WRECK POND
FLOOD CONTROL BERM AND LIVING SHORELINE
Conceptual Plan and Feasibility Analysis

Prepared for
Wreck Pond Brook Watershed Technical Advisory Committee

Under the Authority of the
Wreck Pond Brook Watershed
Regional Stormwater Management Plan Committee

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Table of Contents

1 INTRODUCTION 1

2 EXISTING POND AND SHORELINE CONDITIONS 3
- 2.1 Flooding 4
- 2.2 Tides, Rainfall and Pond Water Level 5
- 2.3 Shoreline Condition 6
- 2.4 Historic Shoreline 10
- 2.5 Pond Water Quality 11
- 2.6 Public Input and Concerns 12

3 IMPACT OF NEW OUTFALL 13

4 SHORELINE BERM FEASIBILITY 16

5 LIVING SHORELINE FEASIBILITY 19
- 5.1 Living Shoreline Design Considerations 19
- 5.2 Proposed Living Shoreline General Design 23
- 5.3 Maintenance 26

6 OVERALL CONCEPTUAL PLAN AND CONCLUSIONS 27

APPENDIX A: Figure Appendix

APPENDIX B: Photographic Album

LIST OF FIGURES

1. Wreck Pond and Watershed Location
2. 2012 Pond Aerial Photograph
3. 1880 USGS Map
4. 1930 Aerial
5. 1962 Aerial
6. FEMA Flood Zones
7. Outfall Construction Plan
8. Tide Data
9. Summer Rainfall and Tide Data
10. Summer Storm Rainfall and Tides
11. Pond Bathymetry and Shoreline Topography
12. Aerial and Topography - Outfall to Brown Avenue
13. Aerial and Topography - Second Avenue Shoreline
14. Aerial and Topography - Ocean Road Shoreline
15. Aerial and Topography - Black Creek Weir
16. Aerial and Topography – Shore Road Shoreline
17. Aerial and Topography - Western Pond
18. Aerial and Topography - Black Creek
19. New Outfall Cross-Section
20. Model Results Summer – Existing and Proposed Outfall
21. Model Results – Proposed Dual Outfall with Invert Modification
22. LS Avakian Shoreline Survey
23. Gauged Salinity Data
24. Salinity Data with Shoreline Monitoring
25. April 2015 Salinity Data
26. Conceptual Plan

1 INTRODUCTION

Wreck Pond is a tidally influenced water connected to the Atlantic Ocean through an outfall structure. The main portion of the Pond forms the boundary between Spring Lake and Sea Girt in southern Monmouth County, New Jersey. The western portions of the Pond extend into Spring Lake Heights and Wall Township. Figure 1 provides a site location plan showing the Pond and watershed.

The Wreck Pond Brook watershed includes about 8,174 acres (±12.74 sq. miles). The western boundary of the watershed is in Wall Township and extends east-southeast to Wreck Pond on the border of Spring Lake and Sea Girt. The Pond discharges through an outlet structure into the Atlantic Ocean. The watershed also includes lands in Spring Lake Heights. The major tributaries are Hannabrand Brook, Wreck Pond Brook and the North Branch of Wreck Pond Brook (known as Black Creek). Numerous ponds are found within the watershed.

The Wreck Pond Brook watershed includes several major streams. These streams drain to Wreck Pond, which has tidal exchange with the Atlantic Ocean. Wreck Pond Brook is the major stream within the watershed and drains the central part of the watershed. Hannabrand Brook, the southern tributary, connects to Wreck Pond Brook at Old Mill Road, west of the upper end of the Pond. Black Creek (aka North Branch of Wreck Pond Brook) drains the western part of the watershed. The lower portion of the Creek is ponded, due to the weir at Ocean Road.

Figure 2 is an overall Pond aerial. Wreck Pond covers about 73 acres. It was originally an estuary open to the Ocean, with the outlet mapped as the Sea Girt Inlet. However, as early as 1888, a topographic map shows that the Pond was divided at Black Creek and that the general shape and the roadway network were in place (see Figure 3). Figure 4 is an early aerial from around 1930, showing that the bridge at First Avenue was in place, but no outfall structure was present.

During the 1930s, the outlet structure was constructed. The structure contains an 84-inch circular pipe that exchanges tidal flow with the Atlantic Ocean. Based on a 1940 aerial, the outfall pipe is visible, but it is not clear if all the flow is through the outfall. By the 1960s (see figure 5), the portion of the Pond between the First Avenue bridge and the outfall is a meandering channel. The picture shows buildup of sand on the southern side of the outfall pipe and that the location of the Ocean end of the pipe did not extend past the waterward end of the sandy beach.

The outfall pipe was extended in 2005, 300 feet farther offshore, to reduce the impact of bacteria in stormwater flows from the Pond on bathing beach water quality. By this time, the lowest part of the pond is straighter. This is visible on Figure 2.

As can be seen from the aerial photographs, the Wreck Pond shoreline and immediate vicinity is mostly developed with residences, and has been for many decades. The shoreline of the Pond, particularly on the Spring Lake side, contains limited natural

vegetation. Thus, the habitat value is low. The Pond itself has become eutrophic, has algal blooms at times, and contains excess sediment. Long-time residents report that in the past the Pond was a recreational feature that could be used for boating and fishing.

The area surrounding the Pond in Spring Lake and Spring Lake Heights, as well as a portion of Wall Township, has been subject to flooding several times over the last ten years. Homeowners and the Borough of Spring Lake are concerned about the potential for future flooding.

NJDEP provided grant funds to develop a feasibility study and conceptual plan to address both of these issues. The grant is being administered by the Monmouth County Division of Engineering. The grant is to explore the potential for developing a living shoreline around the Pond and include a berm to increase flood storage volume.

Since this study was initiated, the USFW Foundation provided a grant to construct a second outfall structure from the Pond to the Ocean to increase the passage of anadromous fish. This structure will increase the tidal exchange between these two waters and is expected to increase the tidal range in the Pond and flushing action.

The new outfall will also allow stormwater generated by inland rainfall events to be discharged more rapidly and in greater quantity, thus reducing the potential for the Pond to overspill its banks. Modeling analyses of rainfall events indicate that the water elevation will drop by about 1.5 feet during rainfall-generated storm events with typical tidal conditions. It must be noted, however, this does not include tidal flood events.

2 EXISTING POND AND SHORELINE CONDITIONS

Currently, the Wreck Pond outfall is an 84-inch diameter pipe that extends 800 feet out into the Ocean. The invert of the outfall on the Pond side is -2.29 ft NAVD88 and on the Ocean side is -7.94 feet.

The outlet structure allows exchange with the Ocean. Residents of the area reported a noticeable decline in the degree of tidal fluctuation after the pipe extension. However, as discussed later herein, tidal fluctuations are still observed.

Wreck Pond can be divided into several sections. Starting at the outfall, this structure contains six weir structures at the face that contain sluice gates. These gates are used primarily to limit inflow of tidal waters prior to a projected rainfall storm event or otherwise for flood control. The top of the structure is at about elevation 12.9 ft NAVD. Prior to Superstorm Sandy, a dune was present between the outfall structure and the beach.

Superstorm Sandy destroyed the dune on the north side of the outfall, opening a channel to the Ocean, the storm damage revealed a spillway, which had been buried by the dune and beach structure. The elevation at the top of this spillway is about 2.3 feet.

Between the outfall structure and the First Avenue bridge, the Pond is about 175 feet wide. The shoreline is natural and sandy, with vegetated shoreline and some homes.

Moving west, the pond is relatively narrow between First and Second Avenues and the bottom is primarily sandy. Along Second Avenue, the pond opens to its widest expanse, about 1,400 feet wide. This section of the pond extends from Second Avenue to the Railroad Bridge, a distance of about 2,000 feet, and is about 57.6 acres in size. The eastern and northeastern shorelines are bulkheaded, the northwestern shoreline is a sloping area, and the southern shoreline is vegetated. The Pond narrows at the western end of this section, where the railroad tracks cross and the Pond passes through a bridge beneath the tracks.

The western portion of the pond extends from the railroad bridge to the end of the Pond at Route 71. It is somewhat narrower and generally has only limited tidal exchange. This portion of the Pond is about 14.2 acres in area.

The end of the Pond is considered to be Route 71. However, Wreck Pond Brook west of this road is still somewhat ponded. This area may be influenced by tide under storm conditions. Wreck Pond Brook enters the Pond in this area.

The ponded portion of Black Creek flows over a weir into the Pond near the intersection of Ocean and Shore Roads.

2.1 Flooding

The area around the Pond is subject to flooding, primarily in Spring Lake and Spring Lake Heights. Figure 6 shows the flood zones from the most recent US Federal Emergency Management Agency (FEMA) Preliminary Flood Insurance Rate Maps (PFIRMs). These maps were published in early 2014 and updated in January of 2015 for Monmouth County. The appeal period for these maps finished at the end of June 2015 and FEMA is now working to resolve any map appeals. It is expected that these maps, with any changes brought due to appeals, will be adopted sometime in 2016 or early 2017.

The PFIRMs map the Pond and surrounding area as the tidal AE zone, which is the 1% flood zone with elevation set for tidal flooding. The 1% flood zone, commonly referred to as the 100-year flood zone, is the area with a 1% chance of flooding per year. The base flood elevation (the elevation to which water is expected to rise in the 1% flood) is 11 feet in the Pond and 10 feet in the surrounding area.

The FEMA flood maps depict Coastal flooding in the site area as the 1% event. That is, the most significant flooding is expected from tidal flows from the Atlantic Ocean associated with coastal storms. However, in the past ten years streets and homes surrounding the Pond have flooded several times due to inland rainfall events. Flooding has been averted at other times by creating a new opening to the Ocean at the Pond for overflow waters by breaching the beach berm in that area. Due to the single outfall pipe, higher than normal tides can block flood waters from exiting the pond or the watershed flows exceed the capacity of the outfall to allow water to exit.

Figure 6 also shows topographic contours at one foot intervals. The contours are from the most recent USGS Elevation model for the area. The contours show that the pond shoreline is generally at least elevation 5, except along Second Ave, where it is between elevation 4 and elevation 5. The elevation 6 contour is at the shoreline along some of it and upland from the pond in a few areas. The lowest elevations are along Second Avenue and the western parts of York and Brown Avenues. This means that street flooding occurs when the pond reaches elevations less than 5 feet.

As discussed in Section 2.2, tides in the Pond rose above Elevation 4 and were still rising during a storm event in the summer of 2014. At that time, the water was close to the top of the shoreline. The dune/beach berm was breached at that point so that water exited the Pond and the water level stopped rising.

The Borough of Spring Lake has received grants from the National Fish and Wildlife Service and a US Housing and Urban Development (HUD) Community Development Block Grant (CDBG) to construct a second outfall structure between the Pond and the Ocean. The structure will be a rectangular concrete structure, about 5.5 by 8 feet. It will extend 600 feet from the edge of the Pond and will parallel the existing outfall. Figure 7 shows the proposed plan.

The new outfall will have several benefits including enhanced tidal exchange and fish passage as well as faster discharge of high flow fluvial rain events. Both the existing and the new outfalls will have movable tide gates to allow the Borough to better control tidal flows during periods when high tides and fluvial storms are anticipated.

For the CDBG grant proposal, modeling was conducted that used the USEPA SWMM model. The model coupled the inland SWMM model for stream flow with the Xtran module which models tidal exchange (see Section 4). The analysis was conducted for storm events caused by rainfall in the watershed, with typical tidal conditions. Under flood event rains, the analysis determined that the water levels in the Pond would drop between 1 and 2 feet depending on the storm. The FEMA flood zone is set by tidal flooding and is not expected to change with the new outfall.

2.2 Tides, Rainfall and Pond Water Level

Wreck Pond exchanges water with the Atlantic Ocean through the existing 84-inch diameter outfall pipe. According to anecdotal reports from residents, tide does not influence the water elevations in the Pond as much as in the past. However, the tidal measurements show the water levels fluctuate with the tide.

During the summer of 2014, the Urban Coast Institute of Monmouth University installed two tide gauges in Wreck Pond. The eastern gauge was located in the main section of the Pond, between the First Avenue bridge and the railroad bridge, while the western gauge was located in the section of the pond just west of the railroad bridge. The gauges measured water levels and conductivity, which was translated to salinity.

Figure 8 shows the tide data for the monitored period from June 16 through October 5, 2014 for both in-pond gauges. The lower panel on the figure shows the summer period with the Sandy Hook ocean tides. As can be seen, the tide pattern generally mimics that of the Sandy Hook tide, except for periods with rainfall. The overall tidal height falls slowly with the approaching neap tide from June 16 through the beginning of July. There is a slight increase in Pond tidal maximum height with the rainfall on July 2-4, which then drops to its lowest point on July 7. After that, the tidal levels slowly rise with the approaching spring tide.

Figure 9 shows the summer period for the eastern tidal gauge, with rainfall shown. The Pond responds to the rainfall on July 14 to 16, with a rapid increase in water level. Once the water depth in the Pond reached about 4 feet, the opening to the Ocean was cut, which rapidly drained the Pond. Thus, it is not known how high the water would have risen without that intervention

Figure 10 shows a detail of the Pond response to each summer storm. The upper panel shows the July storm. The low tide in the Pond is at about 18:30 on July 14. The water level rises to about 3.25 feet by mid-day on the 15th, and then drops slightly with the low tide. The water then rose by about 0.8 feet in about 3.5 hours, when the outlet was then opened. At that point the water level was about 3 feet above the typical high tide level.

The August 2014 storm, on the lower panel, was at a spring tide level. The pre-storm tide height was about 1.4 feet, followed by a low tide of 0.8 feet at about 18:10 on 8/12/14. The water rose rapidly by 3 feet in about 10.5 hours, when the outlet was opened.

This shows how quickly the water level rises in Pond with inland rainfall. For the July storm, there was a bit of delay in the Pond response, but not in the August storm. This may be to some extent an artifact of using daily rainfall. The July storms were a series of thunderstorms, so the exact intensity and location in the watershed may vary from what is reported.

No coastal storms occurred during the time period in which the tide gauges were in the Pond.

2.3 Shoreline Condition

Figure 11 provides an aerial of the project area, with shoreline topography and Pond bathymetry. The Pond bathymetry is based on a hydrographic survey done in 2014 for the US Army Corps of Engineers, New York District, Coastal Restoration Feasibility Study for the Wreck Pond watershed. The data were provided by Princeton Hydro. The point data collected were used in GIS to create the pond bottom elevations shown on Figure 11. Since the mean tide is at about elevation

Along the northeastern part of the main Pond, there is a deeper section. The pond bottom is between -7 and -9 feet NAVD88 in this area. Most of the Pond, however, is at around --1.5 feet NAVD. The western part of the Pond has a generally flat bottom, between elevation 0 and -1.

Black Creek has a pond bottom that is at elevation 0 to 1, in the lower portion, and at 1-2 in the upper area. The outfall weir structure is at about elevation 2.17 feet, which means that the typical water depth may be over two feet in the center.

Appendix A is a photographic appendix of each shoreline area.

<u>Outfall to First Avenue Bridge</u>

Figure 12 provides an aerial with topo of this section of the Pond. The eastern portion of the Pond extends from the bridge on First Avenue to the outfall structure and is about 1.4 acres in size. This section of the pond is the most influenced by tidal exchange. According to the NJDEP, the pond bottom in this area is primarily sandy. This area was dredged in 2012 by Monmouth County Department of Public Works and Engineering with the dredged material placed back on the beach. The Borough of Spring Lake is obtaining a permit to dredge this area again in the next few months.

Both shorelines are vegetated, and are associated with back dune areas. Much of the vegetation on the northern shoreline was damaged or destroyed by Superstorm Sandy. The northwestern portion of this shoreline includes some wetlands vegetation which is primarily *Phragmites australis* at the waters edge. Closer to the outfall, there is more sand and less vegetation on the northern shoreline. The southeastern shoreline, in Sea Girt, contains a more varied vegetative community.

The shoreline elevations here are at 6 feet or higher. Therefore, no berm is proposed in this area.

First Avenue to Second Avenue

Figure 12 also provides topo and aerial for this portion of the Pond shoreline. This narrow area extends from the First Avenue Bridge to the point at which the pond widens at Second Ave. Adjacent to the bridge on the north side, is a vegetated parcel. The remainder of this section of shoreline consists of backyards associated with private homes. The shoreline contains a bulkhead with vegetation. Much of the tidal wetlands here is *Phragmites.*

The southern shore of the Pond here contains an island and in some spots has shoaled considerably. Spring Lake received NJDEP approval in 2014 to dredge the area around the island. Monmouth County is currently conducting this dredging for the Borough. The Sea Girt shoreline has a vegetated area with homes at a higher elevation.

As in the previous section, the shoreline is generally at or above elevation 6 and no berm is proposed.

Second Avenue

Figure 13 provides aerial and topography along the Second Avenue shoreline; photos are provided in Appendix A. From Brown Avenue north, the shoreline contains a cemented rock bulkhead, which ends just south of the Brown and Second intersection. The home on the south side of Brown Avenue is protected by a wooden bulkhead. Vegetation is present behind the wooden part of the bulkhead.

Between Brown and York, Second Avenue widens so that angled public parking is permitted. In this area, a very narrow (around 10-feet wide) mowed grass strip is present between the top of the cemented rock bulkhead and the pavement. North of York, the road is narrower, and the shoreline has a wider mowed grass strip with occasional willow trees.

The corner of Second Avenue and Ocean Road contains a stormwater outfall structures. This outfall used to transmit overflows from Spring Lake itself but this was recently redirected to the Ocean. The rock bulkhead ends just past the outfall.

The Second Avenue shoreline has some of the lowest topography, with the roadway below elevation 5 feet in some areas. Berm/shoreline elevation is proposed in this area.

