Mud Creek Watershed Aquatic Ecosystem Restoration Feasibility Study

Task 6: Alternative Concept Plans for Mud Creek County Park

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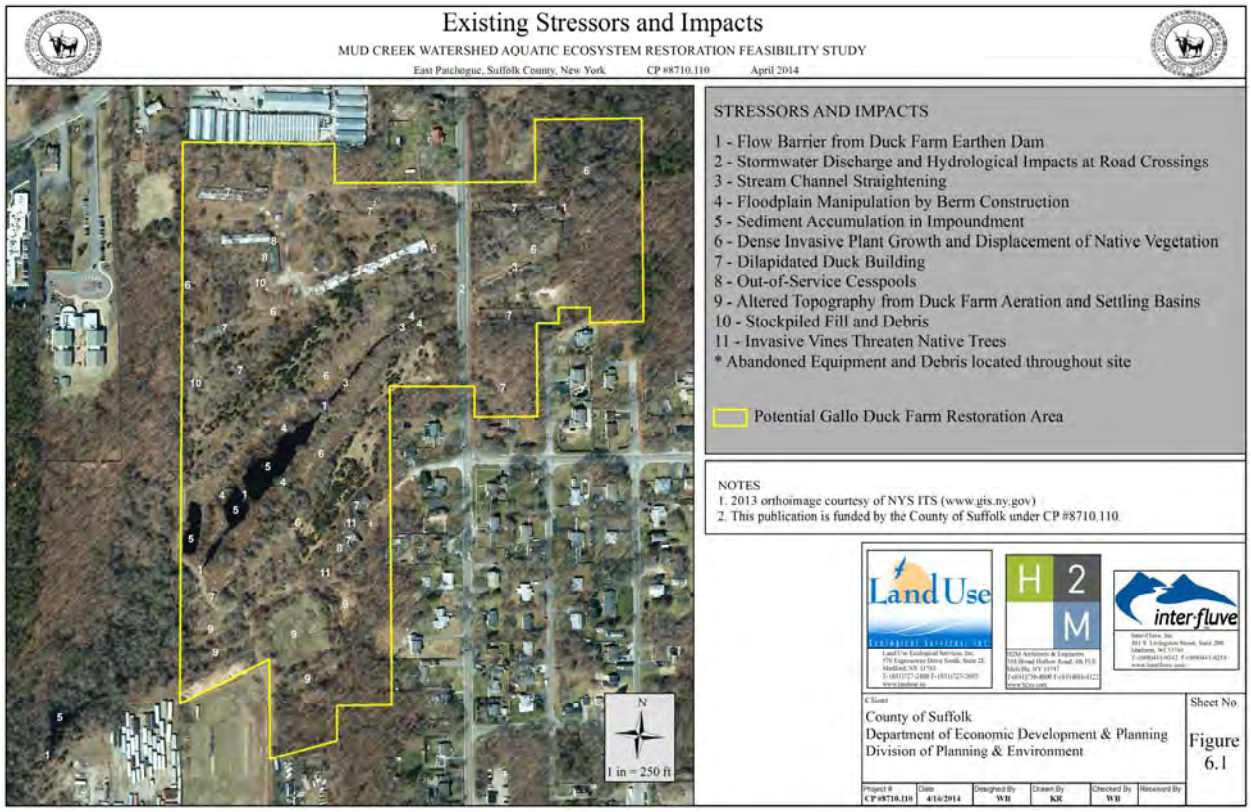
1 Introduction

The purpose of this report (*Task 6 - Alternative Conceptual Plans for Mud Creek County Park*) is to provide a review of existing stressors on the Mud Creek ecosystem and a narrative description of the conceptual design ideas to accompany the visual conceptual renderings of restoration at Mud Creek County Park. The Concept Plan phase is a culmination of the site assessment and analysis effort, defining the impediments to natural function and the associated removal of those impediments to enact restoration. In addition, the Concept Plan phase promotes discussion among the stakeholders ending in a clear decision on the approach to develop in the Final Design phase.

2 Site Impediments to Natural Function (No Action Alternative)

Due to extensive manipulation by duck farming and other activities, the meandering groundwater stream, riparian forested wetlands, and upland oak forests that predated European colonization in Mud Creek are no longer present throughout much of Mud Creek County Park. Duck farming operations ceased in the mid-1980s; however, many of the environmental impacts and stressors of the duck farm persist to the present. While significant re-growth of vegetation has occurred on the former duck farm, the aquatic and terrestrial habitats are still poor quality, dominated by invasive species, and exhibit only limited indications of natural succession toward the high quality ecosystems of the past. As shown on Figure 6.1 and described below, environmental stressors and impacts are present throughout Mud Creek County Park.



Physical Impacts to the East Branch of Mud Creek and its Aquatic Habitats

The East Branch of Mud Creek has been impacted through the construction of impoundments, excavation and modification of the stream channel and floodplain, construction of berms parallel and perpendicular to stream flow, and construction of undersized road crossings at Gazzola Drive and Montauk Highway.

Two earthen berms are located within the stream channel on the former Gallo Duck Farm (Photo 6.1 and Figure 6.1). The berms impound water and sediment, creating shallow pond habitats in place of the native groundwater stream. The ponds are highly eutrophic (i.e. high nutrient concentrations) and low in dissolved oxygen due to the accumulation of fine, organic sediments. These ponds also feature warm water temperatures resulting from the absence of overhanging trees and stagnant flow. Brook trout require streams with flowing, well-oxygenated water and exposed sandy substrate for spawning. Water temperatures greater than 71.5°F are not suitable for brook trout, and water temperatures greater than 75°F are lethal (Ficke et al., 2009). Water temperature data measurements just downstream of the duck farm impoundments were frequently greater than 71.5 ºF during the summer months and occasionally approached 80.0 ºF. These earthen berms and their impounded waters prevent the brook trout population located in the lower East Branch and West Branch from using the former duck farm as habitat, and degrade the stream downstream of the former duck farm by warming stream waters.

Photo 6.1: Earthen berms within and outside of the Gallo Duck Farm property (yellow line). Berms impound water and sediment, decreasing water quality, and prevent fish from moving through Mud Creek.

Due to the low energy of the East Branch watershed, it may be many decades before these earthen berms breach or fail during a storm event. Therefore, the return of brook trout to the former duck farm property through natural dispersal will not occur in the foreseeable future. Active removal of the earthen berms and accumulated fine, organic sediments to provide sandy substrate is necessary to expand brook trout habitat in Mud Creek.

Native groundwater streams on Long Island's coastal plain meander through densely forested floodplains (Photo 6.2, left). The stream channel on the former duck farm has been artificially straightened and widened through excavation and ditching (Photo 6.2, right and Figure 6.1). This manipulation homogenized the stream and destroyed the diversity of aquatic habitat created by variation in substrate composition, and water depth and velocity created by stream meanders. Earthen berms were constructed parallel to the stream channel in the mid-1970s to limit duck access to the straightened stream in an effort to reduce the discharge of duck effluent to the stream and the Great South Bay. These berms disconnect the stream from its natural floodplain and are largely vegetated by invasive shrubs and vines including multiflora rose (*Rosa multiflora*) and glossy buckthorn (*Frangula alnus*). Due to the low energy of the Mud Creek watershed, active re-construction is necessary to restore a natural meandering stream channel and re-connect the stream to its floodplain.

Photo 6.2: (Left) Example of a groundwater-fed stream on Long Island. (Right) Mud Creek, through the former duck farm, has been straightened and widened.

At Gazzola Drive, the flow of water, transport of sediments, and movement of aquatic wildlife and macroinvertebrates is completely blocked by undersized culverts that have filled with sediment (Photo 6.3). Accordingly, under current conditions, water flows downstream by seeping through the accumulated sediments within the culvert. Wildlife, such as reptiles and amphibians, must cross the road, risking injury or mortality to pass upstream or downstream. Re-design and replacement of the culvert at Gazzola Drive is necessary to correct the existing impaired hydraulic and ecological conditions.

Photo 6.3: The culverts under Gazzola Drive are filled with sand.

Proliferation of Invasive Plants in Wetland and Terrestrial Habitats

Common reed (*Phragmites australis*) has colonized the margins of the impoundments and straightened stream because of the extensive physical manipulation and nutrient loading (Photo 6.4 and Figure 6.1). The former duck feedlots on upland portions of the site are largely colonized by dense stands of invasive mugwort (*Artemesia vulgaris*) (Photo 6.4). Both *Phragmites* and mugwort infestations result in significantly degraded ecological conditions, as these plants exclude nearly all other plant species (including most other invasive plants) and provide poor habitat for many wildlife species. *Phragmites* and mugwort exclude other plant species through production of dense aboveground stands of leaves and shoots and formation of dense underground rhizome networks. Mugwort also produces allelopathic chemicals, those that inhibit the growth of competing plant species (Barney and DiTommaso, 2003).

Photo 6.4: (Left) *Phragmites* has colonized much of the floodplain along Mud Creek in the former duck farm. (Right) Mugwort has colonized many upland portions of the site.

Few seedlings or saplings of native trees are interspersed within the site's *Phragmites* or mugwort stands even thirty years after cessation of duck farming. The native ecological community that would be present in the current *Phragmites* stands is a red maple-hardwood swamp (such as the forest downstream of the former duck farm, Photo 6.5). The native ecological community that would be present in the current mugwort stands is a coastal oak-heath

forest (such as the forests located northeast of the former duck farm, Photo 6.5). Without young trees to eventually out-compete and shade-out *Phragmites* and mugwort, these portions of Mud Creek County Park will remain ecologically compromised for many years to come. Restoration actions to remove these invasive species and establish native trees are necessary to restore species and structural diversity to these areas and enhance wildlife habitat. *Phragmites* and mugwort are difficult to control and eradicate, often requiring a combination of both mechanical methods and herbicide applications over multiple growing seasons to provide long-term control.

Photo 6.5: (Left) Red maple hardwood swamp downstream of the former duck farm. This ecological community is appropriate for the area of the duck farm currently colonized by *Phragmites.* (Right) Coastal oak-heath forest to the northeast of Mud Creek County Park. This ecological community is appropriate for the area of the duck farm currently colonized by mugwort.

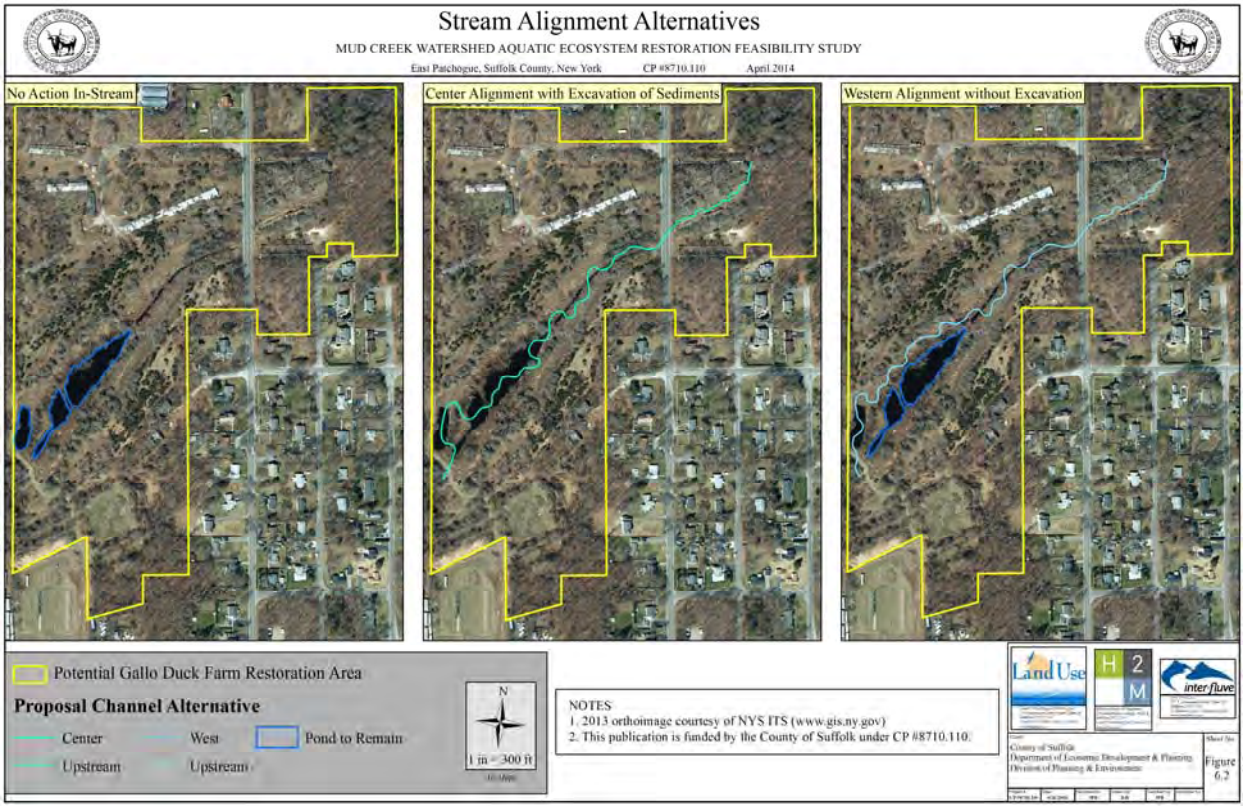
Dilapidated Buildings, Out-of-Service Cesspools, and Debris Removal

Mud Creek County Park contains fourteen dilapidated buildings, four out-of-service cesspools, an extensive network of sub-surface pipes and pipe vaults, and miscellaneous abandoned equipment, debris and garbage, soil stockpiles, and fencing scattered throughout the site (Photo 6.6 and Figure 6.1). The dilapidated buildings adversely impact the aesthetic quality of the surrounding residential neighborhood and the buildings and debris are a hazard to the neighborhood due to the dangerous condition of these structures and presence of asbestos-containing materials. Without remedial actions, the unsightly and dangerous condition of the remnants of the duck farm and their impact to the neighborhood will continue.

Photo 6.6: Dilapidated buildings and abandoned vehicles are scattered throughout the former duck farm, along with other items remaining from the farm operation.

3 Data Analysis to Support Designs for Aquatic Restoration

The following section describes data and information collected on the project site to support the assessment of environmental stressors described above and restoration alternatives to eliminate these stressors. These environmental stressors are impediments to the restoration objectives stated in *Task 5 – Restoration Objectives*. In particular, this section focuses on restoration actions aimed at achieving Objective 2.1 (Restore Coastal Plain Stream Channel and Habitat) and Objective 2.2 (Restore/Enhance Brook Trout Habitat). Assessment of the existing environmental stressors and impacts above, coupled with the analysis below, eliminate consideration of the no action alternative for the site. Under a no action alternative, no aquatic restoration actions would be undertaken and the earthen berms and associated impoundments would remain, as shown in the left panel of Figure 6.2. The current trajectory of passive restoration at the site is ecologically unacceptable and warrants active restoration to remove impediments to natural function.



3.1 Channel Profile Analysis

Man-made hydraulic control structures have greatly affected Mud Creek. A total of nine hydraulic control structures exist along the East Branch, though only four exist within the project boundary (Figure 6.3 and Table 6.1). Highlighted in Figure 6.3 and Table 6.1 below, these control structures block fish passage and create a ponded condition within the project boundary under low flow as well as flood conditions. This ponded condition warms water, reduces dissolved oxygen, and impounds sediment, all of which create a habitat that cannot support brook trout.

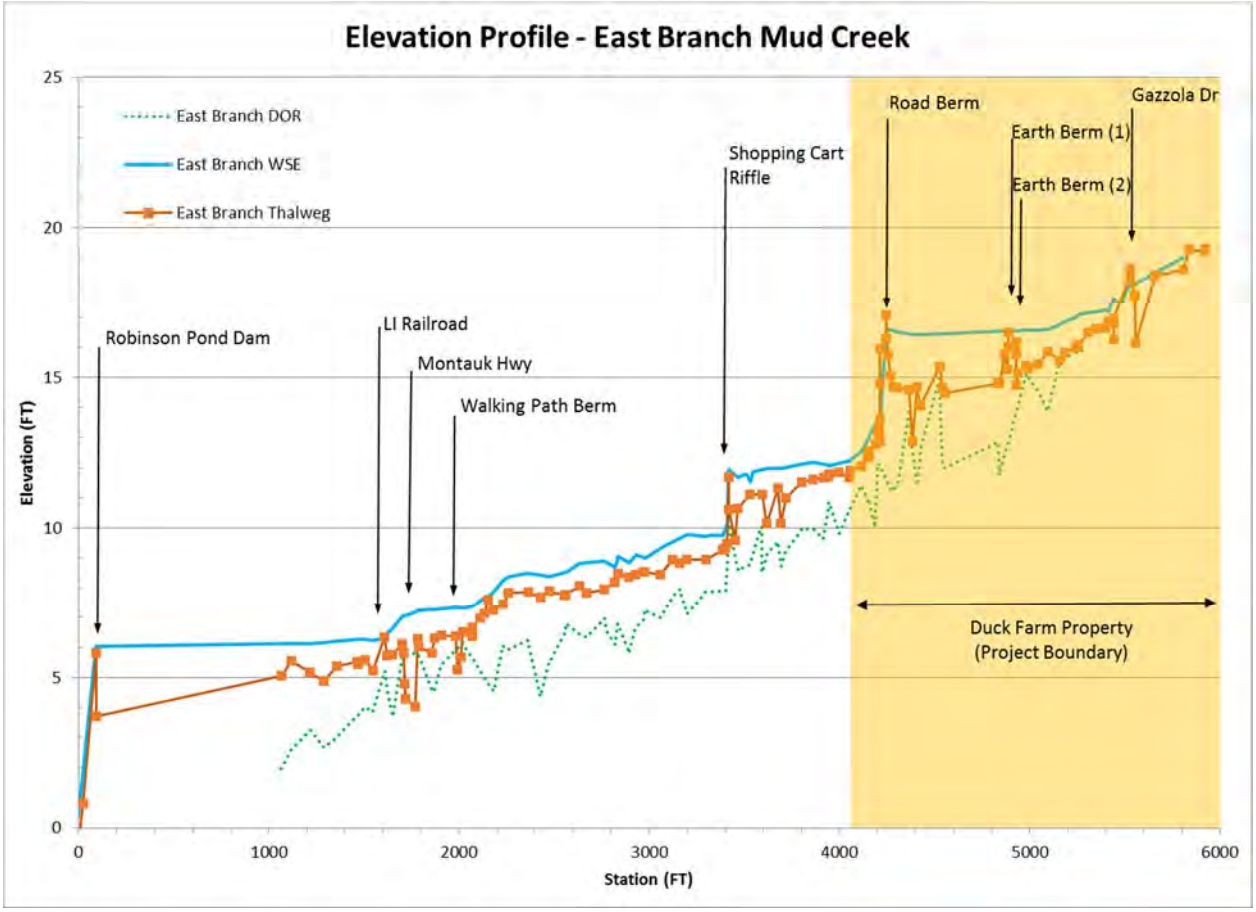


Figure 6.3: Longitudinal profile of the East Branch of Mud Creek. Flat sections of water (blue line) indicate ponded areas in the stream created by man-made structures.

Hydraulic structures downstream of the project area have a direct impact on the success of work within the project area. Streams are intrinsically connected with a transfer of physical, chemical, and biological material in both the upstream and downstream direction. The presence of structures blocking all or a portion of these three attributes will always limit the natural function of the system, and is what restoration over the long term should seek to overcome.

Table 6.1: Control structures in Mud Creek that block fish passage and create a ponded condition under low flow as well as flood conditions. Structures highlighted yellow are restoration alternatives proposed for Mud Creek County Park.

Control	Fish Barrier	Sediment Barrier	Flow Control	Notes
Robinson Pond Dam	YES	YES	YES	- Cuts off all of Mud Creek from saltwater - Controls water and sediment back to LIRR - Investigate Removal or Alt Fish Passage
LI Railroad	NO	YES	YES	- Undersized culvert controls sediment and water elevation upstream - Replace with bottomless culvert
Montauk Highway	NO	YES	YES	- Passable to fish - Concrete bottom exerts control on bed elevation - Replace with bottomless culvert
Walking Path Berm	NO	NO	NO	- Flow control only at flood flow - Cuts off flow from floodplain, though in re-routed section of Mud Creek - Remove
Shopping Cart Riffle	YES	YES	YES	- Impassable to fish at low flow - Induces fine sediment deposition - Impoundment upstream warms water, likely to lethal level for brook trout - Cuts off flow from floodplain - Remove
Grass Road Berm	YES	YES	YES	- Impassable to fish - Causes significant impoundment upstream nearly to Gazzola Dr. - Cuts off flow from floodplain - Remove
Duck Pond Earth Berm 1	NO	NO	NO	- Compromised berm, possible hydraulic control at flood flow - Cuts off flow from floodplain - Remove
Duck Pond Earth Berm 2	NO	NO	NO	- Compromised berm, possible hydraulic control at flood flow - Cuts off flow from floodplain - Remove
Gazzola Drive	YES	YES	YES	- Total fish barrier - Induces sediment deposition upstream - Impounds water at average flows and higher - Replace with bottomless culvert

3.2 Water Quality

As noted above, those areas impounded by hydraulic controls exert a significant impact on the East Branch. Qualitative evidence for this exists with numerous field observations such as the accumulated loose organics and mud observed in the site's impoundments and low diversity, pollution tolerant macroinvertebrate community discussed in *Task 4 – Existing Conditions*. Two parameters, dissolved oxygen and stream temperature, provide quantitative evidence to reinforce these observations. Dissolved oxygen levels that drop below 5 mg/L are well known to stress aquatic fauna, fish in particular. The USEPA guidelines stipulate daily minimums should never fall below 8 mg/L to avoid any impacts to larval and early life stages of fish, and never below 4 mg/L to avoid any impacts to adult cold water species (USEPA, 1986).

