shoreline is to provide tidal wetlands or other coastal resource restoration or enhancement, the DEEP Commissioner may waive or reduce any application fee at their discretion in accordance with CGS section 22-361(a)(2).

Section 404 Permit:

A living shoreline installation proposed waterward of the CJL typically requires a Section 404 Permit from the U.S. Army Corps of Engineers (USACE). The work may be eligible for authorization under one of the USACE's General Permits for the State of Connecticut. If USACE authorization is required, the State's Section 401 Water Quality Certificate (WQC) is integrated into the COP and SDF/TWSD authorization process. For a USACE jurisdiction determination regarding Section 404, the applicant should consult directly with the USACE. For questions on DEEP's regulatory review process, contact LWRD staff. Local permitting may also be required for projects proposed waterward of the CJL. Contact the appropriate local municipal planning office for guidance. Municipal Guidance Coastal municipalities review coastal site plans for living shoreline projects located fully or partially within the coastal boundary and landward of mean high water in accordance with CCMA requirements.

Municipal Guidance, Coastal Site Plan Review and Legal Conditions to be Met:

Coastal municipalities review coastal site plans for living shoreline projects located fully or partially within the coastal boundary and landward of mean high water in accordance with CCMA requirements.

The term "living shoreline" is not included in the legal definition of a shoreline flood and erosion control structure only when its primary purpose or effect is the restoration or enhancement of tidal wetlands, beaches, dunes or intertidal flats. Therefore, to be consistent with CGS section 22a-109(c)(2) a living shoreline must:

- Principally restore or enhance natural coastal or riparian habitat features, functions, and processes;
- Maintain the natural processes and connections between uplands and aquatic areas;
- Not have the primary purpose or effect of controlling flooding or erosion from tidal, coastal, or navigable waters; and
- Not be used to retain, expand, or create yard space or developable land.

If a proposed living shoreline does not meet all of the resource restoration or enhancement criteria, then in accordance with CGS sections 22a-109(a) and 22a-109(d), the coastal site plan:

1. Shall be referred to DEEP and consideration given to any comments and recommendations that DEEP submits in response before final action is taken; and
2. Shall be approved only if the record demonstrates and the commission makes specific written findings that:

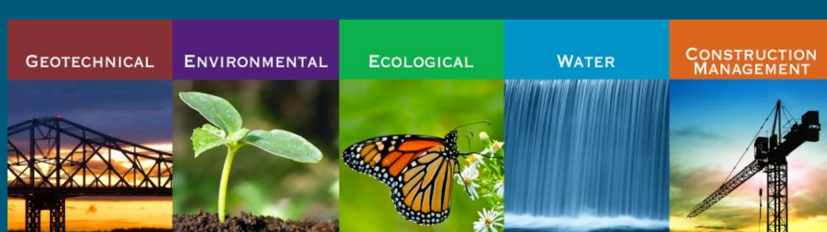
a. such structure is necessary and unavoidable for the protection of: i. infrastructural facilities, cemetery or burial grounds, ii. water-dependent uses being fundamental to habitability or the primary use of such property; or, iii. inhabited structures or structure additions constructed as of January 1, 1995;
b. there is no feasible, less environmentally damaging alternative; and all reasonable mitigation measures and techniques are implemented to minimize adverse environmental impacts:

If DEEP determines that a living shoreline project approved landward of CJL does not specifically meet the resource restoration or enhancement criteria as required, then the DEEP Commissioner may appeal the municipal decision pursuant to CGS section 22a-110. Furthermore, coastal site plans for proposed living shorelines must include methods of construction in accordance with CGS section 22a-105(c), which detail the use, type, location, and storage of construction components and equipment, temporary flood and erosion control measures, and any other incidental work. If construction methods require any such use, placement, storage, or incidental work waterward of CJL, then the project also requires DEEP authorization as specified in the Permitting Process section. If a living shoreline project installed landward of CJL involved any construction activities occurring waterward of CJL without authorization from DEEP, then DEEP may consider the installment to be a public nuisance and seek to enjoin or abate any such nuisance pursuant to CGS section 22a-362. To avoid potential legal conflicts, DEEP LWRD staff should be consulted on any proposed living shoreline project prior to submitting the project plan to either municipal zoning or DEEP for approval.

Additional permits and/or regulatory outreach may be required specific to shellfish management:

- Fisheries Management: Connecticut DEEP – Division of Fisheries;
- Shellfish Aquaculture: Connecticut Department of Agriculture – Bureau of Agriculture;
- Shellfish Sanitation: Connecticut Department of Agriculture – Bureau of Agriculture. State counterpart to National Shellfish Sanitation Program;
- USACE: Aquaculture Projects & Fisheries, Miscellaneous: Category 1 and/or 2 activity.

Additional permits and/or regulatory outreach may be required specific to work within Connecticut Wildlife Management Areas (WMAs).



GZA GeoEnvironmental, Inc.