Suffolk County Peconic Estuary Program
Conceptual Habitat Restoration Designs

Lake Montauk Alewife Access and Habitat Enhancement
Montauk, Town of East Hampton

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1 EXECUTIVE SUMMARY

The Lake Montauk Alewife Access and Habitat Enhancement was one of forty-one (41) priority habitat restoration projects identified in the 2017 PEP Habitat Restoration Plan by the PEP Habitat Restoration Workgroup. Two tributaries to Lake Montauk were evaluated for use and passage by migrating alewife and eels; Stepping Stone Pond and Big Reed Pond (Figure 1).

Stepping Stones Pond is a shallow 10.4-acre pond located at the south end of Lake Montauk that supports high-quality freshwater wetland communities. Water is conveyed from Stepping Stones Pond through two 1-foot diameter HDPE pipe culverts beneath Old West Lake Drive directly into Lake Montauk. Field evidence of attempted alewife migration from Lake Montauk to Stepping Stones Pond was observed in 2018. The downstream and upstream ends of the culverts are perched approximately 1 foot above the bed of the channel bed and alewife are not able to jump this high into the culverts. In addition, the high water velocity and shallow depth of water flow presents a barrier to upstream movement of fish. Replacement of the twin 1-foot culverts with a 3- or 4-sided concrete box culvert with a natural substrate bed and a sequence of 7-8 riffle-pool combinations is recommended to provide passage for fish and aquatic species between Stepping Stones Pond and Lake Montauk.

Big Reed Pond is a 45-acre freshwater pond located within Montauk County Park with extensive high-quality freshwater wetlands and surrounding woodlands. A small stream flows from Big Reed Pond into Little Reed Pond, which is connected to Lake Montauk by a tidal creek channel that flows through a culvert under East Lake Drive. The East Lake Drive culvert is not a passage barrier for alewives or American eel. The small stream outlet from Big Reed Pond to Little Reed Pond features a 1-foot diameter, 15-foot long HDPE culvert that conveys flow under an unpaved park access road. Fish are able to move through this culvert. However, the *Phragmites* plant material obscuring the culvert and the narrow culvert are likely decreasing the success rate of fish trying to move upstream into Big Reed Pond. Replacement of the undersized 1-foot HDPE culvert with a 2-foot diameter corrugated metal pipe arch culvert is recommended to increase the fish passage success rate. The culvert is also located within a stand of invasive small carpetgrass (*Arthraxon hispidus*) – the only known location of this highly invasive species on Long Island. Best management practices to be employed during culvert replacement to avoid transport of *Arthraxon* seeds are provided in this study. A large fish kill and toxic blue-green algae (*Aphanocapsa*) occurred in Big Reed Pond in 2010 that impacted many of the fish species living in the pond. This report also provides recommendations for future fisheries and water quality monitoring to determine a potential cause of the 2010 fish kill and blue-green algae bloom.

The results of this conceptual feasibility and design study can be used to prioritize improvement efforts for fish passage within Lake Montauk. Feasibility level costs and other considerations, such as design constraints and regulatory permitting requirements, are included to inform the final design of construction plans and specifications for recommended structural restoration actions.

2 BACKGROUND

2.1 Project Overview

Two areas were evaluated for use and passage by migrating alewife and eels within Lake Montauk: Stepping Stone Pond and Big Reed Pond (Figure 1). Feasibility level costs and other considerations, such as design constraints and regulatory permitting requirements, are included to inform the final design of construction plans and specifications for recommended structural remedies.

Figure 1: Stepping Stone Pond and Big Reed Pond study locations in East Hampton's Lake Montauk.

The enhancement of alewife access in Lake Montauk was one of forty-one (41) priority habitat restoration projects identified in the 2017 PEP Habitat Restoration Plan by the PEP Habitat Restoration Workgroup. The Lake Montauk Alewife Access and Habitat Enhancement was identified as a "high priority" restoration project in the 2017 PEP Habitat Restoration Plan. This study and development of conceptual plans for the Stepping Stones Pond and Big Reed Pond sites in Lake Montauk contribute to the implementation of actions identified in the 2001 Peconic Estuary Comprehensive Conservation and Management Plan (CCMP), specifically the CCMP's Habitat and Living Resources Actions HLR-7 (Develop and Implement an Estuarywide Habitat Restoration Plan) and HLR-8 (Develop and Implement Specific Restoration Projects).

2.2 River Herring

Alewife (*Alosa pseudoharengus)* and blueback herring (*Alosa aestivalis)* are part of the Clupeidae family. Alewives and blueback herring are morphologically similar species, roughly 250 mm (9.8 in.) in total length as adults, and are commercially referred to collectively as 'river herring'. Both species are present along the North American eastern seaboard. Alewives have a geographic distribution from Newfoundland to South Carolina, whereas blueback herring have a wider and more southern geographical range, from Nova Scotia to the St. Johns River, FL (Bozeman, 1989). River herring are anadromous, spawning in freshwater and living predominantly in estuarine or Atlantic coastal waters. River herring spawn once a year, migrating in the spring into freshwater streams and ponds. River herring play an important trophic role, linking zooplankton and piscivores in marine, estuarine, and freshwater environments (Bozeman, 1989).

2.2.1 Spawning Habitat and Migration Patterns

Though alewives and blueback herring share many similarities, it is important to note some distinct differences in their spawning and migration patterns. Several studies have found that alewives travel farther upstream than blueback herring to spawn. In addition, when alewives and blueback herring share spawning grounds, blueback herring will tend to occupy the lotic or flowing water environment while alewives tend to occupy the lentic or still and terrestrial waters (Loesch and Lund, 1977 and O'Connell, 1977).

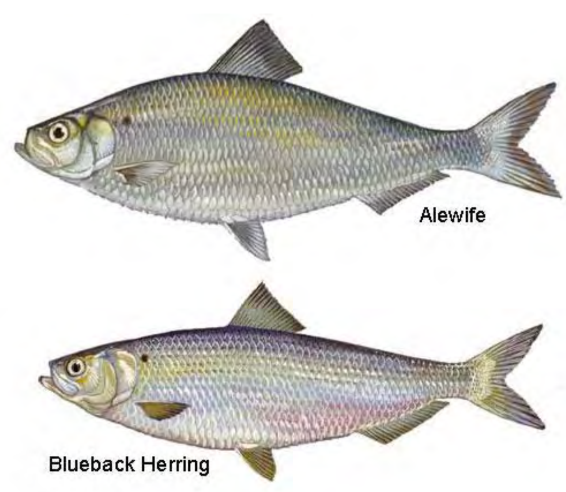


Figure 2: Image of Alewife and Blueback Herring (illustrations by Diane Rome Peebles)

Alewives tend to travel further in the migratory search for spawning grounds (Jones et al. 1978), and exhibit a wider latitude of spawning habitats including large rivers, small streams and ponds with a variety of substrate conditions including gravel, sand, detritus and submerged vegetation with slow-moving water. The depth of water in the nursery can vary from 6 inches to almost 10 feet (Edsall 1964; Masnueti and Hardy, 1967 cited in USFWS, 1983). Alewives spawn 2-3 weeks earlier than blueback herring which is highly influenced by temperature (Jones et al. 1978; Fay et al. 1983; Scott and Scott, 1988 as cited in Iafrate, 2006). Research has found that blueback herring prefer spawning grounds in fast-flowing water over hard substrates, which may be due to the negative affect of sedimentation on fertilized eggs (Klauda and Palmer, 1987). Though preferring flowing water, blueback herring will also spawn in slower-flowing tributaries and flooded low-lying areas adjacent to main streams with soft substrates and detritus (Street et. Al. 1975; Sholar, 1975 & 1977; Fischer 1980; Hawkins 1980a). Blueback herring hatch in June and July. Fertilized river herring eggs are highly tolerant of suspended sediments, varying flow rates, and salinity (Auld and Schubel 1978). Pardue (1983) concluded that substrata with 75% silt or other soft materials containing detritus and vegetation and combined with sluggish water flows were optimal to provide cover for spawning river herring and their eggs and larvae.

Alewife and blueback herring juveniles spend 3-7 months growing in their freshwater nurseries before emigrating downstream to coastal waters. However, the temporal pattern of emigration is quite different, as observed in a 2006 study by Iafrate and Oliveira of factors affecting the migration patterns of juvenile river herring in Massachusetts. They observed a distinct bimodal migration pattern of early and late migrating waves of alewives (unique hatch dates) and a single migration of blueback herring. The timing of the three migrations were staggered temporally, with the early alewives emigrating in July and August, followed by the blueback herring in September through October and the last wave of late migrating alewives in November and December before the winter freeze. Abiotic environmental factors affecting juvenile migration include water temperature, water levels, water visibility, changes in rainfall and lunar phase. For example, the migration of blueback herring is highly correlated to a significant drop in water temperature and the new moon (Iafrate, 2006). Water temperature peaks in the late summer are correlated with early alewife emigration, while dropping water temperatures correlate with late migratory peaks. Biotic factors, namely competition for food resources and food availability in the nurseries, may also play a role in the migration patterns of the species and deserves further study. Temporal separation of spawning and hatching between the two species may minimize competition.

Studies have also concluded that headwater spawning grounds may be ideal for river herring, however fish may not be able to reach them, either due to altered hydrology of the stream or barriers such as dams and culverts (O’Connell, 1997). Obstacles may result in the selection of less than desirable spawning conditions. Upstream habitats and headwaters may provide more cover from aerial predators, such as osprey (Colby, 1973), while open waters leave the herring and their larvae susceptible to aquatic predators such as striped bass and white perch (Scott and Scott, 1988). Additionally, lotic conditions of headwater streams prevents sedimentation over eggs, provides a source of dissolved oxygen, and riparian habitat stabilizes stream temperature as well as provides needed cover (Uzee 1993). Providing access to headwater streams by removing dams, creating passable road crossings and preserving the ecological integrity of first and second order streams will increase the availability of suitable spawning environments for river herring.

2.2.2 Swimming Abilities and Barrier Passage

The ability of river herring to traverse physical and velocity barriers along their inland migration route determines the upstream boundary of their spawning potential. Velocity barriers, or reaches of high water flow, can be either natural or man-made. Although there is not a wealth of research on the swimming performance of river herring, a study by Haro et al. (2004) provides some useful data for understanding the species’ limitations. The experiment tested the performance of alewife and blueback herring to successfully traverse four sustained velocity regimes, at varying lengths, in an open channel flume. The study focused on understanding sprinting performance, otherwise known as steady state burst swimming. The results of the study indicate that blueback herring are stronger swimmers than alewife, able to traverse longer distances in higher flow states (see Figure 3).

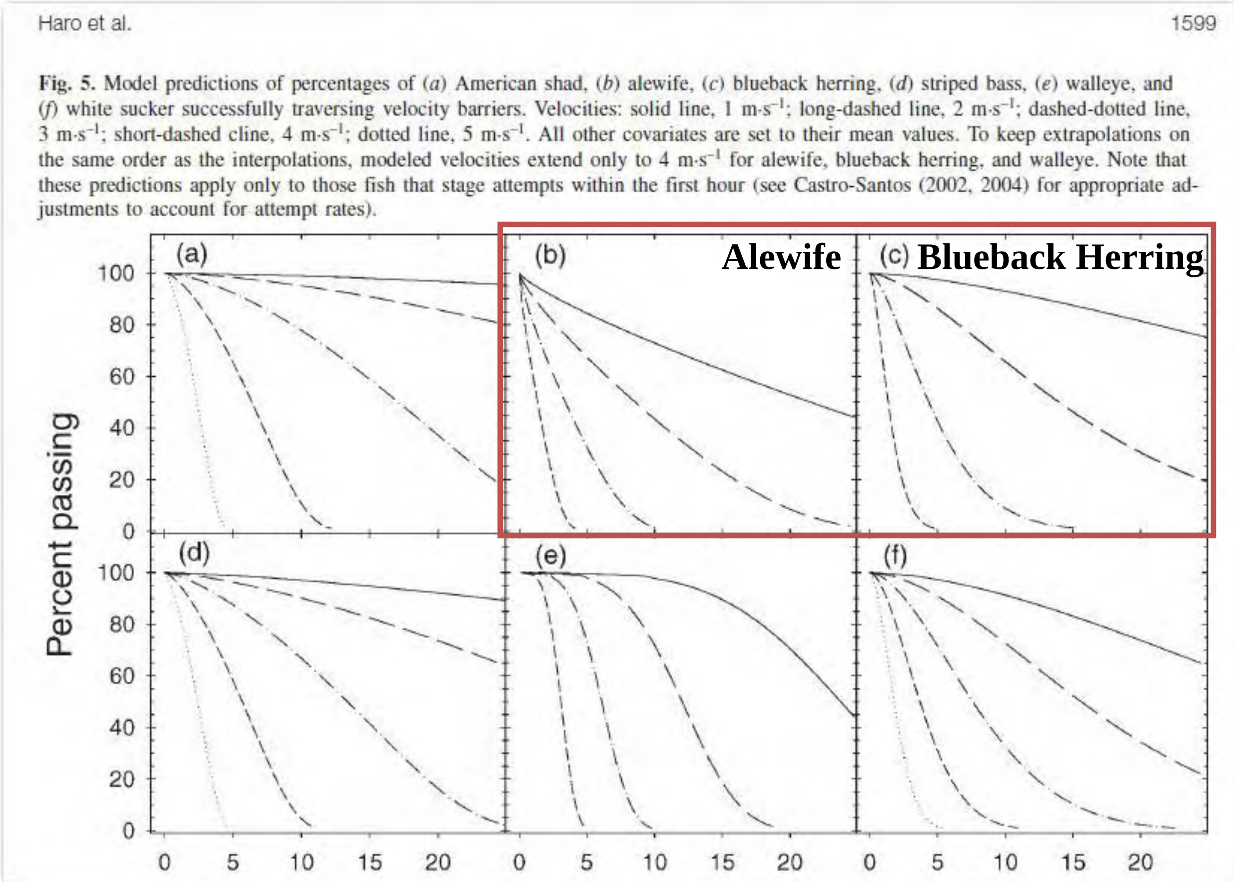


Figure3: Performance of alewife and blueback herring to successfully traverse four sustained velocity regimes. (Haro et al. 2004)

Interpretation of the graph in Figure 3 indicates the following quantitative information in Table 1:

Table 1: Table of interpreted quantities of model prediction graphs from Haro et al. 2004

Species	Distance	Flow Velocity	% Success (+/-)
Blueback Herring	15 m (49 ft.)	1 m/s (3.28 ft./s)	100%
Blueback Herring	15 m (49 ft.)	2 m/s (6.56 ft./s)	45%
Blueback Herring	5 m (16.4 ft.)	3 m/s (9.84 ft./s)	50%
Blueback Herring	1 m (3.2 ft.)	4 m/s (13.12 ft./s)	50%
Alewife	15 m (49 ft.)	1 m/s (3.28 ft./s)	65%
Alewife	15 m (49 ft.)	2 m/s (6.56 ft./s)	25%
Alewife	3.8 m (12.5 ft.)	3 m/s (9.84 ft./s)	50%
Alewife	1.2 m (4 ft.)	4 m/s (13.12 ft./s)	50%

In general, alosids are poor jumpers and minor barriers as small as 6 inches can present challenges and reduce migration success. However, their excellent swimming ability and burst speed allows relatively minor adjustments to be made to most velocity barriers to allow successful migration.