Ocean Road

Figure 14 provides an aerial with topography of the eastern and central section of the Ocean Road shoreline. As noted above, there is an outfall at the Pond corner near the intersection of Second and Ocean. This area contains rock protection.

Moving to the west, just past the rock is a low wooden bulkhead, which extends about 50 feet. A timber bulkhead with sheet piles and vinyl facing is then present, extending to the corner of the Pond near the Black Creek weir. The upland area is a strip of mowed grass with occasional trees, about 25 to 30 feet wide. The road is directly adjacent to the grassed area.

As can be seen on Figures 11 and 14, and using the bathymetric data, the top of the bulkhead is between elevation 4.5 and 5, while the Pond bottom is at elevation -0.6 to the west but about -2 to -3 moving toward the corner of Ocean and Second.

There are stormwater outfalls within the bulkhead. These vary from large concrete structures, with inverts at about the water line (see photo) across from both 3rd and 4th Avenues to a small vinyl pipe within the bulkhead, at an elevation above the water line. There are rocks, presumably to provide erosion protection, at the base of the larger outfalls.

Above the bulkhead, the shoreline contains a mowed grass area, about 25 to 28 feet wide. There are scattered ornamental trees in this area.

Black Creek Weir

Figure 15 provides an aerial and shoreline topography at the Black Creek weir, showing the western part of the Ocean Road shoreline and the northeastern part of the Shore Road shoreline. The bulkhead continues to the weir structure. The outlet weir from Black Creek is located along Ocean Road, just east of its intersection with Shore Road. The weir is a flat-topped structure, with elevation of about 2.17 feet. Photos are included in Appendix A.

On the west side of the weir, the Shore Road shoreline is protected with a rock bulkhead. A pump station is located at the shoreline here.

Based on the bathymetry, at this weir, the Pond bottom elevation is above 0, varying between 0.1 and about 0.4 feet. Along the rock bulkhead, the shoreline elevation is about 6 feet. At times, the Pond bottom is exposed during low tide in the vicinity of the weir.

Shore Road

Moving south and then west around the Pond, Figure 16 shows the Shore Road shoreline; photographs are in Appendix A. The rock bulkhead ends at about the

intersection of Shore Road and Central Avenue. Beyond this point, the shoreline is natural, sloping up from the water to the road. The shoreline is mowed grass, with some trees. Along the shoreline, there appears to be some vegetation, but it has been sparse during most site visits. A couple of canoes or kayaks were visible in this public area, suggesting some boating use. The nearshore sediments appear to be silty.

The shoreline is below elevation 6 in much of this area. There are homes across the road. One stormwater pipe is present in the central part of the shoreline area. Sediment has built up around the structure, with some erosion around it.

The northern most part of this section of shoreline contains more vegetation, with *Phragmites australis* (common reed) at the water's edge. The pond narrows at the railroad bridge culvert. The area under the culvert contains rocks.

The southern shoreline of this part of the Pond in Sea Girt contains wetlands and vegetated shoreline. Homes generally are present at a higher elevation farther from the shoreline.

Western Section

The western section of the Pond extends from the railroad bridge up to Route 71 as shown on Figure 17 and in the photo appendix. The shoreline here generally consists of mowed grass along the road, and a vegetated shoreline with trees, shrubs, and some *Phragmites.* As noted above, water level monitoring revealed regular tidal exchange in this part of the Pond.

Black Creek

Black Creek near the outlet to Wreck Pond is impounded due to the weir structure at Ocean Road. The other end of this section is controlled by a culvert under the railroad tracks. Figure 18 shows this part of the Pond.

The shoreline consists of a park on the corner of Ocean Road and Fourth Avenue, homes on most of the rest of the shoreline, and the Spring Lake municipal yard at the northwest corner. This portion of Black Creek ends at the railroad culvert.

As seen in the Photo Appendix, in some places the shoreline is wooded, but in other mowed grass is present down to the water. At the paper street extension of Pennsylvania at Second Street, there is a wooden bulkhead with mowed grass. *Phragmites* is present along the shoreline in some places.

2.4 Historic Shoreline

Section 1 provides an over view of the Pond history. As noted, the main portion of the Pond has been in generally the same configuration since before 1900. Looking back at Figure 5, however, Ocean Road and Second Avenue were directly adjacent to the Pond

shoreline in the 1930s. The shoreline appears to be straight in this area, suggesting structural shoreline protection. On photographs from the 1940s and 1950s, there appears to be a vegetated area within the Pond, waterward of the road. The vegetated area does not appear to be straight and thus either a bulkhead was not present or there was vegetation in the Pond at the shoreline.

By the early 1960s (Figure 6), however, there is clearly a bulkheaded shoreline along both the Ocean Road and Second Ave shorelines. However, the bulkhead is about 20-30 feet further waterward than the 1930 shoreline and the existing roads line up with the 1930 shoreline. Thus, it appears that the bulkhead was constructed waterward of the shoreline that existed prior to the 1960s. The area between the road and the bulkhead appears to be grassed throughout this period, with the tress added in the 1970s.

The unprotected Shore Road shoreline appears to be in approximately the same location since the 1930 aerial. Thus, there is no evidence of shoreline erosion or accretion. There is an outfall structure along Shore Road, where some sediment has accumulated.

Black Creek was also fed by a small stream on the northeastern side, which entered at around the location of what is now the intersection of 5th and Salem Avenues. This appears to have gradually filled in, with the roads in place on the 1962 aerial. This is now the Spring Lake public works yard and recycling center and homes on Black Creek.

The other sections and shorelines within the Pond appear to be generally the same over time.

2.5 Pond Water Quality

Wreck Pond and its watershed have been the subject of several studies. Most recently, the NJDEP approved a Restoration Plan for Impaired Waters for the Wreck Pond Brook Watershed (WRP), which is in compliance with the USEPA's requirement for a watershed plan.

The WRP and previous studies have found that water quality and habitat value of the Pond and its shoreline are degraded. The Pond does not meet all water quality standards needed to support its designated uses. In particular, nutrients, especially phosphorus, are elevated. Sediment loads have caused shoaling in much of the Pond. Bacteria levels may be elevated as well.

The shoreline conditions, as discussed above, are generally not natural and border residential development. Thus, the habitat value is moderate to low. Ongoing fish surveys have identified the existing outfall structure as an impediment to the passage of anadromous fish.

Thus, like many coastal lakes, Wreck Pond has impaired water quality and habitat value.

2.6 Public Input and Concerns

The Wreck Pond Brook Watershed Regional Stormwater Management Plan (RSWMP) Committee has been actively meeting for more than 10 years. This group meets monthly and includes local government officials and professionals, agencies, and interested members of the public. Public interest in the project is very high. The public has primarily expressed interest in reducing flooding, but are also interested in restoring the Pond environment. Residents along Black Creek have expressed concern in the past about the excessive sediment in the ponded section of the Creek. The Committee directed development of the RSWMP and the more recent Restoration Plan.

The residents that live in areas that were flooded in the past were very interested in the berm project, believing it could enhance storage in the Pond, and thus reduce flooding. The residents are also concerned about preserving both physical and visual access to the Pond.

The conceptual plan for the berm and living shoreline was presented to the RSWMP Committee via a slide show in October 2014. The public had the opportunity to ask questions and understand the proposed berm and living shoreline. The public has been supportive of the project as part of the overall plan to mitigate flooding and enhance the Wreck Pond environment.

3 IMPACT OF NEW OUTFALL

The conclusions of various studies on Wreck Pond was that a new outfall structure would provide several benefits, including faster discharge of fluvial flows, enhanced tidal exchange which would provide better flushing of the Pond, and improved fish passage.

The Pond has been the recipient of several grants to construct an additional outfall structure to meet these goals. The grant moneys were provided by a Community Development Block Grant (CDBG) to reduce flooding, a National Fish and Wildlife grant to enhance fish passage between the Ocean and the Pond, and additional funds from NJDEP and Spring Lake Borough. Monmouth County is providing in-kind support and conducting dredging in the Pond under the grants. Monmouth County has been coordinating the various studies and committees and some of the grant applications for the past 10 years.

At this point in time, the new outfall structure has been designed and permitted and will be constructed in the near future. This structure will be a concrete box, 5.5 by 8.0 feet in size. The invert will be at -3 feet. However, the structure will include stop logs that can raise the invert of the culvert. The invert elevation was determined by US Fish and Wildlife Service fish experts, as the optimal elevation to enhance passage of anadromous fish into the Pond. Figure 7 shows new outfall in plan view, while Figure 19 provides a cross-sectional view.

The new outfall will also change the tidal regime in the Pond. This is expected to enhance flushing and thus water quality. The salinity regime may change as well. Further complicating the picture is that the new outfall will be constructed with flow control “stop logs” that will allow the outfall invert to be raised at times when anadromous fish are not expected to pass in and out of the Pond. Thus, the outfall elevation may vary, which will impact the tidal regime.

As discussed above, the Urban Coast Institute took tide data in the Pond during the summer and early fall of 2014, as shown on Figure 8. Najarian Associates used a model of the watershed and the outfall to estimate the Pond tidal response with the new outfall structure. Figure 20 provide the results for the summer period. The upper panel shows the model versus the eastern Pond data for the existing condition with a single outfall. The model compares well with the measured data, with the exception of the August storm. During both summer storms, an opening was cut through the dune and beach berm to allow the pond to drain. Based on the model, the water level during the July storm would not have risen much above 4 feet, but in the August storm, the water level would have increased to about elevation 6, causing the Pond to overtop its banks.

The middle panel on Figure 20 compares the model results for the current single outfall with the proposed dual outfall configuration, while the lower panel shows results for a shorter, dry period. The model results show that the tidal range will be much greater with the installation of the second outfall. The results also show that the change will be greater on the low tide end.

Using the collected tide data for the summer of 2014, and removing the periods of visibly higher tides during the storm events of July 13-17 and August 12-15, the mean of the high water elevations was about 1.00 ft (NAVD) and the mean of the low water elevations was 0.24 ft (NAVD). Thus, the difference was about 0.75 feet for an estimated typical range.

With the second outfall, the model shows the predicted average high water elevation for the same period is $\pm$1.6 ft (NAVD) and the average of the low water will be about -1.15 ft (NAVD). Thus, the range would be about 2.7 feet. Note that the increase in average high water elevation is about 0.6 feet, but the decrease in average low water is almost 1.5 feet. This is due to the configuration of the new outfall in which the invert will be at -3 feet, or about 0.75 feet lower than the current outfall. In contrast, the top of the outfall will be at about elevation 2, which does not encompass the entire range of the Ocean on the high tide and is at about the same top elevation as the current outfall.

Figure 21 compares the proposed dual outfall system, with the invert of the second outfall at -3 feet, to the same configuration with the invert of the second outfall raised by a foot to about -2 feet. This shows that the high water level will be reduced slightly, while the low water elevation will be increased by several tenths of a foot.

Figure 20 also shows the summer storm events with the current and proposed outfall configurations. The Pond water levels were more affected by the August storm, partly because this was a spring tide period. The highest level of tide at Sandy Hook during this storm was about 4.4 feet, which is above the mean high water elevation of around 2.1 feet. It also exceeds the 99th percentile storm event of around 4 feet, which is the tide elevation at Sandy Hook likely to be exceeded at least once per year for 99 out of 100 years. The Sandy Hook high tide during the storm was below the water level likely to be exceeded in 50% of the years, which is at about 4.9 feet NAVD88. Thus, the August 2014 storm shows that during a higher than normal Sandy Hook tide, a rainfall event of over 3 inches over a two-day period, would have caused the Pond elevation to rise to 6 feet and thus overflow. With the second outfall, that same event would drop the water level by about a foot, to about 5 feet.

As discussed above, the modeling was extended to consider the impact of larger rainfall events, using the tidal regime in July 2014 and synthetic rainfall events in Monmouth County for the 10-year, 25-year, and 100-year rainfall storm events. That is, this analysis did not consider tides that exceeded the typical range due to coastal storms.

The new outfall and the existing outfall will now have gates that can be used to control tidal flow. It is expected that the gates will be opened during low tide and then closed at high tides prior to an anticipated storm event. This way the Pond can be emptied of tidal flows to the extent possible.

During rainfall-generated potential flood events, under typical tidal conditions, the new outfall will reduce flood water heights as shown below.

Storm from Rainfall with Recurrence Interval	Max Flood Elevation (ft)	
	Current Outfall	Proposed Outfall
10 year	6.50	4.91
25 year	8.86	7.03
50 year	9.84	8.11
100 year	11.46	9.77

Thus, the new outfall will reduce the peak pond elevation by about 1.5 to 1.8 feet. The 10-year storm will be contained within the Pond (under typical tides). With the manipulation of the tide gates, it may be possible to control these events further. However, even with the new outfall rare events may still cause flooding. As noted, if a significant rainfall event combines with a coastal storm that raises tide heights, flooding would also be anticipated.

4 SHORELINE BERM FEASIBILITY

Although a second outfall was identified as the best option to alleviate flooding in the area surrounding the Pond, the cost was high and funding was not available prior to Superstorm Sandy. Thus, other options were investigated. Initially, installation of a pumping system was considered but the size of the Pond and the quantity of storm-induced watershed flows, along with the presence of protected habitat at the beach, meant this was not a viable alternative. Dredging was considered, but would only increase flood event storage if it could be done in conjunction with pumping or another means of emptying the pond.

Another option was to directly increase pond storage, by raising the shoreline elevation. Even with the new outfall, increasing the shoreline elevation would provide additional storage in the Pond. However, this would have to be accomplished in a way that would not cause flooding to increase in any other locations. That is, the water that would have overflowed from the Pond onto the streets of Spring Lake cannot be pushed farther up into the watershed and cause flooding there. This would simply relocate the problem.

The portion of the Pond shoreline under consideration was up to the railroad tracks, on both sides of Black Creek and up to Route 71 on the northern shoreline of Spring Lake. A small area in Sea Girt was also included.

The available storage is the space between the normal Pond water elevation and the lowest Pond shoreline elevation. It is well known from historic events and the general shoreline topography that the Spring Lake side of the main pond is at lower elevations than the Sea Girt side. The focus of the shoreline elevation was thus on the Spring Lake side of the Pond, extending a bit into Spring Lake Heights.

Leon S Avakian Associates (LSA) surveyed the shoreline on the Spring Lake side. Figure 22 shows this result. As can be seen, the lowest points along this shoreline are along the southern part of Second Ave, where much of the shoreline is below elevation 5 feet. Moving further north, the shoreline is below elevation 6 up to Union Avenue.

Another lower spot is found along the Ocean Road shoreline between 3rd and 4th Avenues. The elevation is just about 6 feet near the pump station and the intersection of Shore and Ocean Roads, but then is again lower along Shore Road within Spring Lake.

The survey also shows that the elevation of the weir between Wreck Pond and the ponded portion of Black Creek is at about elevation 2.17. The road elevation here is around 7 feet. Thus, the weir would allow water to back up into Black Creek under flooding conditions.

Initially, it was thought that perhaps the Pond shoreline could be raised to a level that would control flooding. Review of shoreline topography shows the areas below elevation 8, which would were flooded during the 2005 storm and would be during other

events. In order to protect these areas, the Pond shoreline would have to be raised by more than 2 feet to almost 4 feet along the Spring Lake shoreline.

This would also require raising the shoreline along Black Creek. There the shoreline contains private homes. Some of the homes are at elevation 8 or lower, with backyard elevations even lower. The shoreline would have to be raised by about 2 feet or more here, which would alter the yard areas.

The project extent was up to the railroad bridge on Black Creek. However, there are homes northwest of the railroad tracks that are below elevation 8. Flood waters could extend onto the homes in this area. Similarly, there are homes below elevation 8 west of Route 71 in Spring Lake Heights and close to that elevation in Wall Township. If the remainder of shoreline was raised to elevation 8, these homes would be the lowest point on the shoreline and would be where overflow would occur. This would constitute a negative flooding impact to homes in those areas. Similarly, to a slightly lesser extent, the elevation 7 contour extends onto homes beyond the project boundaries. Raising the shoreline to elevation 7 or 8 would require moving farther up into the watershed and more extensive work at private homes.

Raising the shoreline by several feet also has other potential concerns. As noted, flooding at times, particularly tidal floods, may reach up to elevation 10 (the 100-year tidal flood elevation). Further, based on the previous pumping analysis and the modeling results, the inflow during maximum rainfall storms to the Pond would fill in the additional storage relatively quickly. Thus, the shoreline would be over topped, even if it were raised to elevation 8. A 2-4 foot high berm would cause the ground elevation on the landward side to be below the crest of the berm. If flood waters over-topped such a berm, the waters could be trapped by a berm and thus not able to drain properly. Gated cross-drains might have to be installed to allow the flood waters to drain which would be costly.

The cost of a two to four foot high berm, extending past the railroad bridge on Black Creek and Route 71 on Wreck Pond would be very expensive, well beyond the available funds.

Further, the new outfall will reduce the water surface elevation in the Pond during flood-producing rainfall events. Thus, the additional storage benefits that might accrue with higher banks is not as necessary, since the water levels in the Pond resulting from the rainfall events will be lower after the second outfall is installed. The new outfall provides benefits beyond flooding as well.

However, there are portions of the Wreck Pond shoreline that are lower than Elevation 6. These are the areas that flood with more regularity. Therefore, a 6-foot higher shoreline is proposed to contain all water in the Pond during certain storms. Beyond the project area, the existing structures are above elevation 6.

Under the current outfall configuration, the proposed six-foot high shoreline was estimated to be protective of a 5-year storm. This shoreline elevation would provide protection for elevated water levels beyond a 10-year rainstorm once the second outfall is installed. As noted above, this analysis considers the runoff created by a 10-year rain storm, with typical tides. A similar rain storm with higher than typical tides may cause higher Pond water levels.