The capacity of water to carry dissolved oxygen is inversely related to its temperature, thus any warming of the water reduces its dissolved oxygen. Figure 6.4 presents the profile of the East Branch with the measured dissolved oxygen taken the morning of August 2, 2013. Ponds created by the shopping cart riffle and the grass road berm essentially create lethal conditions during warm months from Gazzola Drive down to a point just above Montauk Highway.

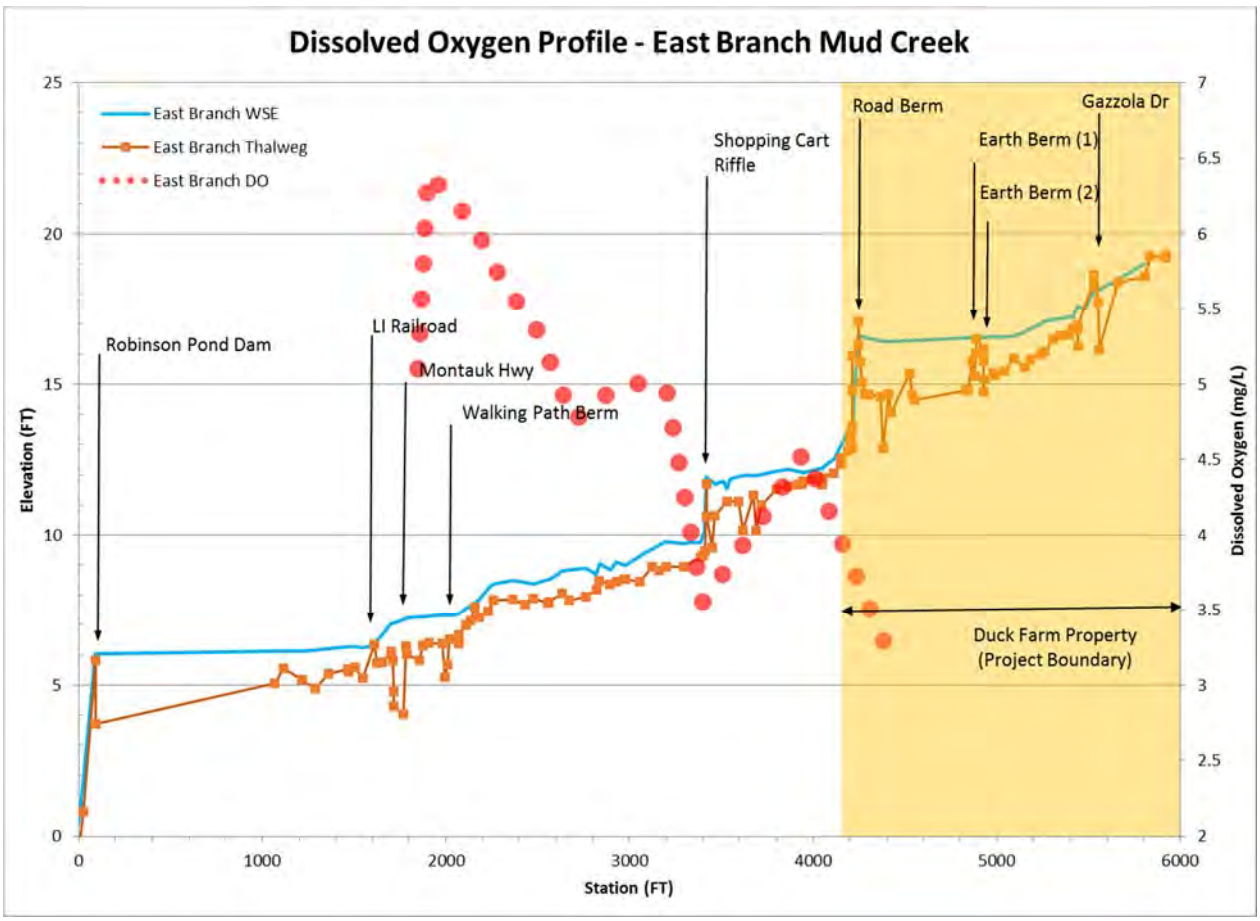


Figure 6.4: Measured dissolved oxygen along the East Branch.

A similar condition is observed with the temperature data, which provides a longer and more frequent period of record. Brook trout are cold water species, warm water can be lethal. The warm summer months between May and August are a vulnerable period for brook trout. The data in Figure 6.5 indicate that cool water refuge exists within the West Branch and in the upper sections of the East Branch near and upstream of Gazzola Drive. An area of warm water created by the impoundments persists from Montauk Highway to near Gazzola Drive during this summer period and is likely avoided by brook trout. Accessing the cool water of the upper East Branch is prohibited given the fish barriers in place at the shopping cart riffle, the grass road berm, and Gazzola Drive.

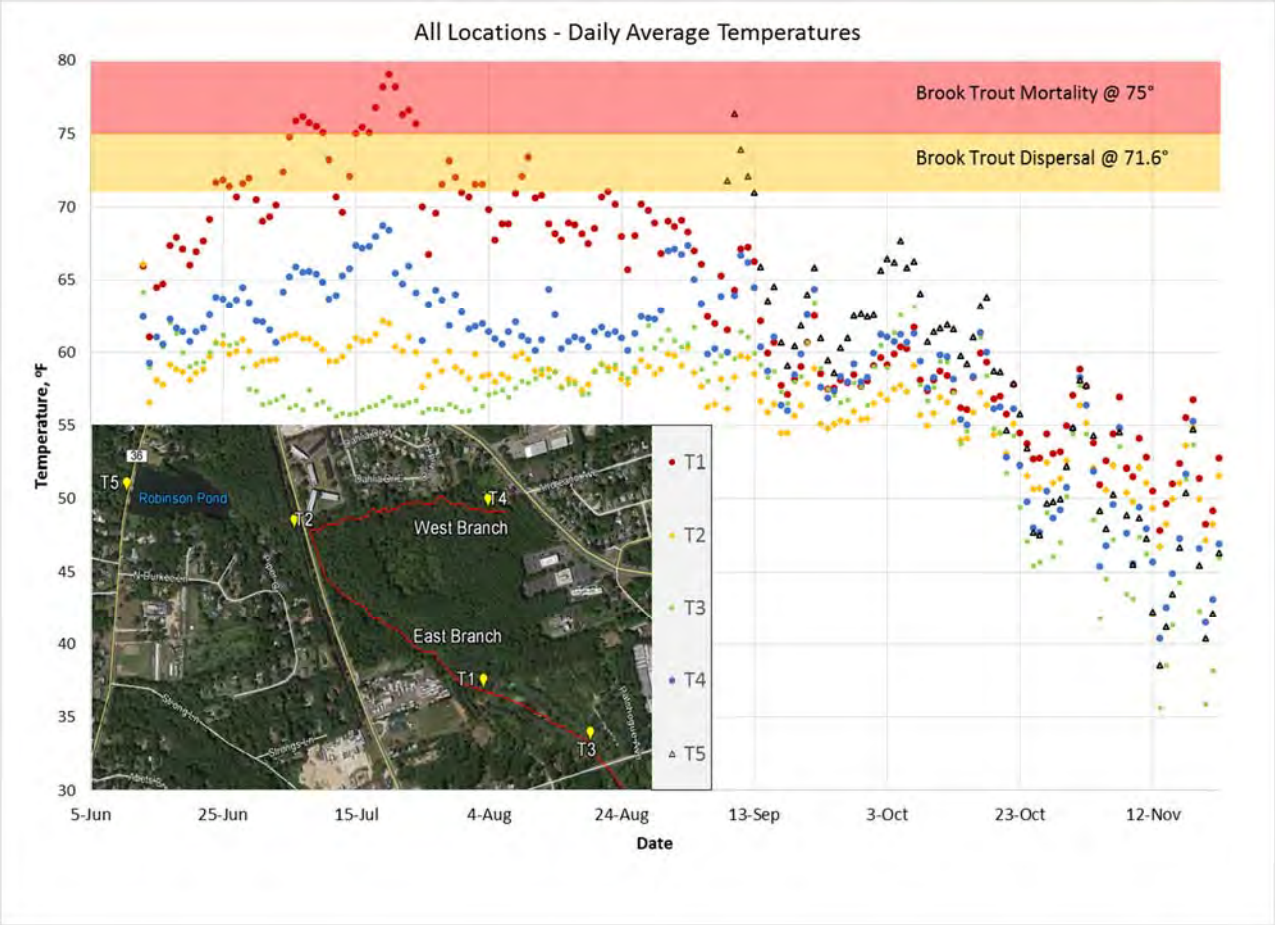


Figure 6.5: Daily average temperature of Mud Creek during the summer of 2013.

3.3 Geomorphology and Stream Planform

Key to restoring aquatic habitat in rivers and streams is restoring the physical processes and characteristics of the fluvial system. Mud Creek, and other streams on Long Island flowing southeast to the Atlantic Ocean, are coastal plain streams. Historically, coastal plain streams were low-gradient meandering streams within well-vegetated floodplain forests. Due to the glacial history of Long Island, the channel banks are made up of sand and sandy loam, and the channel bed of these streams is typically sand and small gravel. Coastal plain streams are dynamic, eroding channel banks in high-energy areas, and depositing material in low-energy portions of the channel. Over time, stream channels may move back and forth across an alluvial

valley. Trees within the floodplains are important components to both the dynamic nature of the stream as well as in-stream and floodplain habitat. As trees along the channel margins fall into the stream, the large woody structure of the trunk, root wad, and branches forces channel change: scour pools are developed around the large wood and depositional areas may develop downstream; large wood may accumulate other large wood creating a log jam, which has the potential to push the stream into a new direction.

Restoration objectives for Mud Creek County Park were discussed in *Task 5 – Restoration Objectives*, which included a discussion of restoring the coastal plain stream channel floodplain habitat. The designs include the restoration of a more natural stream planform, variability in channel depth and substrate, reconnection of the channel and floodplain, and incorporation of large woody habitat features throughout the stream system.

The proposed channel planform was developed based on similarly-sized streams in similar environments that have not experienced the types of degradation as seen along Mud Creek. Finding un-impacted coastal plain streams in New York and the rest of the northeastern U.S. is not possible as all streams have been impacted by a long list of human interventions including dams, cranberry farming, undersized road crossings, logging of the watershed, development in the watershed, straightening and ditching for flood control or irrigation or mosquito control, excessive sedimentation from construction sites or winter road maintenance, and invasive plant species. However, two streams near Mud Creek were analyzed as potential planform templates for Mud Creek: Swan River and Hedges Creek. These nearby creeks are of similar width and watershed size. The planforms of Swan River and Hedges Creek were delineated and overlaid near the Gallo Duck Farm on Mud Creek (Figure 6.6).

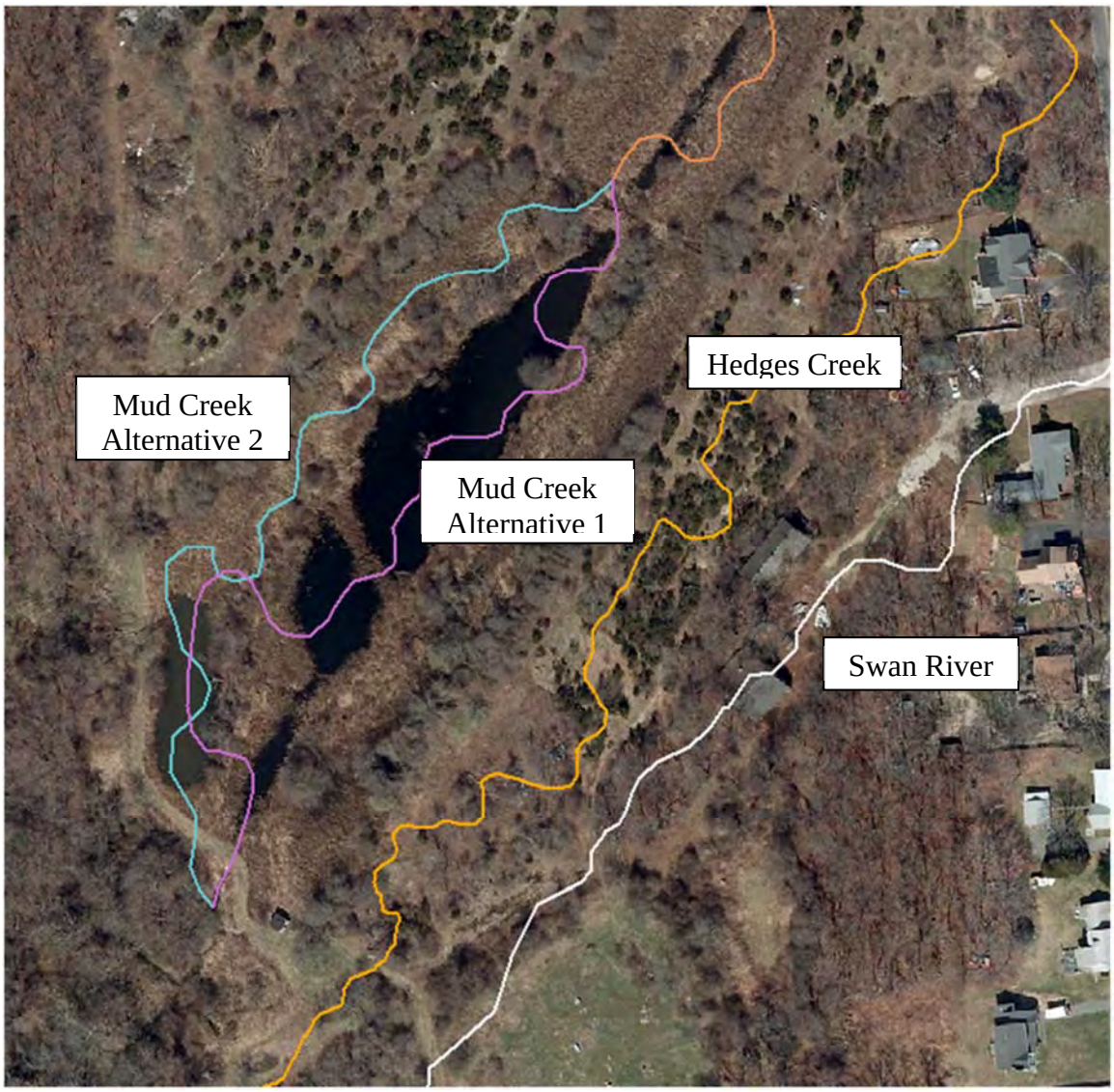


Figure 6.6: Mud Creek proposed channel planform for Alternatives 1 and 2 as well as the Swan River and Hedges Creek stream delineations used as templates for Mud Creek. The Swan River and Hedges Creek stream delineations were moved and rotated to the area adjacent to Mud Creek for comparison purposes.

The proposed Mud Creek channel meander wavelength and amplitude was designed based on those of the template streams. Meander wavelength is the longitudinal distance between common portions of a single meander bend, i.e. from one outer bend to the next outer bend. Meander amplitude is the lateral distance from the outer edge of one meander bend to the outer edge of the next meander bend. Because Mud Creek gains discharge as it flows downstream from groundwater inputs, the channel dimensions and meander wavelengths and amplitudes are smaller upstream of Gazzola Drive than downstream. While channel dimensions will be finalized in *Task 9 – Final Environmental Restoration Design Plan and Specifications*, stream widths may range from 4 to 16 feet and depths may range from 1 to 3 feet through the length of the designed channel. The designed meander wavelength is approximately 70 to 90 feet and the amplitude is approximately 30 to 50 feet.

3.4 Hydrology

Hydrologic estimation of Mud Creek is a challenge due to the relatively small drainage area and the absence of a current or historical USGS stream gage. However, Mud Creek's small watershed and the copious amount of groundwater moving into the creek have worked in favor of maintaining the brook trout refuge over the years. Two levels of hydrologic understanding are important to inform restoration efforts; base flow (also known as groundwater flow) and flood flow or stormwater flow.

3.4.1 Base Flow (Groundwater) Hydrology

Long Island is underlain by deep bedrock with a large wedge-shaped mass of unconsolidated material lying on top of the bedrock. The wedge is comprised of glacial outwash deposits and deposits composed of clay, silt, sand, gravel and boulders, and ranges in thickness from zero where the bedrock surfaces near the East River to 1,100 feet in the southeast part of Queens to 2,000 feet in south-central Suffolk County (U.S. Environmental Protection Agency [EPA], 1975). This porous matrix is responsible for capturing, storing, and slowly releasing the cool groundwater that feeds the trout streams on the south shore of the island. The deep soils of the wedge are generally well draining and contain thick consolidated aquifers of moderate to high permeability (Figure 6.7). Because of this permeable wedge, streams on Long Island generally are groundwater drains, with groundwater continually discharging into the stream bed under natural conditions (Federal Emergency Management Agency [FEMA], 2008).

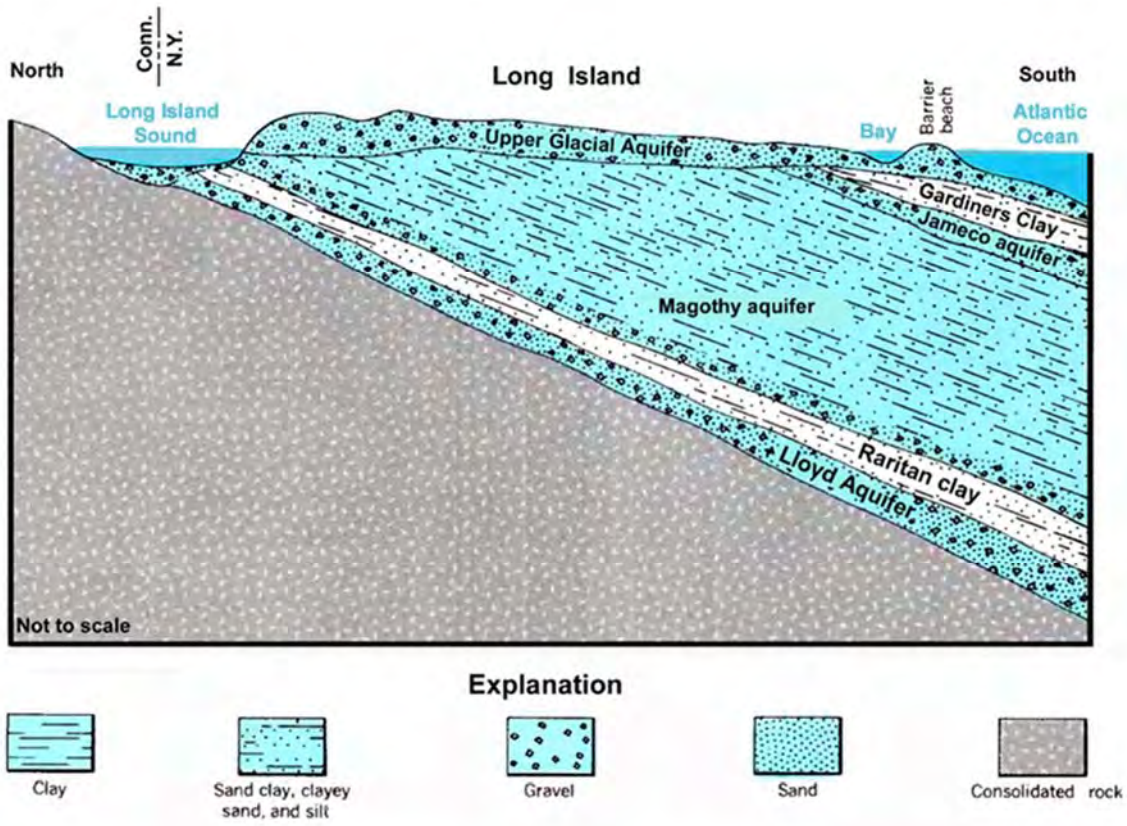


Figure 6.7: Diagram showing the major hydrogeologic units of the Long Island Aquifer.
[From NYSDEC (http://www.dec.ny.gov/lands/36231.html)]

As described in *Task 4 – Existing Conditions*, two HOBO U20 water level data loggers were installed in July 2013 to measure the water surface elevation in the West and East Branches. After the most recent download of the data on February 5, 2014, the data were plotted and compared with simultaneous records at the nearby Swan River USGS gage #01305500 (Figure 6.8). From the data in the graph it is clear to see, even over a short period of record, the constant input of groundwater to both the East and West Branch as well as Swan River. Even when precipitation events cause an increase in discharge or water level, the increase is slight. It is important to note however that 2013 was a very dry year, and larger more sustained floods do occur with some frequency in these watersheds.