2.3 American Eel

Unlike the alosids, the American eel is catadromous, predominantly living in freshwater and breeding in the ocean. The life cycle of an eel begins in the Sargasso Sea north of Cuba before drifting in its larval state on ocean currents to the Gulf of Mexico, up the eastern seaboard of the United States, or as far north as Greenland and Iceland. During the glass eel stage, when the translucent eel is no more than 1.8-2.8 inches long, it begins to swim toward the coast generally during the early summer, from April to July in the Gulf of Maine. It then metamorphoses into an elver, developing pigmentation and growing to 2.6-3.9 inches long. In their elver state, eel start the journey inland, through brackish, tidal channels and finally up freshwater channels to inland streams and ponds. The migration inland can take several years and hundreds of stream miles.

Eels continue to grow during the migration, and once they've exceeded six inches they are considered yellow eels. Yellow eels may live 6 to 30+ years growing to adulthood in fresh, inland waters. Once the eel has reached its final sexually mature life-cycle state known as a silver eel, it begins to prepare for the long migrational journey back to the Sargasso Sea, this time in a very different form. Silver eels have fat bodies, enlarged eyes, and thicker darker skin than yellow eels. The digestive tract degenerates during metamorphosis, evidence that the seaward migration is a one-way trip back. The average size of a female eel at maturity is 50 inches long. Fatality is more likely on the return journey to the ocean due to predation, harvesting, and injury or death in hydroelectric dams. Migration back to the sea occurs nocturnally in the fall, September to December. Eels spawn only once before they die.

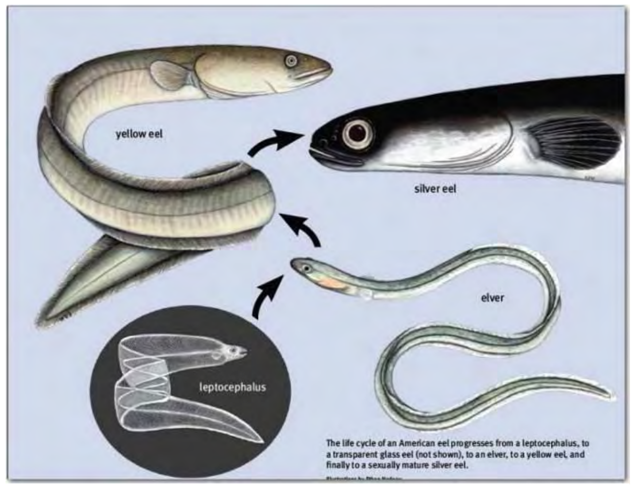


Figure 4: Diagram of American Eel Life Stages (source: Gulf of Maine, 2007)

2.3.1 Eel Passage Requirements

Fish passage challenges for eel are quite different than for river herring due to the life cycle stage during migration. First is the challenge to provide passage opportunities upstream for the small juveniles, and second, to ensure a safe passage for the large adult silver eels back to the sea.

Fish Passage Upstream

Barriers to eel passage upstream include vertical and velocity barriers caused by dams and culverts. Passage requirements for lower watershed barriers closest to the coast, encountered by smaller eels (2.3-5.1 inches) with poorer swimming abilities, will be different than upper watershed barriers encountered by larger and stronger elvers and yellow eels. Refer to Table 2 for the average swimming abilities for a young juvenile.

Table 2: Swimming abilities of juvenile eel (McCleave, 1980 in Gulf of Maine, 2007)

Young Juvenile	Burst Speed	Burst Distance
70-100 mm (2.75-3.9 in.)	0.6-0.9 m/s (2-3 ft./s)	<1.5 m (4.9 ft.)

Younger juveniles can swim a maximum distance of 3 m (9.8 ft.) in a 1 cubic foot per second (cfs) flow velocity. Older juveniles can swim 4 ft/s but not for long distances in fast water (McCleave, 1980 in Gulf of Maine Council on the Marine Environment, 2007). Flow velocities over long distances, such as the conditions found in culverts, inhibit the migration of eels. In addition, strong flows and complex turbulence reduces swimming performance (McCleave, 1980 in Gulf of Maine Council on the Marine Environment, 2007). Reducing flow velocity by roughening the channel surface and providing more opportunities for refuge from high flow is desirable.

Interestingly, elvers have the ability to 'climb' damp, coarse surfaces. Although elvers are capable of climbing vertical surfaces, research has shown greater success with ramps with a climbing substrate (See Figure 5). In addition, some elvers may choose not to climb. A vertical barrier of even a few centimeters is enough to block the migration of a juvenile.

Eels have the ability to ascend damp vertical surfaces (left), but passage is far more successful if we provide ramps with climbing substrate, like this one on Mallemort Dam in France (right). Alex Haro

Figure 5: Eel ramp image from Gulf of Maine Council on the Marine Environment (2007).

Upstream passage solutions include: eel ramps, by-pass channels, rock ramps, and culvert modification. Eel ramps are suitable for conditions where dam removal is unfeasible and head differentials preclude more natural solutions. Eel ramps are a common and cost-effective fishway measure that can be retrofitted within the existing dam structure or alongside the structure. The ramp can be a fairly steep (near vertical), bottle-brush (astro-turf-like) climbing substrate that the elvers can climb over or through, and kept damp. It's important that the ramp is located near attractant flows so that elvers can find the entrance. By-pass channels around the dam can be constructed with riffle-pool sequences, natural substrates and riparian conditions with ample flow to attract elvers. Rock ramps provide a navigable transition between impoundments and downstream flows and are most effective with natural vegetation and roughened climbing mediums. Lastly, smooth-bottomed or perched culverts should be replaced or modified to include a bottom substrate level with the upstream and downstream channel bed.

Eel Passage Downstream

Low-head dams are generally not a barrier to downstream migration. Hydroelectric dams and turbines are by far the greatest threat. Some types of turbines kill half and injure 80-100% of the remaining attempting passage (Haro et al. 2003 in Gulf of Maine). Solutions for the safe passage of eels downstream include: dam removal, by-pass channels, and hydropower operation practices. Since silver eels migrate at night from September to December, plants can suspend operation nightly during the migration season.

2.4 Aquatic Species Passage and Stream Continuity

Historically streams flowed unimpeded between their headwaters and outlet, in this case on Long Island, into the ocean. Modern streams traverse a myriad of dams and road crossings along this path, each creating an unnatural condition. The adverse effects on passage of particular fish species, in this case river herring and American eel, are only a portion of the ecological impact that should be considered in the restoration of these streams. The swimming ability of river herring allows them to navigate all but vertical barriers within most streams. However, although an alewife can pass through, the impact of a road culvert on other species, as well as the stream system itself, remains substantial. Road culverts or crossings can act as small dams, trapping the normal flow of sediment downstream and creating areas of deposition upstream. In addition, other aquatic species, such as amphibians, must cross over roads instead of below, where they are often run over.

Continuity is the key to the healthy functioning of streams and rivers. The Massachusetts River and Stream Crossing Standards, developed by the River and Stream Continuity Partnership in 2006, supports road crossings that take a "stream simulation" approach, rather than species-based approach to fish passage issues. The standards developed support the goals of creating road crossings that are "invisible" to aquatic organisms by maintaining a variety of habitats, connectivity and ecological processes. Standard criteria for new crossings include:

1. Open bottom structures or embedded culverts (bridges, open bottom arches).
2. Spans = 1.2 times the bankfull channel width (minimum).
3. Spans should include at least one bank and allow dry passage for 90% of the year.
4. Natural bottom substrates that match upstream and downstream substrates.
5. Stream depth and velocities in crossing that match base-flow conditions.
6. Openness ratio of 0.75 (optimum) – 0.25 (min.) to allow wildlife passage.

The benefits of a holistic, ecosystem-based approach for fish passage and road crossings are many: unimpeded aquatic and terrestrial organism passage; hydrologic continuity; natural sediment transport; and less maintenance and risk.

In the sections below, many barriers are noted <u>*not*</u> to have an effect on migrating alewifes but they still have an effect on stream continuity. In general, as the service life of a crossing is exceeded, they should be replaced with crossings that provide better stream continuity.

3 STEPPING STONES POND

3.1 Site Description

Stepping Stones Pond is a shallow 10.4-acre pond located at the south end of Lake Montauk (Figures 1 and 6) with a bottom made up of fine-grained sand and silt. Twin 1-foot diameter, 54-foot long HDPE pipes convey flows beneath Old West Lake Drive directly into Lake Montauk (Figures 6 and 8). The freshwater and tidal wetland boundaries are immediately adjacent to the mowed road margin along Old West Lake Drive. Stepping Stones Pond provides high-quality freshwater wetland communities. However, the plant community immediately adjacent to Old West Lake Drive in the vicinity of the culverts is dominated by common reed (*Phragmites australis*). Native species such as jewelweed (*Impatiens capensis*), marsh fern (*Thelypteris palustris*), common elderberry (*Sambucus canadensis*), and various vines including Japanese honeysuckle (*Lonicera japonica*), poison ivy (*Toxicodendron radicans*), and wild grape (*Vitis sp.*) are interspersed within the *Phragmites*-dominated pond margin. Downstream of the culvert, the stream flows through a short pool-riffle reach before entering Lake Montauk. Coarser material- sand to coarse gravel- makes up the bed immediately downstream of the culvert, with finer substrate dominating as the channel approaches the lake. The tidal wetlands downstream of the culvert are similarly dominated by *Phragmites* with scattered groundsel bush (*Baccharis halimifolia*) present. Marsh elder (*Iva frutescens*) is present along the banks of the ditch that drains Stepping Stones Pond. High-quality stands of native herbaceous high marsh and intertidal marsh are present seaward of the approximately 50-ft wide *Phragmites* stand along the north side of Old West Lake Drive.

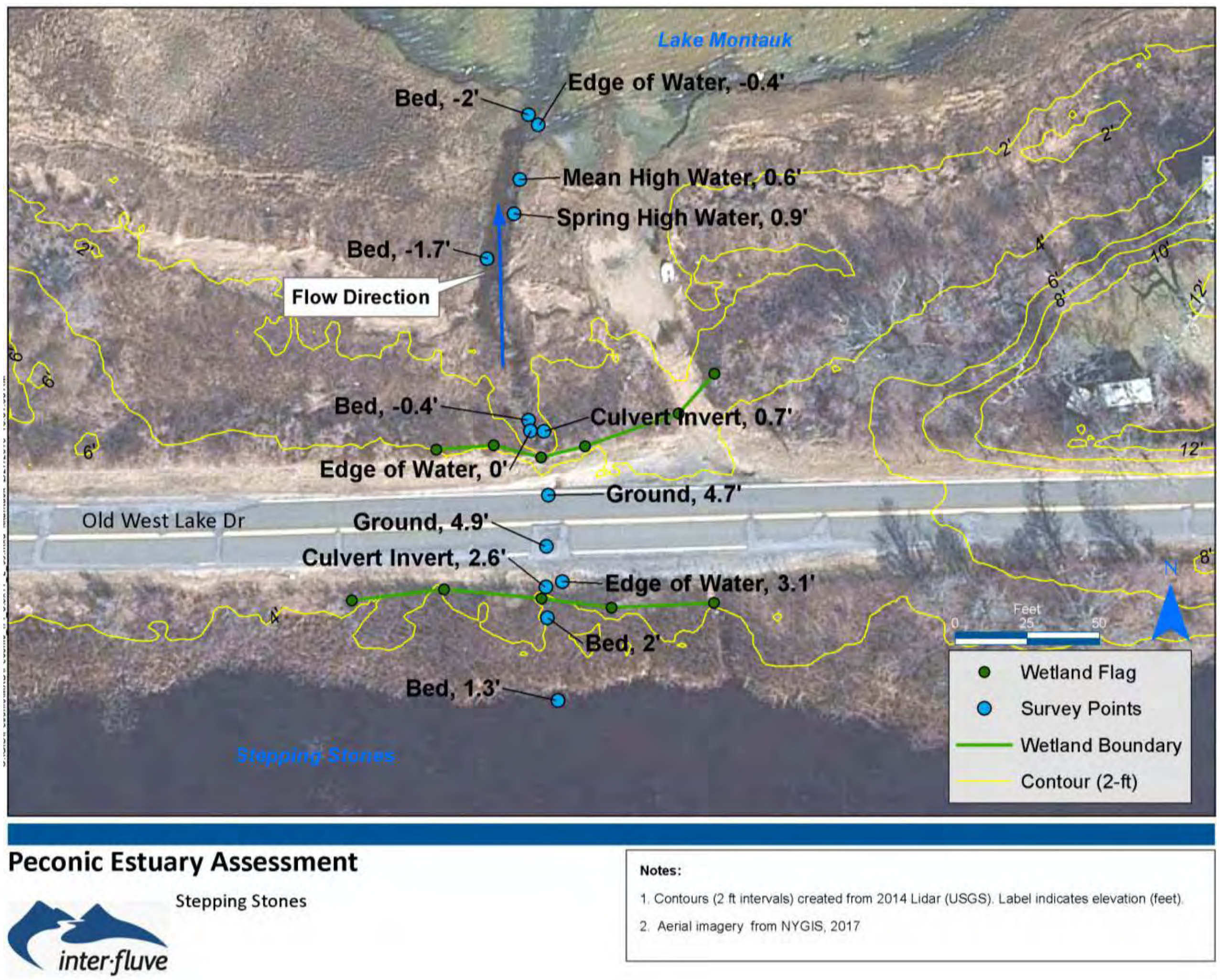


Figure 6: Select survey points from December 2018 survey at Stepping Stones Pond.