As noted above, creation of a high berm could trap flood waters on the landward side. Therefore, the shoreline modification will primarily be to slope the shoreline up to meet elevation 6, not create a visible berm. If a berm is actually necessary due to grading or space considerations, it will not be very high and would be expected to create trapped flood waters.

Based on consideration of cost, project extent, private versus public lands, and the needed additional storage with the installation of the secondary outfall, it was determined that raising the shoreline to elevation 6 was feasible, but raising the shoreline to a higher elevation was not.

5 LIVING SHORELINE FEASIBILITY

Section 2 provides an overview of the existing conditions of much of the shoreline. The shoreline condition varies from wooden bulkhead, cemented stone bulkhead, mowed grass, and vegetation. Portions are public lands, while other areas are the backyards of private homes.

The term “living shoreline” often refers to a solution to shoreline erosion that uses living materials and engineering to reconfigure the shoreline to promote stability and reduce erosion. The definition has evolved to include projects that modify a shoreline to enhance ecological quality, even if the shoreline is not actively eroding. For this project, the proposed shoreline enhancements include both shoreline and upland plantings.

Most of the existing shoreline provides some opportunity for enhancement to enhance habitat value. A living shoreline also provides some improvement to stormwater quality for stormwater that flows across the vegetated area. However, most of the stormwater collected from impervious areas, including roads, is piped and discharged directly into the Pond.

The shoreline of the project area can be categorized by type as follows:

1. Bulkheaded with upland lawn and adjacent roads: - Bulkheaded shorelines including timber and cemented rock are present along Shore Road and Second Avenue and a small portion of the shoreline of Black Creek.

2. Bulkheaded with vegetation: Low bulkheads with vegetation in the water or overgrowing the bulkhead are present at the corner of Second and Brown and along the northwestern shoreline of Black Creek

3. Unprotected shoreline with mowed grass: Shore Road – east; parts of Black Creek

4. Unprotected shoreline with vegetation: Shore Road west, parts of Black Creek

All four types of shoreline include both private and public lands, below. Each of these types of shoreline is analyzed separately.

5.1 Living Shoreline Design Considerations

The living shoreline is to be incorporated into the “berm” proposed to increase shoreline elevation. Although referred to as a berm, in some areas will be grading of the shoreline up to the roadway, and not a raised berm.

Stevens Institute has developed a Living Shoreline Engineering design manual. The purpose is primarily to provide guidance on appropriate design for living shorelines to avoid erosion. In this particular case, the project is focused on ecological restoration,

not on erosion control. However, the engineering parameters were evaluated to assist in the design. The Stevens manual looks at the criterion in ranges. Those ranges were used to evaluate each parameter.

The manual includes a variety of parameters, a few of which are not relevant here. The parameters are:

Erosion History
Relative Sea Level
Tidal Range
Wind Waves
Wakes
Currents
Ice
Storm Surge
Upland Slope
Shoreline Slope
Width
Nearshore Slope
Offshore Depth
Soil Bearing
Water Quality
Soil Type
Sunlight Exposure

Given that this project is on a coastal Pond, and not the Ocean, a Bay or even an open River, the analysis of these factors was conducted primarily at Level 1 – Desktop analysis for the most part. Where available, data and modeling were used in the evaluation, providing higher than Level 1 analysis.

Erosion History: Erosion history can be determined by review of aerial photographs. In this case, as discussed above, historic aerial photographs were reviewed and showed that the shoreline has remained in about the same location for the un-protected areas of the Pond. The current bulkheads were constructed in the 1950s or 1960s and were located waterward of the prior shoreline, with fill behind. Those upland areas became grassed public lands. No evidence of any erosion is noted. Photographs maintained on the NJ webmap as well as online maps from NETR were reviewed for this analysis. Thus, the level of erosion would be in the low range.

Sea Level Rise: Sea level rise would be considered to result in gradual change to tidal processes in the Pond. A general rise of about 1.3 feet per century is expected, which equates to about 0.15 in per year and is in the low/mild range.

Tidal Range: A critical factor in the success of a living shoreline is tidal range. In this case, tidal range is not being used to design an engineered shore protection structure, but is essential to the survival of the plantings. This critical piece of the design has been studied by both field data collection and by modeling. The field data collection occurred from June through October of 2014, including two rain storms but no tidal storms. This showed that the tidal range was about 0.75 feet, and mean high water was about 1.0 feet.

However, the installation of a second outfall structure and the use of stop logs in that structure to control tidal exchange could not be measured, but clearly the tidal range will

be greater. As presented above, a model was developed to investigate tidal fluctuation with installation of an additional outfall.

With the second outfall, the model shows the predicted average high water elevation for the same period is ±1.6 ft (NAVD) and the average of the low water will be about -1.15 ft (NAVD). Thus, the range would be about 2.7 feet. Note that the increase in high water is about 0.6 feet, but the decrease in low water is almost 1.5 feet. This is due to the configuration of the new outfall.

The new outfall would cause water to retreat from most of the shoreline that is currently below the MLW elevation and might cause portions of the Pond to be dry at certain times. Thus, at times that the anadromous fish are not expected to be traveling between the Ocean and the Pond, it is expected that the second outfall may have a 1-foot high stop log placed in the outfall. As discussed above, the high tide elevations are raised slightly while the low tide elevations would increase more. In this scenario, the low tide elevation would not drop to or below -1 ft as it does with the open second outfall.

The modeled high and low tides demonstrate that a greater tidal range will occur and will be used in the detailed living shoreline design. Using the Stevens manual, the tidal range would be considered to be in the Moderate range.

Wind Waves: Wind waves are generated by fetch. In this case, the fetch is limited by the size of the Pond and the presence of the beach. Overall, the maximum fetch is less than 0.5 miles, which suggests a very low energy environment.

Wakes: No power boats use the Pond, thus wakes are not relevant.

Currents: Limited information is available on currents in the Pond. The strongest currents are expected along the line between the outfall, the 1st Avenue Bridge and the railroad bridge. There is also a “channel” along the Second Ave. shoreline where the pond is much deeper. This may be a remnant from when the outfall at the corner of Brown and Second Avenues regularly received overflow from the Spring Lake. Currents would not be expected to be high on the unprotected portions of the shoreline.

Ice: The Pond is known to freeze during colder winters. The depth of ice is not known.

Storm Surge: Storm surge is not expected to be of concern for the living shoreline since the entire area would be under water during any significant coastal storm event.

Upland Slope: Upland slope is generally relatively mild throughout the project area, with few exceptions. Based on the Stevens Manual, the slope would be in the low to moderate range.

Shoreline Slope: The available bathymetric data were used. The shoreline slope varies with the location along the Pond. In the area of bulkheads, the slope is vertical. In these areas, the difference between the top of the bulkhead and the Pond bottom is

often 6 feet or more. Along the unprotected shoreline at Shore Road, a mild shoreline slope is present of around 3-4%. This parameter will be further evaluated during detailed design.

Width: The shoreline width before a roadway or home varies from about 90 feet along Shore Road, to about 25 feet along Ocean Road, and 10 feet to 20 feet along Second Ave. Along Black Creek, the distances vary with the placement of the homes and available land will depend on homeowner preference.

Nearshore Slope: Nearshore slopes are very mild, with the Pond bottom almost flat. Thus, this slope would be in the mild class.

Offshore Depth: Given that the Pond is protected and tidal range is controlled by the outfall structure, there is no real offshore depth here. The water depths are shallow enough to dissipate any deep water waves.

Soil Bearing Capacity: This is not relevant as armoring is not proposed.

Water Quality: Water quality data has been measured at various times in the Pond. The most comprehensive ambient monitoring was done for the Wreck Pond characterization study for the Borough back in the mid-2000s. Those samples were taken to sample Pond water quality, not the Ocean water, and thus were taken at low tide. During that sampling, overall water quality was found to be impaired, although DO levels were over 4 mg/l for every sample in the main section of the Pond. DO was lower in the section west of the railroad bridge. Black Creek water quality was measured at the weir, not within the ponded area. The DO levels were found to generally meet NJDEP standards, with occasional very low levels. Nutrient data suggest the Pond is somewhat eutrophic.

Salinity data were collected at stations in the central portion of the main Pond. As noted, the sampling was done during low tide. The Pond salinity was low, at 1 to 3 ppt.

During the summer of 2014, the tide gauges installed in Wreck Pond also measured salinity as shown on Figure 23. The eastern gauge was placed in the main section of the Pond, while the western gauge was placed west of the railroad bridge. The salinity from the eastern gauge was generally above 15 psu, except for the two storm events. However, the western salinity varied from close to 0 psu to over 20 psu. The western gauge was in the upper part of the tidal pond, with direct inflow from the freshwater tributaries.

As the available data were from the central part of the Pond, some shoreline data was desired. Two samples were collected by NJDEP along the shoreline. The data collection happened to coincide with the rainfall event in July 2014. Figure 24 adds the results for the Shore Road shoreline station. As can be seen, the salinity here is low as it is at both in-pond stations on July 18. However, by July 21 salinity levels in the main section of the Pond had recovered, but the shoreline station was still lower. It is not

clear if these levels were due to lingering effects of the rainfall, or if the shoreline salinity levels are always lower here.

In April of 2015, a shoreline salinity survey was done. Figure 25 summarizes the data. At that time, the in-pond tide gauges were not operating. Thus, it is not possible to compare the shoreline salinity to the center of the Pond. Review of the tide data for Sandy Hook, reported by NOAA, showed that the actual tide levels were between 0.45 and 0.7 feet higher at the high tides around the sampling time. However, this was the end of a neap tide period, so that the morning high tide that day of 2.3 ft. NAVD was lower than the reported high tide elevation on May 2 of around 3 ft. NAVD. No rain had fallen since April 22, when 0.14 inches were reported at Allaire Airport preceded by 0.04 inches on April 21 and 0.39 inches on April 20. Thus, this sampling provided results from a relatively typical dry weather period.

As shown on Figure 25, the salinity in this portion of the pond is at about 5 psu, based on the results from NPSWP 25. At the same time, the maximum levels at NPSWP-10, at just below 25 psu. The minimum at NPSWP-25 was at around 0, but it is not clear if that is an accurate reading.

Thus, further data are needed to determine the specific plantings for each area of living shoreline.

Soil Type: The soils appear to be adequate and will be amended as needed.

Sunlight Exposure: Sunlight is not limited along most of the areas proposed for living shoreline. The upland species to be planted will be designed to avoid excessive shading of marsh vegetation.

Other Factors

The primary other factors to consider are the needs to preserve public roads and parking, impacts on local homeowners including use of private property and visual impacts, cost, maintenance requirements, public input, and aesthetics.

5.2 Proposed Living Shoreline General Design

The Pond Living Shoreline is generally feasible, as it is a low energy environment with limited potential for large waves. However, other constraints are present in portions of the shoreline that limit options. These are considered by area as follows:

1. **Outfall to First Avenue**

   The shoreline here is unprotected, with vegetation present, on both shorelines. Portions of the area will be disturbed for construction of the new outfall structure. As part of that project, vegetation may be replaced. However, it is likely there will be opportunity for additional enhancement and plantings beyond that anticipated to be

constructed as part of the outfall installation. This area is not mapped on the feasibility map, as the proposed planting to be completed as part of the outfall installation is not known.

2. First Avenue to Brown Avenue

This shoreline is bulkheaded, with vegetation growing along and through the bulkhead. The homes are above elevation 6 and generally above elevation 7. Thus, no work is proposed in this area.

3. Bulkheaded Shorelines: Second Avenue and Ocean Road

The Second Avenue shoreline includes low points on the main Pond shoreline. The elevation of the Pond bottom here is around -2 to -3 feet, with the "channel" at -7 feet or more in some places as close as 60 feet offshore. Thus, for a proposed top elevation of 6 feet, the vertical distance to the Pond bottom would 8 to 9 feet in the near shore. To achieve a 1:15 shoreline slope would require a minimum of 120 feet of linear distance. This width is not available along the shoreline.

Similarly, the Ocean Road shoreline contains a wooden and sheet metal bulkhead, with a number of stormwater outfall structures. The elevation at the top of the bulkhead is below 6 feet, while the elevation of the Pond bottom varies from about -2 feet to the east to about -0.5 feet to the west. There are pockets of Pond bottom that approach or exceed elevation 0, generally in the vicinity of the stormwater outfall structures. The upland grassed strip is only about 30 feet wide. The distance from elevation 6 to the bottom of the Pond is 6.5 to 8 feet, requiring around 100 feet of width to provide an average 1:15 slope.

The project mean high water line without the use of the stop logs is about 2.6 feet. Thus, the inter-tidal zone could be expected up to about 3 feet for this preliminary analysis. Thus, the shoreline zone would require close to 120 feet of intertidal zone to provide a 1 vertical to 30 horizontal slope. The possible impacts of this on Pond storage capacity would have to be analyzed.

In both areas, removal of the bulkhead and replacement with a living shoreline would be challenging due to the lack of land, the presence of outfall structures, and cost at this time.

However, it may be possible to construct a marsh fringe, waterward of the bulkhead, particularly along the Ocean Road bulkhead. In this area the Pond bottom is relatively level. The living shoreline would be created by grading within the Pond to create an intertidal zone with appropriate slope. Appropriate substrate material will be brought to the site as needed. Native wetland plants will then be planted within the area.

The upland in this area will be graded up to elevation 6 near the road or the road itself may be raised. The area will be re-landscaped with native plants that will provide enhanced habitat value, along with continued public access to the waterfront.

The primary factors still to be evaluated are the substrate composition and strength and the actual tidal and salinity regime in this area once the second outfall is installed. The existing stormwater outfall pipes will have to be incorporated into the design.

4. <u>Unprotected Shoreline – Shore Road</u>

The Shore Road shoreline is open, with a somewhat gradual slope. As noted above, this section of the shoreline generally meets the low to mild criterion in the Stevens Manual. This area has been selected as a pilot location for a Living Shoreline pilot project within the Pond. The project was awarded a NFWF grant and design is underway.

The design calls for a gently sloping marsh with an enhanced upland shoreline/riparian zone upland of the marsh. The marsh will be planted in a variety of wetland plants, to determine which will be best suited to the varying salinity within the Pond. In particular, this shoreline is in the vicinity of freshwater inflows from the culvert beneath the railroad bridge and over the Black Creek weir.

The plan will incorporate a public access path from the road to a small kayak launch to allow the public continued access to the water, but discourage them from walking through the marsh.

5. <u>Vegetated Shoreline</u>

West of the railroad bridge, the grassed area landward of the vegetated fringe will be re-graded to elevation 6. Both the shoreline and upland vegetation can be enhanced in some areas. *Phragmites australis* (common reed) is typical along the shoreline. This non-native plant provides less quality habitat than other marsh vegetation. The feasibility of controlling this species will be investigated. Other non-native plants may be present at the shoreline and may provide some opportunity for replacement with native plants.

6. <u>Black Creek</u>

The Black Creek shoreline includes mostly private lands. Homes are present whose backyards abut the Creek. Exceptions include the small park at the corner of Ocean Road and 4th Avenue and the adjacent paper street extension of Pennsylvanian Avenue, the Spring Lake Public Works Yard at the corner of 5th and Salem, and the paper street extension of Pennsylvania Avenue from the corner of 2nd Street, all in Spring Lake.

As noted above, the shoreline here is a mix of bulkheads with upland grass, low bulkheads, mowed grass down to the water line, and vegetated shoreline. The shoreline will be elevated, as needed, to reach elevation 6.

There is potential for living shoreline enhancement. The first areas will be at the Borough-owned lands. The shoreline will be graded up to the desired berm elevation. Vegetation will be planted within the intertidal zone and upland vegetation enhanced to improve habitat value and yet also allow public access.

In other areas, the project will require cooperation with private homeowners for both construction and for future maintenance. The specifics of shoreline work and vegetative planting will be determined in cooperation with the homeowners.

5.3 Maintenance

A key component to the viability of a living shoreline is ongoing maintenance of the plantings. The Borough of Spring Lake will approve of the project plants and will be responsible for on-going maintenance of the living shoreline. The Borough has indicated their willingness to undertake this responsibility.

6 OVERALL CONCEPTUAL PLAN AND CONCLUSIONS

Figure 26 is the overall conceptual plan for the living shoreline. The plan shows the areas where a shoreline "berm" is proposed to raise the shoreline to elevation 6. As discussed above, in most areas this will consist of grading the shoreline up to this elevation, not construction of a literal berm.

The Plan also presents the conceptual types of living shoreline and riparian zone work anticipated. Three types of conceptual shorelines are anticipated.

Area 1

Area 1, open shorelines without existing vegetation, the area will be graded to create an inter-tidal zone based at an appropriate slope. This area will be planted with low marsh and high marsh plants, based on salinity and other considerations.

Above the inter-tidal zone, the shoreline will be graded up to the road to create the necessary shoreline elevation. Native, salt tolerant plants are anticipated here. The concept plan provides a preliminary list of possible plants.

Area 2

Area 2 consists of bulkheaded shorelines. Here, as feasible, wetland will be created in front of the bulkhead. The upland will be enhanced with native vegetation.