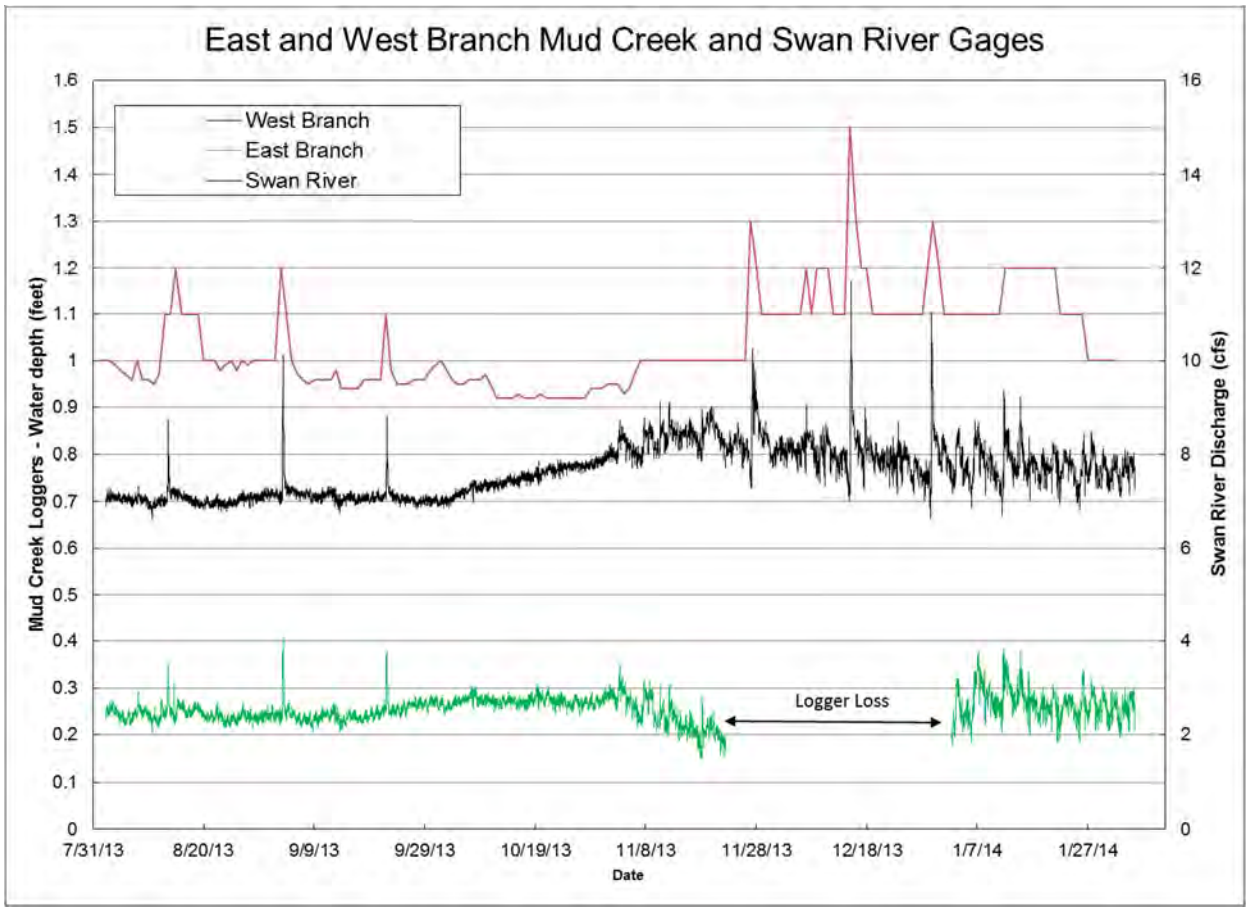


Figure 6.8: Water depth in the East and West Branches of Mud Creek (left y-axis) and stream discharge in Swan River (right y-axis) between August 2013 and February 2014.

3.4.2 Flood (Storm) Hydrology

The spikes in water level in the East and West Branch data are indicative of flashy (fast peak and return to baseflow following a storm) hydrology typically observed in urban streams. The West Branch includes substantial runoff from Sills Rd (Hwy 101) and the East Branch receives runoff from about 0.5 miles of Gazzola Drive (Photo 7).

Based on the resulting increase in water elevation from the same storm, it appears the West Branch receives more urban runoff than the East Branch (Figure 6.9). Suffolk County Department of Public Works is planning to construct a detention pond and bio-swale with rip-rap check dams to mitigate urban runoff impacts associated with discharge from Sills Road to the headwaters of the West Branch.

For the East Branch, an intact floodplain to allow stormwater to spread out and dissipate the energy of a flood can mitigate effects of urban runoff. The ample wetlands in this floodplain can absorb and even infiltrate flood water.

Photo 7: A section of Gazzola Drive about 0.5 miles long drains directly into the East Branch, the low spot in the photo.

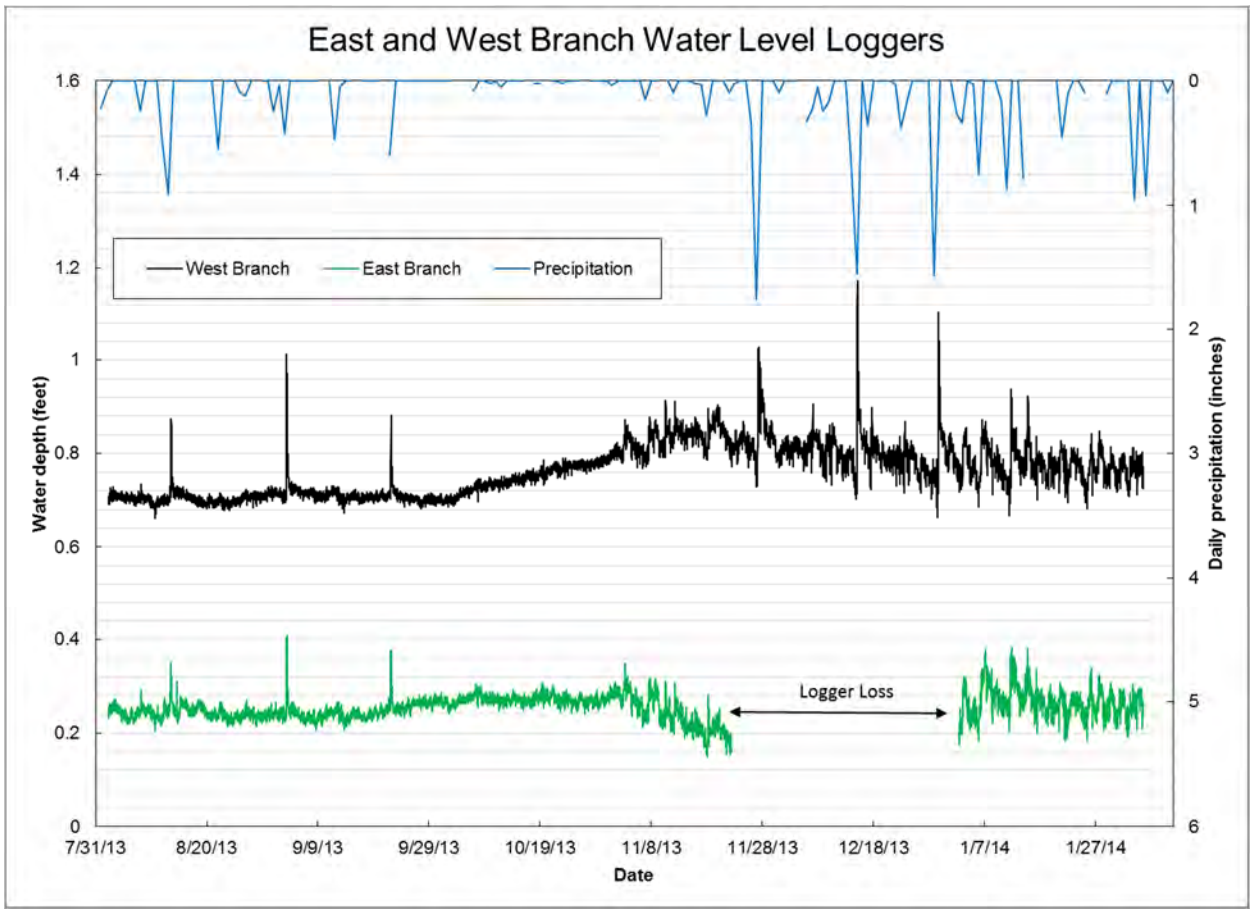


Figure 6.9: Comparison of daily precipitation records and water depth (from water level loggers) for East and West Branches between August 2013 and February 2014. Stream water depth data is presented on left y-axis and daily precipitation is presented on right y-axis.

To predict larger flood events, such as the often referred to 100-year event, various methods were utilized. Regression equations require large regional areas with similar flow characteristics. These characteristics define resulting flood flow, allowing the user to define a set of characteristics for an ungaged site, and develop a reasonable estimate of flood flows. On Long Island, a large, hydrologically similar region does not exist to develop a robust set of characteristics for regression. Given the geology of Long Island, standard regression approaches are not applicable because trends in flood flow are decidedly watershed specific, even between adjacent watersheds. Flood flows were estimated using StreamStats, an online tool that uses watershed characteristics of a gaged site to estimate flows at ungagged sites with similar characteristics. In addition, gage transfer, a similar but slightly different method to StreamStats, was used, and the results fitted to a statistical distribution. All estimates/methods will return different values for flood recurrence intervals and provide a range that can be used to bracket site hydrology and determine how flows may impact restoration. Carlls River, Massapequa Creek, and Sampawams Creek were utilized in the gage transfer analysis.

One limitation for the three gages used for the gage transfer process relates to the period of record for available annual peak flow data. Collins (2009) and Hodgkins (2010) indicate that flood frequency estimates for much of the Northeastern U.S. based on time series of flood data that end in the 1970s and 1980s are not representative of the modern climatic regime. The three gages listed above were used to estimate the potential influence of pre- and post-1970 climate regimes. With the exception of basin size, these three gages possess basin characteristics similar to Mud Creek. The adjusted flow recurrence intervals for the East and West branches of Mud Creek are shown in Table 6.2. These represent the most conservative flood recurrence interval flows for the East and West Branches of Mud Creek and were used in the hydraulic modeling and analysis.

Table 6.2: Predicted flood magnitudes for the East Branch and the West Branch just upstream of Montauk Highway, based on flood recurrence intervals where Q2 = 2-year recurrence interval, Q5 = 5-year recurrence interval, etc.

Stream	Base Flow	Q2	Q5	Q10	Q25	Q50	Q100
	cfs	Adjusted* Flow (cfs)	Adjusted Flow (cfs)	Adjusted Flow (cfs)	Adjusted Flow (cfs)	Adjusted Flow (cfs)	Adjusted Flow (cfs)
East Branch Mud Creek	2.2	32	36	39	45	49	53
West Branch Mud Creek	1.0	12	12	14	15	17	19

* Average Log Pearson III Distribution (LP3) flow increased by percent change in flow when only post-1970 period of record used for Carlls, Massapequa and Sampawams gages.

3.5 Hydraulic Analysis

Survey data collected by Inter-Fluve and H2M in June 2013 along with the analytical photogrammetry survey provided by Geomaps in April 2014 were combined with the flood recurrence interval estimates and measured flow rates to develop a one-dimensional, steady-state hydraulic model (HEC-RAS, developed by the U.S. Army Corps of Engineers). HEC-RAS calculates average hydraulic characteristics in each cross section set up in the model.

Cross-sections were located to model pertinent hydraulic conditions for the project reach. For this phase of the project the subject reach of the stream was determined to be 300 ft downstream of the "shopping cart" riffle crest to approximately 400 ft upstream of the Gazzola Drive crossing. Seventeen cross sections were used for the model with three culvert crossings. Distances for overbank flow paths between cross sections were estimated from the CADD model and averaged along each floodplain (left and right).

The model was calibrated by adjusting the channel roughness values so modeled water surface elevations reasonably matched measured water surface elevations during the June 2013 survey (Figure 6.10). Model calibration was difficult in the duck pond area due to uncertainty about culvert configurations (i.e. percent of culvert blocked) at the time of the survey. Areas modeled outside of the influence of the instream structures were hydraulically similar to the field observations.

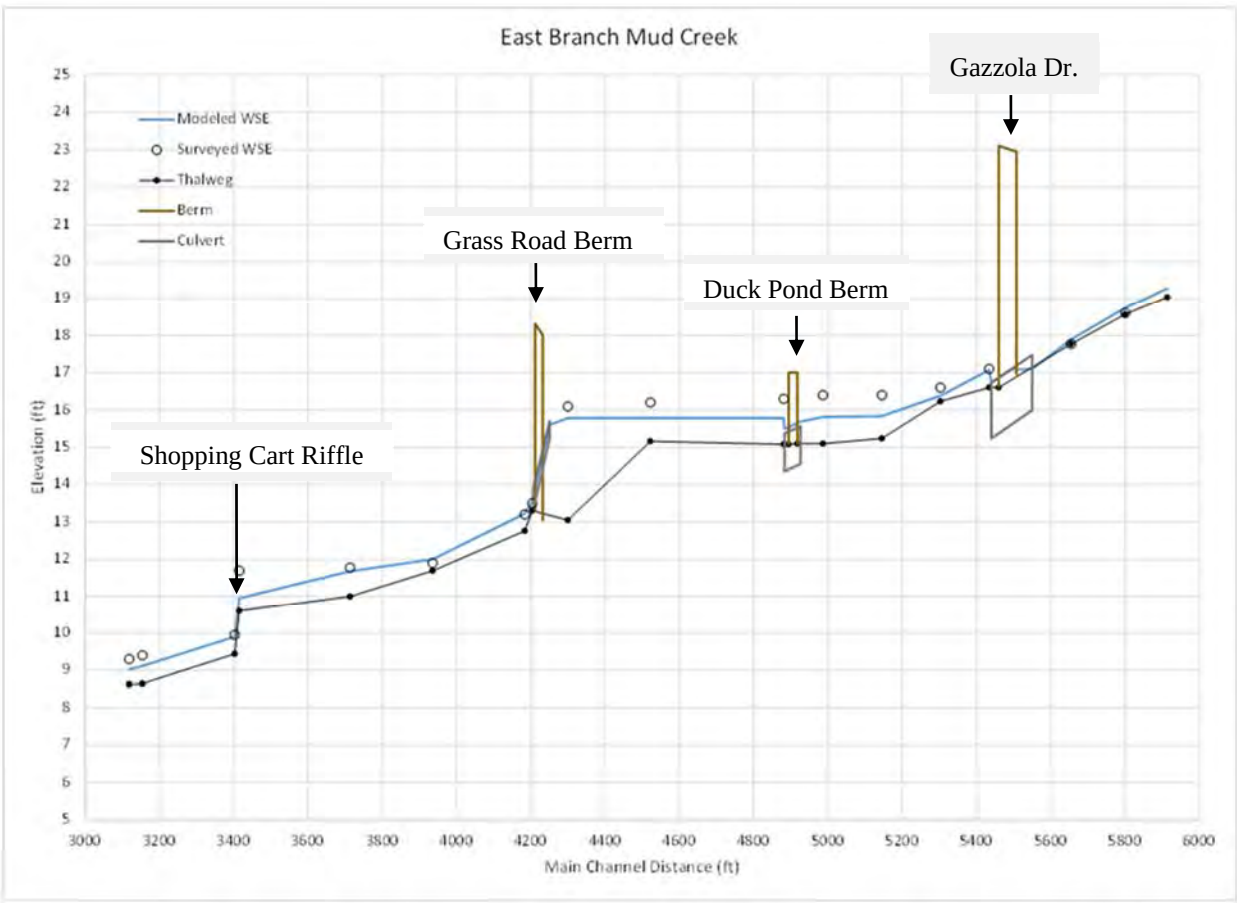


Figure 6.10. Water surface profile of East Branch Mud Creek showing the thalweg, or channel bottom, (black line), surveyed water surface elevation (black circle), modeled water surface elevation (blue line) and instream structures.

With reasonable low flow calibration achieved, the adjusted flood recurrence intervals estimated in the hydrologic analysis, shown in Table 6.2, were added to evaluate floods within the model. Downstream boundary conditions were established using normal depth and a measured downstream slope of 0.003 ft/ft. The results from the HEC-RAS model indicate that floods begin

overtopping berms and culverts beginning at the 2-year flood recurrence interval at all existing culvert crossings (Figure 6.11).

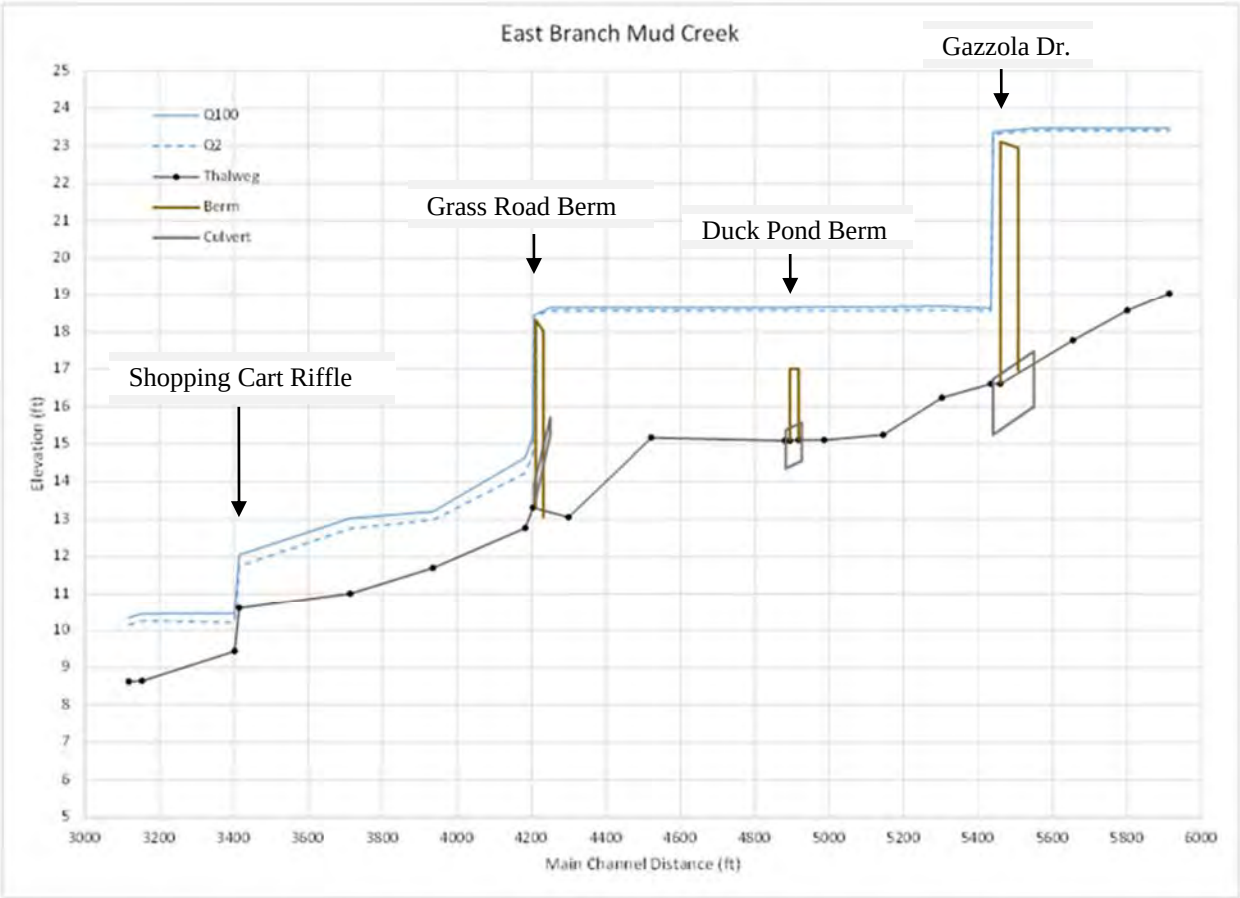


Figure 6.11. Water surface profile of East Branch Mud Creek showing the modeled water surface elevations of the 2-yr flood recurrence interval (blue dashed line) and the 100-yr flood recurrence interval (blue solid line).

Hydraulic analysis confirmed the controls at higher flood events that exist on the East Branch. Most of the hydraulic structures become dams at high flow on the East Branch and impede the natural flow of water through the valley bottom

4 Alternatives and Conceptual Plans for Ecological Restoration at Mud Creek County Park

Restoration at the County Park will focus on four major elements: stream and floodplain, upland, site re-development, and stormwater. Restoration objectives and potential corrective actions for each of these elements were thoroughly discussed in *Task 5 – Restoration Objectives*. Two alternatives have been developed at this Concept Level, the product of the evolution of the project assessment and analysis performed to date.

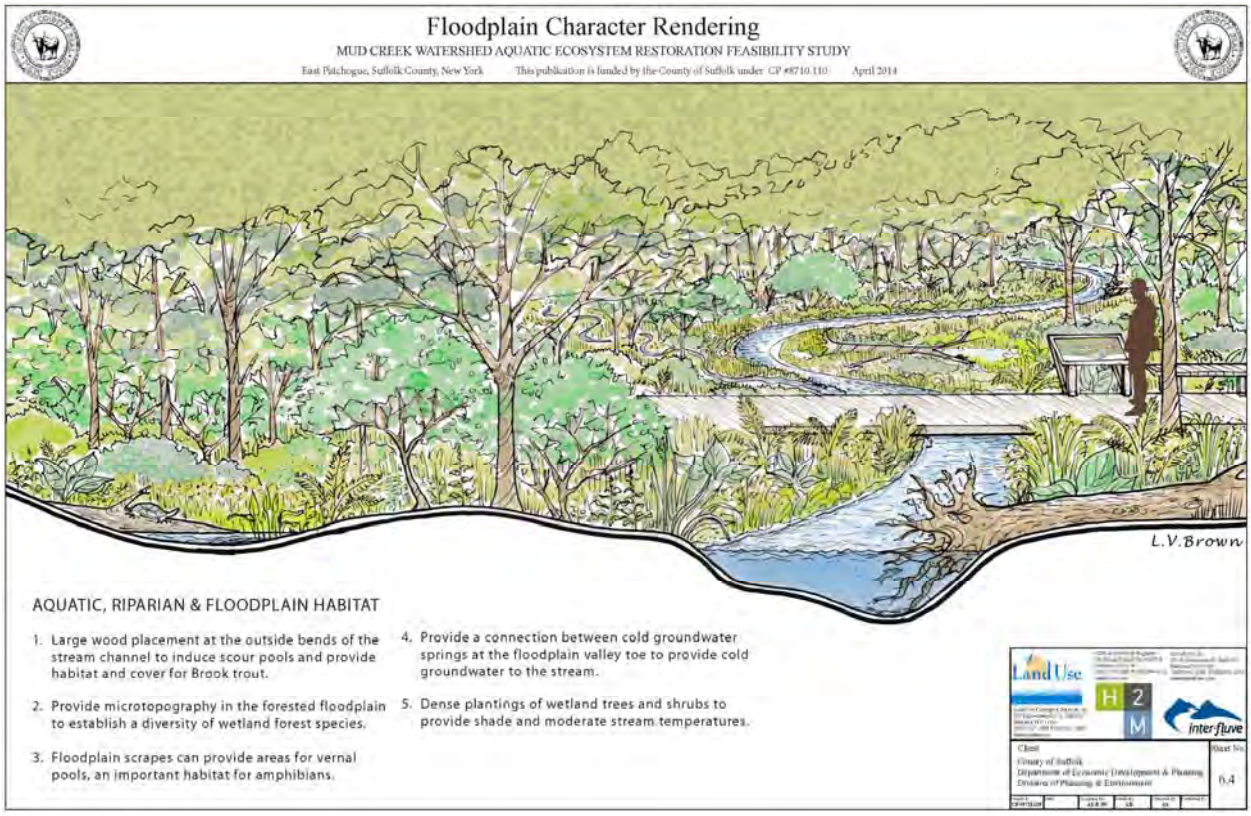
It is important to note that there are several options among each of the four elements that will accomplish project goals. A number of combinations of these exist and will be vetted among the stakeholders to arrive at a single approach to begin the process of Final Design. The design team

has assembled two alternatives with combinations of elements that will promote discussion and generate a common vision for the site.