3.2 Diadromous Fish

Field investigation of the Stepping Stones Pond culverts to assess potential evidence of diadromous fish passage was conducted during the 2018 alewife spawning run (May 7, 2018). Evidence of alewife migration was observed at the downstream side of the Stepping Stone culverts under Old West Lake Drive. Three (3) alewife scales were observed attached to the culvert pipe and the stream bed (Figure 7). No scales were observed on, in, or adjacent to the upstream side of the culvert. Accordingly, it is not known if these alewives successfully crossed through the culvert. This observation corroborates earlier observations in 2018 by Kate Rossi-Snook (Concerned Citizens of Montauk) on or about April 24, 2018. According to Enrico Nardone (Seatuck Environmental Association), these 2018 observations are the first known documentation of a remnant alewife spawning migration at Stepping Stones Pond.

Figure 7a (Left): Alewife scale on Downstream Culvert Pipe at Stepping Stone Pond

Figure 7b (Right): Alewife scale on Stream Bed on Downstream Side of Stepping Stone Pond Culvert

3.3 Fish Passage Opportunities & Challenges

The downstream and upstream ends of the culverts are perched approximately 1 foot above the bed of the channel (Figure 8). While high tides backwater the downstream end of the culvert, the invert elevation of the upstream end of the culvert prevents salt water from entering Stepping Stones Pond under existing sea level conditions. Extreme high tides likely flow over the road and into Stepping Stones Pond, but typical tidal fluctuations currently do not impact the pond.

Figure 8: Downstream end of culverts at Stepping Stone Pond. Culverts perched approximately 1' above bed of channel.

The upstream invert of the pipes is elevation 2.6 feet and the downstream invert is elevation 0.6 feet, resulting in a relatively steep 3.6% slope over approximately 54 feet of culvert length (Table 3). The corrugated culvert is smooth on the inside, with no roughness elements to slow and deepen flow. At low tide, fish are unable to move upstream into Stepping Stones Pond due to two primary reasons:

1) the culverts are perched above the downstream channel bed and herring are not able to jump this high into the culverts, and

2) the water velocity is high and water depth low through the culverts, and high velocity and low depth of flow presents a barrier to upstream movement of fish. An alewife scale has been observed on the downstream end of the culvert, suggesting the fish are attempting to access the habitat in Stepping Stone pond, but the current configuration precludes passage.

In addition, alewives and other migratory fish need a transitional estuary zone where they can acclimate to the more fresh water ecosystems they are migrating into. The outlet of Stepping Stones Pond does not provide much opportunity for this acclimation process, which would be limited to the channel between the culverts and Lake Montauk and the mixing of the fresh water as this channel enters the saltier Lake Montauk.

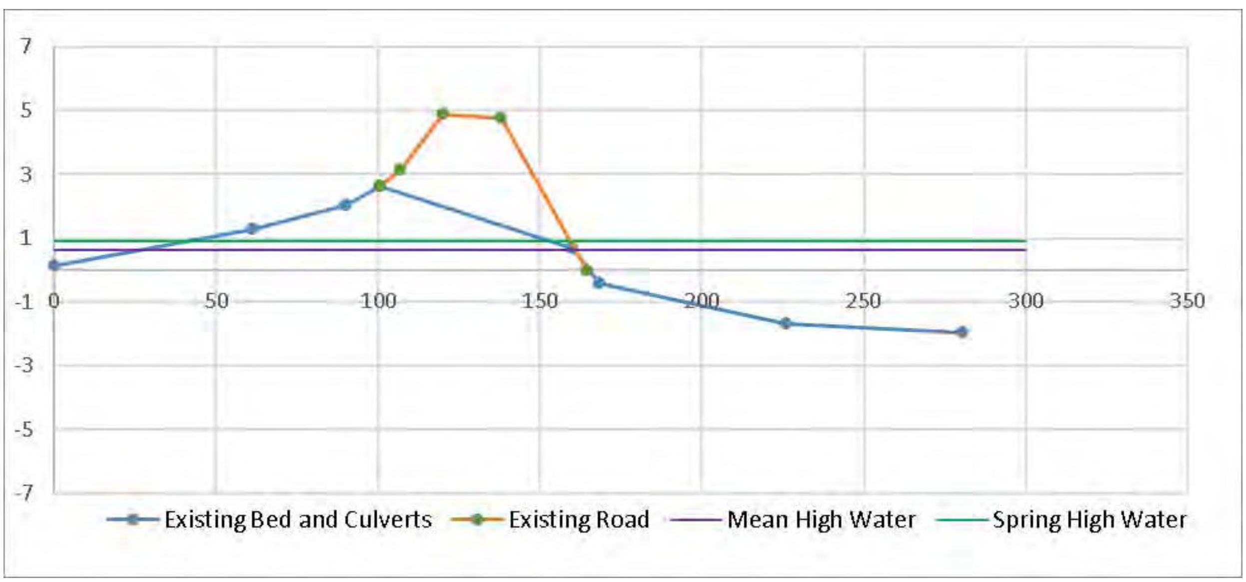


Figure 9: Cross section of Stepping Stone outflow culvert and channel.
MHW and SHW are based on vegetation survey.

Table 3: Dimensions and condition of the culverts under Old West Lake Drive at Stepping Stones Pond.

Diameter (ft)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Slope (%)	Notes
1 (both)	2.61	0.67	3.6%	Perched, steep, and undersized

3.4 Recommendations and Conceptual Plan

A conceptual plan was developed to improve fish passage into Stepping Stones Pond. The following assumptions and performance criteria were also used in the development of this conceptual plan:

- Due to high ecological quality of Stepping Stones Pond, fish passage improvements should not substantially increase the potential tidewater intrusion into the freshwater pond.
- Maintain elevation of the existing road.

We are proposing the replacement of the twin 1-foot culverts with a 3- or 4-sided concrete box culvert with a natural substrate bed (Appendix A). As shown on the conceptual drawings, the culvert would be capable of holding a pool-riffle sequence, with a riffle constructed specifically to prevent tidal inflow to the pond without flooding Old West Lake Drive. Approximately 7-8 riffle-pool combinations would be constructed to accommodate the 3.5 feet of elevation difference between the pond and Lake Montauk. Each riffle-pool would be approximately 0.5 feet high and 15 feet long, with an overall slope of 3%. Our design of the slope, substrate, and channel configuration allows migratory fish, such as alewives and American eel, to move upstream and downstream. Alewives are capable of jumping modest-sized steps and generally have high passage rates on channels that have slopes of 3% or less. The pools in the new channel will provide resting areas for the fish as they gain strength to continue to move upstream. These smaller pools could become the transitional zone for fish moving from saltwater to freshwater. This kind of channel construction is also conducive to American eel passage. Eel are able to swim close to the bottom of stream channels where water velocities are greatly reduced, especially with the roughened surface that the gravel and cobbles provide.

The channel would be constructed of rounded gravel and cobble, sized during the next engineering phase of design to be immobile during flood events. The channel top width would be approximately 3 feet, allowing a 1-foot floodplain bench to be constructed adjacent to the channel for terrestrial organism passage (Figure 10). This would help minimize deaths for animals that try to cross over the road.

Downstream of the culvert, the gravel would be embedded into the adjacent marsh so as to minimize the risk of water outflanking the channel banks. The channel bed elevation would tie into the downstream channel bed elevation prior to entering Lake Montauk.

Upstream of the culvert, the channel bed elevation of the most upstream riffle would be the same as the existing culvert invert to maintain pond elevations. The *Phragmites* would be removed from the construction zone upstream of the culvert to improve water flow, fish passage, and recreational opportunities. A small amount of fill (approximately 1 foot depth) will be placed on top of the existing pond bottom where the *Phragmites* is growing in order to raise the channel bed elevation and allow the riffle crest to reach the elevation of the existing culvert invert. While recreational usage of this pond is unknown, it would be possible to enter Stepping Stones Pond with a canoe or kayak at this fill location adjacent to the proposed channel.

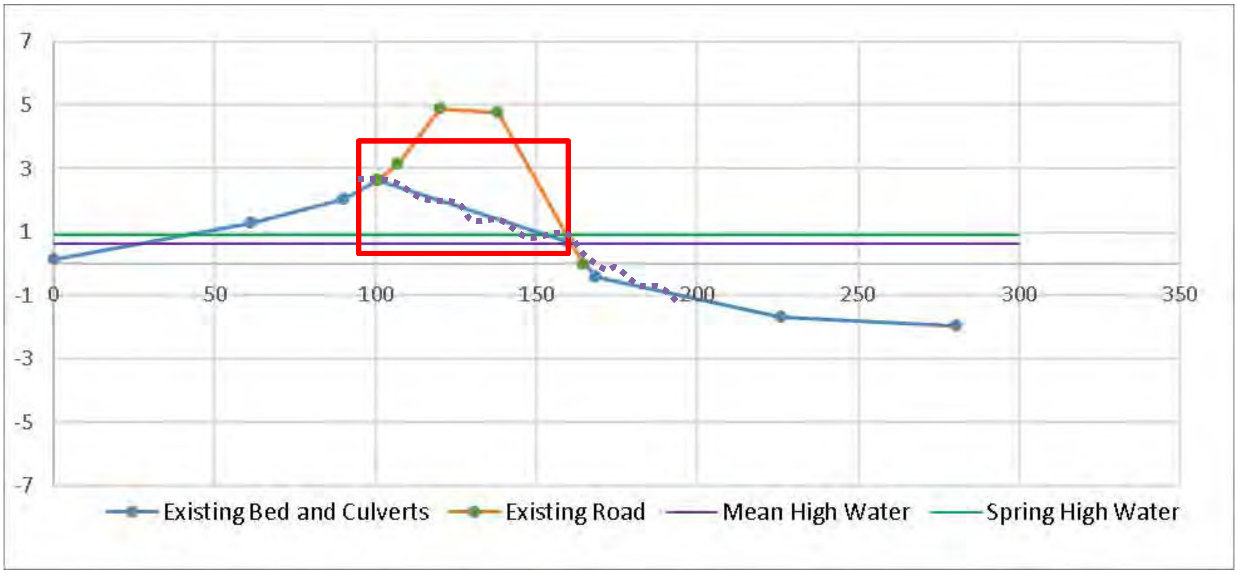
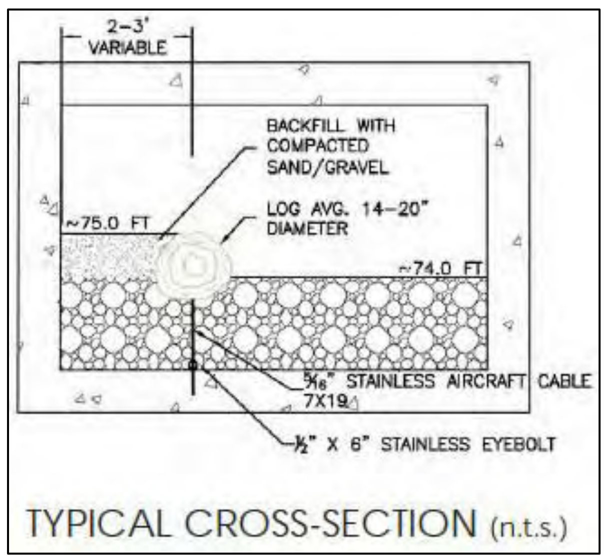


Figure 10: Stepping Stones Pond crossing, with proposed box culvert shown in red, with proposed bed in dashed purple. Dimensions and locations are approximate and would be determined in the design phase of the project.

Figure 11: An example of a concrete box culvert with natural channel substrate on the bottom and a floodplain bench built for terrestrial organism passage.



3.5 Construction Costs Summary

Costs here are concept level engineer estimates to provide approximate values for project planning purposes. Actual design and construction costs will vary following a more detailed data collection effort and ensuing design. A detailed account of costs is provided in Appendix B. These costs have been based on knowledge of similar projects and construction components. A contingency was added to each estimate to provide the range noted below.

Table 4: Conceptual Construction Costs for Stepping Stones Culvert Replacement

Restoration Recommendation	Design Cost	Construction Cost	Notes
Culvert Replacement and Riffle Construction	$91-118K	$182-244K	- Assumes road closure during construction; no active duty traffic control needed during construction. - Assumes passive water control through gravity-fed pipe, rather than continuous pumping during construction. - Proposed culvert is approximately 4x4 feet and approximately 45 feet long. - The proposed gravel/cobble channel is approximately 100 feet long. - Channel bed will be made up of rounded cobble and gravel.

3.6 Environmental Permitting

The culvert replacement and riffle construction for alewife passage at Stepping Stones Pond will require the following environmental permits:

- *United States Army Corps of Engineers:* Section 404 of Clean Water Act, Section 10 of Rivers and Harbors Act
- *New York State Department of Environmental Conservation:* Article 24 (Freshwater Wetlands), Article 25 (Tidal Wetlands), Article 15 (Protection of Waters)
- *New York State Department of State, Division of Communities and Waterfronts:* Consistency Determination under Coastal Zone Management Act
- *Town of East Hampton*: East Hampton Town Trustees, East Hampton Zoning Board

3.7 Endangered and Threatened Species

Lake Montauk is listed as a Significant Coastal Fish and Wildlife Habitat by the New York State Department of State, Division of Coastal Resources (NYSDOS, 2002). Consultation with the New York Natural Heritage Program (dated September 25, 2018) indicates the potential presence of four species of rare and protected plants found in or near to Stepping Stones Pond including Southern arrowwood (*Viburnum dentatum var. venosum*), Saltmarsh spike rush (*Eleocharis uniglumis*), Long-tubercled spike rush (*Eleocharis tuberculosa*), and Sandplain wild flax (*Linum intercursum*). The potential presence for these species at recommended work areas and potential for impacts to these species is discussed below. Sandplain wild flax and Southern arrowwood are both listed as threatened in New York State and inhabit sandy maritime habitats, such as maritime dunes, shrublands, and grasslands (New York Natural Heritage Program, 2017a and 2017b). The dense *Phragmites* marsh present in the construction area at Stepping Stones Pond is not suitable habitat for these species. Accordingly, no impacts to these species are expected to result from this project. Saltmarsh spike rush is listed as threatened in New York State and is found along the fluctuating shorelines of coastal plain ponds and high salt marshes (New York Natural Heritage Program, 2017c). Due to the dense growth of *Phragmites* at this site, suitable habitat for Saltmarsh spike rush is not present within the construction area. Long-tubercled spike rush is listed as threatened in New York State and prefers the wet soils of freshwater ponds (New York Natural Heritage Program, 2017d). This species has been found along the wet margin of the pond in its headwaters.

None of the rare and protected plant species known to occur at or in the vicinity of Stepping Stones Pond are expected to occur within the construction area due to the presence of dense *Phragmites* growth. Further, the recommended riffle construction and culvert replacement to enhance alewife access to Stepping Stones Pond has been designed (at a concept level) to maintain the pond elevation of Stepping Stones Pond and prevent additional tidal intrusion to maintain the hydrology and salinity of the species-rich and high quality freshwater habitats.