Area 3

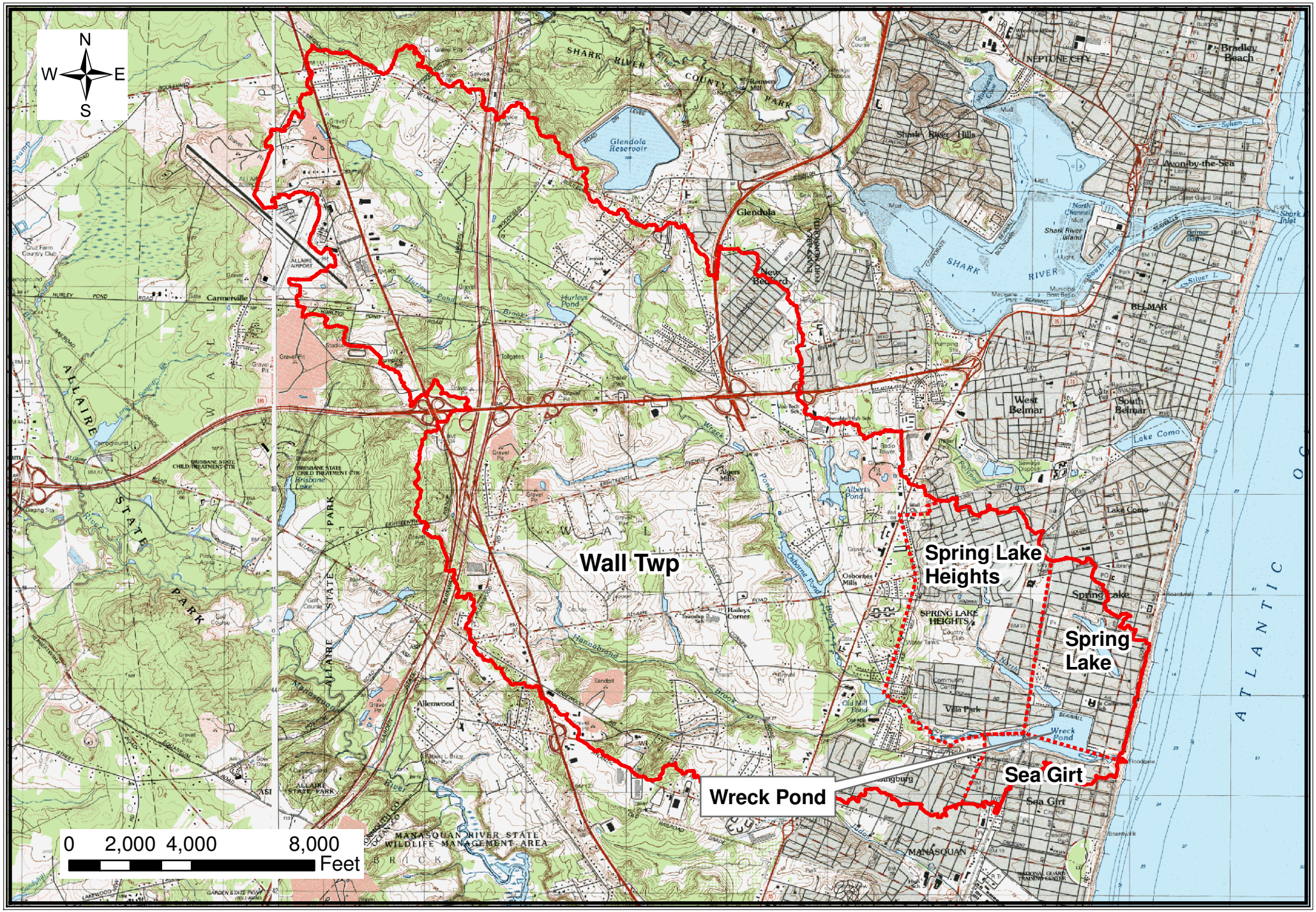
Area 3 shorelines contain existing shoreline vegetation. Thus, plantings here will enhance the existing shoreline.

As noted above, the outfall area may also be a location where a living shoreline and/or riparian zone enhancement can be conducted. However, this will depend on how the area is restored following the outfall construction.

As this is a conceptual plan, additional data will be needed to finalize. This may include further salinity and topographic data, as well as public and agency input.

Overall, a viable project is proposed that will provide additional storage in the Pond to retain more flood waters and to provide a living shoreline which will enhance the overall Pond environment.

FIGURE APPENDIX



Sources:
Asbury Park and Farmingdale USGS Quad Maps

10-29-2015

Najarian Associates
30 years
The Science of Engineering

Figure 1: Pond and Watershed

Sources:
2012 Aerial
NJ Geodata

11-13-15

0 500 1,000 Feet

Figure 2: 2012 Wreck Pond Aerial

Najarian Associates
30 years
The Science of Engineering

Sources:
1920 Aerial
NJWeb Map Historic Topo based on
USGS 1880 AsburyPark Quad

10/29/15

0 500 1,000 Feet

Figure 3: 1880 USGS Pond Map

Najarian Associates
30 years
The Science of Engineering

Sources:
1930 Aerial
NJWeb Map

10/29/15

0 500 1,000 Feet

Figure 4: 1930 Aerial

Najarian Associates
30 years
The Science of Engineering

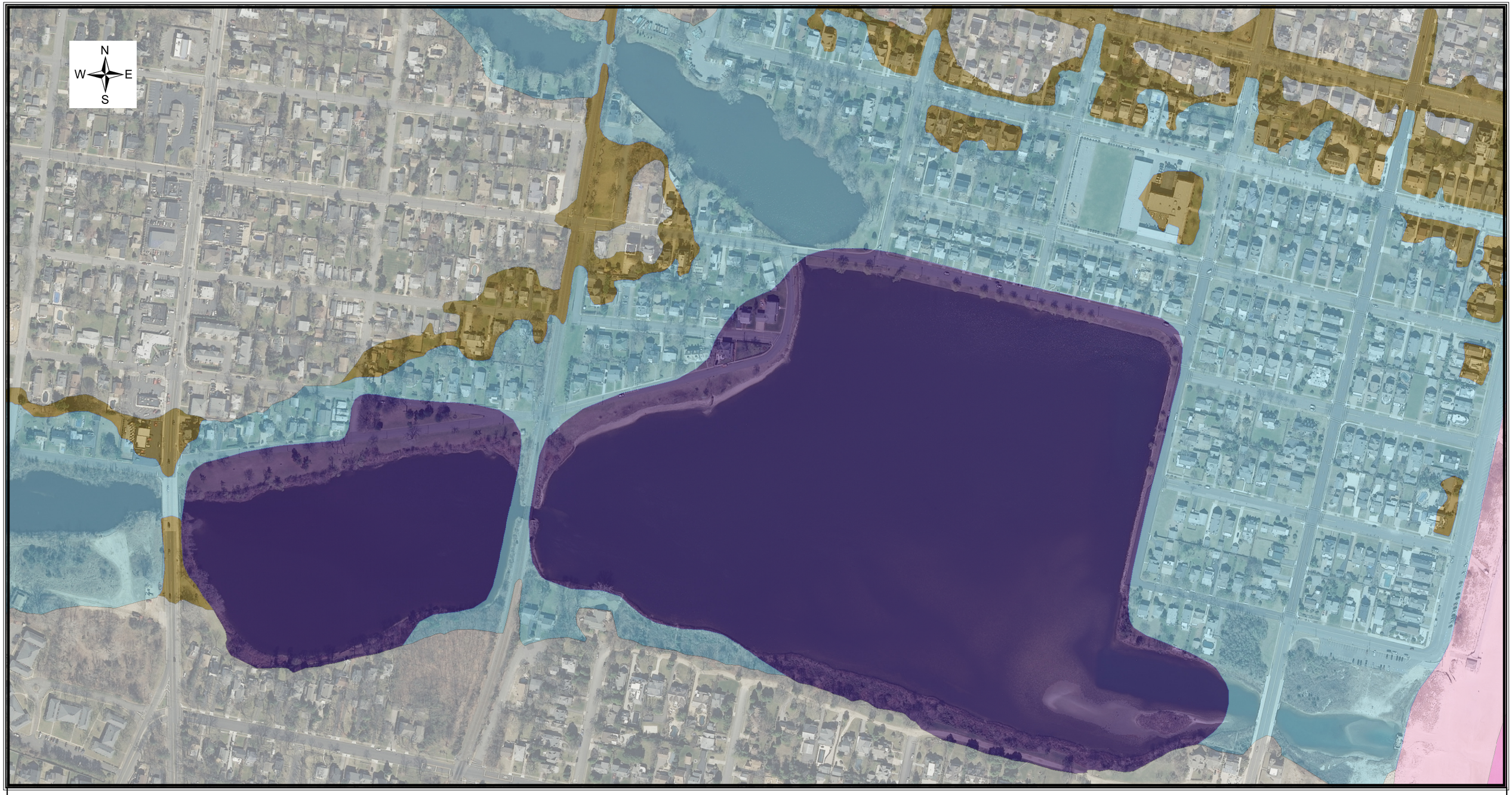
Sources:
1962 Aerial
NJDEP Wreck Pond Web Site

10/10/15

0 500 1,000
Feet

Figure 5: 1962 Pond Aerial

Najarian Associates
30 years
The Science of Engineering



Sources:
2012 Aerial NJwebmap

FEMA PFIRM GIS Layers Jan 2015

0 400 800 Feet

Legend

FLD_ZONE, STATIC_BFE

- 0.2 PCT FZ
- AE, -9999
- AE, 10
- AE, 11
- VE, 12
- VE, 15
- VE, 16
- X, -9999

Figure 6: PFIRM Flood Zones

Najarian Associates
30 years
The Science of Engineering

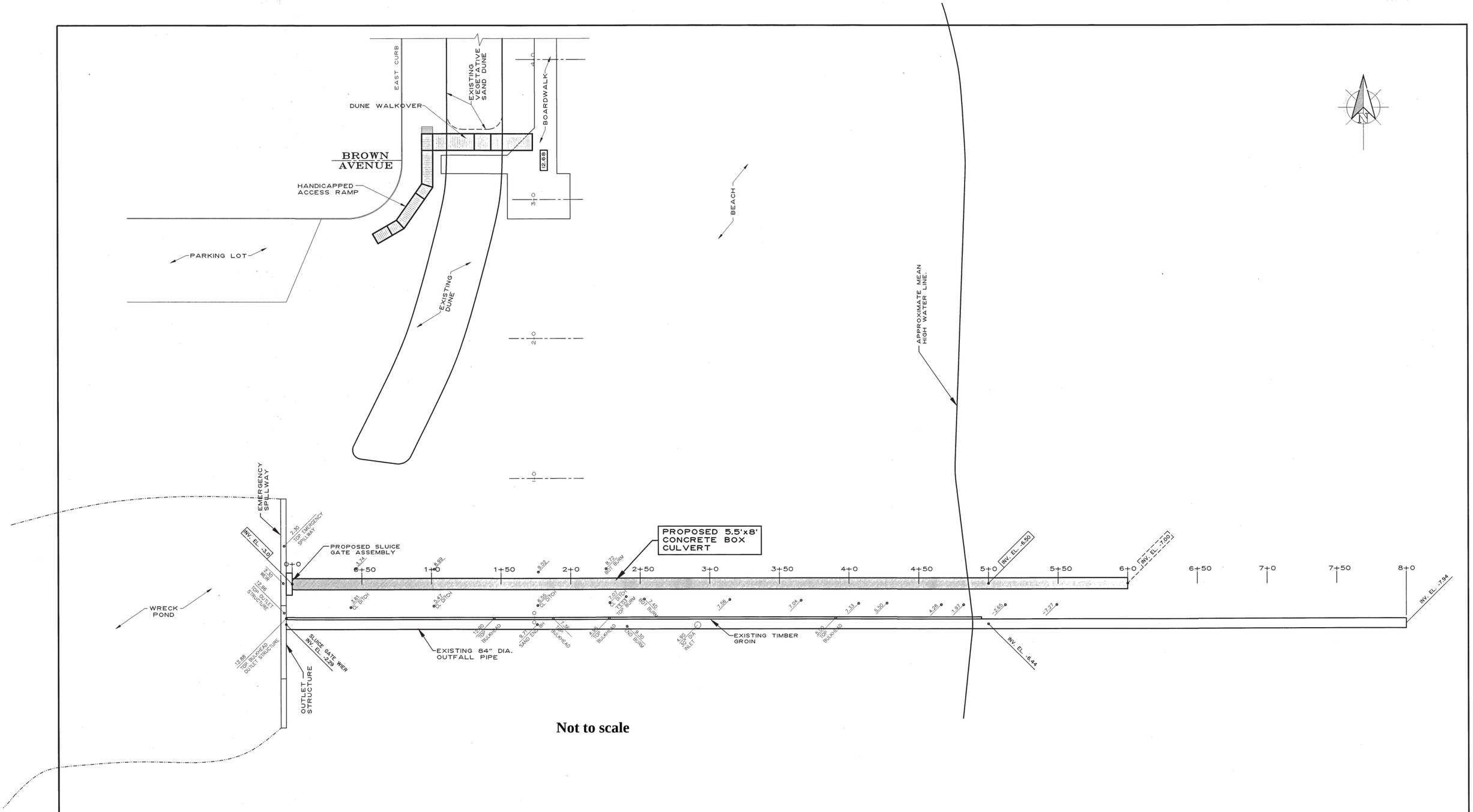


Figure 7: Outfall Construction Plan

Note: Plan for Illustration Only. Final Construction Plan may vary

FLOOD HAZARD RISK REDUCTION AND RESILIENCY GRANT PROGRAM

LEON S. AVAKIAN, INC.
Consulting Engineers
768 WAYSIDE ROAD
NEPTUNE, NEW JERSEY 07753
OFFICE: (732) 922-9229 FAX: (732) 922-0044