4.1 Elements Common Among Alternatives

4.1.1 Floodplain Complexity

Similar to the importance of geomorphic complexity for maintaining complex in-stream habitat, floodplain complexity is important for maintaining a diverse floodplain and wetland habitat, as shown on Plan Sheets 6.1 – 6.7 (Plan Sheet 6.4 is below). A stream or river's floodplain is the relatively flat ground surface between the channel and valley hillslopes that is inundated when floodwaters exceeded the channel banks. Small changes in topography within the floodplain provide variability in soil moisture, which leads to variability in plant and animal habitat. Low-lying areas away from the river channel may hold water for longer periods of the year, providing habitat for amphibians and reptiles, and a water source for many terrestrial animals and birds.



The conceptual renderings for aquatic restoration at Mud Creek County Park incorporate floodplain complexity to increase the diversity of plant and animal species, improve aquatic and terrestrial habitat quality, and provide storage of flood waters during high-water events. Alternative 1, the preferred alternative, includes spring pools and tributary channels, off-channel ponds (vernal pools), and floodplain scrapes and mounds (Plan Sheets 6.2 and 6.6). Incorporation of these features in final construction designs would provide for a floodplain habitat that is most consistent with the natural conditions in the floodplains of Long Island's south shore streams. Stream discharge data collected throughout Mud Creek (and presented in

Task 4 – Existing Conditions) shows that the stream increases in discharge volume in the downstream direction with no tributaries to provide this additional water. This suggests that groundwater is entering Mud Creek. This groundwater typically emerges from the landward edges of the valley and flows through diffuse channels to the stream. Because groundwater maintains a consistently cool temperature, these groundwater sources are important for maintaining cool stream water temperatures ideal for brook trout. Therefore, the conceptual plans include the construction of small and deep spring pools along the margins of the alluvial valley with narrow tributary channels flowing from the spring pools to the main channel. The spring pools will be small in areal extent to prevent warming by the sun, but deep to maximize the cold-water potential. These cold-water tributaries and spring pools will provide cold-water refugia during the warm summer months for brook trout and other species.

In addition to the spring pools and tributary channels, we have included small off-channel ponds (vernal pools) between the stream channel and the valley edges. These ponds are not designed to be interactive with the stream channel. These ponds will likely hold water that will warm during the summer months and provide diversity of habitat for amphibians, birds, and plants, with aquatic vegetation growing within, rushes and sedges growing along the margins, and wetland shrubs and trees growing around the ponds. These ponds will fill during over-bank flood events or rain storms, with the water seeping into the underlying sand in the weeks and months following.

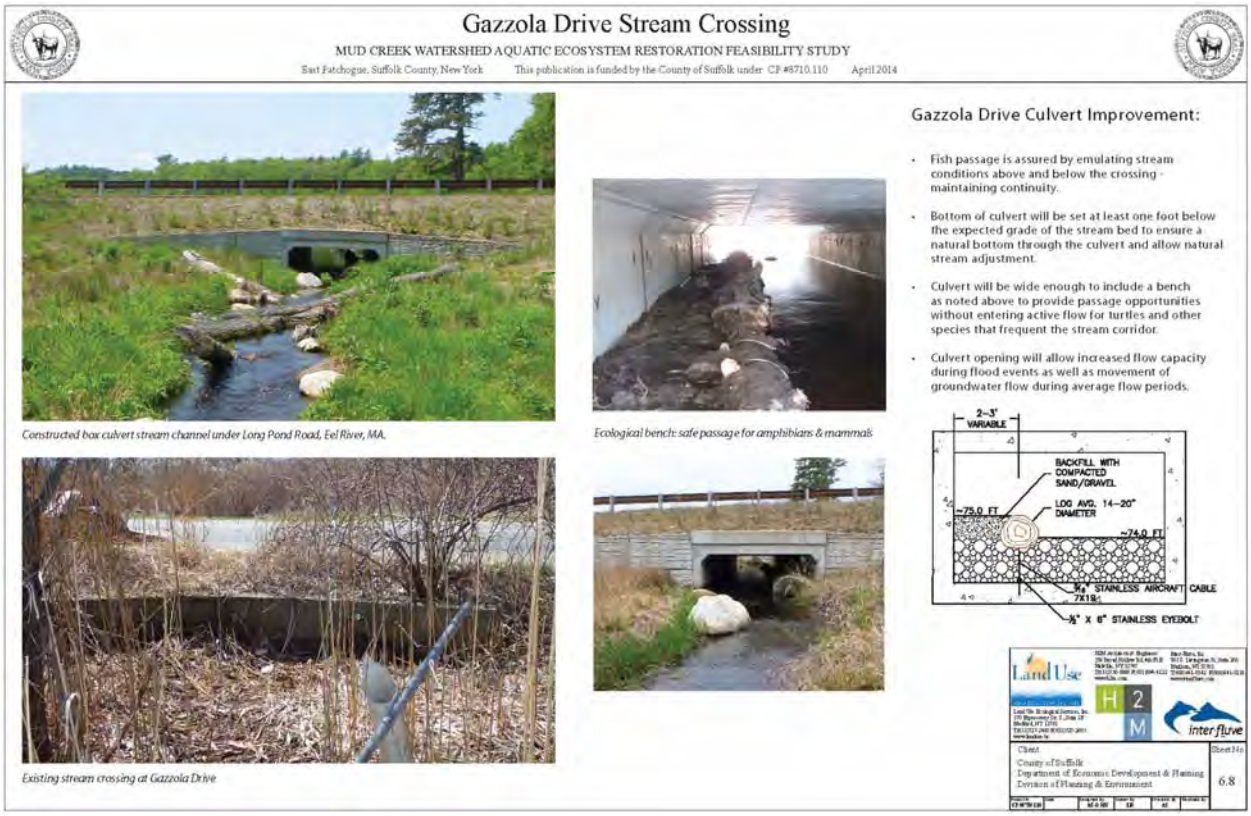
Floodplain scrapes and mounds will also be constructed throughout the floodplain. These features will replicate the scouring and deposition on floodplains that occurs during flood events around trees and other floodplain features. This microtopography will be approximately one foot above or below the average floodplain elevation. Trees and shrubs appropriate for the differing moisture levels will be planted throughout these features.

The channel and floodplain are being designed to allow regular flooding of the floodplains. This regular interaction between the channel and floodplain helps maintain the floodplain microtopography features described above and delivers wood and nutrients to the river channel critical for maintaining habitat complexity. An example of the channel and floodplain forest that will develop in the East Branch above Gazzola Drive and elsewhere with restoration is presented in Photo 8.

Photo 8: The upper section of the West Branch provides an example of the channel and floodplain forest that will develop in the East Branch above Gazzola Drive and elsewhere with restoration.

4.1.2 Barrier Removal

All barriers within the project area will be removed to allow fish access throughout the project area. The undersized pipes under Gazzola Drive will be replaced with a larger crossing that provides natural water and sediment transport, fish and aquatic organism passage, as well as terrestrial organism passage (Plan Sheet 6.8, below). The culvert will be partially buried and native channel substrate will be placed inside the culvert. A floodplain bench with similar bank heights as the proposed Mud Creek channel upstream and downstream of the culvert will be constructed inside the culvert. This floodplain bench will remain dry during most water flows and provide terrestrial passage for turtles, raccoons, foxes, and other small animals that live along Mud Creek.



It is important to note that while all barriers in the Gallo Duck Farm Restoration Area will be removed and full fish and aquatic organism passage will be available under both alternatives, hydraulic controls downstream still effect the channel and inhibit the full restoration of the Mud Creek corridor.

4.1.3 Site Re-Development

All alternative conceptual plans for Mud Creek County Park show the razing of all dilapidated buildings under controlled demolition. Eight of the buildings (approximately 33,000 square feet) have asbestos containing materials (ACM) in the form of transite board, but also included flashing, floor tiles, wallboard and transite pipe. The poor and dilapidated condition of the site buildings severely restricts or prohibits a normal asbestos abatement. Accordingly, controlled demolition with asbestos in place is planned for these structures. The footprints of the demolished buildings will be included in the upland restoration and re-vegetated with native plants.

Building demolition shall include the removal or abandonment in place of the four out-of-service cesspools identified in *Task 4 – Existing Conditions* in accordance with applicable Suffolk County Department of Health Services (SCDHS) regulations. While not shown on the conceptual plans developed for this task, site re-development will address the extensive network of sub-surface pipes present on the property by excavating and removing pipe access vaults, capping pipe ends, and filling and grading the pipe vault with clean material. Utility poles and overhead wires within the project site shall be removed.

Similarly, the extensive distribution and required removal of debris cannot be clearly shown on the conceptual plans. However, debris and soil/debris stockpiles will be removed from the project site and disposed of at a licensed municipal landfill or recycling facility. Removed debris shall include the identified soil and debris stockpiles, the rowboat, boat motor, lawn mower and wood splitter inside Building A; the automobile, boat and personal watercraft located outside the Slaughterhouse; the top to a pickup truck outside Building C; the pickup truck outside Building I; the truck trailer located south of Building B; the refrigerated truck trailer and gas cylinders of indeterminable size north of Building 11; the bulldozer located northwest of the aeration basins; the payloader located in the northeastern portion of the site; the miscellaneous vehicle parts located east of the trailer in the northwest portion of the site; and all small debris including fence posts, sections of fence, tires, bricks, and miscellaneous garbage and trash. A key to the building identification numbers/letters is provided in *Task 4 – Existing Conditions*.

All containers of potentially hazardous materials identified will be disposed of at a licensed waste disposal facility including the approximately two dozen 1-gallon paint cans, four 5-gallon buckets filled with an aqueous solution, one 5-gallon bucket filled with an oil-like substance, two 1-gallon cans of paint thinner, and several empty 55-gallon drums and three 5-gallon propane tanks inside Building A.

The conceptual restoration plans for Mud Creek County Park include parking areas with driveway access from Gazzola Drive. The parking area, 21,600± square feet, provides sufficient space for two school buses and ten passenger cars. To minimize new clearing, the existing driveway on Gazzola Drive has been maintained. Drainage for the parking lot would be provided by drywells, pending the results of the soil borings. Porous pavement will also be investigated in the final construction design phase, which would eliminate the need for drywells.

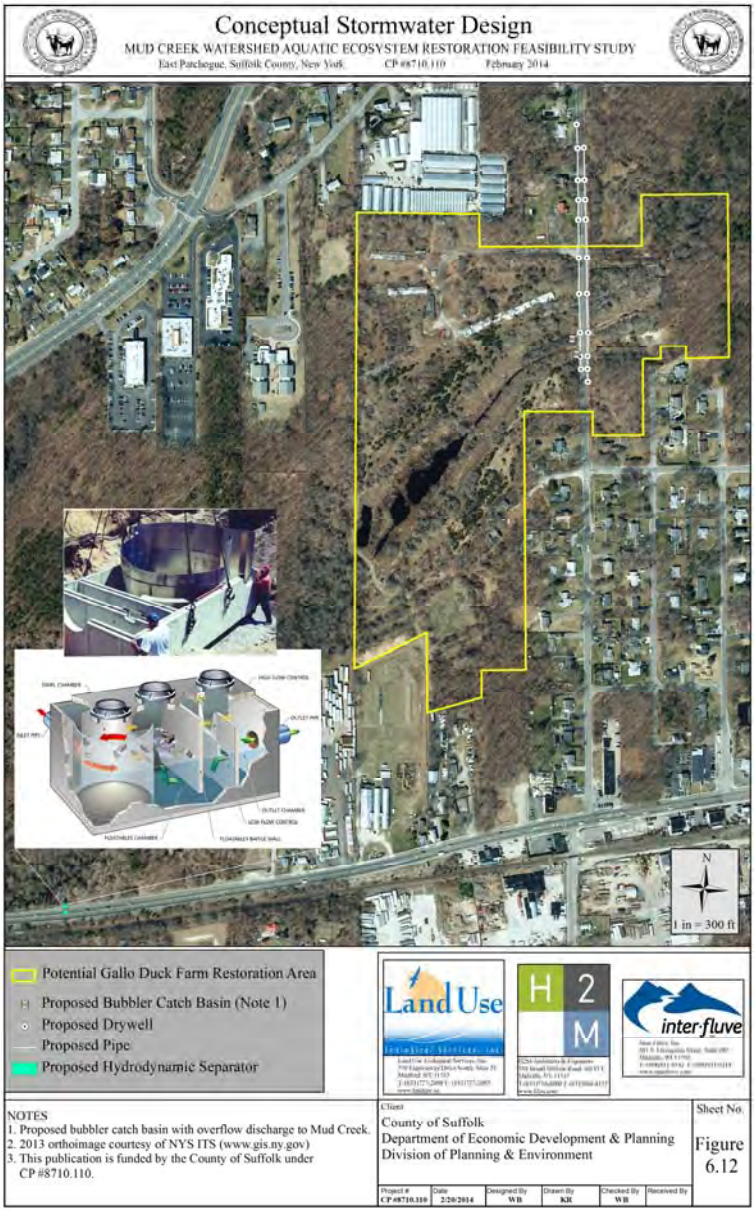
4.1.4 Stormwater Elements

Within the study area, there are two locations where stormwater from roadway surfaces discharges into the East Branch of Mud Creek. These include the stream crossings on (1) Gazzola Drive, approximately 500 feet north of Atlantic Avenue, and (2) Montauk Highway, approximately 2,300 feet west of Gazzola Drive. At each of these locations, sediments and pollutants in stormwater from paved surfaces and developed sites is discharged directly into Mud Creek without treatment.

On Gazzola Drive, there are four catch basins in the roadway that collect runoff from a 12.6 acre watershed in the immediate vicinity of Mud Creek. There are no catch basins in upland locations to allow for the collection of stormwater and discharge to the ground. As part of the restoration of Mud Creek County Park, improvements in this area will include the installation of a series of drywells at upland locations on Gazzola Drive to collect the water before discharging into Mud Creek. Drywells will effectively remove sediment and debris from storm water runoff. Additionally, the installation of drywells along Gazzola Drive will also prevent direct discharge of stormwater runoff from the watershed and maintain groundwater as the primary water source for Mud Creek.

In order to contain runoff from the 90% rainfall event of 1.2 inches (NYSDEC, 2010) for the entire contributing watershed (approximately 13,000 cubic feet of runoff), approximately 20 drywells (10 ft in diameter) would be required along Gazzola Drive between Atlantic Avenue

and Patchogue-Yaphank Road (Figure 6.12). For storm events that produce more than 1.2 inches of rain, an overflow device will be included with the drywell system that allows excess stormwater to drain to Mud Creek via a vegetated swale.



On Montauk Highway, stormwater runoff is collected by a series of catch basins along Montauk Highway between Gazzola Drive and Mud Creek. These catch basins discharge untreated stormwater runoff into the side of the culvert that passes Mud Creek under Montauk Highway. The watershed for this drainage system is approximately 43.4 acres and includes commercial properties along Montauk Highway and residential properties along Gazzola Drive and Atlantic Avenue. The size and geometry of the watershed and quantity of stormwater runoff precludes the use of drywells to contain all runoff from the 90% rain event. Therefore, rather than collect the runoff and discharge it into the ground, the runoff can be treated with a hydrodynamic separator prior to discharge. A hydrodynamic separator is a pollutant removal device for storm

water runoff that is typically constructed of concrete and is installed on a drainage line similar to a catch basin or manhole. It removes debris, sediment and oil from storm water runoff through the use of a screen, baffles, and by creating a vortex within the chamber as storm water flows through the structure. The size and percentage of impervious surface within the watershed dictates the use of a parallel system that can be installed in-line on the existing drainage system along the north side of Montauk Highway (Figure 6.11).

4.2 Upland Habitat Restoration

4.2.1 Alternative 1: Forest Restoration

Prior to human settlement, ecological communities in upland portions of Mud Creek County Park were likely coastal oak-heath forests and/or oak-pine forests, similar to the forests observed to the northeast of the former Gallo Duck Farm (Photo 6.5). Under Alternative 1, forest restoration would be implemented on the successional fields dominated by mugwort and in the footprints of the dilapidated buildings (Plan Sheets 6.1, 6.2, and 6.6). The ecological benefits of restoring native oak forests include 1) creating a habitat corridor connecting the existing oak forests downstream and upstream of the former duck farm, 2) providing tree and shrub species whose seeds and fruits serve as excellent food resources for wildlife, and 3) increasing structural complexity (i.e. the presence of both understory and mature tree canopy) and improving habitat diversity. The existing successional fields do not provide these ecological benefits, as they are comprised nearly entirely of invasive mugwort and provide limited habitat benefits for wildlife. Due to paucity of recruitment of native oak trees into these existing mugwort fields, the ecological benefits of forest ecosystems will not be realized on the former duck farm for the foreseeable future without restoration.

Site preparation for forest restoration would involve demolition of buildings, removal of debris, and control of invasive mugwort through both mechanical methods (mowing and grubbing) and herbicide application. Recent investigations by Cornell Cooperative Extension have indicated that a combination of mechanical methods (roto-tilling) and herbicide application (dichlorenil) reduced mugwort re-emergence by 98% (Senesac and Eschenauer, 2014). After mugwort control, forest restoration areas may need additional soil preparation and augmentation depending on soil chemistry (pH, total organic carbon, and nutrient concentrations). Existing native trees located within or at the margins of the successional fields, such as black cherry, eastern redcedar, or various sumacs, will be maintained or integrated into the forest restoration design wherever possible.

Prior to tree planting, a native seed mix comprised of warm season grasses and herbaceous wildflowers shall be spread to stabilize soils and to improve habitat and aesthetics during the initial stages of forest development. This grass-dominated understory layer may persist well into forest development as shown in Photo 9. This forest restoration alternative also includes the establishment of small meadow areas comprised of warm season grasses and wildflowers surrounding the parking area and access road to increase road visibility and provide a more open view from the parking area.

Photo 9: Immature forest with grass-dominated understory. This condition may persist well into development of the forest as trees mature.

After site preparation, small caliper tree saplings (2-4' whips in #2 - #5 containers) shall be planted at a rate of 400 trees per acre (10 ft centers) following preferred stocking guidelines by (USDA-NRCS, 2000). At this stocking rate, the planted forest would be expected to achieve canopy closure in less than ten years. Tree species would consist of white oak (*Quercus alba*), black scarlet (*Quercus velutina*), chestnut oak (Quercus coccinea), red oak (*Quercus rubra*), sassafras (*Sassafras albidum*), pitch pine (*Pinus rigida*), mockernut hickory (*Carya tomentosa*), flowering dogwood (*Cornus florida*), and shadbush (*Amelachier canadensis*). Due to the open, high-light conditions present in the initial phases of forest restoration, the restoration areas will not be suitable to the shade-tolerant understory shrubs found in mature oak forests. Accordingly, only small numbers of clustered understory shrubs, such as lowbush blueberry (*Vaccinium angustifolium* and *V. vacillans*), black huckleberry (*Gaylussacia baccata*), highbush blueberry (*Vaccinium corymbosum*), bayberry (*Morella pensylvanica*), and maple-leaved viburnum (*Viburnum acerifolium*), shall be planted in suitable microsites adjacent to nearby forest stands or beneath existing native trees. In order to achieve the extensive blueberry-huckleberry shrub layer present in undisturbed oak-heath forests, it would be necessary to plant these understory shrubs after closure of the tree canopy.

White-tailed deer exert significant browsing pressure on small trees and seedlings in Suffolk County due to very high population densities (80-150 deer per square mile) (Stiller, 2013) resulting in significant changes to forest recruitment and composition (McGarvey et al. 2013). Accordingly, the planted trees must be protected from deer browsing to prevent mortality and avoid significant re-planting costs. The lowest maintenance method of protecting planted trees from deer herbivory is the construction of an 8' tall woven wire fence around the perimeter of the forest restoration areas (Photo 10). This fencing would be removed when the planted trees have grown above deer browse height.

Photo 10: Fencing installed to prevent deer browsing of forest restoration areas.