4 BIG REED POND

4.1 Site Description and Overview

Big Reed Pond is a 45-acre freshwater pond located within Montauk County Park with extensive marshes, high-quality freshwater wetlands, and surrounding woodlands. A small stream flows from Big Reed Pond into Little Reed Pond, which is connected to Lake Montauk by a tidal creek channel. The outlet of Big Reed Pond to Little Reed Pond is a 1-foot diameter, 15-foot long HDPE culvert that conveys flow from the pond under an unpaved park access road to a channel that passes through Little Reed Pond before emptying into Lake Montauk (Figures 1 and 12). Freshwater wetland communities are present immediately adjacent to the unpaved road at Big Reed Pond. A dense *Phragmites* marsh with little native plant diversity is present on the downstream side of the culvert. The immediate proximity of the upstream side of the culvert features an emergent marsh dominated by common reed (*Phragmites australis*), narrow-leaved cattail (*Typha angustifolia*), swamp rose (*Rosa palustris*), and marsh fern (*Thelypteris palustris*).

In 2010, a large fish kill occurred in Big Reed Pond that impacted many of the fish species living in the pond. While the exact cause of mortality is unknown, water levels were approximately 8 inches lower than typical, leaving the outlet channel dry and not tidally-connected (NYSDEC 2017). In addition, cyanobacteria algae later identified as *Aphanocapsa* covered the pond bottom. These blue-green algae are known to release toxins deadly to the fish in the pond.

Prior to the 2010 fish kill, fish surveys had been completed in 1954, 1984, and 1994, finding alewife, largemouth bass, pumpkinseed, white perch, American eel, and banded killifish. In 2016, the NYSDEC completed another fish survey, finding white perch, largemouth bass, American eel, killifish, and alewife (NYSDEC 2017). The blue-green algae were identified during this survey as well, though a second fish kill had not occurred. NYSDEC (2017) did not conclude or speculate the cause of the fish kill in 2010 and it is difficult to make conclusions based on limited data. While the cause of the fish kill and algal blooms is unknown, the NYSDEC (2017) did identify the outlet channel at Big Reed Pond and the accompanying culvert as potential causes for reduced fish passage between Big and Little Reed Pond.

A significant stand of the invasive small carpetgrass (*Arthraxon hispidus*) is located along the shoreline and grassy margin of the County Parks road on the western shoreline of Big Reed Pond (V. Bustamonte, pers. comm.). Big Reed Pond is the only known location of *Arthraxon* on Long Island. Due to the high invasive potential for *Arthraxon*, eradication and containment of the *Arthraxon* population at Big Reed Pond is a high priority.

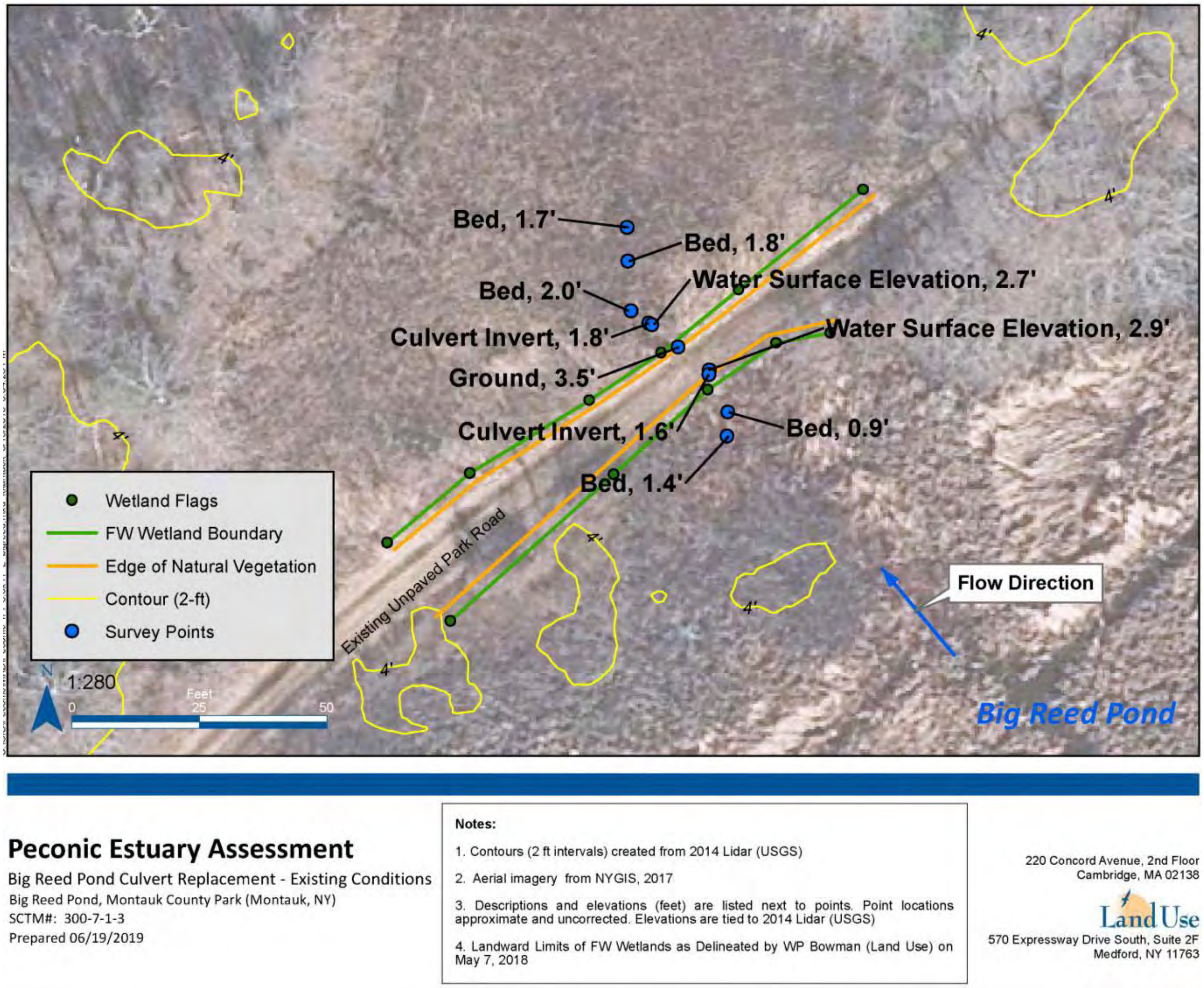


Figure 12: Select survey points from December 2018 survey at Big Reed Pond.

4.2 Culvert Evaluation

The outlet of Big Reed Pond is a 1-foot diameter, 15-foot long HDPE culvert (Figure 13). On either side of the culvert, the channel bed is composed of fine to coarse sand, with *Phragmites* the dominant plant growing in the wetlands. Upstream of the culvert, a wide ditch conveys water from the open water portion of Big Reed Pond through the *Phragmites* marsh for about 450 feet. Within about 50 feet of the culvert, the ditch is not well defined and *Phragmites* obscures the channel. No distinct channel is apparent immediately upstream of the culvert. Downstream of the culvert, we walked along a barely-defined channel for approximately 150 feet before the channel becomes obscured by the *Phragmites*.

The culvert slope is currently approximately -1%, with the upstream invert at elevation 1.6 feet and the downstream invert at elevation 1.8 feet (Table 4, Figure 14). At the time of the survey, the culvert was nearly submerged on the downstream end and completely submerged on the upstream end.

Table 5: Dimensions and condition of the culvert under the dirt access road.

	Diameter (ft)	Upstream Invert Elevation (ft)	Downstream Invert Elevation (ft)	Slope (%)	Notes
Big Reed Pond	1	1.6	1.8	-1	Undersized

The culvert was also assessed during the 2018 alewife spawning run (May 7, 2018). No typical evidence of alewife (*Alosa pseudoharengus*) spawning migration, such as live or dead fish, or loose scales on the stream bank or bed, were observed at the culverts at Little Reed Pond or Big Reed Pond or the nearby stream and wetlands. Hundreds of American eel (*Anguilla rostrata*) elvers were observed at the downstream end of the Big Reed Pond double culverts apparently feeding on zooplankton in the culvert outflow.

While fish are able to move through this culvert, the *Phragmites* plant material obscuring the upstream entrance and channel and the narrow culvert are likely decreasing the success rate of fish trying to move upstream into Big Reed Pond. Higher passage success rates are found in culverts with more space for fish to turn around where water velocities are low within the culvert. With this partial barrier replaced, alewives should be capable of reaching spawning areas in Big Reed Pond. While the channel was difficult to identify during our survey downstream of the dam, fish are likely able to move through the vegetation by following the active flow signatures. Alewives and American eel will also be able to move through the culvert under East Lake Drive as this was not determined to be a fish passage barrier. The culvert is wide, the slope is within the ability of fish passage, and portions of the channel bottom are natural gravel and cobbles.

Figure 13: The downstream end of the culvert at Big Reed Pond.

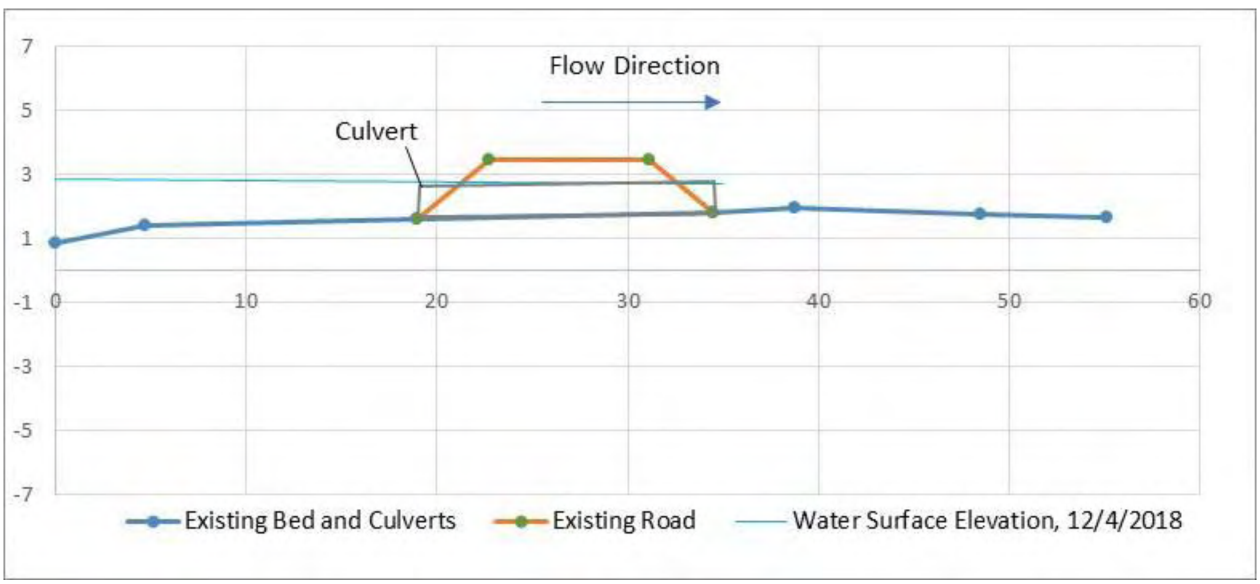


Figure 14: Longitudinal profile of Big Reed Pond outflow culvert and channel. Water flow is from left to right.

4.3 2010 Fish Kill and Recommendations for Future Fisheries and Water Quality Monitoring

In 2010, a large fish kill occurred in Big Reed Pond that impacted many of the fish species living in the pond. While the exact cause of the deaths is unknown, water levels were approximately 8 inches lower than typical, leaving the outlet channel dry and not tidally-connected (NYSDEC 2017). In addition, globular algae later identified as *Aphanocapsa* covered the pond bottom. This alga is known to release toxins deadly to the fish in the pond.

Prior to the 2010 fish kill, fish surveys had been completed in 1954, 1984, and 1994, finding alewife, largemouth bass, pumpkinseed, white perch, American eel, and banded killifish. In 2016, the NYSDEC completed another fish survey, finding white perch, largemouth bass, American eel, killifish, and alewife (Figure 15) (NYSDEC 2017). The globular algae were identified during this survey as well, though a second fish kill had not occurred.

NYSDEC (2017) did not conclude or speculate the cause of the fish kill in 2010 and it is difficult to make conclusions based on limited data. Annual surveys of the fish populations would improve our understanding of the fish populations, age and size classifications, natural mortality, typical angling mortality, and typical predatory trends. Annual monitoring of water levels, water temperature, dissolved oxygen, and other water quality parameters would improve our understanding of the environmental conditions in which the fish live throughout the year. Lastly, monitoring the extent of *Aphanocapsa* growth will help us better understand the potential impacts of this harmful alga on the fish populations in Big Reed Pond. In other ponds in the northeast U.S., researchers believe algal blooms have been caused by an imbalance in the trophic cascade: an over-abundance of white perch results in a decrease in zooplankton which subsequently results in increased algae (Halliwell and Evers, 2010). Solutions elsewhere have been to reduce the target fish populations (primarily white perch). While 37% more white perch were identified in Big Reed Pond in the 2016 survey than the 1994 survey, it is unknown when this increase occurred, if the fish collection methods were comparable, and if this increase is enough to result in the trophic imbalance described above.

A few questions remain that further studies could help answer:

- Are fish populations in recovery since 2010 given the slightly younger age categories in some species?
- What is the overall trend in fish populations by species and age category?
- If the algal blooms are present every year, why was the fish kill observed in 2010 and no other years?
- What is the extent of types of mortality (natural causes, predation, angling)?

After analyzing the background data and making observations during our site visit, we believe there could be a few causes for the fish kill in 2010:

- Low water year resulted in increased water temperature, increased aquatic plant growth, increase algal blooms, and decreased dissolved oxygen and water quality;
- An imbalance in the trophic cascade resulted in excessive algal blooms that release deadly toxins;

- Other environmental factors such as salt-water intrusion, increased air temperature due to climate change, and/or air pollutants resulting in an altered water chemistry and decreased water quality;
- Combination of the above.