PETER R. AVAKIAN, P.E.
PROFESSIONAL ENGINEER N.J. LIC. NO. 28142
12.15.14
DATE

OUTFALL CONSTRUCTION PLAN

WRECK POND IMPROVEMENT PLAN
IN THE
BOROUGH OF SPRING LAKE
MONMOUTH COUNTY, NEW JERSEY

SCALE	DATE	DRAWN BY	CHECKED	JOB NO.	SHEET
1" = 30'	DEC. 15, 2014	M.T.B.	D.J.H.	SL 14-12	3 of 9

REV.	DESCRIPTION	BY	CHK.	DATE

SL-14-12-BYPASS BYPASS CONST PLAN SHT 4

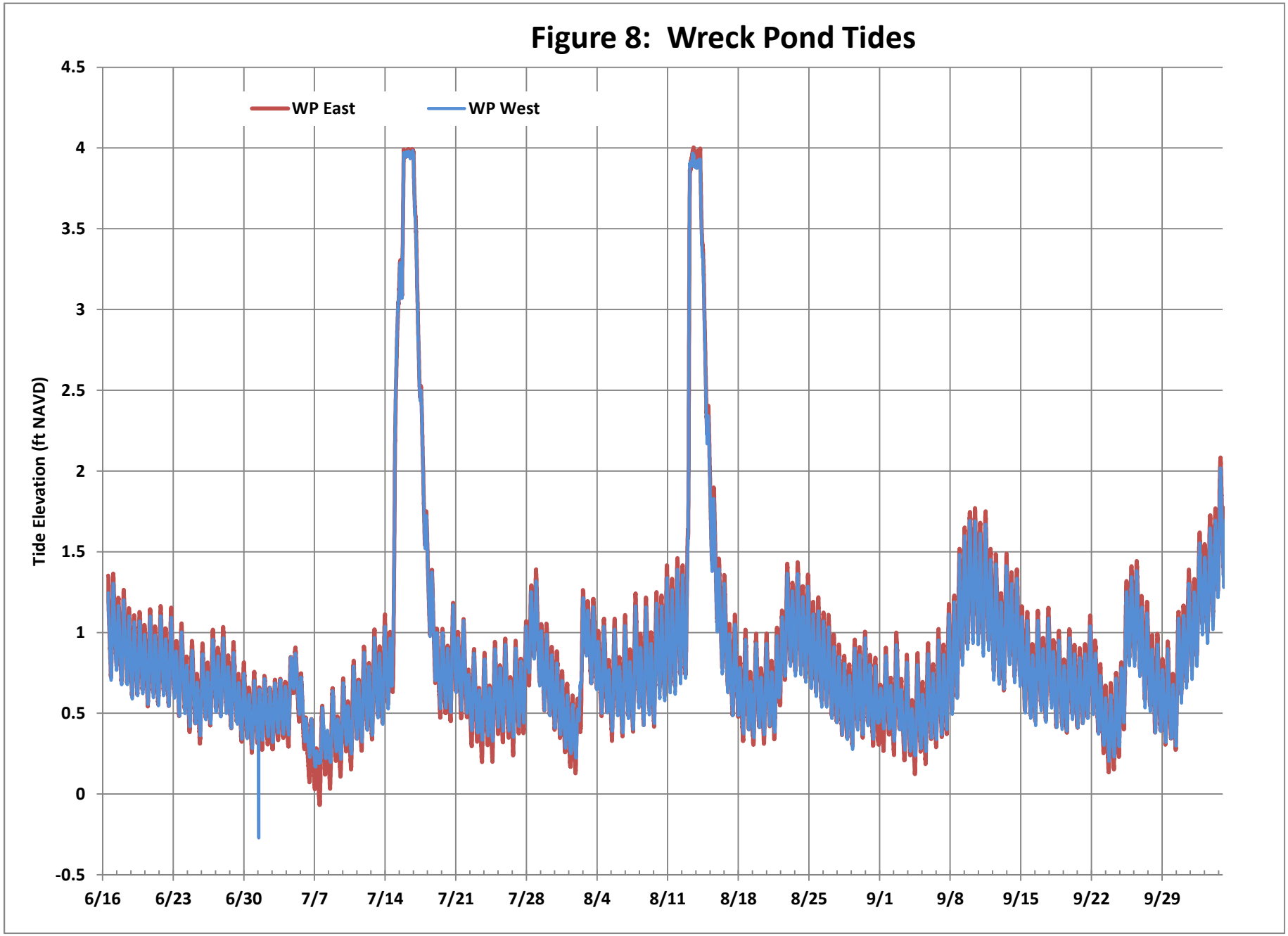
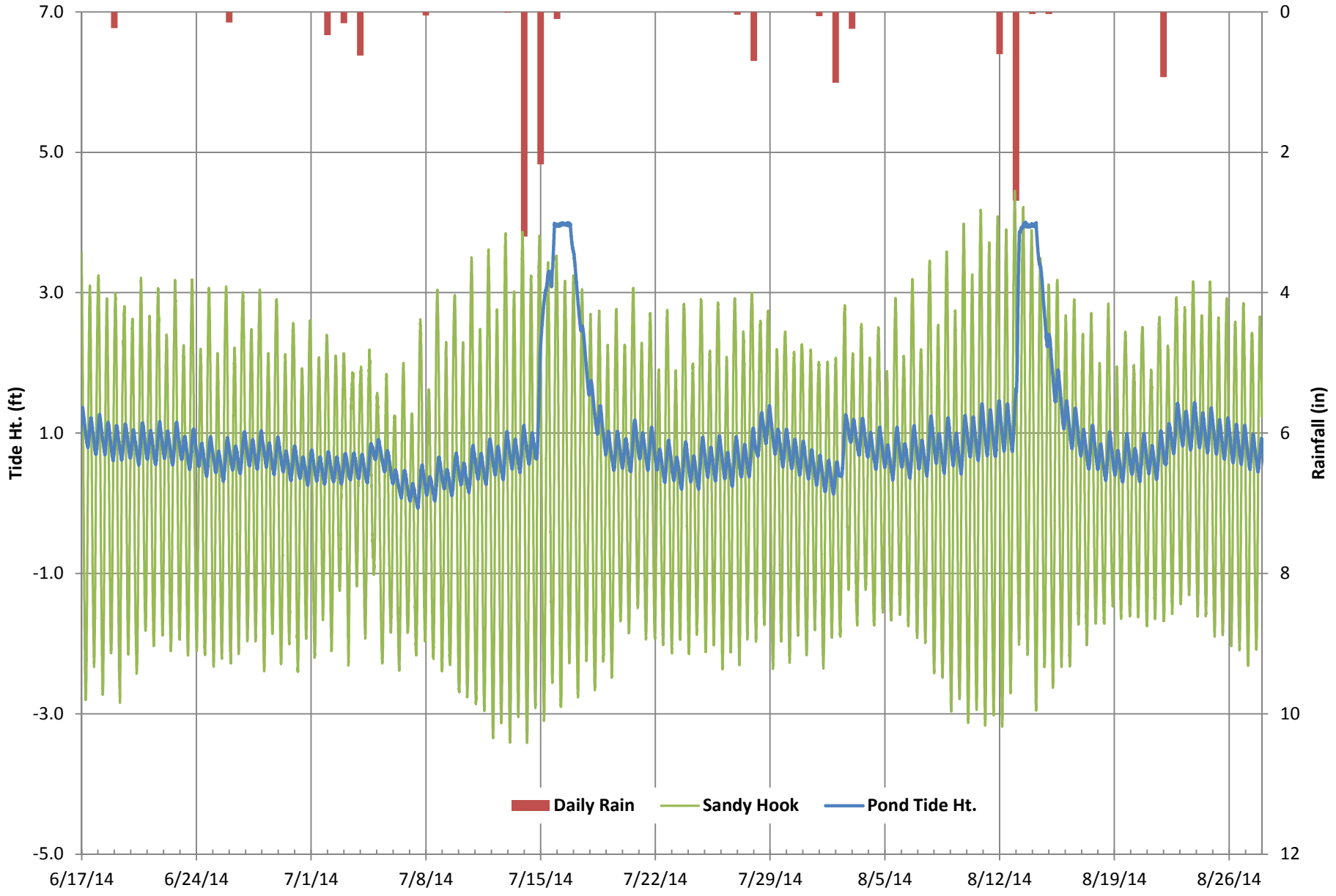
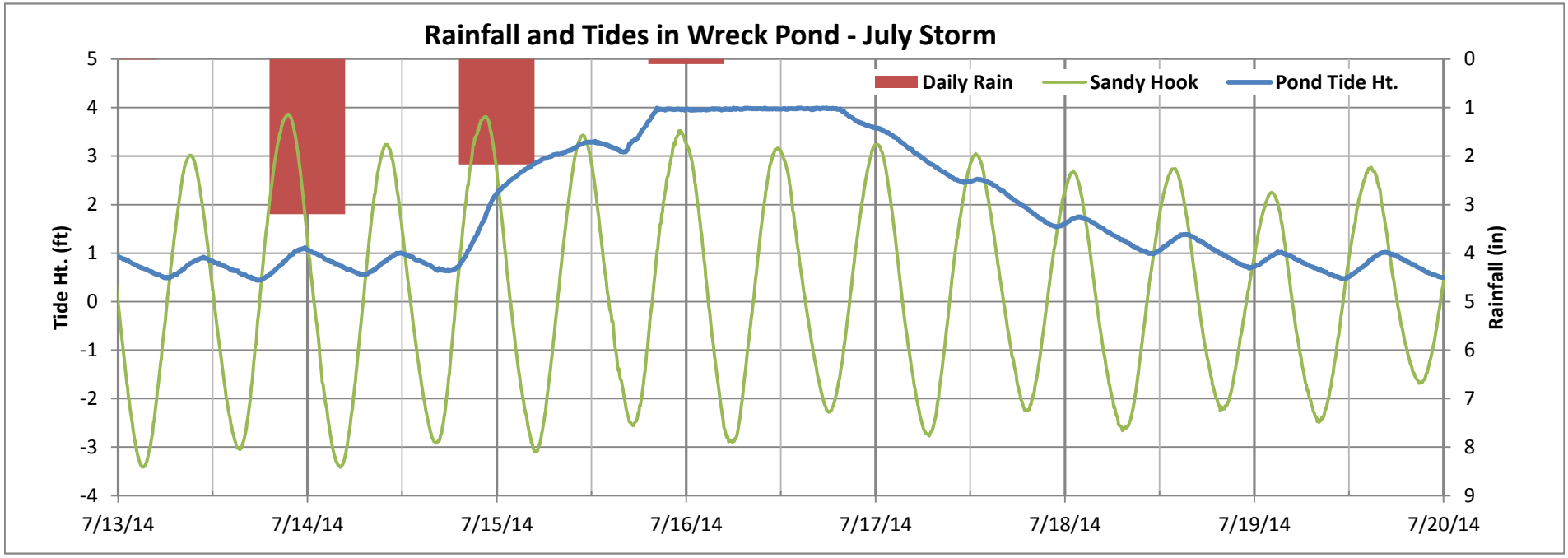


Figure 8: Wreck Pond Tides
WP East
WP West
Tide Elevation (ft NAVD)
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
6/16
6/23
6/30
7/7
7/14
7/21
7/28
8/4
8/11
8/18
8/25
9/1
9/8
9/15
9/22
9/29

Figure 9: Summer Rainfall and Tides in Wreck Pond





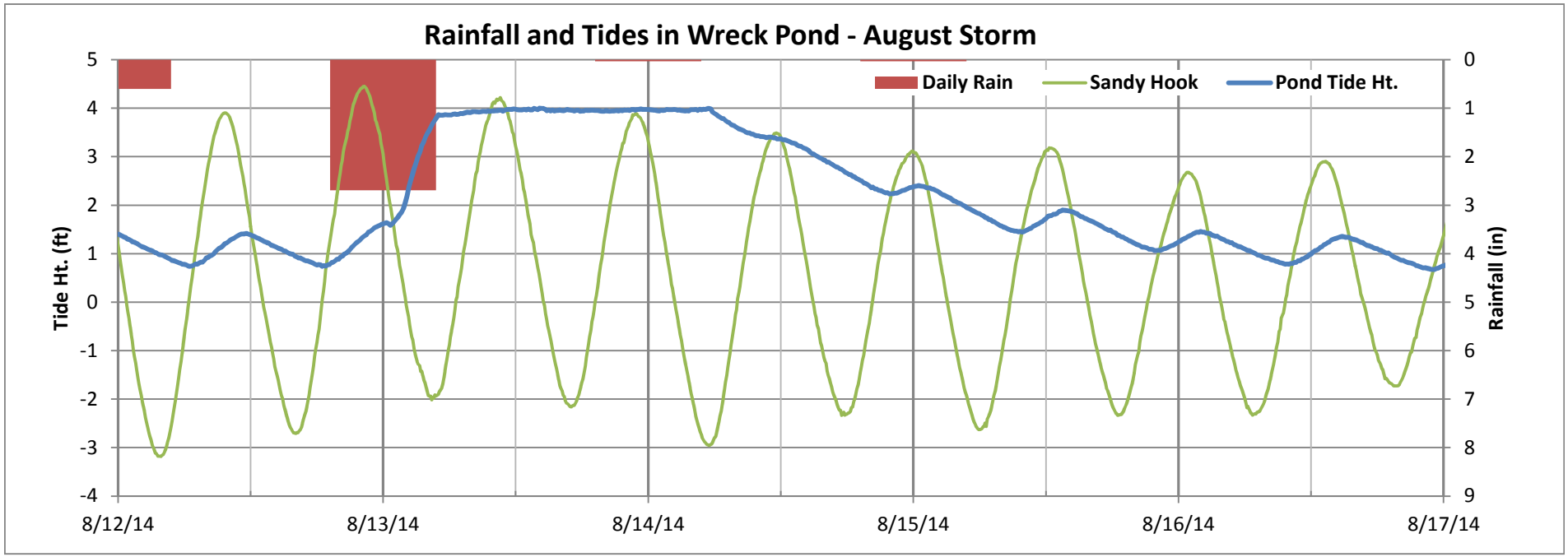


Figure 10: Tide and Rainfall - Storm Events - Summer 2014

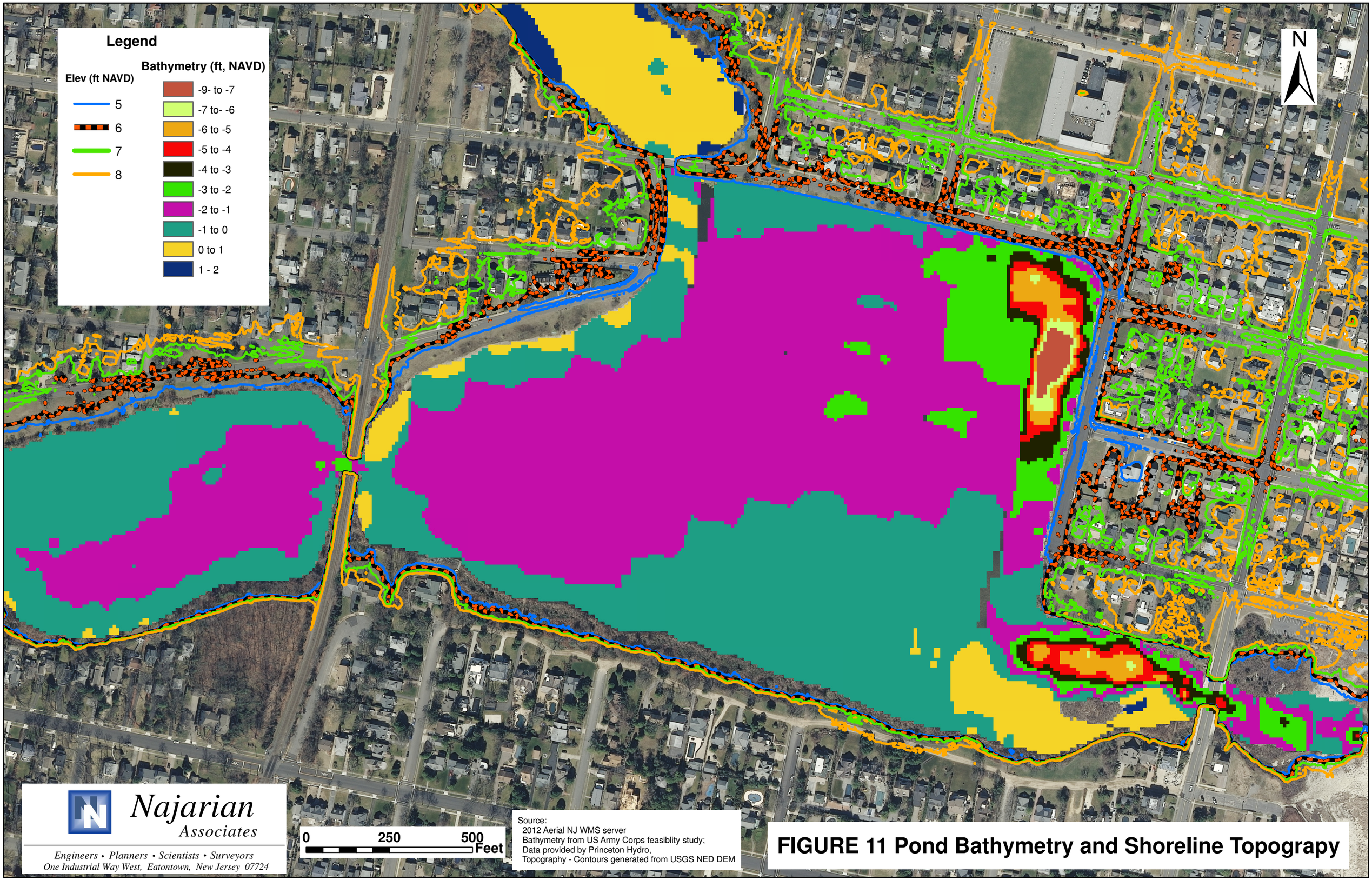
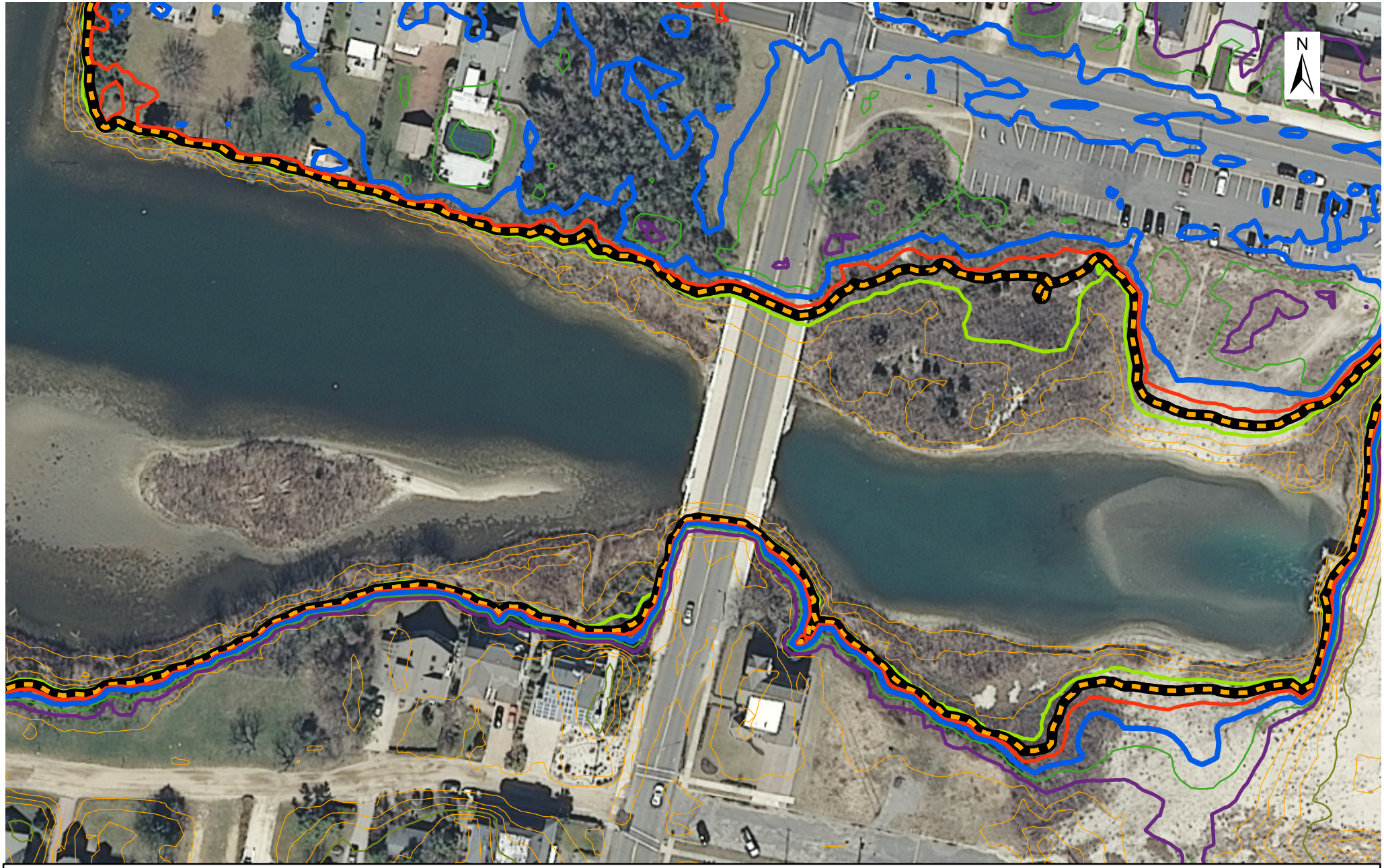