4.2.2 Alternative 2: Meadow Restoration

In Alternative 2, the mugwort-dominated successional fields and dilapidated building footprints would be converted into open meadows comprised of native warm season grasses and wildflowers (Plan Sheets 6.1, 6.3, and 6.7). Grasslands are imperiled on Long Island and throughout eastern North America due to development and forest re-growth. As a result, the populations of many grassland-dependent birds are in decline throughout New York State (New York Breeding Bird Atlas, 2000). Restored meadows and grasslands provide valuable habitat for declining bird species and native pollinators, and can be aesthetically attractive due to open vistas and the abundance and diversity of wildflowers. Approximately 13 acres of meadow habitat would be created on the successional fields and building footprints by sowing a warm season grass and wildflower mix after control of mugwort through mechanical and herbicide treatment; subsequent soil amendments, if necessary; and discing or roto-tilling to prepare the seed bed, if necessary. Warm season grass seeds are most effectively spread using a no-till seed drill and cultipacker, although a hydroseeder can also be used successfully. Appropriate warm season grasses would include little bluestem (*Schizachyrium scoparium*), switch grass (*Panicum virgatum*), Indian grass (*Sorghastum nutans*), and big bluestem (*Andropogon gerardii*) along with a diversity of herbaceous wildflowers. During the first several growing seasons of grassland establishment, early spring mowing and herbicide treatments and/or hand pulling is necessary to remove woody shrub seedlings, invasive plants, and weeds. Meadows and grassland require periodic maintenance to prevent the recruitment and growth of woody shrubs and trees. After meadow establishment, the fields would need to be mowed every 1-3 years to minimize growth of woody vegetation and invasive plants and to reduce accumulation of dead biomass and thatch. This maintenance mowing should take place in the late summer after bird nesting season.

4.2.3 Preservation of Native Forest Areas

Both Alternatives 1 and 2 preserve existing stands of native mature trees in both upland and wetland habitats and incorporate them into restoration designs. These mature trees will serve as seed sources for the restored wetland and upland habitats. Both alternatives maintain 1.6 acres of Eastern redcedar stands located on former duck feedlots (Plan Sheets 6.2 and 6.3). These redcedar stands will provide habitat complexity within the restored oak forest and will provide important winter shelter locations for wildlife and food resources (cedar fruits) for birds such as

cedar waxwing, eastern bluebird, and American goldfinch. In addition, 1.3 acres of red maple and pussy willow trees located at the landward margins of the stream restoration area will be preserved. The shade provided by these forests stands will not only cool the waters of the restored stream, but the decreased light availability will reduce the proliferation and growth of *Phragmites.*

4.2.4 Forest Enhancement Areas

Both Alternatives 1 and 2 include actions to improve habitat quality in degraded forest areas on the former duck farm (Plan Sheets 6.1 – 6.3). Forest Enhancement Area 1 consists of several stands with large mature trees, both native and invasive species. Stands of large oak trees (generally black and white oaks) are present around the asphalt driveway adjacent to the farm buildings on the north side of the site, to the east and west of the slaughterhouse, on the southern side of paved access road to the west of Gazzola Drive, and along Gazzola Drive to the south of the freshwater wetlands. The understory of these stands is dominated by native black cherry, but Asiatic bittersweet vines heavily infest the crowns of many of the oak trees. These vines can cause reduced growth and mortality of trees by shading the trees' foliage and contributing weight to the canopy branches. Restoration of these areas would include removal of occasional small caliper, invasive trees and control of the invasive vines through cutting and herbicide application to the cut vine stems. Two monospecific stands of Norway maple (*Acer platanoides*) are located in Forest Enhancement Area 1, a 1.4-acre stand in the northwestern corner and a 0.5-acre stand in the southeastern corner on the east side of Gazzola Drive. Forest Enhancment Area 1 also includes a 0.7-acre successional forest stand dominated by black locust (*Robinia pseudoacacia*) and black cherry (*Prunus serotina*) located directly west of the garage building. In these cases, the Norway maple and black locust trees are too large to be inexpensively cut and removed. Furthermore, the Norway maple stands are located at the margins of the property and, therefore, serve as a transition between the restoration areas and the neighboring greenhouse facility. Accordingly, the only restoration actions undertaken in these stands will be the removal of debris and abandoned equipment.

Forest Enhancement Area 2 includes approximately 8.8 acres of successional hardwood forest. These forests have re-grown on previously cleared areas, largely open feed pens for ducks, adjacent to the various duck farm buildings. The stands are approximately 30 years old with small, early successional, fast-growing, small trees generally ranging in size from 5-10 inches in diameter. Dominant tree species include black cherry (*Prunus serotina*), white mulberry (*Morus alba*), apple (*Malus sp.*), Norway maple (*Acer platanoides*), and black locust (*Robinia pseudoacacia*). The understory of these successional forests is typically dominated by invasive species such as mugwort (*Artemesia vulgaris*), garlic mustard (*Allaria petiolata*), Japanese honeysuckle (*Lonicera japonica*), multiflora rose (*Rosa multiflora*), and other invasive plants. Abandoned farm equipment, unconsolidated debris and refuse, and various fill (soil, sand, broken concrete, and bricks) are located throughout the successional forests. Restoration actions in these successional forests would include selective removal of co-dominant white mulberry and Norway maple to provide an advantage to the native black cherry trees. This restoration action will increase the likelihood that the future forest canopy is dominated by native black cherry. Removal of invasive trees and shrubs would involve cutting the stems as close to ground level as possible and removal of cut biomass from the project site. Herbicides would then be applied directly to the cut stumps, as many of these trees and shrubs will re-sprout from cut stems without herbicide application. All debris and abandoned equipment shall be removed

from the successional forests and disposed of off-site.

4.3 Nature Trail

Both Alternatives 1 and 2 provide for a nature trail within the restored upland and wetland habitats to offer opportunities for recreation and nature appreciation (Plan Sheets 6.2 and 6.3). Compacted earth trails shall meander through the restored upland habitats and low profile timber boardwalks and overlooks will provide views of the restored stream and forested wetlands. Compacted earth trails are recommended for the upland habitats to reduce construction and maintenance costs. The nature trail shall feature approximately ten interpretive signs providing information about the terrestrial and aquatic ecosystems of Mud Creek County Park and Long Island's duck farming history. Two alternative configurations for the nature trail are presented for evaluation by Suffolk County (Figure 6.13).

The "Meandering Loops" trail alternative aims to maximize the trail distance available to recreational users by providing multiple loops for walking or jogging. The total trail distance for this alternative is 1.54 miles. The "Mud Creek Greenbelt" trail alternative envisions the future extension of the trail system to the southwest through Suffolk County property to Montauk Highway and to the northeast on Suffolk County lands to Brookwood Lane forming a Mud Creek Greenbelt trail. This trail is less winding and more centrally located within the former duck farm property. The total trail distance for this alternative on the former duck farm property is 1.02 miles. For clarity, the nature trail on the conceptual plan views for Alternatives 1 and 2 is a more generic trail showing common features of both trail alternatives. The trail alignment

selected to proceed with the construction drawings could be the Meandering Loop alternative, the Mud Creek Greenbelt Alternative, or a hybrid of the two alternatives.

4.4 Alternative 1 –Complete Floodplain Restoration with Coastal Plain Stream

Alternative 1, the preferred alternative, includes the removal of all barriers within the former duck farm property (Plan Sheets 6.1, 6.2, and 6.6; Sheet 6.2 below). The full extent of all earthen dams and berms will be removed to allow for natural stream flow, full floodplain reconnection, and the movement of aquatic and terrestrial organisms. The stream planform will be reestablished through the center of the alluvial valley thereby maximizing the floodplain width with which the stream interacts. Cold water from springs or seeps near the valley edge traverse the floodplain, and will enter the restored stream providing cold-water habitat for brook trout and other aquatic organisms.

The restoration designs under Alternative 1 include the removal of all *Phragmites* by excavation and removal of two feet of the organic floodplain soils under the *Phragmites* to remove the rhizomes. The complete removal of *Phragmites* will allow for re-grading of the floodplain to an elevation that matches the one to two year flood elevation as well as the incorporation of the microtopography as described above. A comprehensive planting plan will incorporate native herbaceous plants, shrubs, and trees to be planted through the reconstructed floodplains. It is important to plant a diversity of floodplain species to provide short- and long-term growth, sufficient root growth and bank protection along the channel margins, differing food and habitat

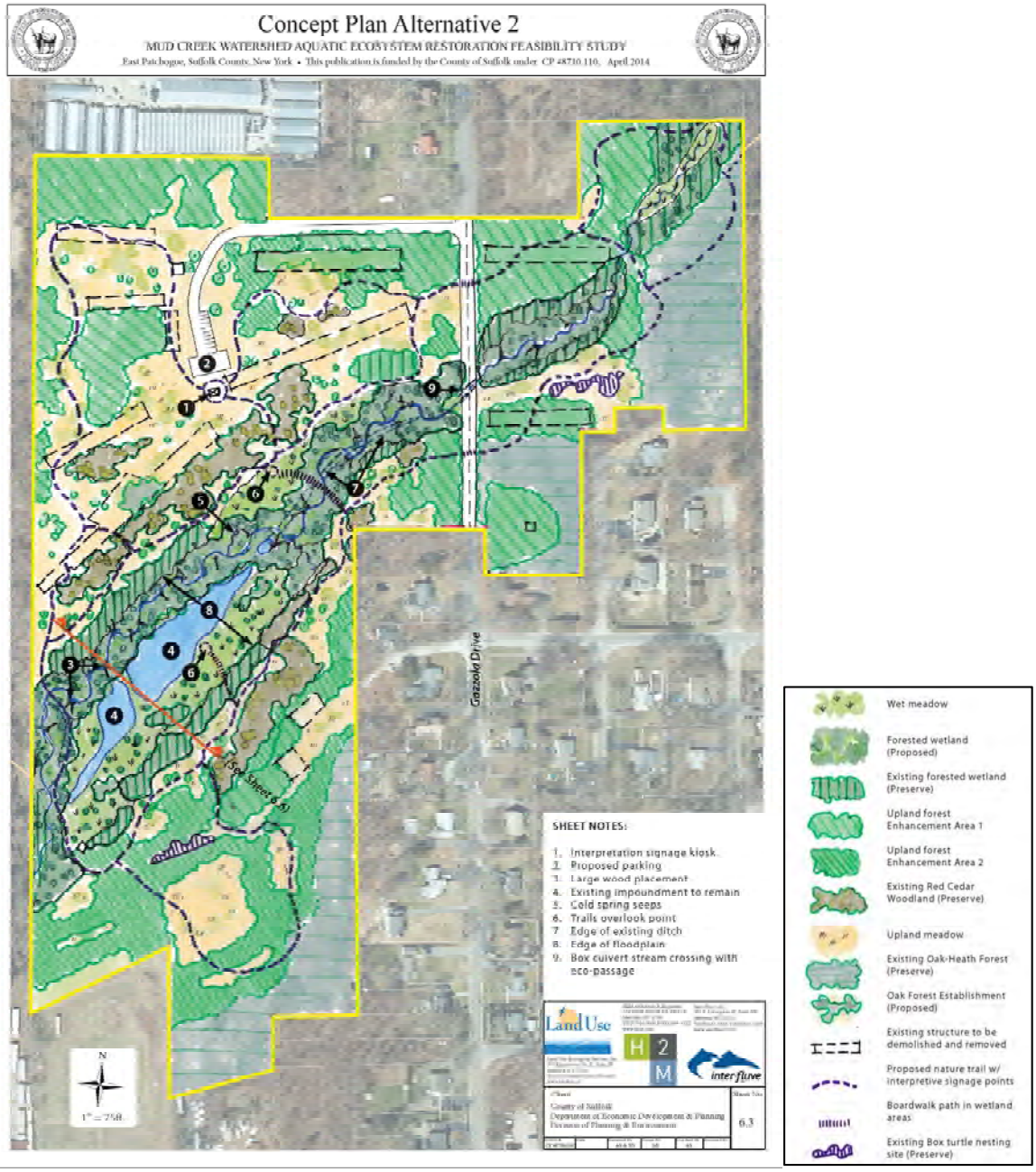
sources for a diversity of bird and terrestrial animal life, and to ensure the survival of trees and shrubs with the variability of moisture and soils on the floodplains.

Two primary options have been identified for the removal and disposal of the excavated material (19,600 cubic yards). The first option includes the disposal of the material in existing depressions that served as leaching basins for the former duck farm located outside of the Mud Creek floodplain. The material could be deposited in these depressions, capped with clean material, and planted with native herbaceous seeds, shrubs, and trees to blend into the surrounding vegetated habitats. The second option includes off-site removal of excavated material to a municipal landfill. This sediment management option increases the cost of sediment disposal three to five times (Refer to Section 5).

Alternative 1 accomplishes all ecological objectives identified in *Task 5 – Restoration Objectives* and aims to return the site to a pre-disturbance condition to the maximum extent possible.

4.5 Alternative 2 –Limited Floodplain Restoration with Coastal Plain Stream

Alternative 2 provides a lower cost alternative to aquatic ecosystem restoration at Mud Creek. The tradeoff to the lower construction costs is that Alternative 2 provides for a more limited restoration with reduced ecological and hydrological function thereby accomplishing only some of the restoration objectives identified in *Task 5*. Under Alternative 2, all barriers will be removed from the restored stream channel but some will remain within the floodplain (Plan Sheets 6.1, 6.3, and 6.7; Sheet 6.3 below).



Alternative 2 retains the open ponds within the duck farm downstream of Gazzola Drive, and as a result, the earthen barriers and dams will remain in place and the restored channel will be constructed to the west of the ponds. As described in *Task 4*, many of the earthen berms are colonized by various invasive vines, shrubs, and trees. For the earthen dam at the downstream end of the former duck farm (grass road berm), the northern portion of the dam will be removed to allow the new stream channel to flow through. The remainder of the dam will remain in place and will connect with earthen berms upstream to retain the open ponds.

While the planform and channel dimensions can be maintained in Alternative 2, the stream will not benefit from a wide floodplain. In order to minimize the interaction between the restored stream and the warm water of the ponds, the berms along the pond edges will be maintained. This will impact the ability of the floodplain to store floodwaters at larger flow events, and will also limit the extent of off-channel pools and spring channels that may develop and provide additional aquatic habitat. A few small spring pools will be incorporated from the west valley edge with associated tributaries, but off channel ponds will not possible. The large open-water ponds on the duck farm would be preserved, providing pond habitat, and will continue to get some water inputs from groundwater and potentially large floods. While the discharge will not be large to Mud Creek, the water that does enter the restored stream will be warmer during the summer months and this will decrease the water quality of Mud Creek (to what extent is unknown).

Alternative 2 will leave most of the sediment within the valley floor intact, attempting to manage *Phragmites* with herbicide instead. Due to the reduced excavation of *Phragmites* rhizomes, it is expected that Alternative 2 will require more herbicide application than Alternative 1 during construction. This approach is also less ideal as successful long-term establishment of a native floodplain community will be dependent on maintenance herbicide applications in successive years to eliminate the new growth. Excavated soil will be primarily from the stream channel and some limited adjacent floodplain grading as well as the material necessary to maintain ponds and complete berms to limit the outflow of warm water to the stream channel.

As stated previously, Alternative 2 is primarily a lower cost alternative with cost savings provided by substantial reduction of the volume of organic sediments removed from the floodplain (3,250 cubic yards compared to 19,600 cubic yards in Alernative 1). Though Alternative 2 still attains some of the restoration objectives (i.e. restoration of a coastal plain stream), the level of ecological and hydrological function is reduced and the risk of possible long-term failure, due to a re-establishment of *Phragmites* or a future breach of a pond and warm water infusion to Mud Creek, is increased.

5 Engineer's Opinion of Probable Cost

Presented costs are concept level engineer estimates to provide approximate values for comparison purposes. Actual construction costs will be finalized in *Task 9 – Prepare Final Environmental Restoration Design Plans and Specifications,* and may increase or decrease as additional information and design data are generated.

A detailed account of costs is provided in Appendix A. These costs have been based on knowledge of similar projects and construction components. A 25% contingency was added to each estimate to provide the range noted below. Cost summaries are presented below and do not include costs associated with removal of downstream barriers in the lower East Branch (such as the shopping cart riffle), any restoration efforts on County property outside of the Gallo Duck Farm Restoration Area developed in *Task* 2 – *Study Area Boundary*, long-term ecological monitoring, or long-term maintenance of the park related to stormwater, trails, and ecological elements (such as periodic meadow mowing).

Table 6.3: Range of Costs for Restoration at Mud Creek County Park

Alternative	Construction Cost	Description and Notes
Alternative 1: Complete Floodplain Restoration with Coastal Plain Stream	$1.6 – 2.0 Million	This alternative provides for complete floodplain restoration with removal of duck farm legacy sediments and *Phragmites* rhizomes, creation of 2,140 lf of new stream channel, and forested wetland restoration. - Assumes 2' excavation of floodplain to remove 20,000 cy of organic sediments, berm removal, pipe and structure removal, on-site dewatering, & off-site disposal. - Assumes *Phragmites* management through herbicide application for three years. - Assumes planting 400 trees and shrubs per acre and seeding with wet meadow mix. - Assumes fabric encapsulated soil lifts and surface fabric treatments to construct channel banks. - Assumes construction of side channels, vernal pools, and installation of woody debris for habitat enhancement throughout 6.2 acre floodplain.
Alternative 2: Limited Floodplain Restoration with Coastal Plain Stream	$370-465K	This alternative provides for partial floodplain restoration with limited removal of duck farm legacy sediments and *Phragmites* rhizomes, creation of 2,050 lf of new stream channel, and wet meadow restoration. - Assumes excavation of new stream channel (3,250 cy) will provide only removal of legacy sediments, incomplete berm removal, pipe and structure removal, on-site dewatering, and off-site disposal. - Assumes *Phragmites* management through herbicide application for five years. - Assumes planting 200 trees and shrubs per acre and seeding with wet meadow mix to create wet meadow floodplain. - Assumes fabric encapsulated soil lifts and surface fabric treatments to construct channel banks. - Assumes construction of side channels, vernal pools, and installation of woody debris for habitat enhancement only in 3.1 acre restored stream.
Alternative 1: Forest Restoration	$490-610K	This alternative provides for oak forest restoration in the site's fields and building footprints and includes: - Assumes mugwort management through grubbing and herbicide application. - Assumes planting of 450 upland trees and shrubs per acre and application of native grass seed. - Assumes installation of 8' woven wire deer exclosure fencing. - Assumes forest enhancement measures (invasive tree/shrub/vine control and debris removal) in existing forests.
Alternative 2: Meadow Restoration	$245-310K	This alternative provides for meadow restoration in the site's fields and building footprints and includes: - Assumes mugwort management through grubbing and herbicide application. - Assumes application of native warm season grass and wildflower seed. - Assumes forest enhancement measures (invasive tree/shrub/vine control and debris removal) in existing forests. - Cost does not include cost for periodic maintenance mowing (every 1-3 years) to prevent woody tree/shrub encroachment.
Stormwater Management and Gazzola Drive Culvert Improvements	$550 – 685K	Alternatives 1 and 2 are similar regarding stormwater and Gazzola Drive improvements. Proposed actions include: - Installation of 20 drywells on Gazzola Drive to minimize stormwater discharge to restored stream. - Installation of hydrodynamic separator on Montauk Highway to reduce pollutant discharge. - Installation of box culvert under Gazzola Drive to increase stream connectivity. - Stream diversion during aquatic construction.
Site Re-Development	$1.1 - $1.3 Million	Alternatives 1 and 2 are similar regarding site re-development. Proposed actions include: - Removal of dilapidated buildings (45% without asbestos and 55% with asbestos), non-hazardous debris, and abandoned equipment. - Construction of new driveway and parking facility. - Construction of 5,400-8,100 lf of bare earth nature trail, 180 lf of elevated timber boardwalk, 10 interpretive signs, benches, and litter receptacles.
Estimated Total Cost	$2.3 - $4.6 Million	

6 Recommended Option for Restoration at Mud Creek County Park

Although a number of aspects of the project can be developed in an a la carte approach as stakeholders and the design team absorb the information presented to date, the design team developed a preferred option that accomplishes the goals of the project as outlined in *Task 5 – Restoration Objectives*. Alternative 1 – Complete Floodplain Restoration and Coastal Plain Stream, including the proposed coastal plain stream, complete floodplain restoration with forested wetlands, and upland oak forest restoration is the recommended option for proceeding with construction designs and specifications.

Alternative 1 is the more expensive alternative to construct due to the costs associated with complete removal of the berms, organic sediments, and *Phragmites* rhizomes and the costs of planting woody trees and shrubs compared to herbaceous plants. However, this alternative will attain more of the County's objectives stated in *Task 5 – Restoration Objectives*, provide greater ecological function for the aquatic and upland habitats, reduce the County's long-term maintenance costs, and has increased probability of long-term success. Alternative 2 was developed largely as a lower cost option, but as discussed above, concerns abound with the assurance of success of this option, consistent with a smaller investment in the site.

Ecological restoration must exist within the realities of economic constraints. However, with restoration, investments in a site tend to mature and grow stronger and more complex with time, in essence *improving* in function. This is in direct contrast to more traditional investments in infrastructure which degrade over time and require maintenance and upkeep. There are mixtures of both components on this site, parking lots and trails will require long term maintenance, but floodplains and uplands, if developed correctly as outlined in Alternative 1, will require less maintenance over time as they mature.