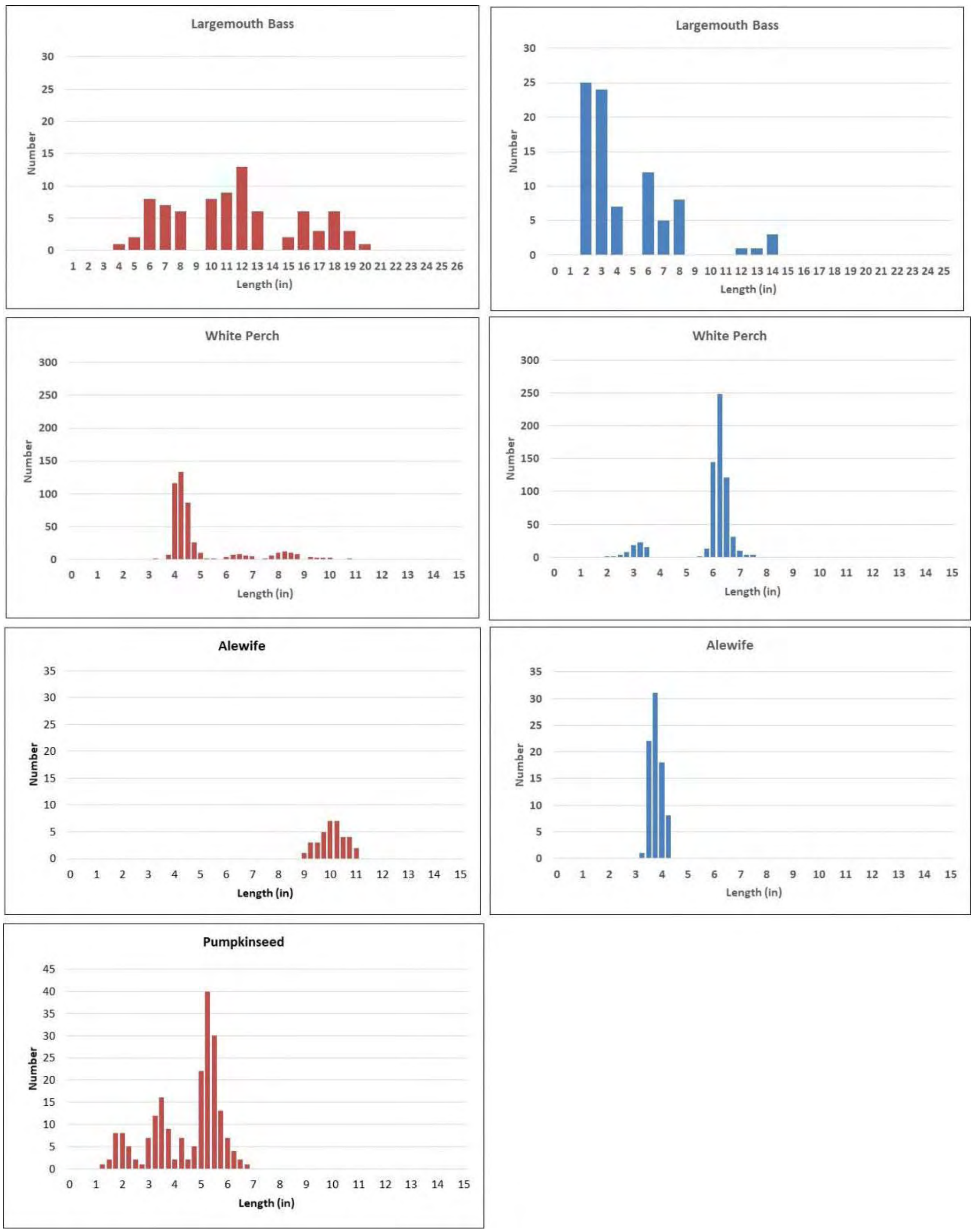


Figure 15: Species length frequencies for fish species captured during studies in 1994 (left in red) and 2016 (right in blue) (from Figures 1 and 2 in NYSDEC 2017).

While the cause of the fish kill and algal blooms is unknown, the NYSDEC (2017) did identify the outlet channel at Big Reed Pond and the accompanying culvert as potential causes for reduced fish passage between Big and Little Reed Pond.

4.4 Culvert Recommendations and Conceptual Plan

A conceptual plan was developed to improve fish passage into Big Reed Pond. This conceptual plan was developed based on several assumptions and performance criteria. Due to the high ecological quality of Big Reed Pond, fish passage improvements should not substantially increase the potential tidewater intrusion into the freshwater pond.

The existing 1-foot HDPE culvert is undersized and presents at least a partial barrier to fish passage. To improve fish passage, the culvert should be replaced with a 2-foot diameter corrugated metal pipe arch culvert (design drawings, Appendix A). As shown on the drawings, this style of culvert has a broadened, flat bottom, requiring less excavation while providing the same space for water above the bed of the channel. During installation, the bottom of the culvert will be partially filled with natural channel substrate, creating a nature-like channel bed through the culvert that is more conducive to fish passage.

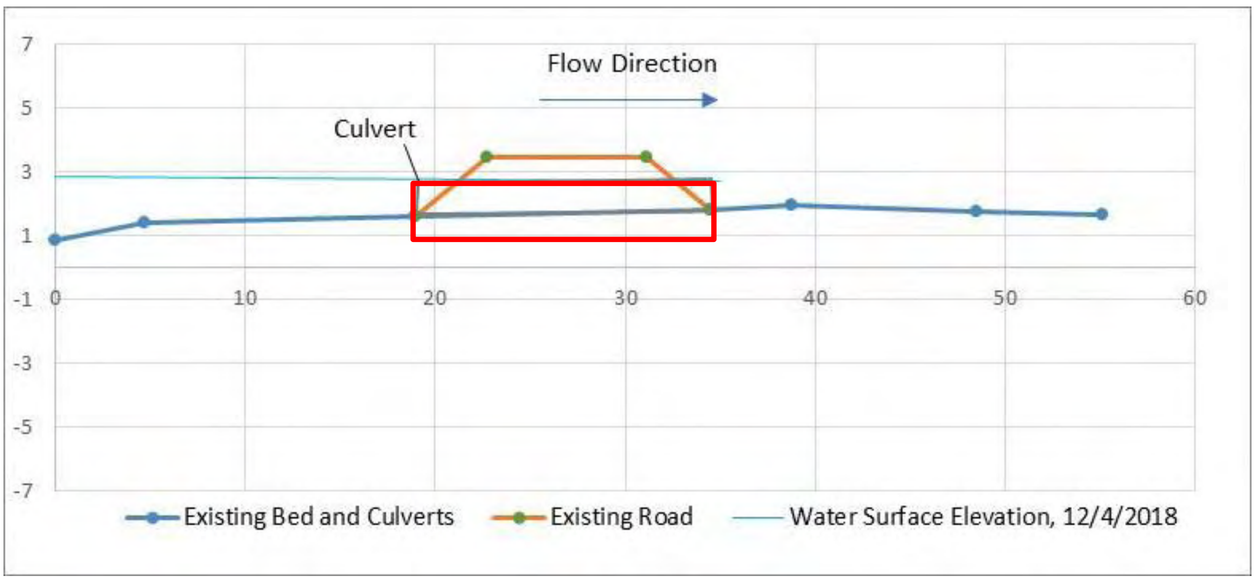


Figure 16: Cross section of Big Reed outflow, with proposed 2-foot culvert shown in red. Location and dimensions are approximate and would be determined in design phase.

Figure 17: Pipe arch culvert, photo courtesy of Downeast Lakes Land Trust. The diagram on the right is a schematic detail of this type of culvert depicting stream bed materials placed in the bottom of the culvert.

Another option to improving fish passage at this stream crossing is to remove the culvert and replace it with an open channel. During our site visit, it did not appear that this road was frequently traveled, and when vehicles did pass they were likely to be trucks, SUVs, ATVs, or other vehicles capable of traveling over difficult terrain. A wet ford, in which a vehicle would drive through less than 1-foot depth of water over coarse gravel and cobble, would provide increased fish passage, would reduce the issue of the culvert being clogged with *Phragmites* plant material, and would be less costly than installing a new culvert. However, this option may not be desirable if traffic is more frequent, if vehicles will not be able to drive through the crossing, or if local and state permits do not allow such a crossing.

4.5 Construction Cost Summary

Costs here are concept level engineer estimates to provide approximate values for project planning purposes. Actual design and construction costs will vary following a more detailed data collection effort and ensuing design. A detailed account of costs is provided in Appendix B. These costs have been based on knowledge of similar projects and construction components. A contingency was added to each estimate to provide the range noted below.

Table 6: Conceptual Construction Costs for Big Reed Pond Culvert Replacement

Restoration Recommendation	Design Cost	Construction Cost	Notes
Recommended Culvert Replacement	$6.5-8.5K	$13-17.5K	- Proposed 15-ft long, 2-ft wide ellipsoid culvert - Assumes no concrete headwalls or wingwalls - Assumes no engineering design - Assumes only local permit - Assumes passive water control
<u>Alternative 1:</u> Culvert Removal and Wet Ford	$6.5-8.5K	$4-6.5K	- Assumes single day of construction to remove the existing culvert and create a channel with coarse bed material that vehicles can drive over - Assumes import of up to 3CY of coarse channel bed material to be installed to create the wet ford - Assumes no water control – work will be completed in wet conditions

4.6 *Arthraxon* Containment

A stand of small carpetgrass (*Arthraxon hispidus*) is located along the shoreline and grassy margin of the County Parks road on the western shoreline of Big Reed Pond (V. Bustamonte, pers. comm.). Big Reed Pond is the only known location of *Arthraxon* on Long Island. Due to the high invasive potential for *Arthraxon*, eradication and containment of the *Arthraxon* population at Big Reed Pond is a high priority.

The small carpetgrass at Big Reed Pond flowers and sets seed between September and October (V. Bustamonte, pers. comm.). Culvert replacement should not be conducted during that time to prevent transport and spread of seed by equipment or workers. The following best management practices are recommended to avoid transport of *Arthraxon* seeds.

4.6.1 Containment Protocols During Construction

- Culvert replacement should not be completed between August 1 and February 28 to minimize dispersal of invasive *Arthraxon hispidus* seeds. Culvert replacement should not be completed between April 1 and May 31 to avoid impacts to alewife migration.
- Clean tools, equipment, and vehicles in large main parking area of Big Reed County Park prior to leaving the site.
- Inspect tools, equipment, and vehicles before entering and leaving the worksite. Most importantly, equipment and vehicles should be inspected and cleaned, as needed, before equipment proceeds from the worksite to uninfested areas of the County park road located to the north of the worksite.
- Remove soil, seeds and plant parts from tools, the undercarriage, tires, sideboards, tailgates, and grills of all vehicles and equipment. Equipment and vehicles may be cleaned without water using bristle brushes, brooms, scrapers, vacuum cleaners, and other hand tools (to remove heavy accumulation of soil and debris prior to washing with other tools).
- Prevent the spread of seeds on clothing, boots, or gear by designate cleaning areas for clothing, boots and gear away from uninfested areas. Clothing, boots and gear should be cleaned and removed of soil, mud, seeds, and any plant material before leaving worksite. Appropriate equipment for removal of soil, seed, and plant parts should be on-site including wire brushes, small screwdrivers, boot brushes, extra water free of invasive species, and bags for plant material. Workers should be informed about possible seeds or other propagules carried on their clothing, footwear and gear.

4.7 Environmental Permitting

The culvert replacement at Big Reed Pond will require the following environmental permits:

- *United States Army Corps of Engineers:*
  - Section 404 of Clean Water Act, Section 10 of Rivers and Harbors Act
  - Note that 8.5 x 11-inch versions of the conceptual plans have been provided to facilitate US Army Corps of Engineers permitting.
- *New York State Department of Environmental Conservation:*
  - Article 24 (Freshwater Wetlands)
  - Article 25 (Tidal Wetlands)

    - Article 15 (Protection of Waters)
    - Note that the conceptual plans have been developed in order to conform with NYSDEC standards for Article 24 plan review.
- *New York State Department of State, Division of Communities and Waterfronts:*
    - Consistency Determination under Coastal Zone Management Act
- *Suffolk County:*
    - Council on Environmental Quality
- *Town of East Hampton:*
    - East Hampton Town Trustees
    - East Hampton Zoning Board

4.8 Endangered and Threatened Species

Lake Montauk is listed as a Significant Coastal Fish and Wildlife Habitat by the New York State Department of State, Division of Coastal Resources (NYSDOS, 2002). Consultation with the New York Natural Heritage Program (dated September 25, 2018) indicates the potential presence of a four species of rare and protected plants found in or in the vicinity of Big Reed Pond including clustered bluets (*Oldenlandia uniflora*), whorled marsh pennywort (*Hydrocotyle verticillata var. verticillata*), sandplain wild flax (*Linum intercursum*), and southern arrowwood (*Viburnum dentatum var. venosum*). Historical records of two additional species, dwarf glasswort (*Salicornia bigelovii*) and saltmarsh spike rush (*Eleocharis uniglumis*), exist for this location.

Clustered bluets are listed as endangered in New York State and typically grow across coastal plain pond shores (New York Natural Heritage Program, 2017d). At Big Reed Pond, they have been found along sandy roadbeds at the northwest side of the pond. Whorled marsh pennywort is also endangered in New York State and is found in coastal plain pond shore habitat (New York Natural Heritage Program, 2017d). Whorled marsh pennywort has been documented along the entire margin of Big Reed Pond in both shallow water and gravelly banks. The marsh and roadway habitats present in the construction location are suitable habitat for clustered bluets and whorled marsh pennywort. Accordingly, the construction footprint for the culvert replacement has been minimized to reduce potential impacts to potential habitat for these species or the overall native plant community at Big Reed Pond. In addition, the recommended culvert replacement to enhance alewife access has been designed (at a concept level) to maintain the pond elevation and prevent additional tidal intrusion in order to maintain the hydrology and salinity of the species diverse and high quality freshwater habitats of Big Reed Pond.

Sandplain wild flax and southern arrowwood are both listed as threatened in New York State and prefer more sandy maritime habitats, such as maritime dunes, shrublands, and grasslands (New York Natural Heritage Program, 2017a and 2017b). The tall emergent marsh and roadway habitats present at the construction site are not suitable habitat for sandplain wild flax and southern arrowwood; these species are not expected to be impacted by the project.

5 REFERENCES

Auld, A.H., and J.R. Schubel. 1978. Effects of suspended sediment on fish eggs and larvae: a laboratory assessment. Estuarine Coastal Marine Science. 6:153-164.

Colby, P.J. 1973, Response if the alewives, Alosa pseudoharengus, to environmental changes, p 163-198. In W. Chavind 9ed.) Response to Fish Environmental Changes. Charles C. Thompson, Springfield, IL.

Edsall, T.A. 1964. Feeding by three species of fishes on the eggs of spawning alewives. Copeia 1964: 226-227.