FIGURE 11 Pond Bathymetry and Shoreline Topograpy



Legend

- Other
- 0
- 5
- 6
- 7
- 8
- 9
- 10

Sources:
2012 Aerial NJwebmap
Contours Generated from USGS DEM

0 100 200 Feet

Figure 12: Aerial and Topo Outfall to Second Avenue

Najarian Associates
30 years
The Science of Engineering

Legend

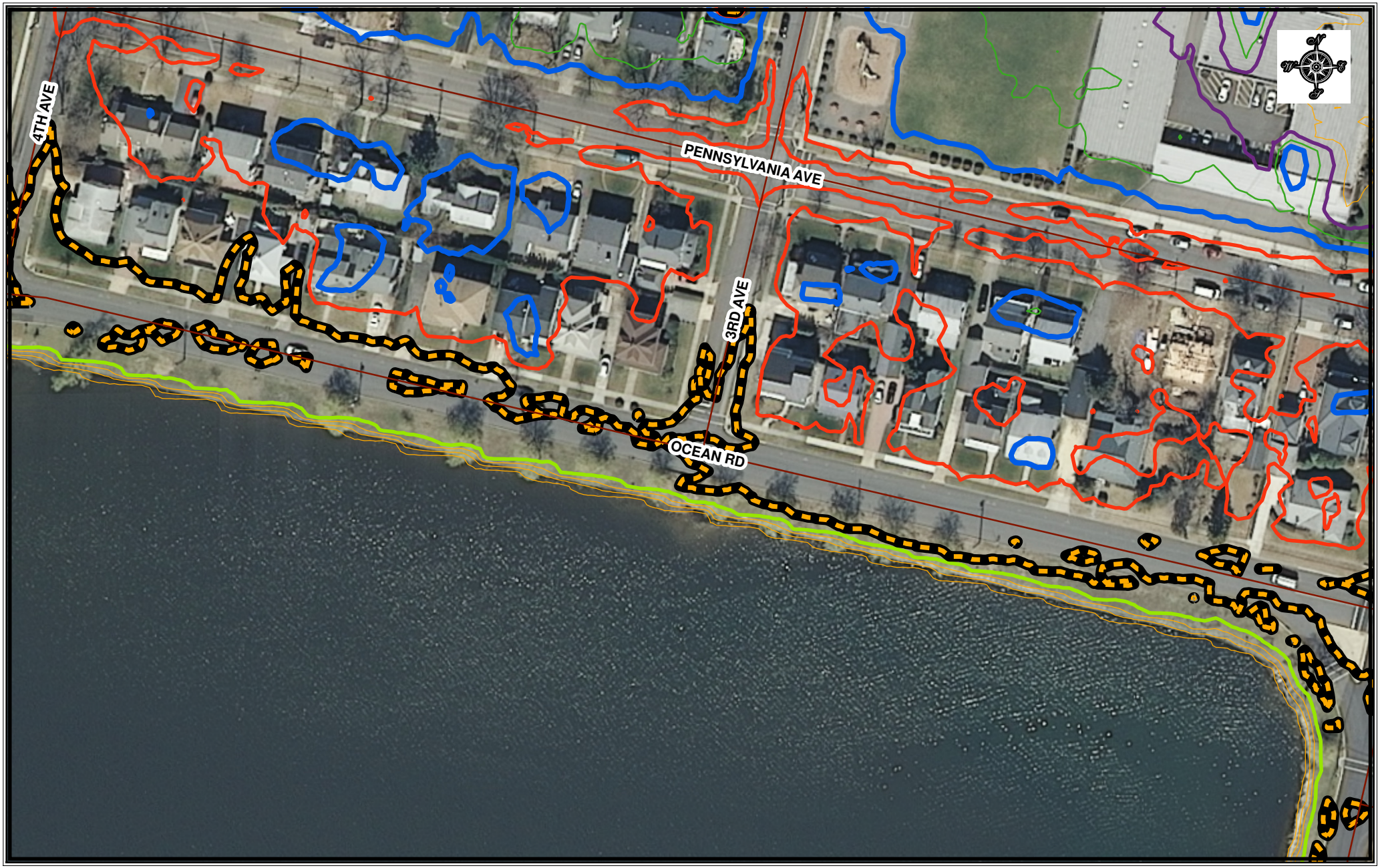
- Other
- 0
- 5
- 6
- 7
- 8
- 9
- 10

Sources:
2012 Aerial NJwebmap
Contours Generated from USGS DEM

0 100 200 Feet

Figure 13: Aerial and Topo
Second Avenue

Najarian Associates
30 years
The Science of Engineering



Legend

- Other
- 0
- 5
- 6
- 7
- 8
- 9
- 10

Sources:
2012 Aerial NJwebmap
Contours Generated from USGS DEM

0 100 200 Feet

Figure 14: Aerial and Topo Ocean Road

Najarian Associates
30 years
The Science of Engineering

Legend

- Other
- 0
- 5
- 6
- 7
- 8
- 9
- 10

Sources:
2012 Aerial NJwebmap
Contours Generated from USGS DEM

0 100 200 Feet

Figure 15: Aerial and Topo
Black Creek Weir and Ocean Road West

Najarian Associates
30 years
The Science of Engineering

Legend

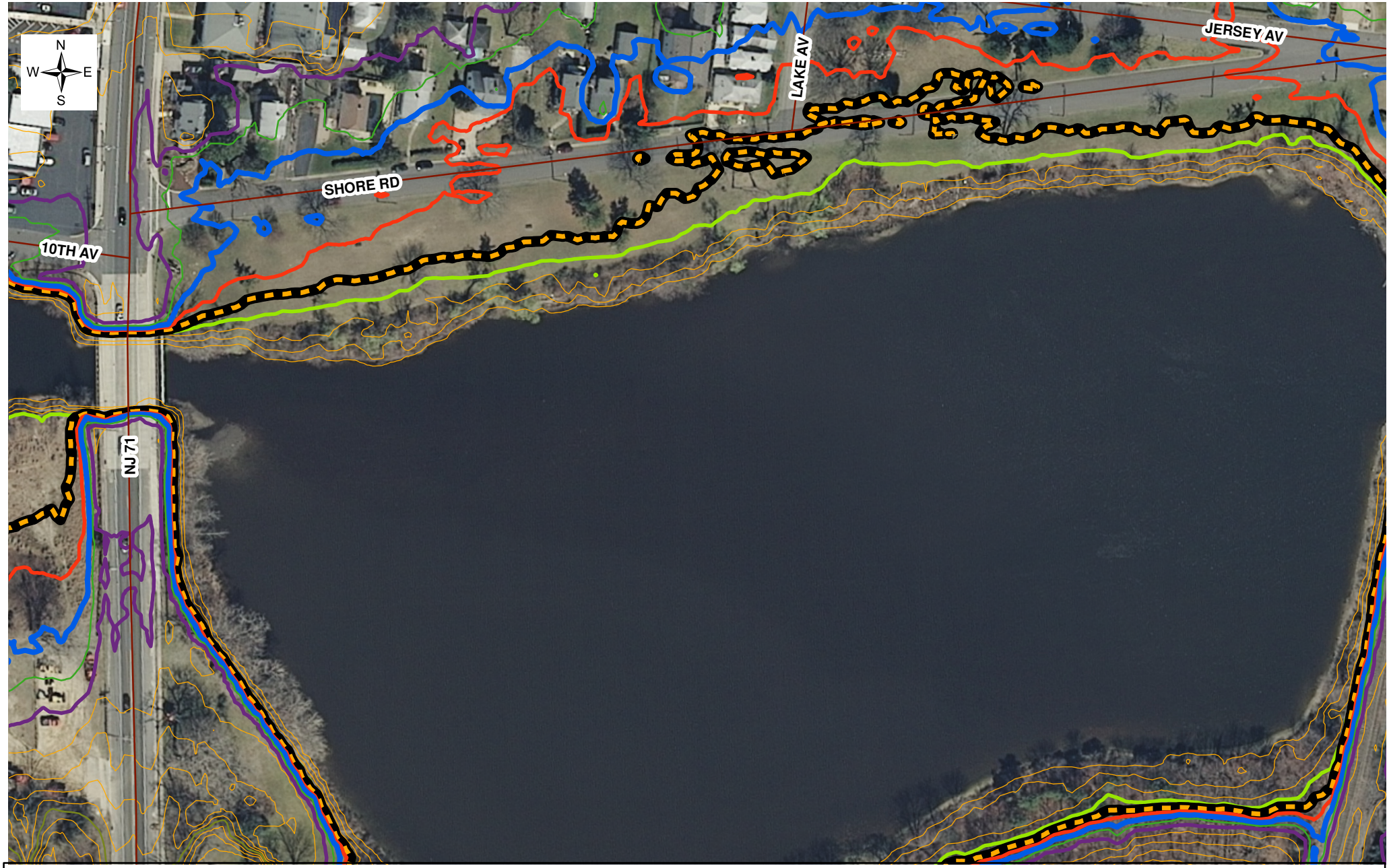
- Other
- 0
- 5
- 6
- 7
- 8
- 9
- 10

Sources:
2012 Aerial NJwebmap
Contours Generated from USGS DEM
Bathymetry from LGA Hydrographic Survey 2006

0 100 200 Feet

Figure 16: Aerial and Topo Shore Road Shoreline

Najarian Associates
30 years
The Science of Engineering



Legend

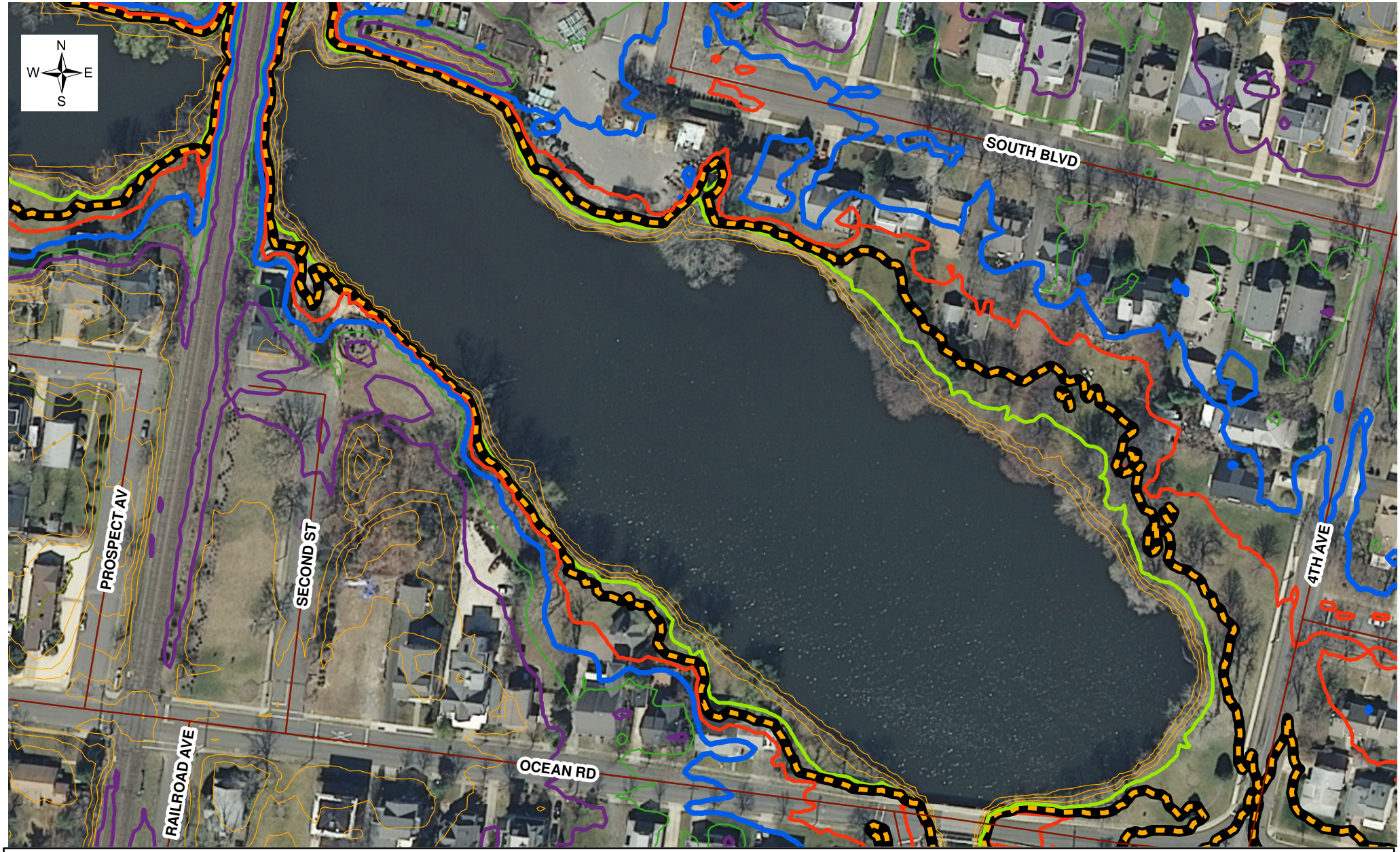
- Other
- 0
- 5
- 6
- 7
- 8
- 9
- 10

Sources:
2012 Aerial NJwebmap
Contours Generated from USGS DEM

0 125 250 Feet

Figure 17: Aerial and Topo West Pond

Najarian Associates
30 years
The Science of Engineering



Legend

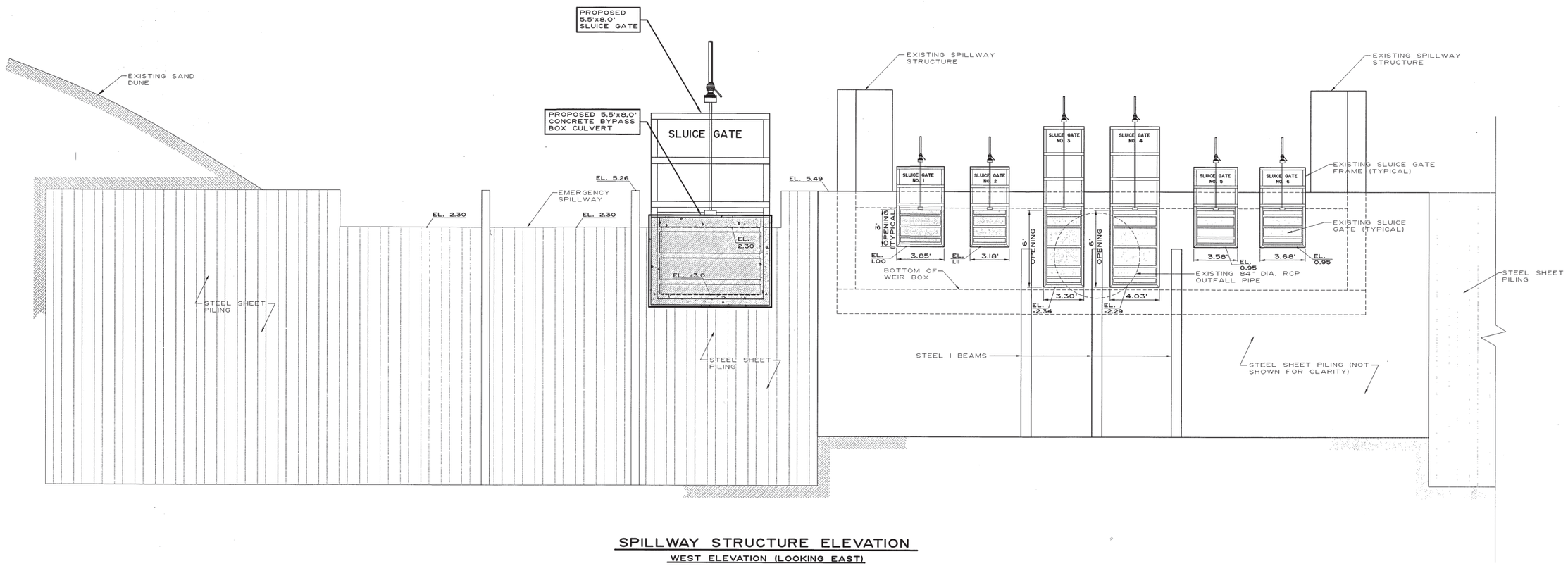
- Other
- 0
- 5
- 6
- 7
- 8
- 9
- 10

Sources:
2012 Aerial NJwebmap
Contours Generated from USGS DEM

0 125 250 Feet

Figure 18: Aerial and Topo
Black Creek

Najarian Associates
30 years
The Science of Engineering



SPILLWAY STRUCTURE ELEVATION

WEST ELEVATION (LOOKING EAST)

SCALE : 1/4" = 1'-0"

Figure 19: Outfall Cross-Section Plan

Note: Plan for Illustration Only. Final construction plan may vary.