Complete removal of the accumulated organic sediments on the former duck farm is consistent with Suffolk County's efforts beginning in the late 1960's (by dredging duck sludge from tidal creeks) to remediate the adverse effects of the duck farming industry on the County's freshwater streams and tidal creeks and bays. Complete floodplain restoration at Mud Creek County Park will remove all legacy sediments from the duck farm site and the potential for these sediments to contribute nutrients to downstream reaches of Mud Creek and the South Shore Estuary. The complete removal of *Phragmites* rhizomes and the planting of the restored floodplain with wetland trees to provide shade will minimize the likelihood of *Phragmites* re-colonizing the restored floodplain and the maintenance efforts required by the County to keep these habitats free of *Phragmites*. In addition, the shade created by the proposed riparian forest canopy will serve to cool the floodplain and stream waters thereby maximizing the habitat quality for brook trout. Finally, complete floodplain restoration will provide greater floodplain width, increased area of off-channel pools and side channels, and more diverse wetland and aquatic habitats for brook trout and other aquatic species. In contrast, Alternative 2 creates less floodplain and side channel habitats for brook trout and aquatic species, is more dependent on herbicides to control *Phragmites* during and after construction, and maintains the existing shallow ponds likely resulting in higher water temperatures and reduced habitat quality for brook trout.

In the upland portions of the project site, it is recommended that restoration actions aim to create oak forests rather than warm season meadows. The restored oak forests will connect the oak forests located downstream and upstream of the Gallo Duck Farm Restoration Area, provide greater habitat area for wildlife, create a more complex and diverse habitat with multiple strata of vegetation (i.e. ground layer, understory, and forest canopy), will provide food resources for wildlife such as acorns and other fruits and seeds, and will create shaded habitats that are less likely to be re-colonized by mugwort and other invasive herbaceous plants. Lastly, these oak forests will require less long-term maintenance by Suffolk County Parks, as the upland meadows proposed in Alternative 2 will require mowing every one to three years to prevent the encroachment of woody shrubs/trees and invasive plants.

Regardless of the aquatic and upland habitat restoration alternatives selected, it is recommended that all dilapidated buildings, abandoned equipment and debris, stockpiled soils, out-of-service sanitary systems, pipes and pipe vaults, and out-of-service utility poles be removed from the site to remove the hazardous condition and aesthetic impacts posed to the surrounding neighborhood and to create a safe recreational amenity for residents.

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Appendix A – Engineer's Opinion of Probable Cost

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Stream and Floodplain

Alternative 1: Complete Floodplain Restoration with Coastal Plain Stream

Item	Provision	Item	Unit	Quantity	Unit Price	Subtotal	Notes
1	Stream	Stream Diversion & Dewatering	LS	0	$0	$0	See Stormwater - Stream Diversion/Bypass Pumping Item
2	Stream and Floodplain	General Earthwork	CY	1500	$10	$15,000	General earthwork including berm removal, microtopography, removal of pipes and structures
3	Floodplain	Floodplain *Phragmites* Excavation	CY	18130	$55	$997,150	2-foot depth excavation of all delineated phragmites, disposed off site; Cost for off-site disposal including on site drying
4	Floodplain	*Phragmites* Treatment	AC	5.6	$5,000	$28,000	Herbicide Phragmites prior to excavation (Year 1), Two follow-up Treatments (Years 2 and 3)
5	Floodplain	Floodplain Fill	CY	6040	$12	$72,480	Floodplain filling to get proposed floodplain elevation. Estimated 1/3 of Duck Pond impoundment needs to be brough up to grade with fill
6	Stream and Floodplain	Pond Sediment Removal	CY	1870	$55	$102,850	Estimated 1520 CY upper pond (ave 2.25 foot depth) , 270 CY middle pond (ave 1.5 foot depth), 80 CY lower pond (ave. 3 foot depth); Cost for off-site disposal including on site drying
7	Stream	Fabric Encapsulated Soil Lift	LF	3085	$28	$86,380	2-foot height channel bank construction, outside bends only and both banks through transition zones, 2 lifts high, total single sided channel length = 1330 ft, total double sided channel length = 106 ft
8	Stream	Surface Fabric Treatment	SY	2030	$20	$40,600	Channel bank construction on inside bends and straight channels, total fabric length ~2726 ft, fabric width = 6.7 ft
9	Stream	Streambed Gravel	TON	245	$40	$9,800	Downstream tie-in transition riffle replacing berm crossing (70'x25'x1.5'), Gazzola culvert embedding (100'x10'x1.5'), 1.6 tons/cy
10	Stream	Large Woody Debris Placement	EA	210	$350	$73,500	Roughly 10 pieces every 100-ft total stream length of 2140 ft
11	Planting	Seeding	AC	5.6	$7,000	$39,200	Entire phragmites area plus ponded areas minus stream
12	Planting	Tree Planting	EA	980	$45	$44,100	Supply, Install, Guarantee Woody Tree (2-4' tree, #3 container), 175 trees per acre
13	Planting	Shrub Planting	EA	1260	$30	$37,800	Supply, Install, Guarantee Woody Shrub (2-4' shrub, #2 container). 225 shrubs per acre
14	Maintenance	Invasive Species Control	AC	5.6	$2,000	$11,200	Invasive species control (Herbicide Application) for Years 4-5
					Total Complete Floodplain Restoration Cost	$1,558,060	

Alternative 2: Limited Floodplain Restoration with Coastal Plain Stream

Item	Provision	Item	Unit	Quantity	Unit Price	Subtotal	Notes
1	Stream	Stream Diversion & Dewatering	LS	0	$0	$0	See Stormwater - Stream Diversion/Bypass Pumping Item
2	Stream and Floodplain	General Earthwork	CY	3250	$12	$39,000	General earthwork including channel excavation, berm removal, microtopography, removal of pipes and structures
3	Floodplain	Floodplain *Phragmites* Excavation	CY	0	$55	$0	Not proposed with limmited floodplain restoration alternative
4	Floodplain	*Phragmites* Treatment	AC	5.6	$7,000	$39,200	Herbicide Phragmites, Follow Treatments over 5 years
5	Floodplain	Floodplain Fill	CY	0	$12	$0	Not proposed with limmited floodplain restoration alternative
6	Stream and Floodplain	Pond Sediment Removal	CY	0	$55	$0	Not proposed with limmited floodplain restoration alternative
7	Stream	Fabric Encapsulated Soil Lift	LF	2955	$28	$82,740	2-foot height channel bank construction, outside bends only and both banks through transition zones, ratio with option 1
8	Stream	Surface Fabric Treatment	SY	1948	$20	$38,960	Channel bank construction on inside bends and straight channels, ratio with option 1
9	Stream	Streambed Gravel	TON	245	$40	$9,800	Downstream tie-in transition riffle replacing berm crossing (70'x25'x1.5'), Gazzola culvert embedding (100'x10'x1.5')
10	Stream	Large Woody Debris Placement	EA	200	$350	$70,000	Roughly 10 pieces every 100-ft total stream length of 2050 ft
11	Planting	Seeding	AC	5.7	$7,000	$39,900	Entire phragmites treatment area minus stream
12	Planting	Tree Planting	EA	285	$45	$12,825	Supply, Install, Guarantee Woody Tree (2-4' tree, #3 container), 50 trees per acre
13	Planting	Shrub Planting	EA	560	$30	$16,800	Supply, Install, Guarantee Woody Shrub (2-4' shrub, #2 container). 100 shrubs per acre
14	Maintenance	Invasive Species Control	AC	5.6	$3,000	$16,800	Invasive species control (Herbicide Application) for Years 4-5
					Total Limited Floodplain Restoration Cost	$366,025	

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Upland Transitions

Alternative 1: Forest Restoration

Item	Provision	Item	Unit	Quantity	Unit Price	Subtotal	Notes
1	Planting	Mugwort Treatment	AC	10.6	$2,500	$26,500	Herbicide Mugwort prior to grubbing, Follow-up Treatments over 3 years
2	Planting	Grubbing	AC	10.6	$3,500	$37,100	Grub Herbaceous Field (6-12" depth)
3	Planting	Seeding	AC	10.6	$7,000	$74,200	Upland Seed Mix Sowed with No Till Seed Drill
4	Planting	Tree Planting	EA	3180	$45	$143,100	Supply, Install, Guarantee Woody Tree (2-4' tree, #3 container), 300 trees per acre
5	Planting	Shrub Planting	EA	530	$30	$15,900	Supply, Install, Guarantee Woody Shrub (2-4' tree, #2 container), 50 trees per acre
6	Deer Fencing	Deer Exclosure Fencing (Includes Wetland A	LF	6500	$15	$97,500	8' Woven Wire Fence Installed
7	Deer Fencing	Corner	EA	30	$140	$4,200	
8	Deer Fencing	10' Gate with Latch	EA	5	$380	$1,900	
9	Planting	Forest Enhancement 1	AC	3.9	$3,000	$11,700	
10	Planting	Forest Enhancement 2	AC	8.8	$8,500	$74,800	
10	Maintenance	Maintenance Mowing of Parking Lot Meado	AC	2	$1,200	$2,400	Annual mowing of meadow around parking area (Years 3-5)
					Total Forest Restoration Cost	$489,300	

Alternative 2: Meadow Restoration

Item	Provision	Item	Unit	Quantity	Unit Price	Subtotal	Notes
1	Planting	Mugwort Treatment	AC	10.6	$2,500	$26,500	Herbicide Mugwort prior to grubbing, Follow-up Treatments over 3 years
2	Planting	Grubbing	AC	10.6	$3,500	$37,100	Grub Herbaceous Field (6-12" depth)
3	Planting	Seeding	AC	10.6	$7,000	$74,200	Upland Seed Mix Sowed with No Till Seed Drill
4	Planting	Tree Planting	EA	0	$45	$0	
5	Planting	Shrub Planting	EA	0	$30	$0	
6	Deer Fencing	Deer Exclosure Fencing (Includes Wetland A	LF	0	$6	$0	
7	Deer Fencing	Corner	EA	0	$140	$0	
8	Deer Fencing	10' Gate with Latch	EA	0	$380	$0	
9	Planting	Forest Enhancement 1	AC	3.9	$3,000	$11,700	
10	Planting	Forest Enhancement 2	AC	8.8	$8,500	$74,800	
11	Maintenance	Maintenance Mowing of Parking Lot Meado	AC	2	$1,200	$2,400	Annual mowing of meadow around parking area (Years 3-5)
12	Maintenance	Maintenance Herbicide Treatment	AC	10.6	$950	$10,070	Invasive species control (Herbicide Application) for Years 4-5
13	Maintenance	Meadow Maintenance	AC	10.6	$600	$6,360	Mowing of meadows to prevent woody shrub encroachment (Years 3 and 5)
					Total Meadow Restoration Cost	$243,130	

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Stormwater Management

Item	Provision	Item	Unit	Quantity	Unit Price	Subtotal	Notes
Gazzola Drive							
1	Drainage (Gazzola Drive)	Erosion Control	LS	1	$ 5,000	$5,000	
2	Drainage (Gazzola Drive)	Remove Pavement	SY	700	$ 7	$4,900	
3	Drainage (Gazzola Drive)	New Drywells	EA	20	$ 4,000	$80,000	
4	Drainage (Gazzola Drive)	New Pipe	LF	1170	$ 70	$81,900	
5	Drainage (Gazzola Drive)	Dewatering	LS	1	$ 30,000	$30,000	
6	Drainage (Gazzola Drive)	Utility Modifications	LS	1	$ 10,000	$10,000	
7	Drainage (Gazzola Drive)	Stream Diversion/Bypass Pumping	LS	1	$ 30,000	$30,000	
8	Drainage (Gazzola Drive)	New Culvert	LF	100	$ 700	$70,000	
9	Drainage (Gazzola Drive)	New Pavement Base	CY	120	$ 70	$8,400	
10	Drainage (Gazzola Drive)	New Asphalt Pavement	TON	150	$ 110	$16,500	
11	Drainage (Gazzola Drive)	Restoration/Seeding	LS	1	$ 5,000	$5,000	
12	Drainage (Gazzola Drive)	Traffic Maintenance	LS	1	$ 10,000	$10,000	
					Total Gazzola Drive	$351,700	
Montauk Highway							
13	Drainage (Montauk Highway)	Erosion Control	LS	1	$ 3,000	$3,000	
14	Drainage (Montauk Highway)	Remove Pavement	SY	200	$ 7	$1,400	
15	Drainage (Montauk Highway)	New Hydrodynamic Seperator	EA	1	$ 150,000	$150,000	
16	Drainage (Montauk Highway)	New Manholes	EA	2	$ 3,000	$6,000	
17	Drainage (Montauk Highway)	New Pavement Base	CY	30	$ 70	$2,100	
18	Drainage (Montauk Highway)	New Asphalt Pavement	TON	60	$ 110	$6,600	
19	Drainage (Montauk Highway)	Miscellaneous Site Restoration	LS	1	$ 15,000	$15,000	
20	Drainage (Montauk Highway)	Traffic Maintenance	LS	1	$ 10,000	$10,000	
					Total Montauk Highway	$194,100	
					Total Cost for Stormwater Improvements	$545,800	

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Site Re-Development

Option: Meandering Loops

Item	Provision	Description	Unit	Quantity	Unit Price	Subtotal	Notes
1	Building Demolition	Remove Existing Buildings (No Asbestos)	SF	25000	$ 10	$250,000	
2	Building Demolition	Remove Existing Buildings (With Asbestos)	SF	33000	$ 15	$495,000	includes demo of structures without separate abatement
3	Debris Removal	Dispose non-hazardous debris	CY	100	$ 100	$10,000	
4	Debris Removal	Dispose cars, trucks, trailers	LS	1	$ 10,000	$10,000	
5	Driveway and Parking	Remove Existing Pavement	SY	1600	$ 7	$11,200	
6	Driveway and Parking	Rough Grading	LS	1	$ 5,000	$5,000	
7	Driveway and Parking	New Pavement Base	CY	450	$ 70	$31,500	
8	Driveway and Parking	New Asphalt Pavement	TON	530	$ 110	$58,300	
9	Driveway and Parking	New Drywells	EA	5	$ 4,000	$20,000	
9	Trail	Boardwalk Trail	LF	180	$ 330	$59,400	
10	Trail	Bare Earth Trail	LF	8120	$ 10	$81,200	
11	Trail	Overlook	EA	2	$3,500	$7,000	
12	Site	Benches	EA	4	$2,000	$8,000	
13	Site	Litter Receptacles	EA	1	$1,000	$1,000	
14	Site	Interpretive Signage	EA	10	$1,500	$15,000	
					Total Meandering Loop Cost	$1,062,600	

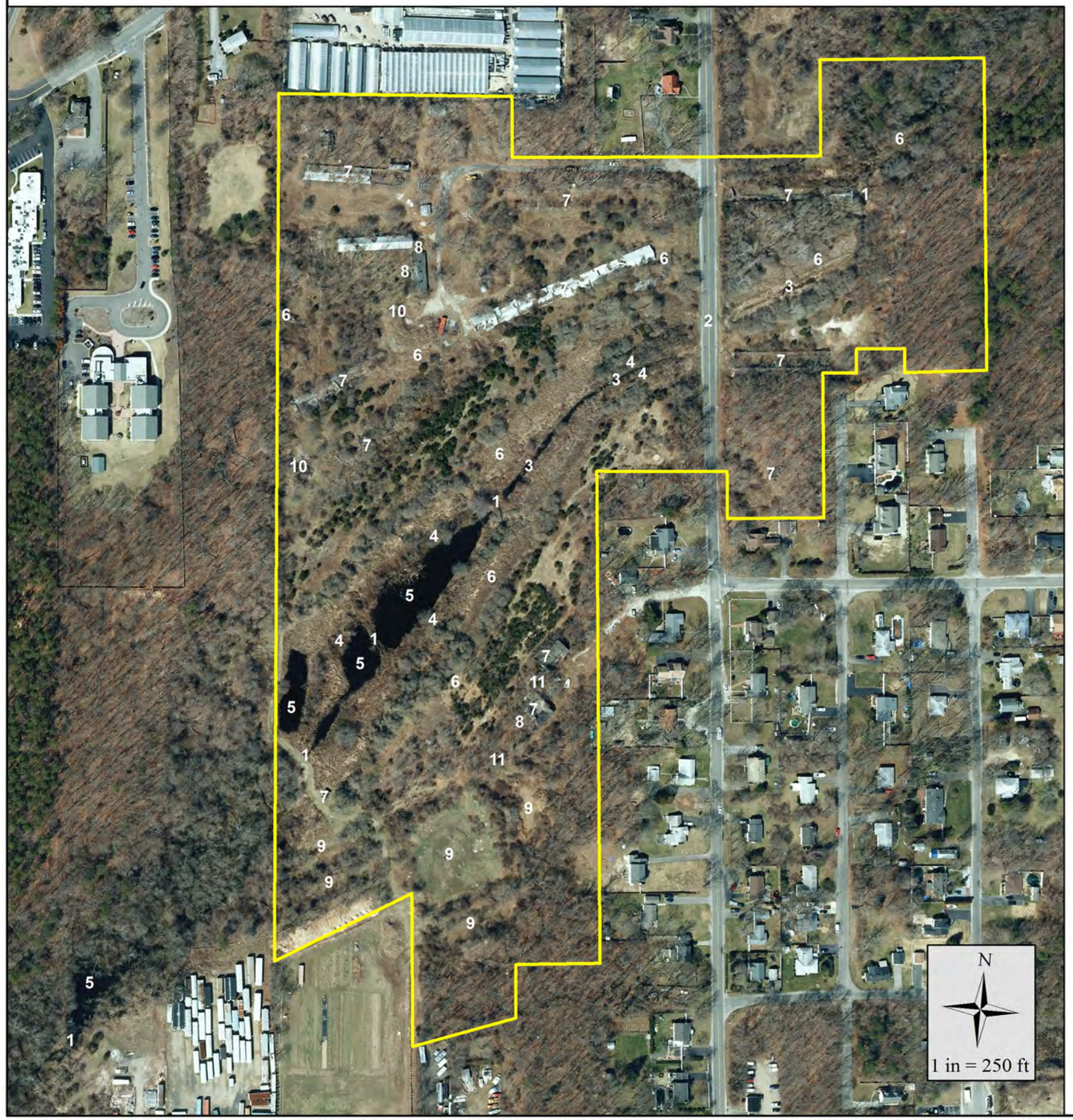
Option: Greenbelt

Item	Provision	Description	Unit	Quantity	Unit Price	Subtotal	Notes
1	Building Demolition	Remove Existing Buildings (No Asbestos)	SF	25000	$ 10	$250,000	
2	Building Demolition	Remove Existing Buildings (With Asbestos)	SF	33000	$ 15	$495,000	includes demo of structures without separate abatement
3	Debris Removal	Dispose non-hazardous debris	CY	100	$ 100	$10,000	
4	Debris Removal	Dispose cars, trucks, trailers	LS	1	$ 10,000	$10,000	
5	Driveway and Parking	Remove Existing Pavement	SY	1600	$ 7	$11,200	
6	Driveway and Parking	Rough Grading	LS	1	$ 5,000	$5,000	
7	Driveway and Parking	New Pavement Base	CY	450	$ 70	$31,500	
8	Driveway and Parking	New Asphalt Pavement	TON	530	$ 110	$58,300	
9	Driveway and Parking	New Drywells	EA	5	$ 4,000	$20,000	
9	Trail	Boardwalk Trail	LF	180	$ 330	$59,400	
10	Trail	Bare Earth Trail	LF	5410	$ 10	$54,100	
11	Trail	Overlook	EA	2	$3,500	$7,000	
12	Site	Benches	EA	4	$2,000	$8,000	
13	Site	Litter Receptacles	EA	1	$1,000	$1,000	
14	Site	Interpretive Signage	EA	10	$1,500	$15,000	
					Total Greenbelt Cost	$1,035,500	

Existing Stressors and Impacts

MUD CREEK WATERSHED AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

East Patchogue, Suffolk County, New York CP #8710.110 April 2014



STRESSORS AND IMPACTS

1 - Flow Barrier from Duck Farm Earthen Dam
2 - Stormwater Discharge and Hydrological Impacts at Road Crossings
3 - Stream Channel Straightening
4 - Floodplain Manipulation by Berm Construction
5 - Sediment Accumulation in Impoundment
6 - Dense Invasive Plant Growth and Displacement of Native Vegetation
7 - Dilapidated Duck Building
8 - Out-of-Service Cesspools
9 - Altered Topography from Duck Farm Aeration and Settling Basins
10 - Stockpiled Fill and Debris
11 - Invasive Vines Threaten Native Trees
* Abandoned Equipment and Debris located throughout site

Potential Gallo Duck Farm Restoration Area

NOTES
1. 2013 orthoimage courtesy of NYS ITS (www.gis.ny.gov)
2. This publication is funded by the County of Suffolk under CP #8710.110.