Fay C.W., Neves R.J. Pardue G.B., 1983. Species profiles: life histories and environmental requirements of coastal fishes and invertebrates (mid-Atlantic) –alewife/blue-back herring. Fish US, and Wildlife Services Program FWS/OBS-82/11.9.

Fischer, C.A. 1980. Anadromous fisheries research program. Cape Fear River system, phase II. Compl. Rep. Proj. AFCS-15 N.C. Dept. Natural Resources Community Development Division, Marine Fisheries 65pp.

Gulf of Maine Council on the Marine Environment. 2007. American Eels: Restoring a Vanishing Resource in the Gulf of Maine. www.gulfofmaine.org. 12 pp.

Haro, A., T. Castro-Santos, J. Noreika, and Mufeed Odeh. 2004. Swimming performance of ustream migrant fishes in open-channel flow: a new approach to predicting passage through velocity barriers. Can. J. Fish. Aquat. Sci. 61: 1590-1601.

Haro, A., T. Castro-Santos, K. Whalen, G. Wippelhauser, and L. McLaughlin. 2003. Simulated effects of hydroelectric project regulation on mortality of American eels. American Fisheries Society Symposium 33:357-365.

Hawkins, J.H. 1980. Anadromous fisheries research program, Tar-Pamlico River. N.C. Dept. Natural Resources Community Development Division, Marine Fisheries 26pp.

Iafrate, J. K. Oliveira, 2006. Factors affecting migration patterns of juvenile river herring in a coastal Massachusetts stream. Environ Biol Fish (2008) 81:101-110

Jones P.W., F.D. Martin, J.D. Hardy Jr. 1978. Development of fishes of the Mid-Atlantic Bight: an atlas of the egg, larval and juvenile stages, Volume I. Fish US, and Wildlife Service Biological Service Program FWS.OBS-78/12

Loesch, J.G. and W.A. Lund, Jr. 1977. A contribution to the life history of the Blueback Herring, Alosa aestivalis. Transactions of the American Fisheries Society. 106(6): 583-589.

Masnueti, R.J., and J.D. Hardy Jr., 1967. Development of fishes of the Chesapeake Bay region, an atlase of eff, larval and juvenile stages, Part I. Nat. Resourcces Institute, University of Maryland, Baltimore. 202pp.

McCleave, J.D. 1980. Swimming performance of European eel (Anguilla anguilla (L.)) elvers. Journal of Fish Biology 16:445-452.

New York State Department of Environmental Conservation. 2017. Biological Survey Abstract (Survey 116012), Big Reed Pond. NYSDEC Division of Fish, Wildlife & Marine Resources- Bureau of Fisheries.

New York State Department of State. 2002. Significant Coastal Fish & Wildlife Habitat Assessment Form. Lake Montauk. May 15, 2002.

New York Natural Heritage Program. 2017a. Sandplain Wild Flax (*Linum intercursum*) Conservation Guide. New York Natural Heritage Program. Albany, New York.

New York Natural Heritage Program. 2017b. Southern Arrowwood (*Viburnum dentatum var. venosum*) Conservation Guide. New York Natural Heritage Program. Albany, New York.

New York Natural Heritage Program. 2017c. Salt-marsh Spikerush (*Eleocharis uniglumis var. halophila*)Minute Duckweed (*Lemna purpusilla*) Conservation Guide. New York Natural Heritage Program. Albany, New York.

New York Natural Heritage Program. 2017d. Long-beaked Beakrush (*Rynchospora scirpoides*) Conservation Guide. New York Natural Heritage Program. Albany, New York.

New York Natural Heritage Program. 2017e. Clustered Bluets (*Oldenlandia uniflora*) Conservation Guide. New York Natural Heritage Program. Albany, New York.

New York Natural Heritage Program. 2017f. Whorled-pennywort (*Hydrocotyle verticillata* Conservation Guide. New York Natural Heritage Program. Albany, New York.

O'Connell, A.M., P.L. Angermeier, 1997. Spawning Location and Distribution of Early Stages of Alewife and Blueback herring in a Virginia stream. Coastal and Estuarine Research Federation.

Pardue, G.B., 1983. Habitat suitability index models: alewife and blueback herring. U.S. Dept. Int. Fish Wildl. Serv. FWS/OBS-82/10.58. 22 pp.

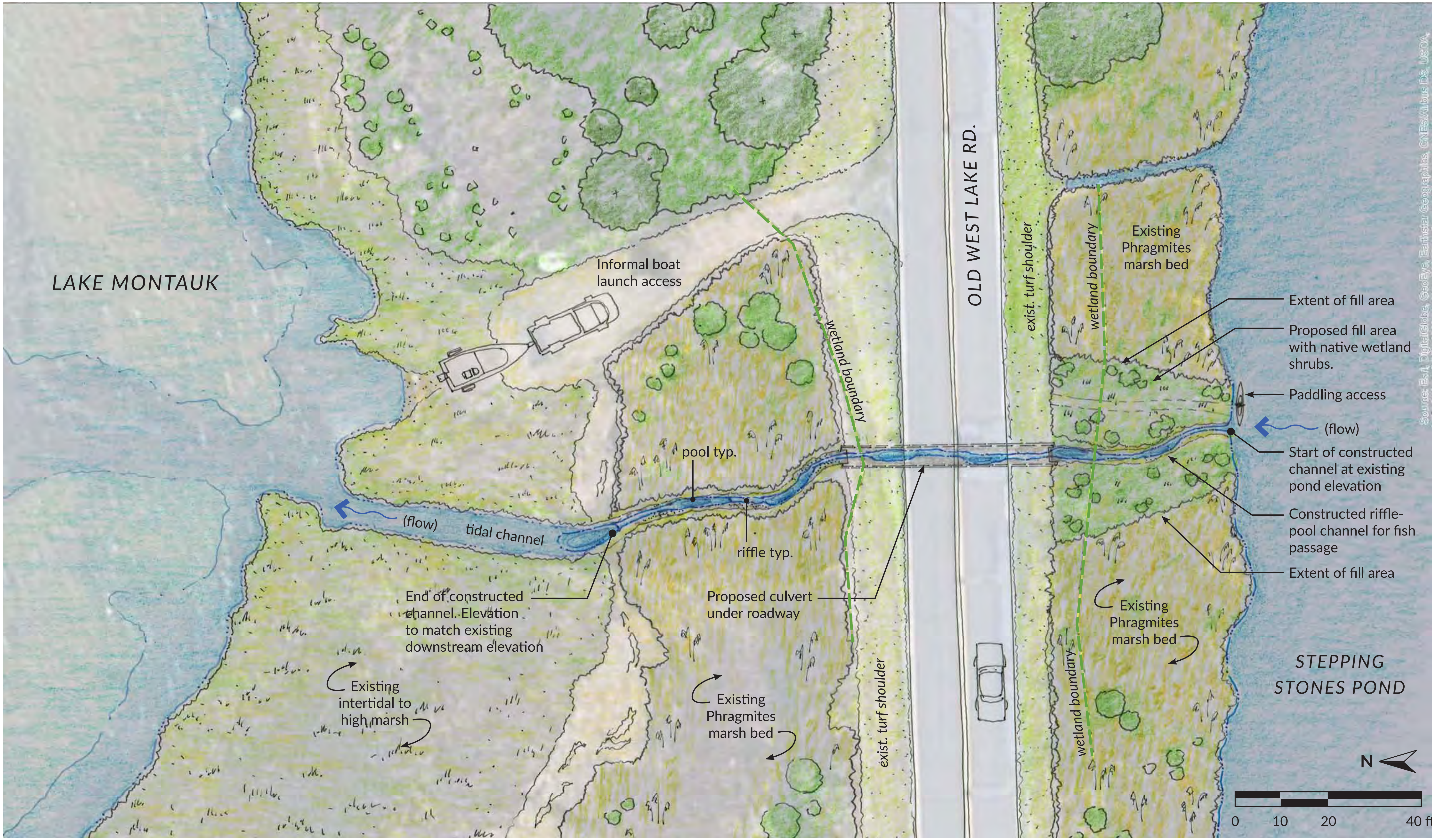
Scott W.B, M.G Scott. 1988. Atlantic fishes of Canada. Can Bull Fish Aquatic Sci., No 219, 713 p.

Sholar, T.M. 1975. Anadromous fisheries survey of the New and White Oak River systems. Comp. Rep. Cot. 73-June 75, proj. AFCS-9 N.C. Div. Mar. Fish. 49 pp.

Street M.W. et. Al. 1975. Anadromous fisheries research program, northern coastal region. Compl. Rep. Proj. AFCS-8. N.C. Div. Mar. Fish. 235 pp.

Uzee, A.M., P.L. Angermeier. 1993. Analysis of impediments to spawning migrations of anadromous fished in Rappahannock and Chickahominy river drainages, Virginia. Final Report, Virginia Highway Research Council, VA Dept. of Highways and Trans., Charlottesville, VA.

Appendix A – Conceptual Restoration Plans for Stepping Stones Pond & Big Reed Pond

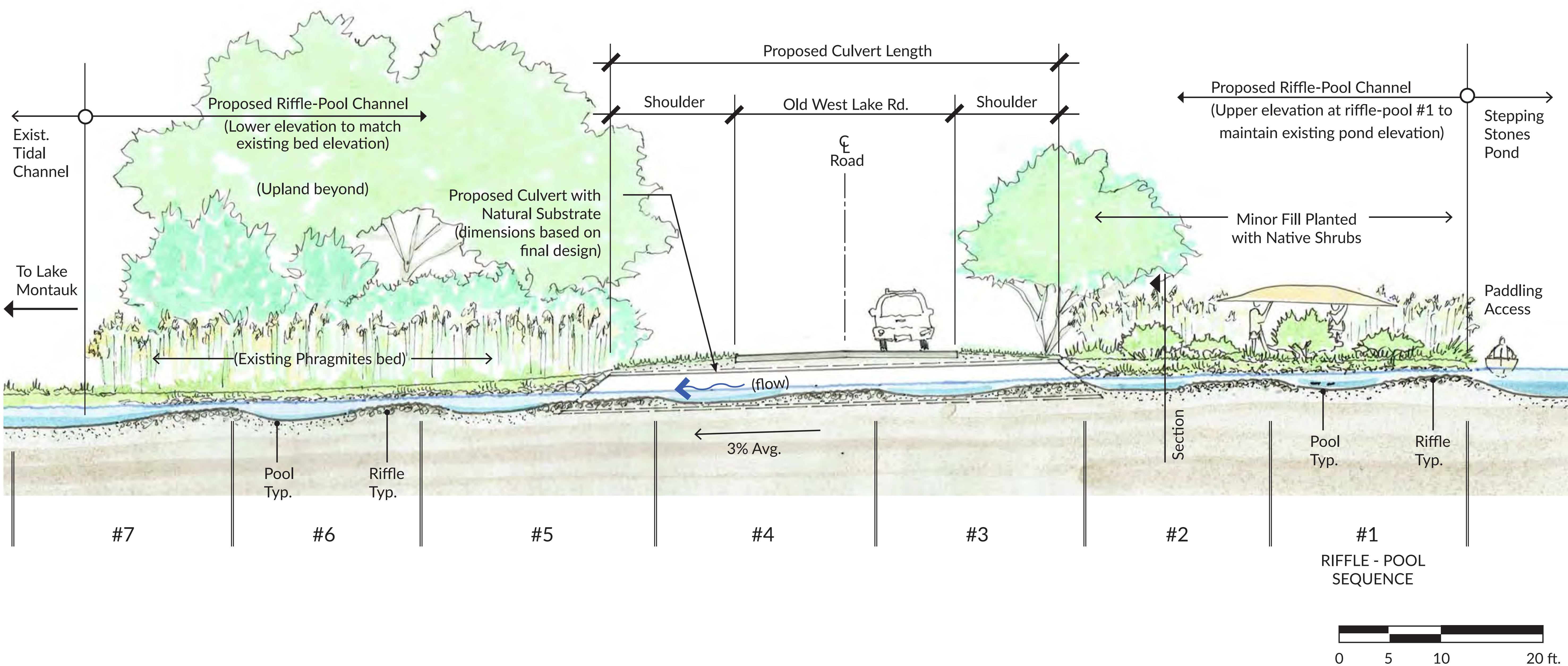


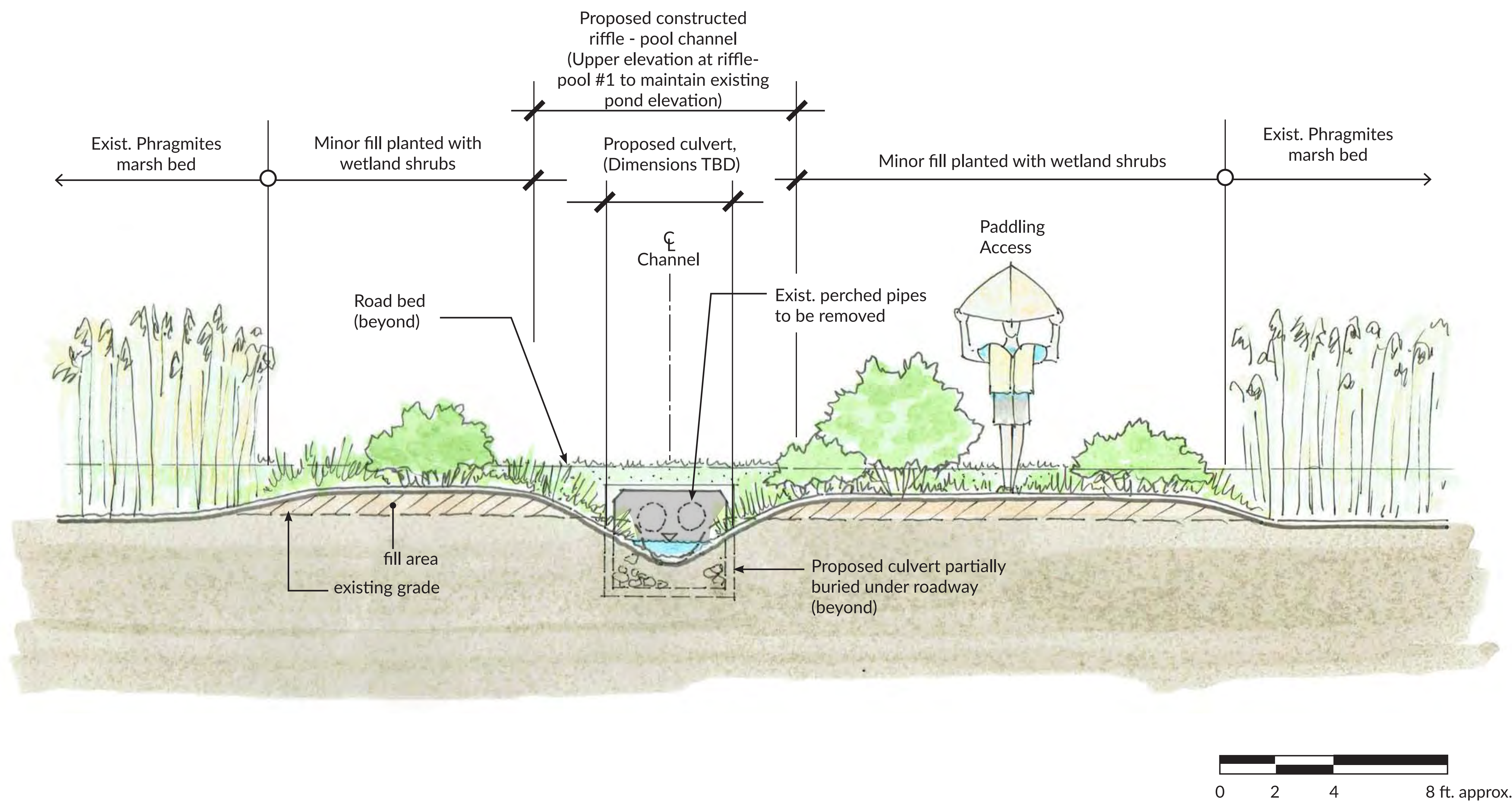
A1 | **PECONIC ESTUARY**
May 31, 2019

Conceptual Restoration Plan

LAKE MONTAUK ALEWIFE ACCESS & HABITAT ENHANCEMENT (STEPPING STONES POND)