FLOOD HAZARD RISK REDUCTION AND RESILIENCY GRANT PROGRAM

LEON S. AVAKIAN, INC.
Consulting Engineers
766 WAYSIDE ROAD
NEPTUNE, NEW JERSEY 07753
OFFICE: (732) 922-9229 FAX: (732) 922-0044

PETER R. AVAKIAN, P.E.
PROFESSIONAL ENGINEER N.J. LIC. NO. 28142

12-15-14
DATE

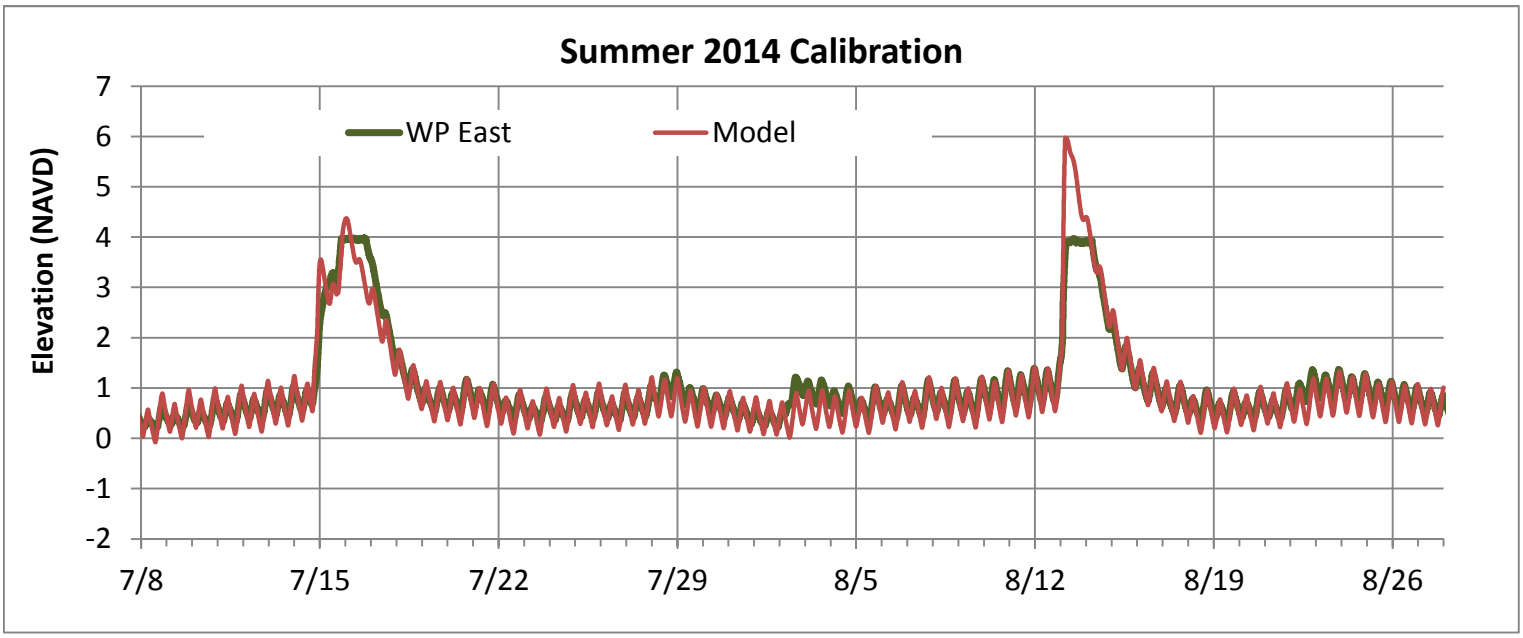
OUTFALL CROSS SECTION PLAN

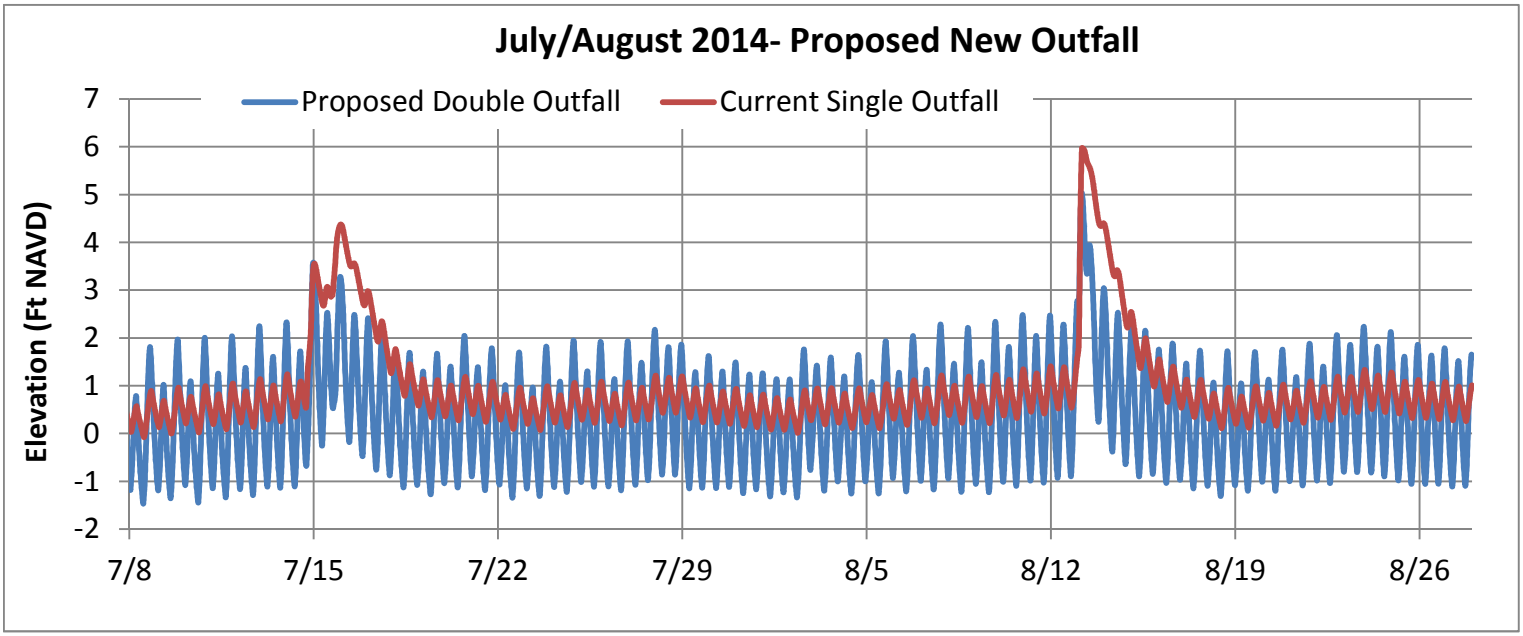
WRECK POND IMPROVEMENT PLAN
IN THE
BOROUGH OF SPRING LAKE
MONMOUTH COUNTY, NEW JERSEY

SCALE	DATE	DRAWN BY	CHECKED	JOB NO.	SHEET
AS SHOWN	DEC. 15, 2014	M.T.B.	D.J.H.	SL 14-12	4 of 9

REV.	DESCRIPTION	BY	CHK.	DATE

SL-14-12-BYPASS X-SECTION PLAN SHT 5





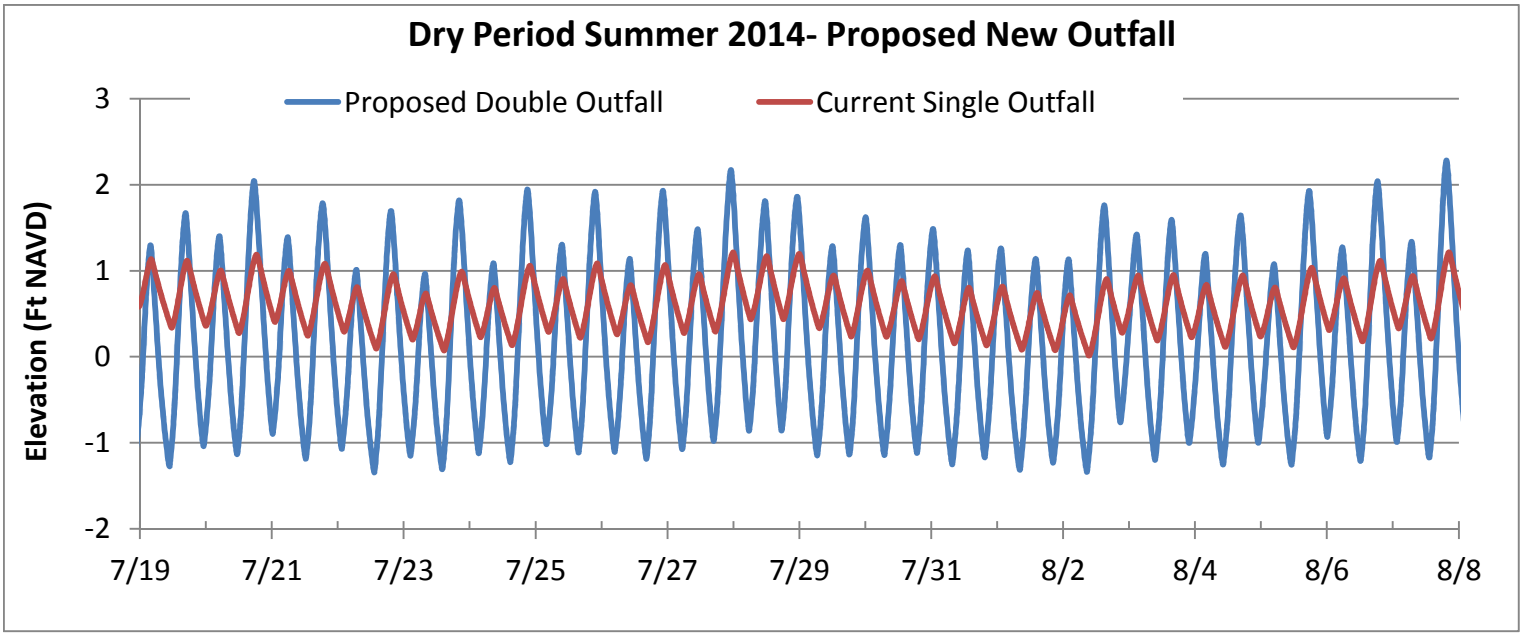
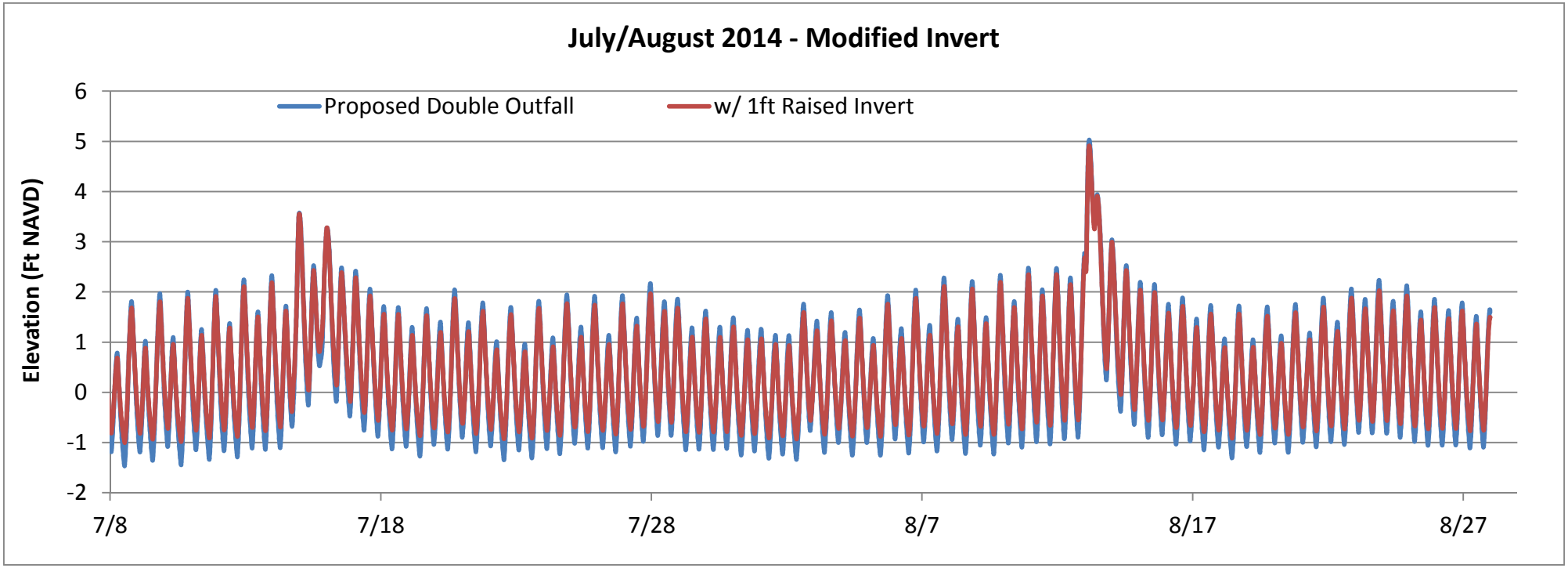


Figure 20: Modeling Results



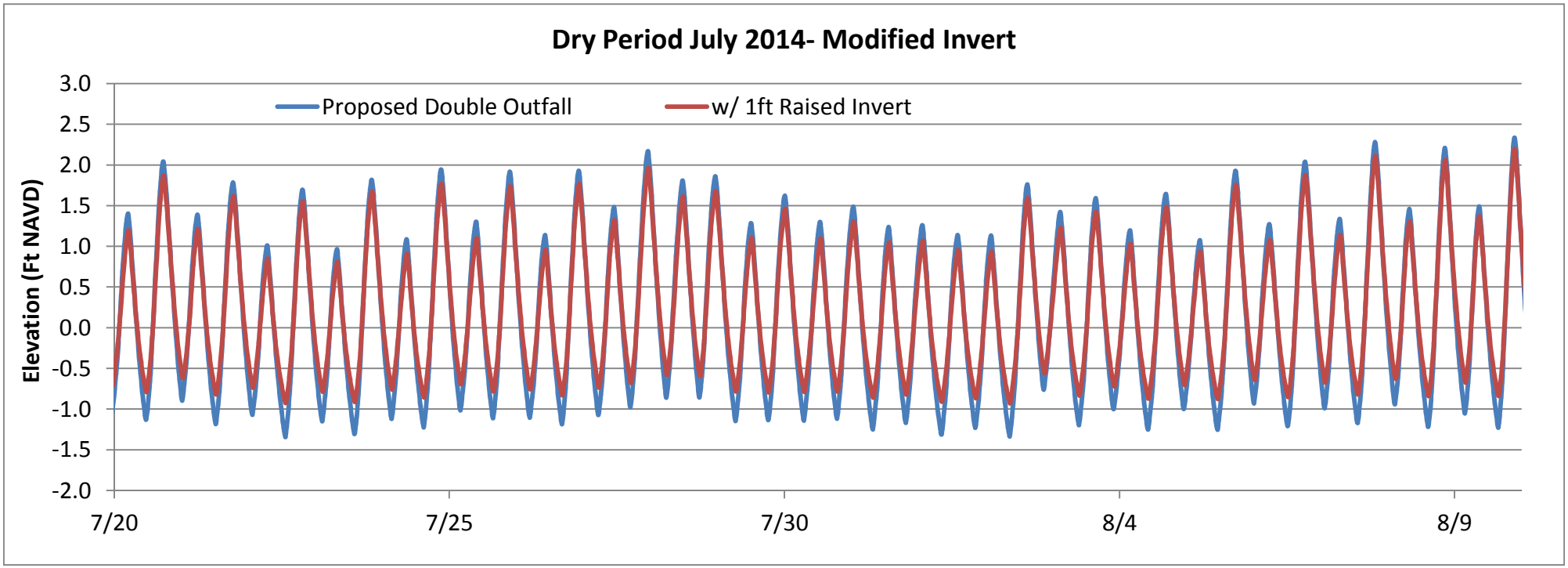
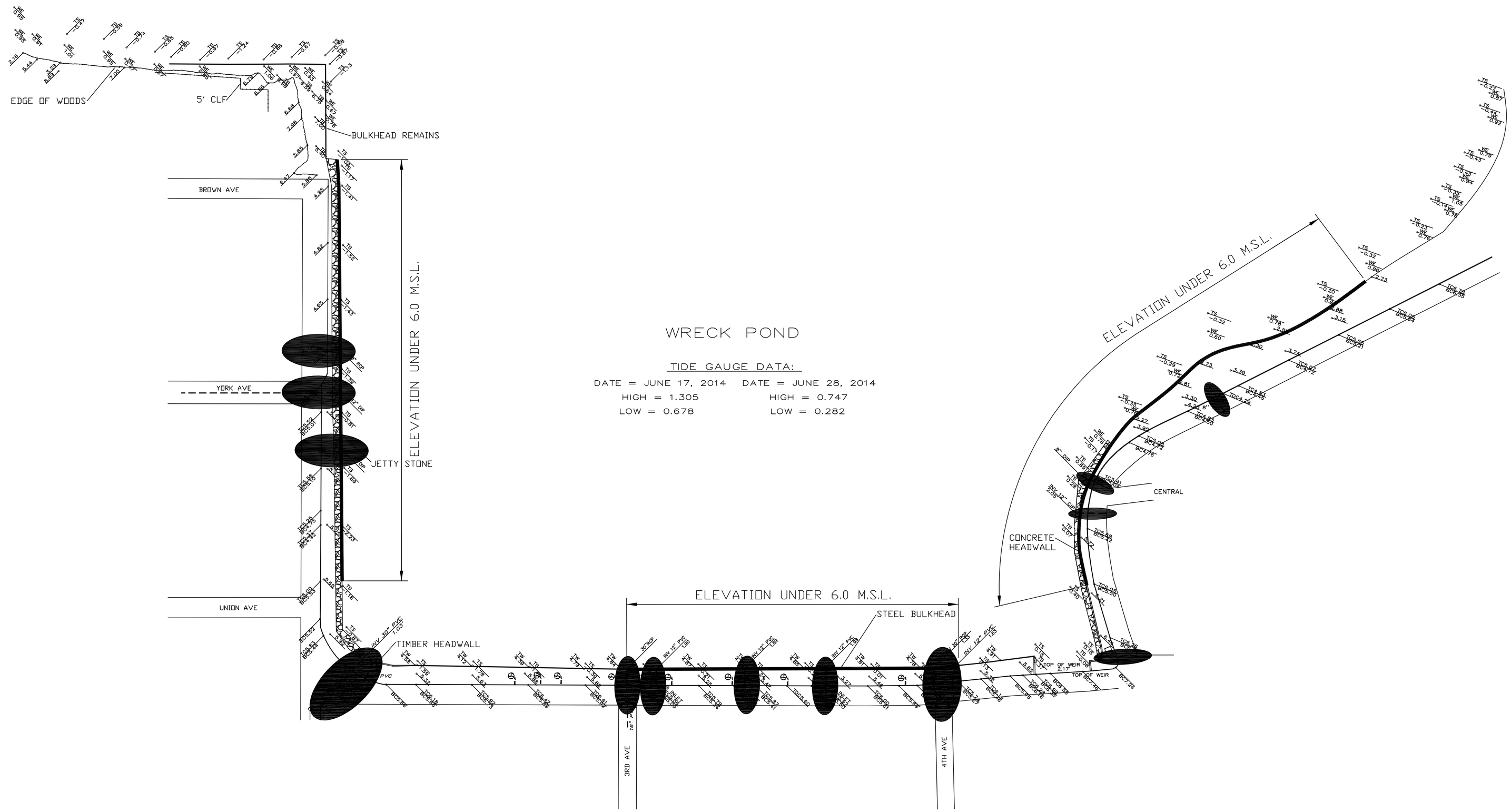