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County of Suffolk
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Division of Planning & Environment

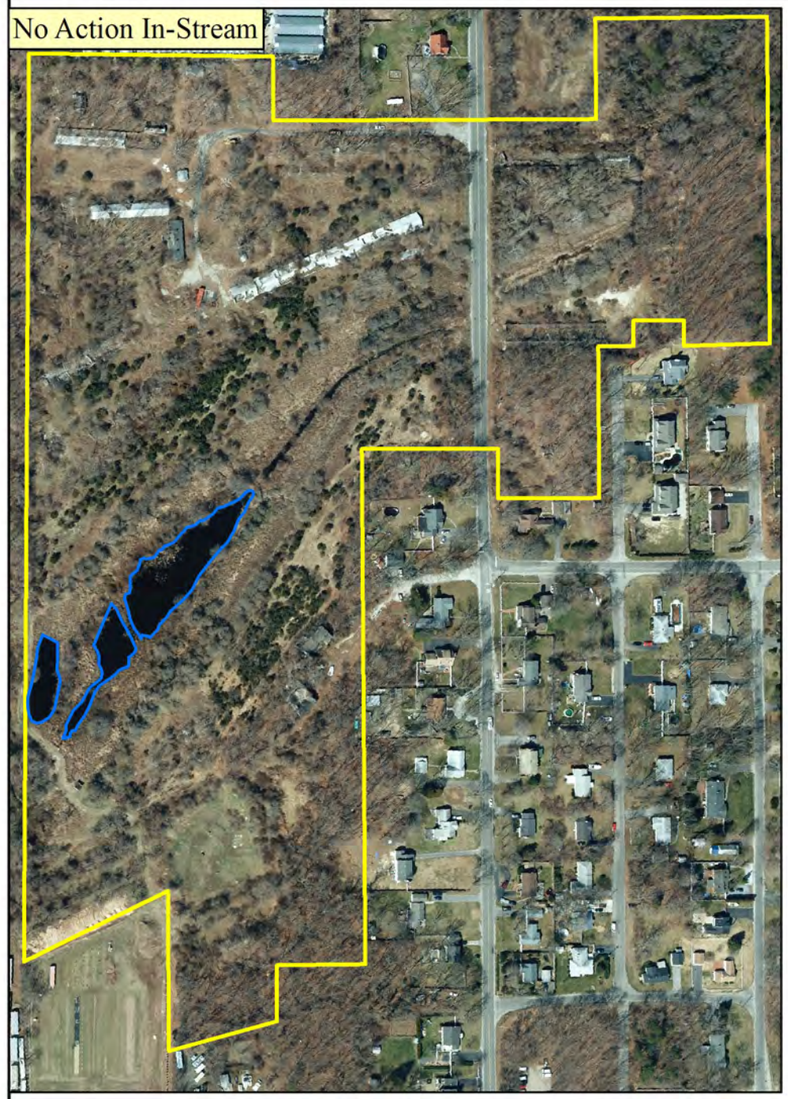
Sheet No.
Figure 6.1

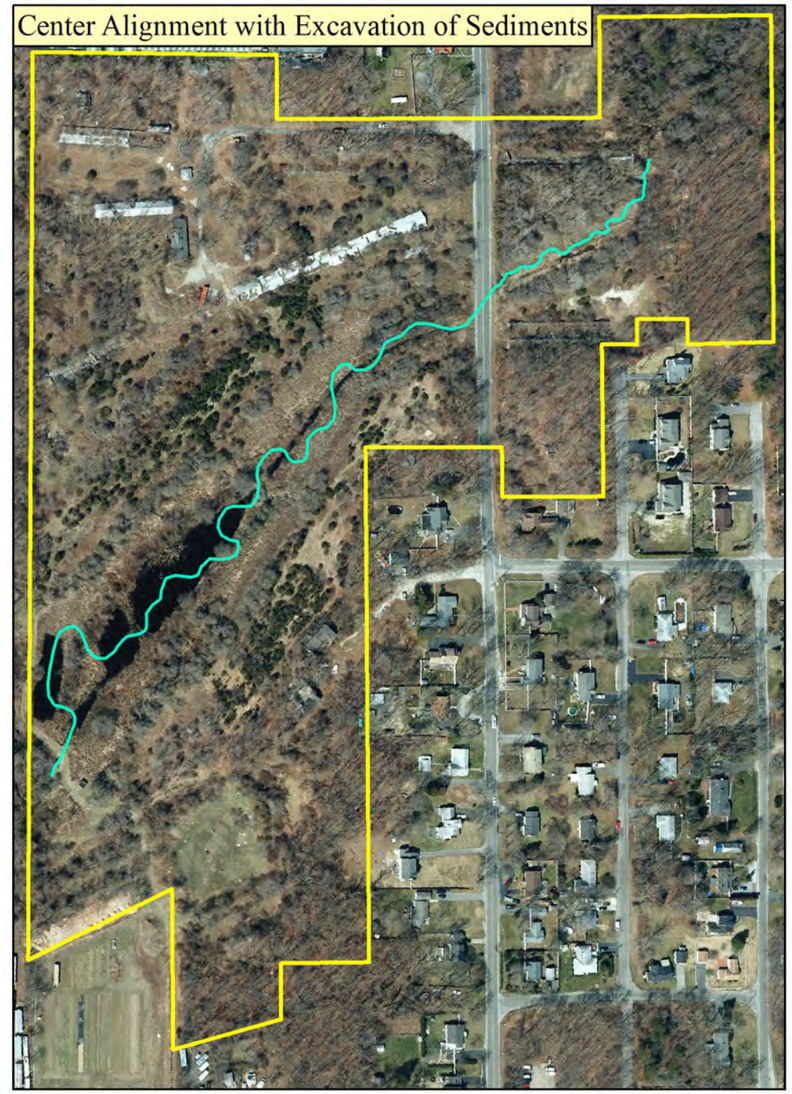
Project #	Date	Designed By	Drawn By	Checked By	Received By
CP #8710.110	4/16/2014	WB	KR	WB	

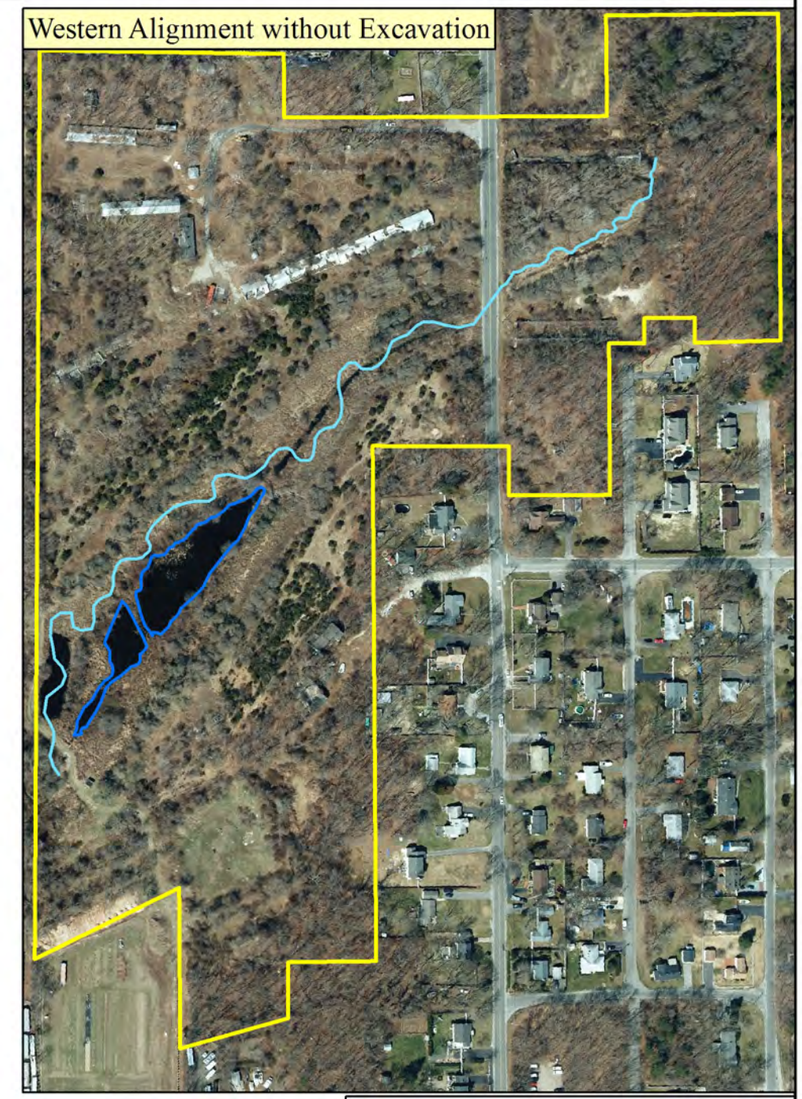
Stream Alignment Alternatives

MUD CREEK WATERSHED AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

East Patchogue, Suffolk County, New York CP #8710.110 April 2014







Potential Gallo Duck Farm Restoration Area

Proposal Channel Alternative

Center — West — Pond to Remain

Upstream — Upstream

N

1 in = 300 ft

All Maps

NOTES

1. 2013 orthoimage courtesy of NYS ITS (www.gis.ny.gov)
2. This publication is funded by the County of Suffolk under CP #8710.110.

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Figure 6.2

Project #	Date	Designed By	Drawn By	Checked By	Received By
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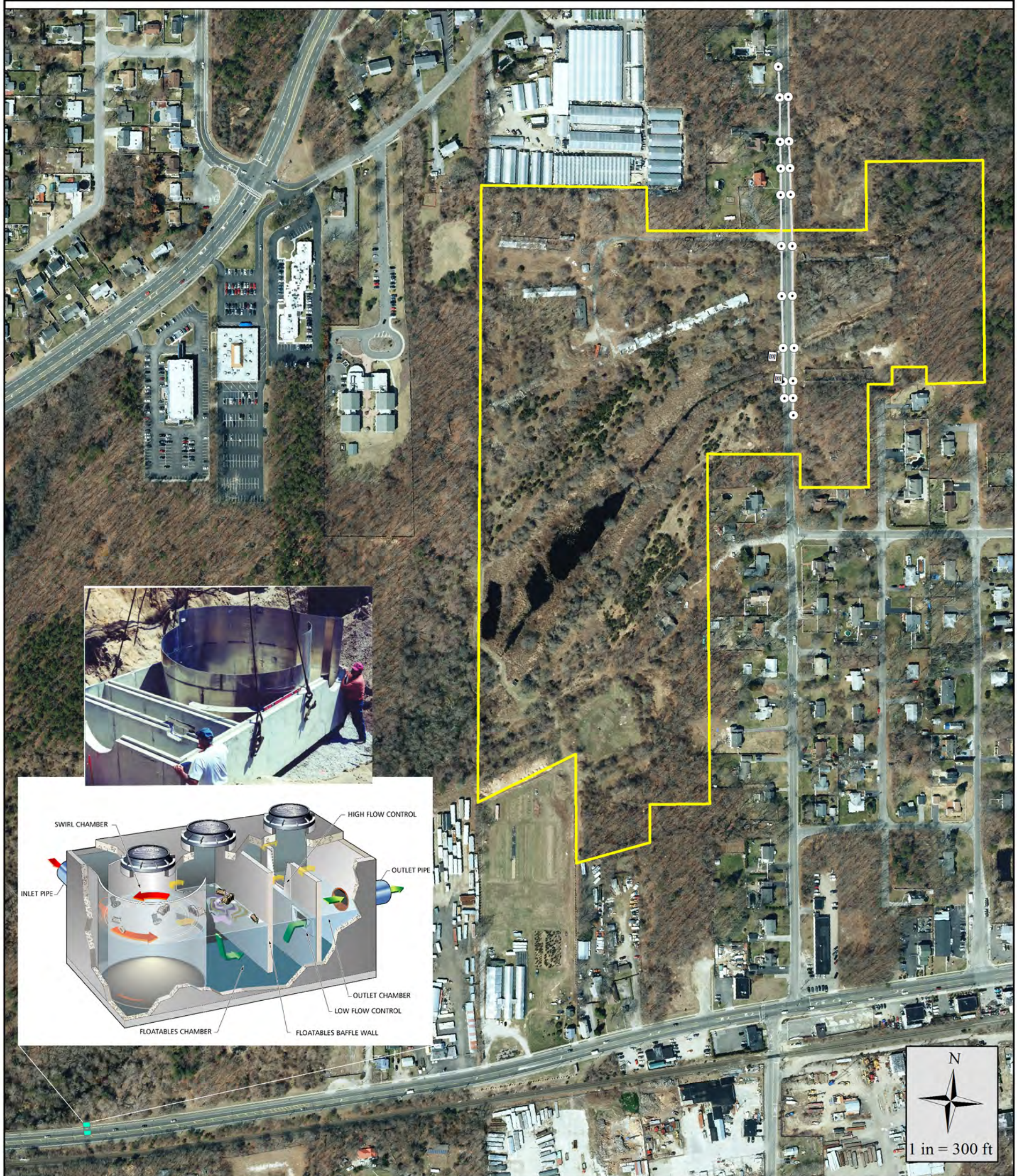
Conceptual Stormwater Design

MUD CREEK WATERSHED AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

East Patchogue, Suffolk County, New York CP #8710.110 February 2014



Potential Gallo Duck Farm Restoration Area

Proposed Bubbler Catch Basin (Note 1)

Proposed Drywell

Proposed Pipe

Proposed Hydrodynamic Separator

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NOTES

1. Proposed bubbler catch basin with overflow discharge to Mud Creek.
2. 2013 orthoimage courtesy of NYS ITS (www.gis.ny.gov)
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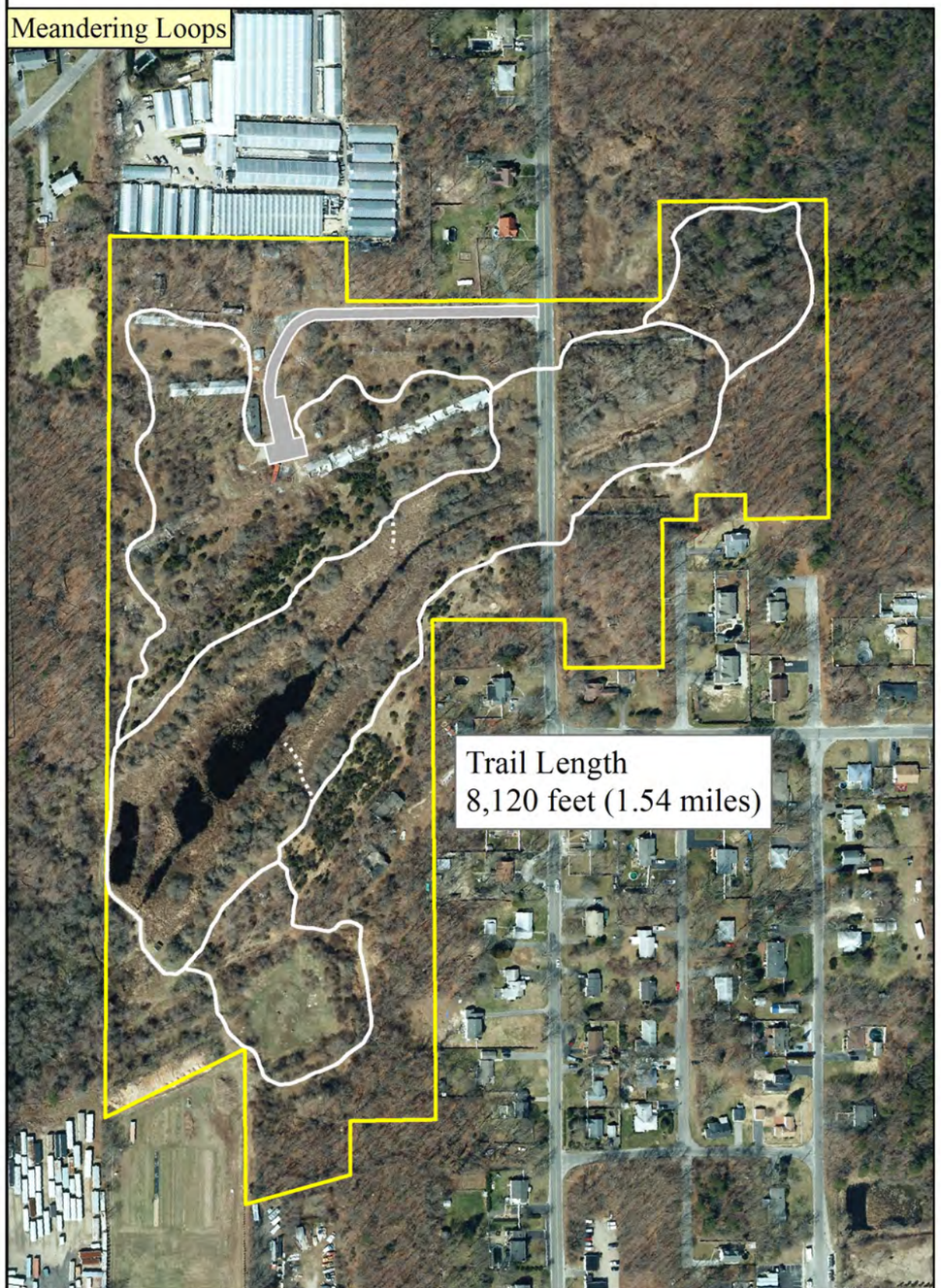
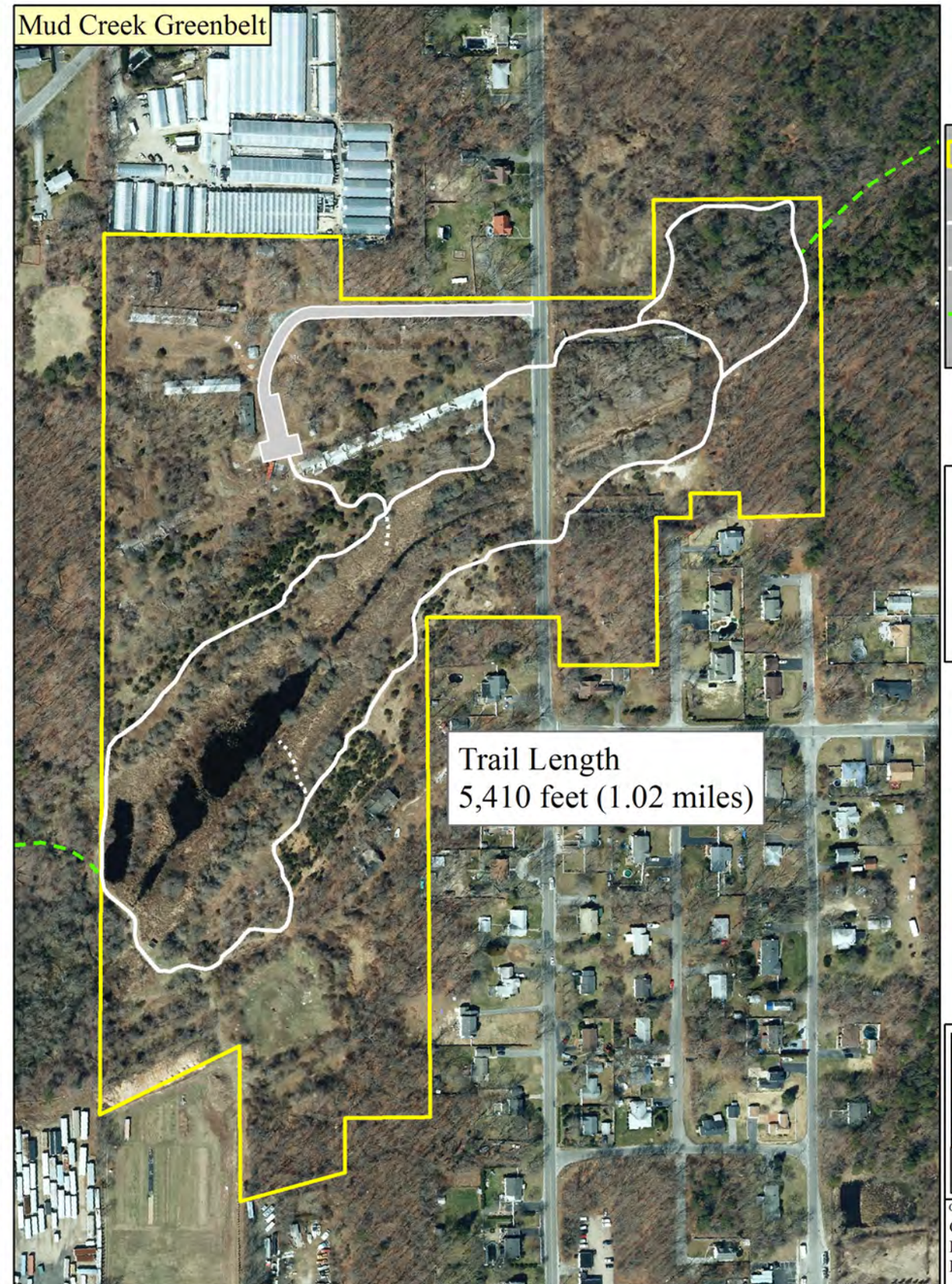
Trail Alternatives

MUD CREEK WATERSHED AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

East Patchogue, Suffolk County, New York CP #8710.110 April 2014





Gallo Duck Farm Restoration Area

Trail

Stream Overlook

Future Greenbelt Trail

NOTES

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N

1 in = 300 ft

All Maps

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Concept Plan Legend

MUD CREEK WATERSHED AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

East Patchogue, Suffolk County, New York This publication is funded by the County of Suffolk under CP #8710.110 April 2014

Demolition & removal of dilapidated buildings

Forested Wetland

Upland Meadow

Existing Eastern Red Cedar Woodlands

Mature Oak Forest

Large wood in stream and wet meadow floodplain (before tree and shrub maturity)

Nature Trail & Interpretive Signage

Boardwalk through wetland areas

Nature Trail Signage Kiosk

- Wet meadow
- Forested wetland (Proposed)
- Existing forested wetland (Preserve)
- Upland forest Enhancement Area 1
- Upland forest Enhancement Area 2
- Existing Red Cedar Woodland (Preserve)
- Upland meadow
- Existing Oak-Heath Forest (Preserve)
- Oak Forest Establishment (Proposed)
- Existing structure to be demolished and removed
- Proposed nature trail w/ interpretive signage points
- Boardwalk path in wetland areas
- Existing Box turtle nesting site (Preserve)