Land Use Ecological Services, Inc. | inter-fluve | LVB LVBrown Studio LLC

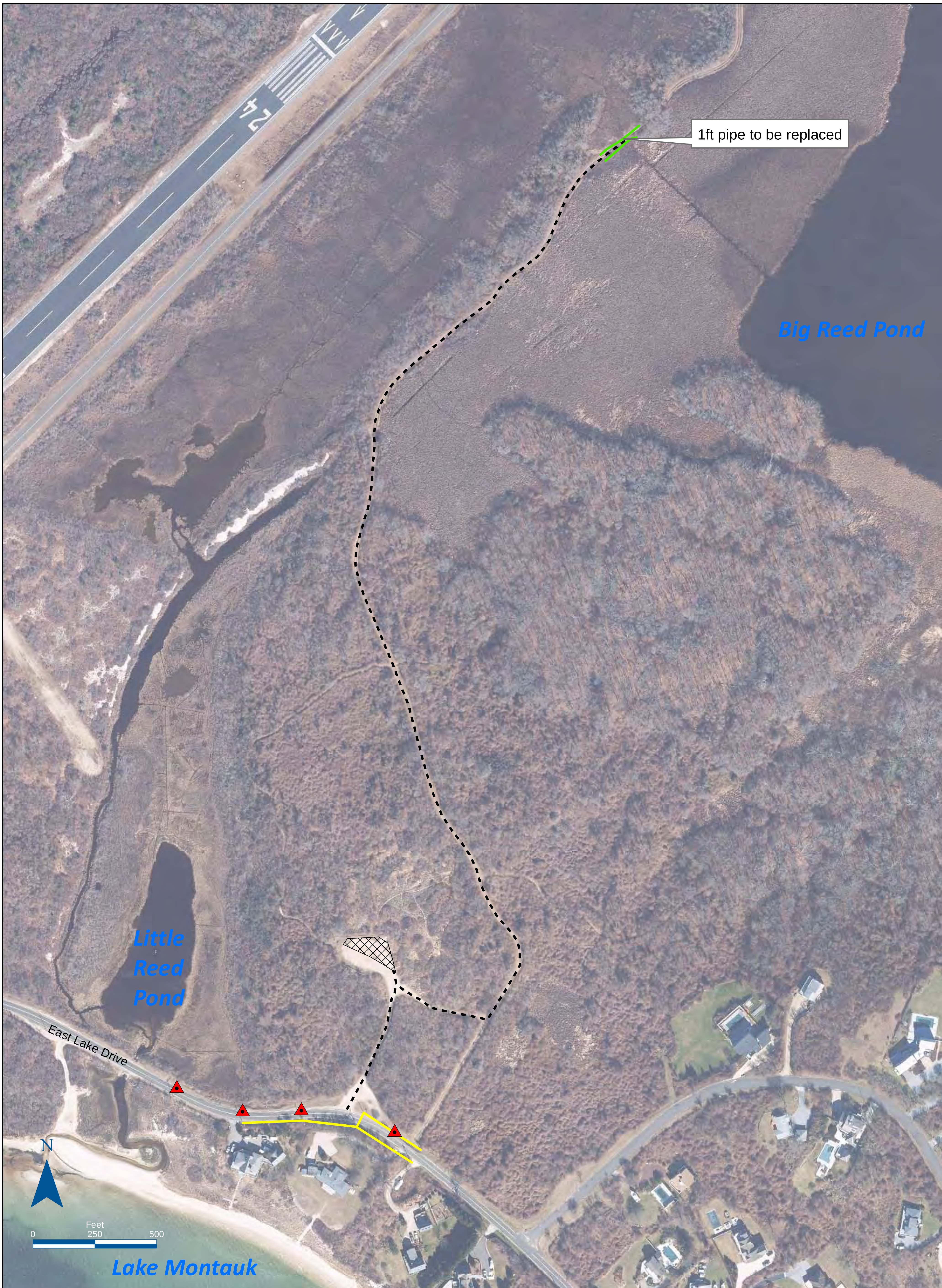

Proposed Culvert Length
Shoulder
Old West Lake Rd.
Shoulder
Proposed Riffle-Pool Channel
(Lower elevation to match existing bed elevation)
Exist. Tidal Channel
(Upland beyond)
Proposed Culvert with Natural Substrate (dimensions based on final design)
℄ Road
Proposed Riffle-Pool Channel
(Upper elevation at riffle-pool #1 to maintain existing pond elevation)
Stepping Stones Pond
Minor Fill Planted with Native Shrubs
To Lake Montauk
Paddling Access
(Existing Phragmites bed)
(flow)
3% Avg.
Section
Pool Typ.
Riffle Typ.
Pool Typ.
Riffle Typ.
#7
#6
#5
#4
#3
#2
#1
RIFFLE - POOL SEQUENCE
0
5
10
20 ft.



A3 | **PECONIC ESTUARY**
May 31, 2019

Conceptual Upstream Channel Section

LAKE MONTAUK ALEWIFE ACCESS & HABITAT ENHANCEMENT (STEPPING STONES POND)



Peconic Estuary Program Conceptual Restoration Design

Big Reed Pond Culvert Replacement
Big Reed Pond, Montauk County Park (Montauk, NY)
SCTM#: 300-7-1-3

Prepared 07/22/2019

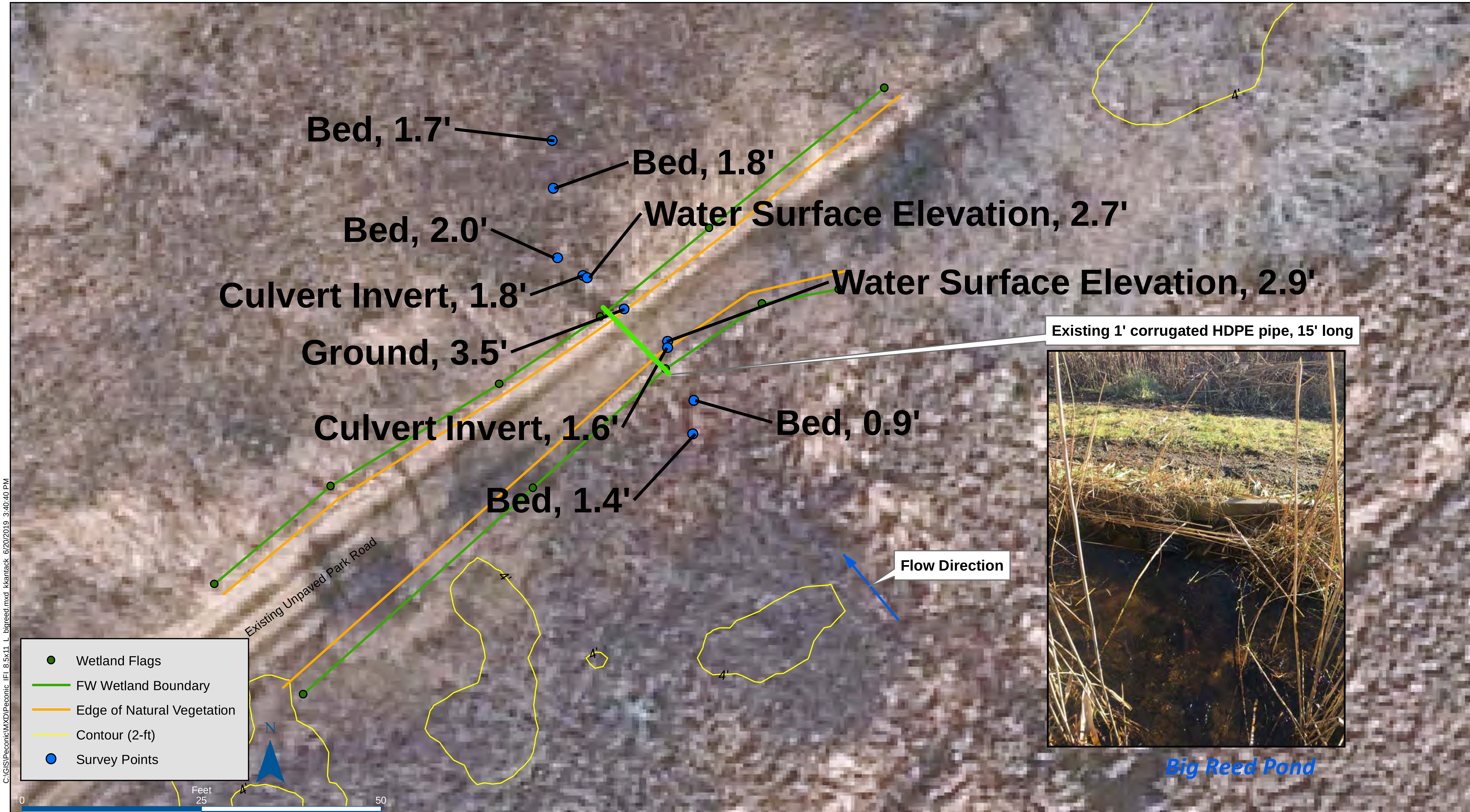
Control Points	Access
Wetland Boundary	Overhead Electric
	Staging

Notes:

1. Aerial imagery from NYGIS, 2017
2. Datum: 2014 USGS Lidar (NAVD88)
3: Scale is 1:4,262

inter·fluve
220 Concord Avenue, 2nd Floor
Cambridge, MA 02138

Land Use
570 Expressway Drive South, Suite 2F
Medford, NY 11763



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Peconic Estuary Program Conceptual Restoration Design

Big Reed Pond Culvert Replacement - Existing Conditions

Big Reed Pond, Montauk County Park (Montauk, NY)

SCTM#: 300-7-1-3

Prepared 07/22/2019

Notes:

1. Contours (2 ft intervals) created from 2014 Lidar (USGS)

2. Aerial imagery from NYGIS, 2017

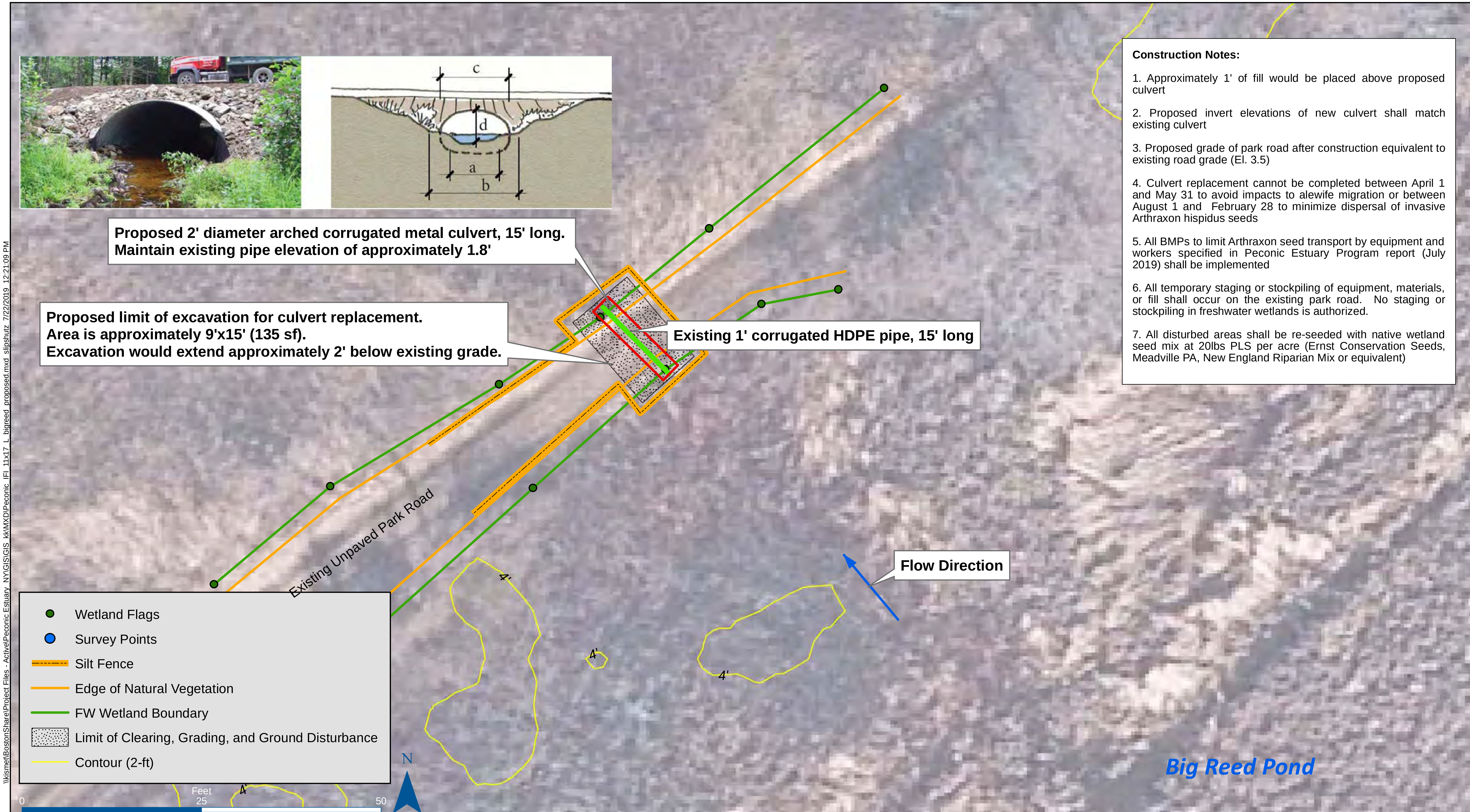
3. Descriptions and elevations (feet) are listed next to points. Point locations approximate and uncorrected. Elevations are tied to 2014 USGS Lidar (NAVD88)

4. Landward Limits of FW Wetlands as Delineated by WP Bowman (Land Use) on May 7, 2018.

5. Scale is 1:150

inter-fluve
220 Concord Avenue, 2nd Floor
Cambridge, MA 02138

Land Use
570 Expressway Drive South, Suite 2F
Medford, NY 11763



Peconic Estuary Program Conceptual Restoration Design

Big Reed Pond Culvert Replacement - Proposed Conditions

Big Reed Pond, Montauk County Park (Montauk, NY)

SCTM#: 300-7-1-3

Prepared 07/22/2019

Map Notes:

1. Contours (2 ft intervals) created from 2014 Lidar (USGS)
2. Aerial imagery from NYGIS, 2017
3. Landward Limits of FW Wetlands as Delineated by WP Bowman (Land Use) on May 7, 2018.
4. Scale is 1:150

inter·fluve
220 Concord Avenue, 2nd Floor
Cambridge, MA 02138

Land Use
570 Expressway Drive South, Suite 2F
Medford, NY 11763

Peconic Estuary Program Conceptual Restoration Design

Big Reed and Stepping Stone Ponds Culvert Replacements

Big Reed and Stepping Stones Pond, Montauk County Park (Montauk, NY)
SCTM#: 300-7-1-3
Prepared 07/19/2019

Legend			
▲	Control Points		Overhead Electric
	Wetland Boundary		Staging
	Access		

Notes:

1. Aerial imagery from NYGIS, 2017
2. Datum: 2014 USGS Lidar (NAVD88)
3. Scale is 1:4,054

inter-fluve
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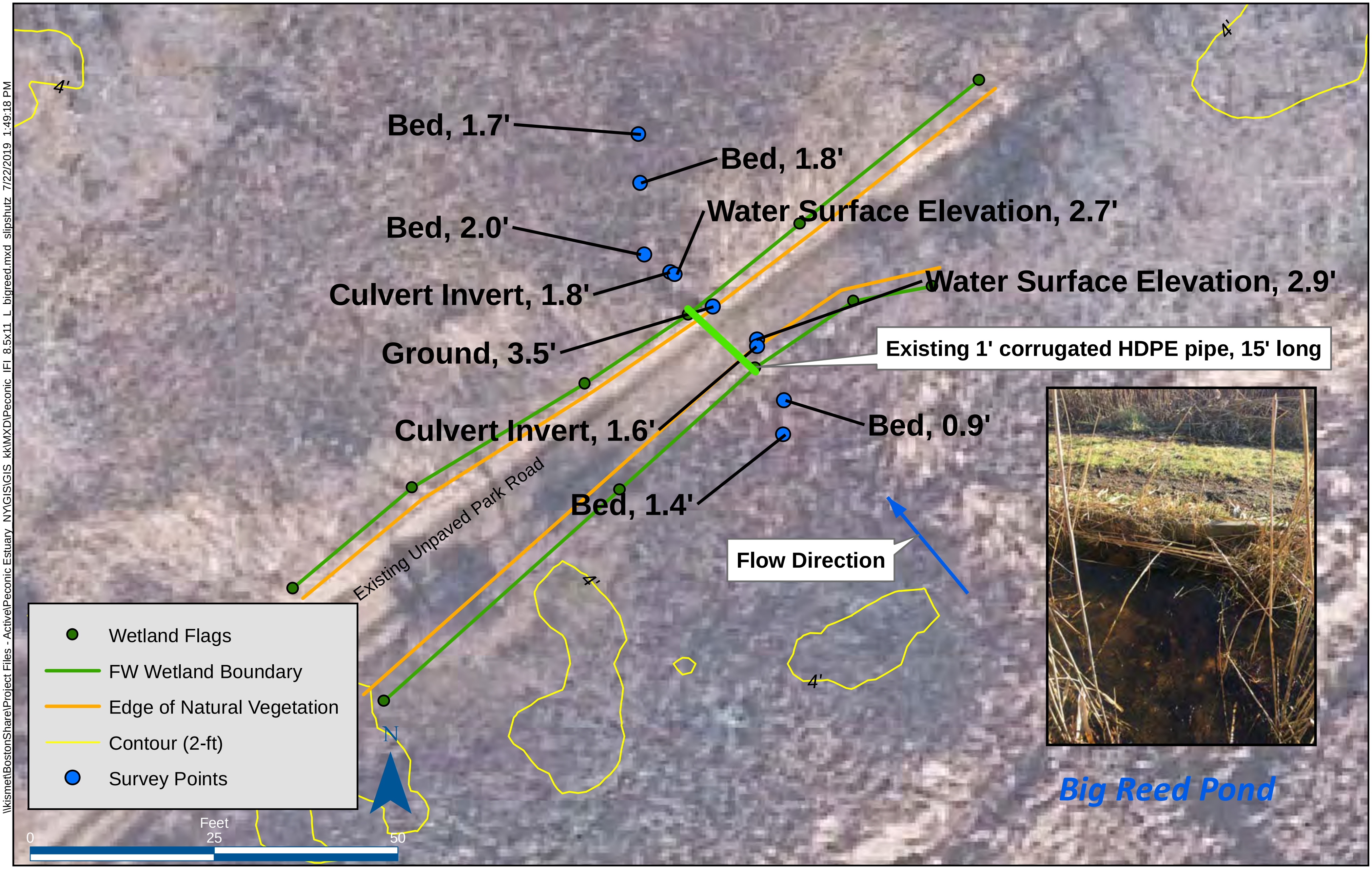
Medford, NY 11763



Peconic Estuary Program Conceptual Restoration Design

Big Reed Pond Culvert Replacement - Existing Conditions

Big Reed Pond, Montauk County Park (Montauk, NY)

SCTM#: 300-7-1-3

Prepared 07/22/2019

Notes:

1. Contours (2 ft intervals) created from 2014 Lidar (USGS)
2. Aerial imagery from NYGIS, 2017
3. Descriptions and elevations (feet) are listed next to points.

Point locations approximate and uncorrected. Elevations are tied to 2014 USGS Lidar (NAVD88)

4. Landward Limits of FW Wetlands as Delineated by WP Bowman (Land Use) on May 7, 2018.
5. Scale is 1:212

inter·fluve
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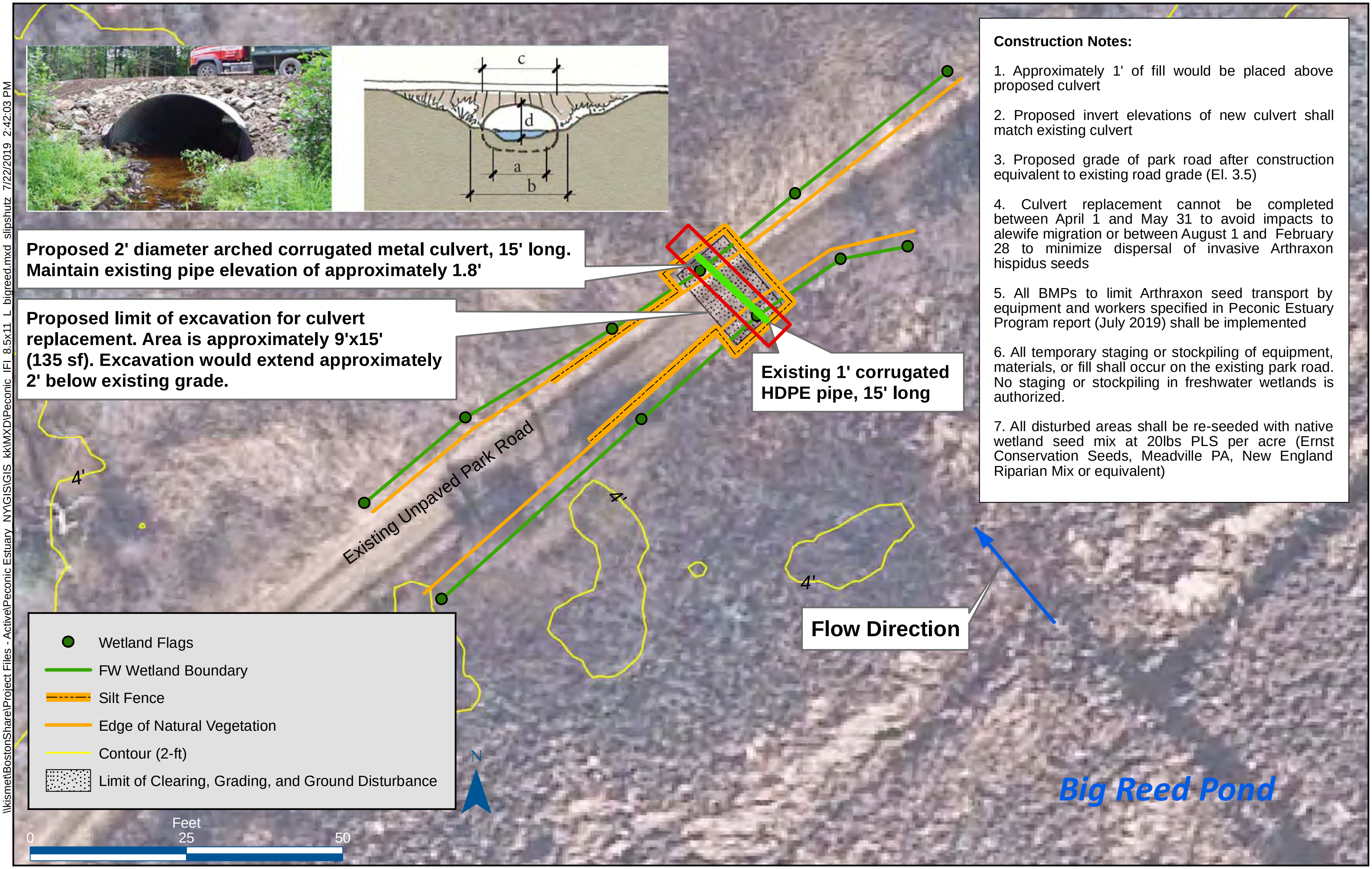

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Peconic Estuary Program Conceptual Restoration Design

Big Reed Pond Culvert Replacement - Existing Conditions

Big Reed Pond, Montauk County Park (Montauk, NY)

SCTM#: 300-7-1-3

Prepared 07/22/2019

Notes:

1. Contours (2 ft intervals) created from 2014 Lidar (USGS)
2. Aerial imagery from NYGIS, 2017
3. Landward Limits of FW Wetlands as Delineated by WP Bowman (Land Use) on May 7, 2018.
4. Scale is 1:250

inter·fluve
220 Concord Avenue, 2nd Floor
Cambridge, MA 02138

Land Use
570 Expressway Drive South, Suite 2F
Medford, NY 11763

Appendix B – Estimate of Construction Costs Based on Conceptual Plans

Stepping Stones Pond

Cost Estimate Based on Conceptual Design Plans

No.	Bid Item	Unit	Unit Price	Quantity	Subtotal	Notes
1	Mobilization & Demobilization	LS	$18,200	1	$18,200	
2	Access & Traffic Control	LS	$10,000	1	$10,000	
3	Erosion & Pollution Control	LS	$5,000	1	$5,000	
4	Flow Management	LS	$15,000	1	$15,000	Passive bypass channel as road is closed
5	Clearing & Grubbing	LS	$3,500	1	$3,500	Removal of *Phragmites* and misc shrubs
6	Demolition	LS	$4,000	1	$4,000	Road surface and old culverts
7	Excavation (cut)	CY	$50	200	$10,000	
8	Import Clean Floodplain Fill	CY	$30	30	$900	
9	Road reconstruction	SF	$15	625	$9,375	
10	Headwall	EA	$5,000	2	$10,000	
11	Precast Box Culvert - 4 ft x 4 ft	LF	$1,200	45	$54,000	
12	Import and Place Channel Substrate	CY	$230	30	$6,900	4ft wide in culvert; 6ft outside; Avg thickness 1.5 ft
13	Utility coordination/relocation	LS	$25,000	1	$25,000	
14	Planting	LS	$10,000	1	$10,000	
				CONSTRUCTION SUBTOTAL	$181,900	
				30% Construction Contingency	$54,600	
				3% Escalation, assuming 2020 construction	$7,100	
				CONSTRUCTION TOTAL with Contigency & Escalation	**$243,600**	
				PROJECT DELIVERY (design, permitting, construction support)	$91,000	50% of Construction Subtotal
				30% Project Delivery contingency	$27,300	
				PROJECT DELIVERY TOTAL with Contigency	**$118,300**	
				GRAND TOTAL with all contingencies	**$361,900**	

Big Reed Pond Culvert Replacement

Cost Estimate Based on Conceptual Design Plans

No.	Bid Item	Unit	Unit Price	Quantity	Subtotal	Notes
1	Mobilization & Demobilization	LS	$1,300	1	$1,300	
2	Erosion & Pollution Control	LS	$1,000	1	$1,000	
3	Flow Management	LS	$2,500	1	$2,500	Misc Pumping as needed; Passive flow Management w/existing culvert
4	Demolition	LS	$1,000	1	$1,000	Dispose or reuse old plastic pipe
5	Excavation (cut)	CY	$25	30	$750	Reuse on Site to regrade road
6	Headwall/Sloped End Treatment	EA	$2,250	2	$4,500	
7	Arch Pipe (2-foot equiv. dia.)	LF	$120	15	$1,800	Approx 30" W x 18" H
				CONSTRUCTION SUBTOTAL	$12,900	
				30% Construction Contingency	$3,900	
				3% Escalation, assuming 2020 construction	$600	
				CONSTRUCTION TOTAL with Contigency & Escalation	**$17,400**	
				PROJECT DELIVERY (permitting, construction support)	$6,500	50% of Const. Subtotal; 1 day of Construction observation; No Designs/Specs
				30% Project Delivery contingency	$2,000	
				PROJECT DELIVERY TOTAL with Contigency	**$8,500**	
				GRAND TOTAL with all contingencies	**$25,900**	