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Concept Plan Alternative 1

MUD CREEK WATERSHED AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

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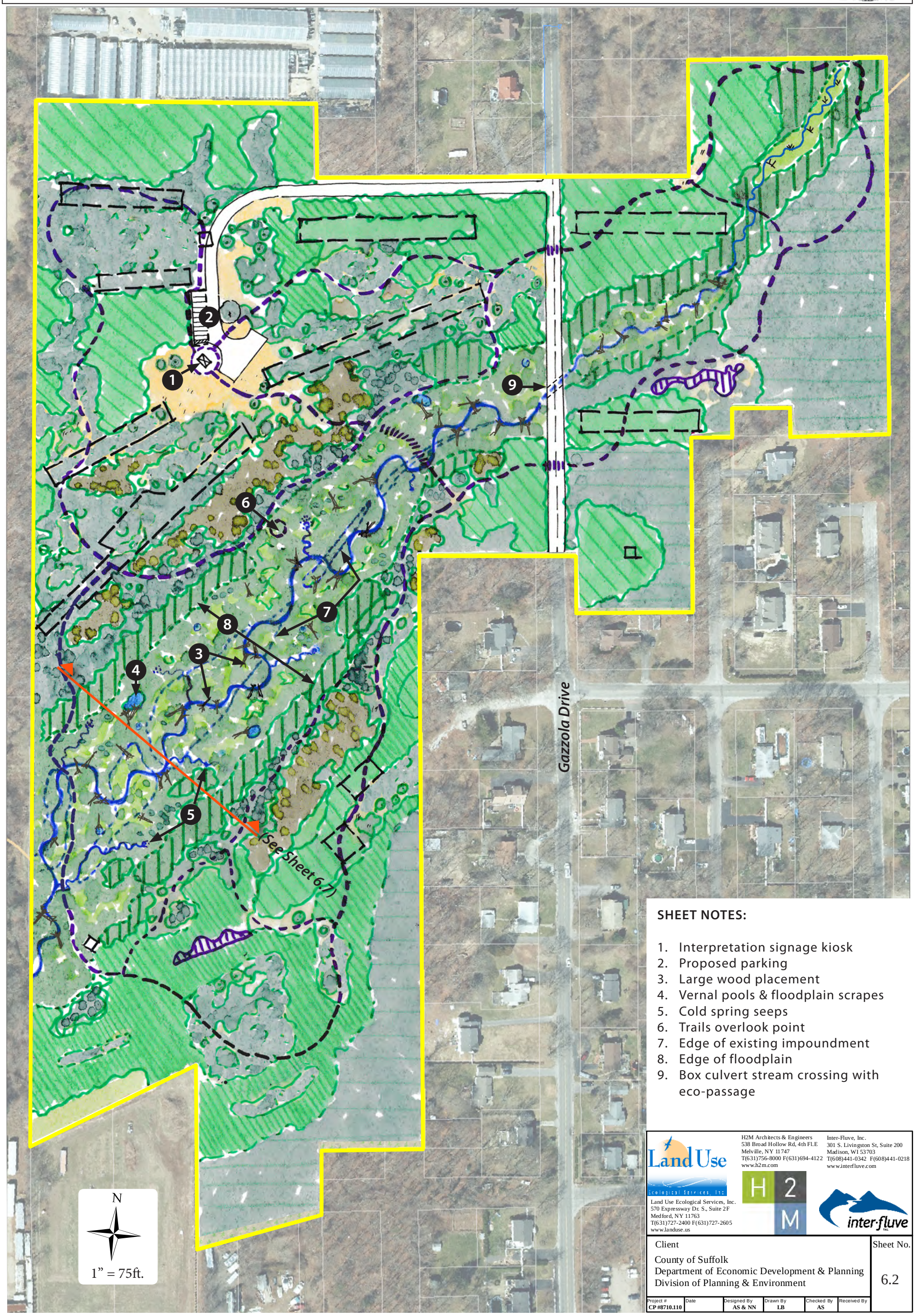

SHEET NOTES:

1. Interpretation signage kiosk
2. Proposed parking
3. Large wood placement
4. Vernal pools & floodplain scrapes
5. Cold spring seeps
6. Trails overlook point
7. Edge of existing impoundment
8. Edge of floodplain
9. Box culvert stream crossing with eco-passage

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Concept Plan Alternative 2

MUD CREEK WATERSHED AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

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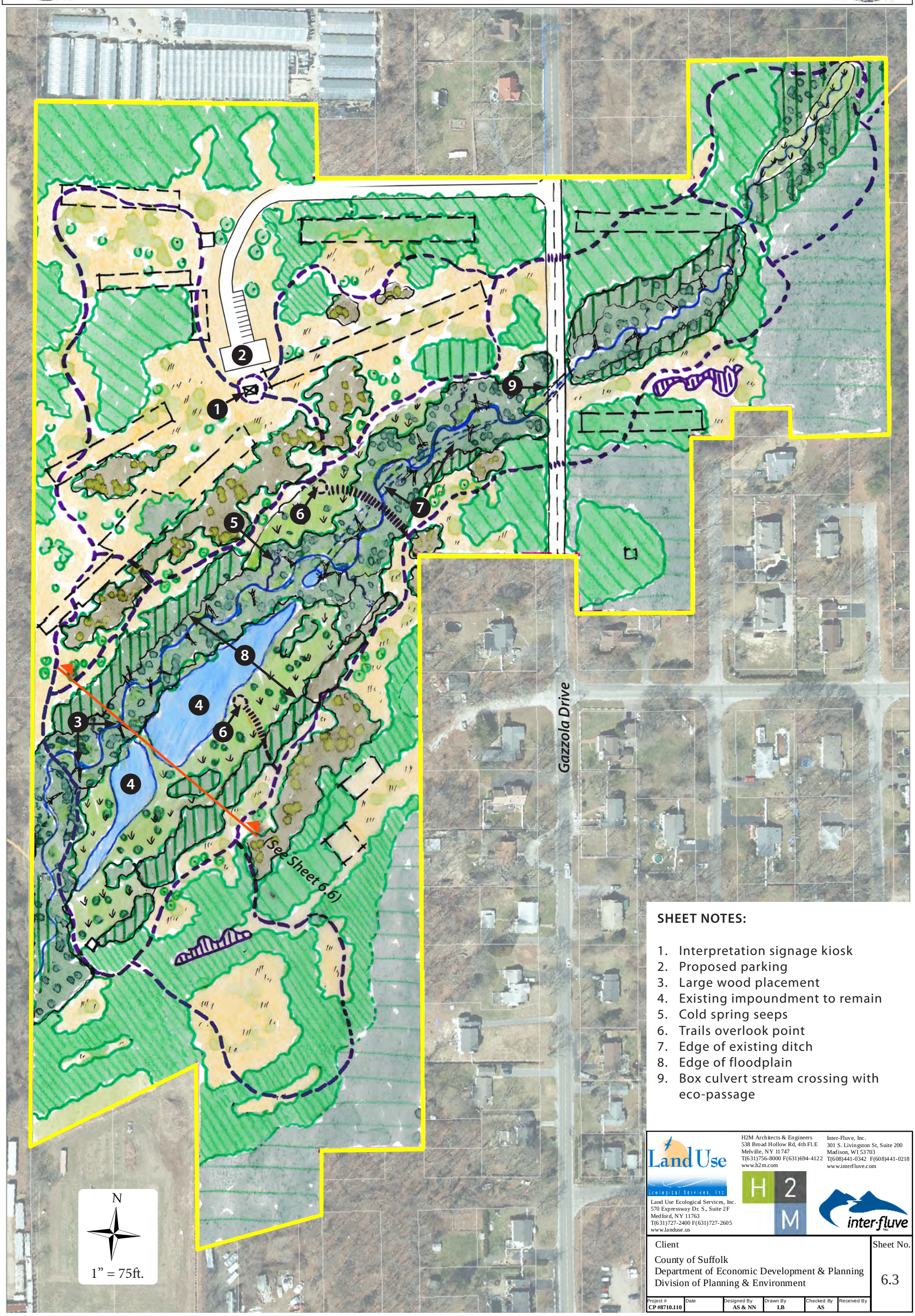

SHEET NOTES:

1. Interpretation signage kiosk
2. Proposed parking
3. Large wood placement
4. Existing impoundment to remain
5. Cold spring seeps
6. Trails overlook point
7. Edge of existing ditch
8. Edge of floodplain
9. Box culvert stream crossing with eco-passage

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Floodplain Character Rendering

MUD CREEK WATERSHED AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

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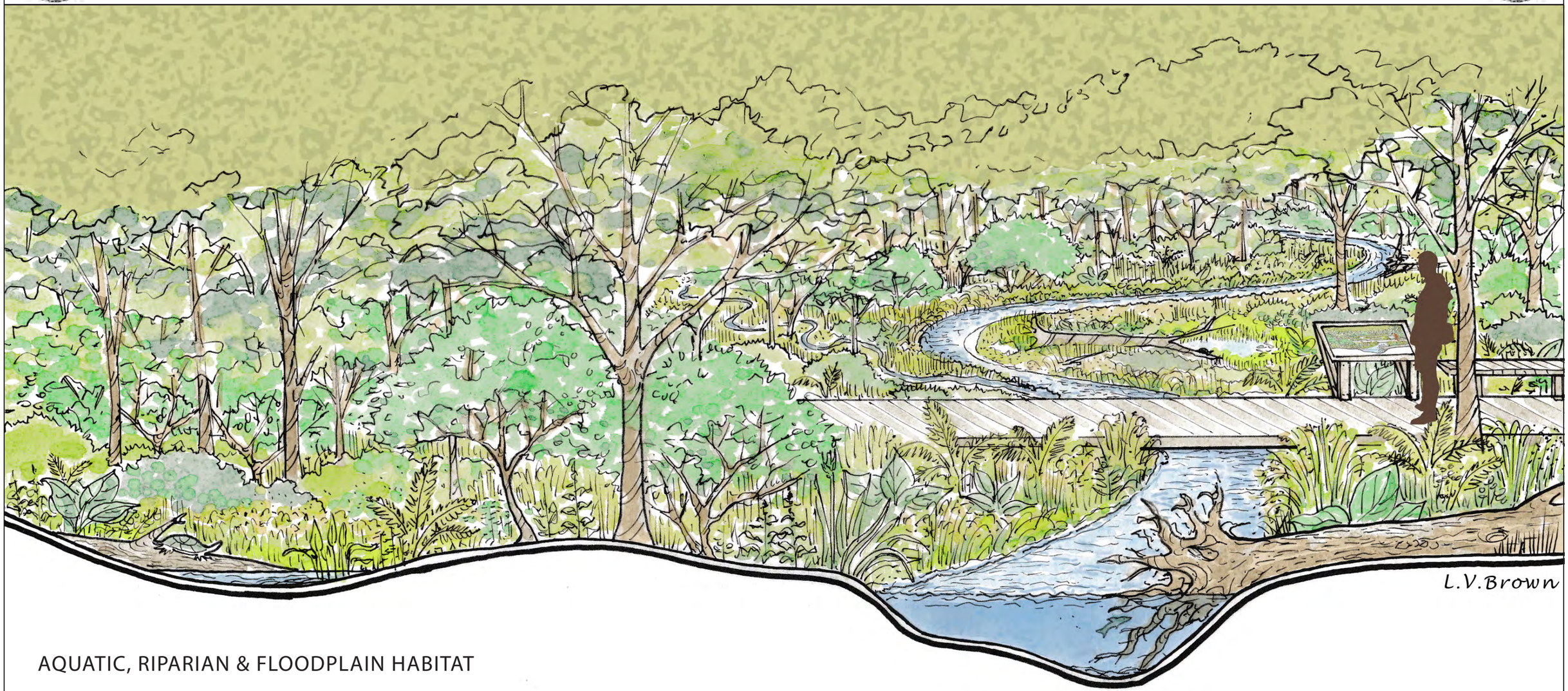

AQUATIC, RIPARIAN & FLOODPLAIN HABITAT

1. Large wood placement at the outside bends of the stream channel to induce scour pools and provide habitat and cover for Brook trout.
2. Provide microtopography in the forested floodplain to establish a diversity of wetland forest species.
3. Floodplain scrapes can provide areas for vernal pools, an important habitat for amphibians.
4. Provide a connection between cold groundwater springs at the floodplain valley toe to provide cold groundwater to the stream.
5. Dense plantings of wetland trees and shrubs to provide shade and moderate stream temperatures.

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Existing Conditions - Floodplain

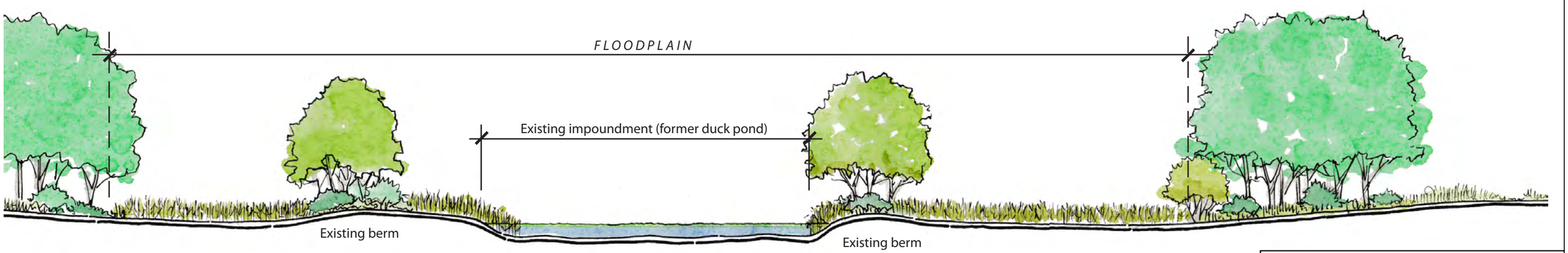
MUD CREEK WATERSHED AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

East Patchogue, Suffolk County, New York This publication is funded by the County of Suffolk under CP #8710.110 April 2014

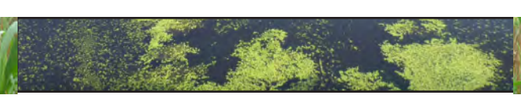
Existing stands of Phragmites throughout the wetland floodplain.

Existing eutrophic impoundments / duck farm ponds at Mud Creek.

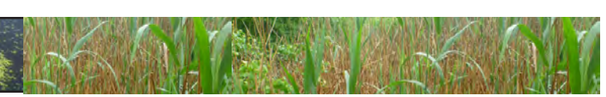
- Impounded ponds and channel artificially excavated during duck farm operations.
- High nutrient (nitrogen and phosphorus) levels make ponds highly eutrophic.
- Open surroundings, lack of tree canopy, and shallow depth of pond create conditions for higher water temperature which adversely affect Mud Creek ecology downstream and can be lethal for Brook trout.
- Presence of mounds or berms in the floodplain with tree and shrub growth are relics of historic excavation spoil piles.
- Wetland areas in the floodplain valley are dominated by highly invasive Phragmites monocultures.



Invasive monoculture of Phragmites



Algae covered pond surface



Invasive monoculture of Phragmites

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Floodplain Alternative 1

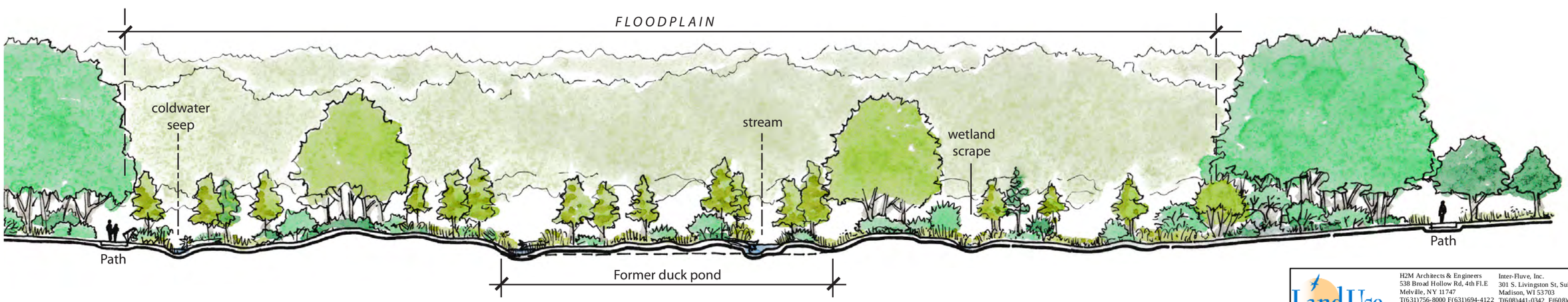
MUD CREEK WATERSHED AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

East Patchogue, Suffolk County, New York This publication is funded by the County of Suffolk under CP #8710.110 April 2014

Mature wetland forest ecosystem with stream channel

Stream and floodplain restoration - 3 years establishment

- Impoundments eliminated. Sediments contaminated with invasive plant rhizomes, organic matter and nutrients will be disposed of either on site (in former aeration basins) or at a landfill.
- Phragmites above and below ground biomass excavated and hauled off-site to eradicate the invasive species from site. Site regraded for floodplain microtopography and wetland forest establishment.
- Areas disturbed by excavation to be filled per engineered floodplain elevations with site fill and textured to provide microtopography of scrapes and hillocks to promote a diversity of vegetative zones and species habitat such as vernal pools, wet meadows and wetland forest.
- Newly excavated stream channel to occupy the center of the floodplain valley, fed by cold spring seeps at the existing valley toe and shaded by the establishment of a dense wetland forest.



Forested Wetland Floodplain microtopography with large wood wetland scrapes and vernal pools Forested Wetland

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Floodplain Alternative 2

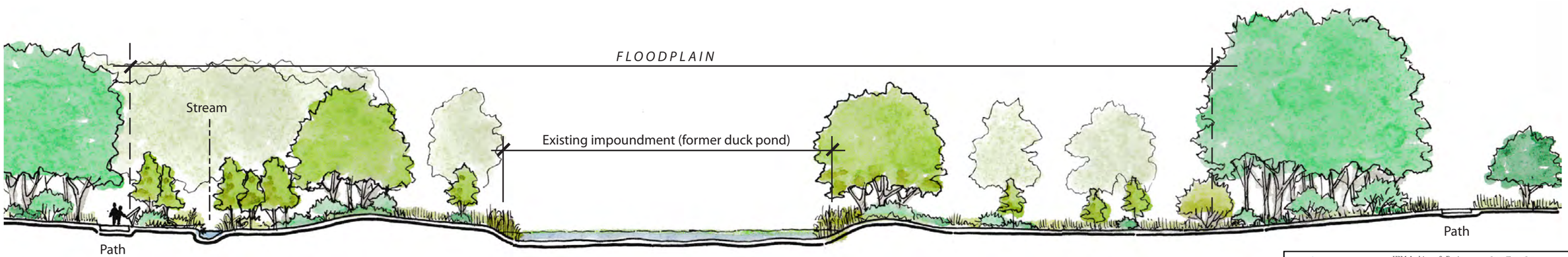
MUD CREEK WATERSHED AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

East Patchogue, Suffolk County, New York This publication is funded by the County of Suffolk under CP #8710.110 April 2014

Forested wetland stream channel (photo of West Branch of Mud Creek)

Existing eutrophic ponds at Mud Creek.

- Shallow water impoundments and sediments maintained. Phragmites along pond shoreline and within floodplain managed through herbicide application, but not excavation of sediments.
- Phragmites stands seeded with native wet meadow grasses and herbaceous plants and planted with clusters of native trees and shrubs to provide shade.
- Preserve existing, native canopy trees and shrubs.
- Excavate a stream channel in the wetland floodplain along the north side of the ponds.
- Excavate phragmites along new stream corridor and establish a wetland forest habitat.
- Provide floodplain features such as wetland scrapes / vernal pools, large wood habitat placement in stream and floodplain, and dense tree and shrub plantings to establish shade quickly and thus moderate stream temperatures for Brook trout habitat.



Forested wetland with dense plantings of woody trees and shrubs | Wet meadow w/ limited woody plantings | Algae covered pond surface | Wet meadow w/ limited woody plantings

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Gazzola Drive Stream Crossing

MUD CREEK WATERSHED AQUATIC ECOSYSTEM RESTORATION FEASIBILITY STUDY

East Patchogue, Suffolk County, New York This publication is funded by the County of Suffolk under CP #8710.110 April 2014

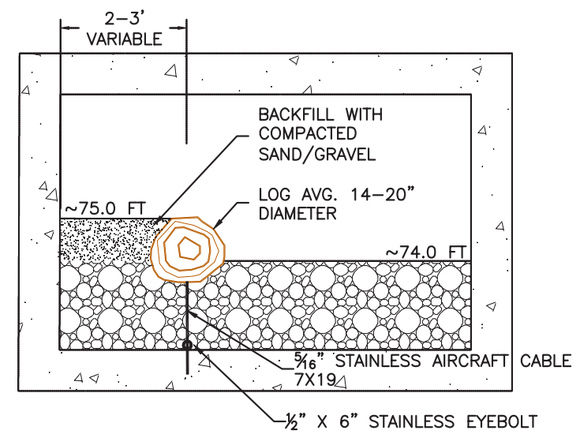
Constructed box culvert stream channel under Long Pond Road, Eel River, MA.

Ecological bench: safe passage for amphibians & mammals

Existing stream crossing at Gazzola Drive

Gazzola Drive Culvert Improvement:

- Fish passage is assured by emulating stream conditions above and below the crossing - maintaining continuity.
- Bottom of culvert will be set at least one foot below the expected grade of the stream bed to ensure a natural bottom through the culvert and allow natural stream adjustment.
- Culvert will be wide enough to include a bench as noted above to provide passage opportunities without entering active flow for turtles and other species that frequent the stream corridor.
- Culvert opening will allow increased flow capacity during flood events as well as movement of groundwater flow during average flow periods.



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