Figure 21: Model Result Modified Invert on New Outfall



WRECK POND

TIDE GAUGE DATA:

DATE = JUNE 17, 2014	DATE = JUNE 28, 2014
HIGH = 1.305	HIGH = 0.747
LOW = 0.678	LOW = 0.282

GENERAL NOTES:
1. TS INDICATES TOP OF SEDIMENT
2. WE INDICATES WATER ELEVATION
3. TB INDICATES TOP OF BANK
4. TW INDICATES TOP OF WALL

REF: SL-13-13 WRECK POND SHORELINE

REV.	DESCRIPTION	BY	CHK.	DATE

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PETER R. AVAKIAN, P.E.
PROFESSIONAL ENGINEER N. J. LIC. NO. 28142

DATE

SHORE LINE ELEVATIONS

BOROUGH OF SPRING LAKE

WRECK POND LIVING SHORE LINE
IN THE
BOROUGH OF SPRING LAKE

MONMOUTH COUNTY
NEW JERSEY

SCALE	DATE	DRAWN BY	CHECKED	JOB NO.	SHEET
1" = 100'	Oct. 15, 2014	S.J.A.	P.R.A.	SL-13-13	1 of 1

Figure 23: Pond Salinity

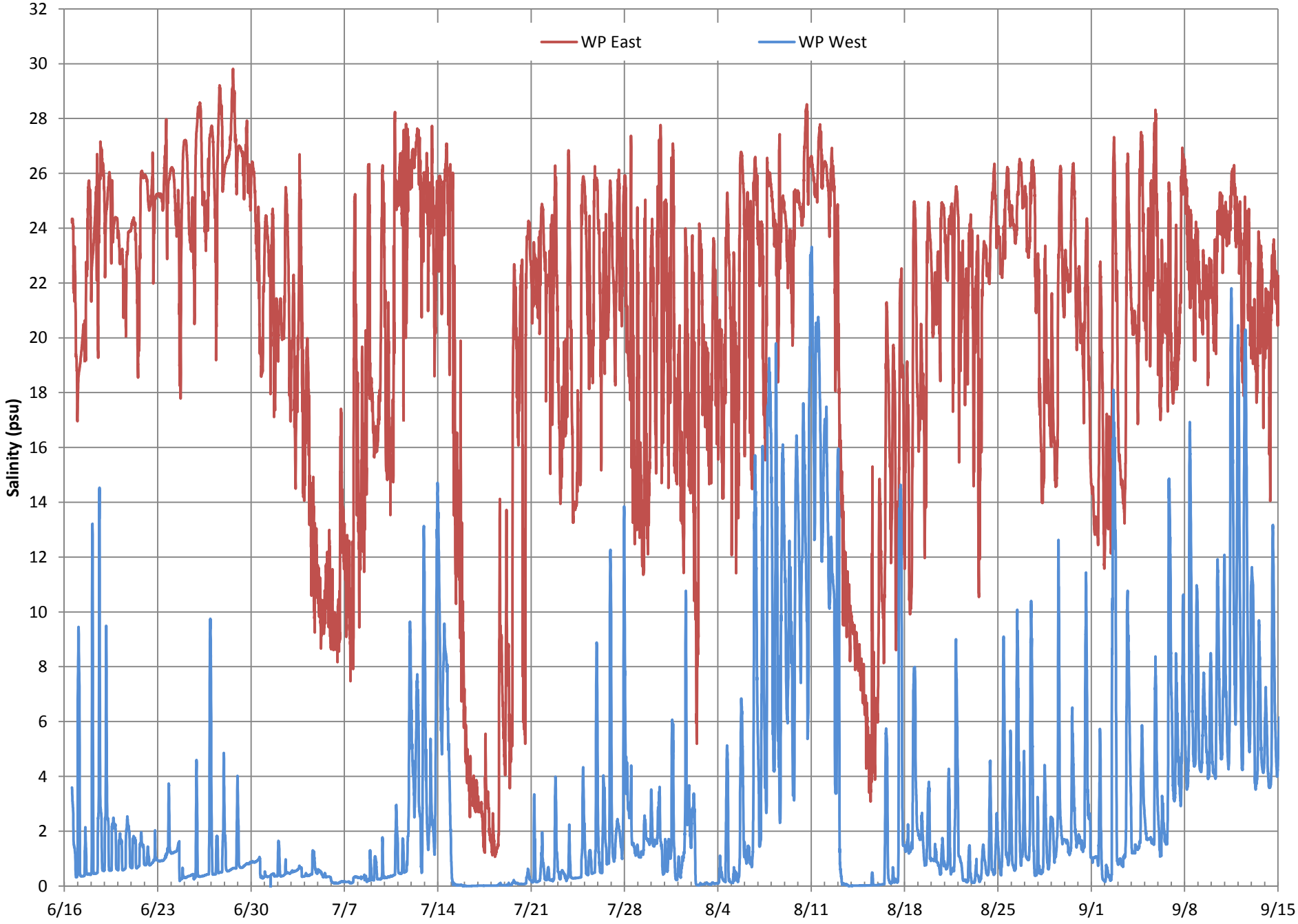
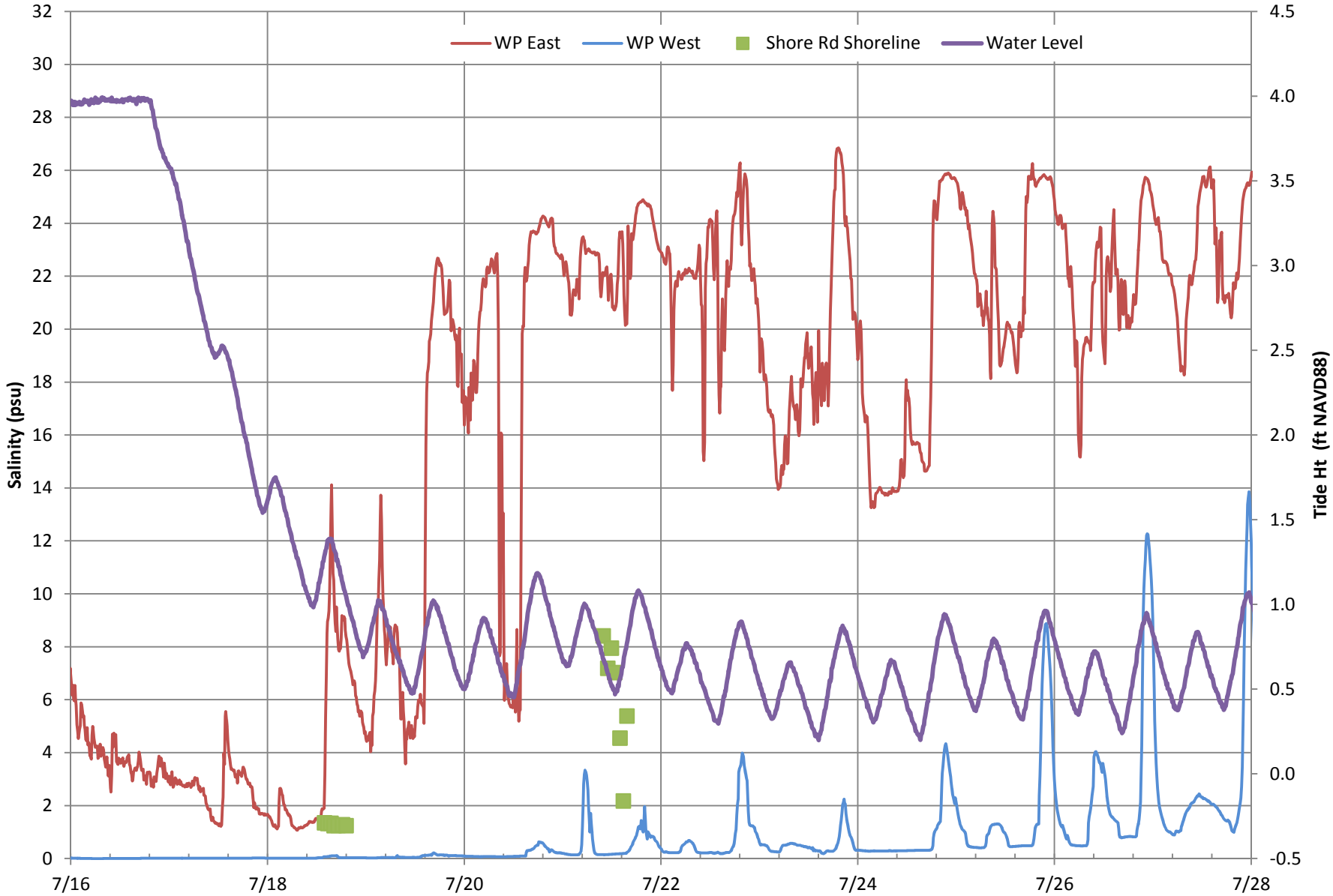
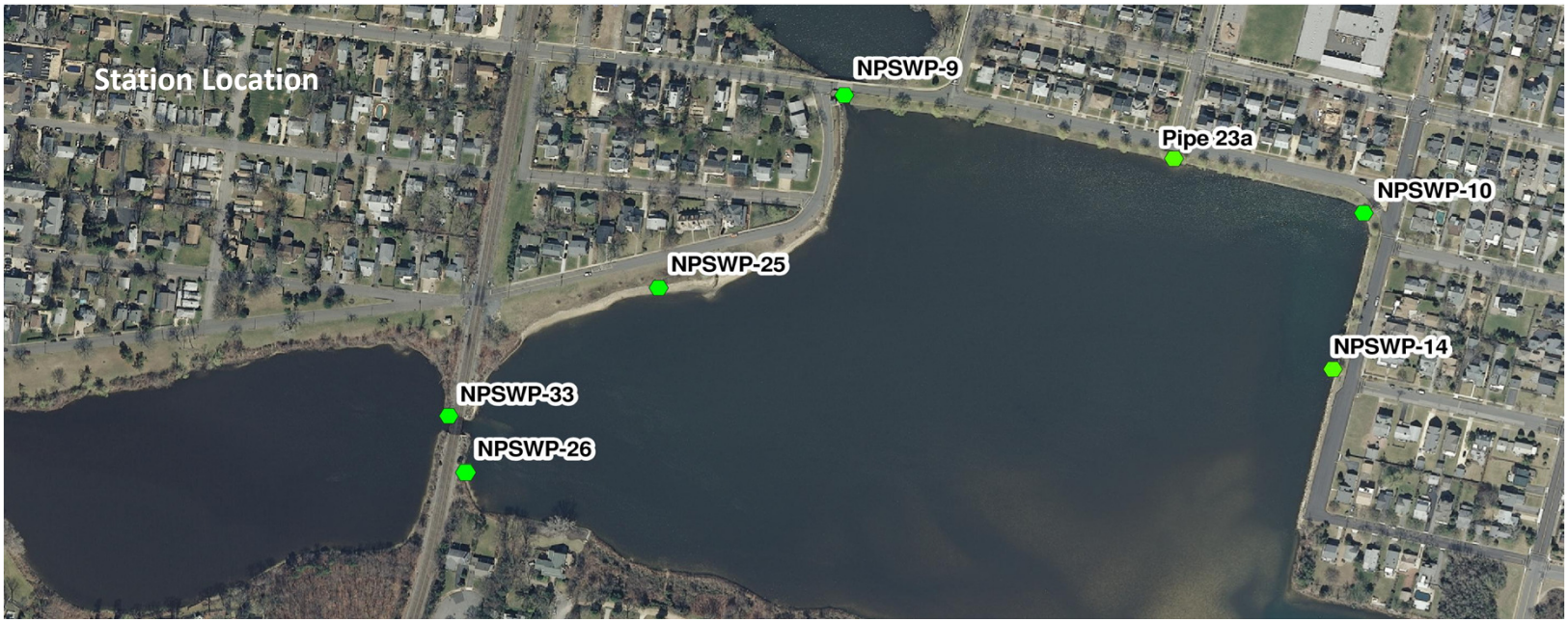


Figure 24: Pond Salinity - with Shore Road Station





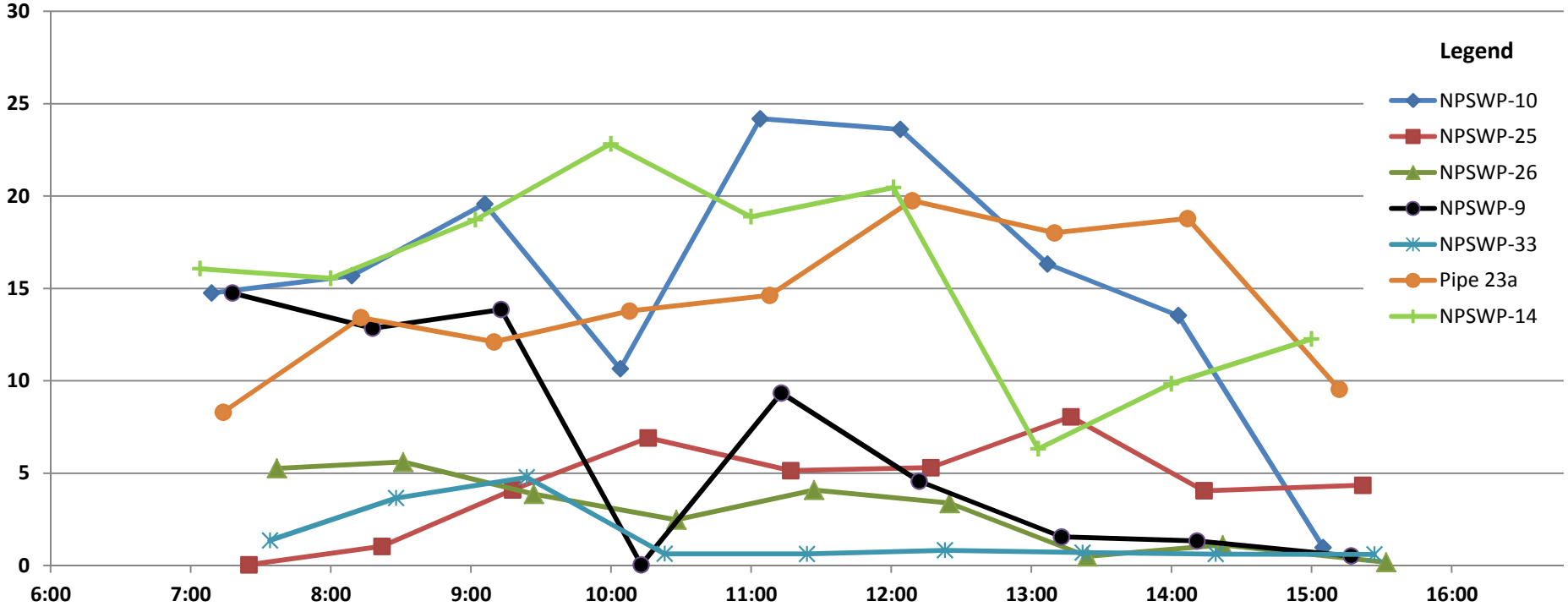
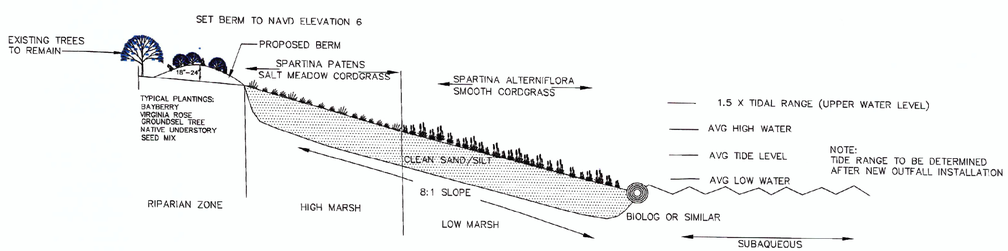
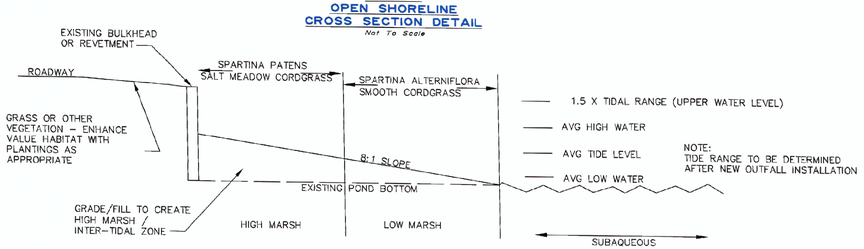


Figure 25: April 30, 2015 Sampling Locations and Salinity



AREA 1
OPEN SHORELINE
CROSS SECTION DETAIL
Not To Scale



AREA 2
PROTECTED SHORELINE
CROSS SECTION DETAIL
Not To Scale

PLAN DETAILS

GENERAL CONSTRUCTION SEQUENCE:

Site-specific conditions to define necessary steps:

Grading (shoreline)

- If substrate is inappropriate, place biolog or similar at waterward base around MLW (elevation 0.5 NAVD prior to new outfall)
- Remove layer of muck/plant detritus
- Place layer of sand/sandy silt about one foot thick
- Grade to create an intertidal zone as per tide from outfall operation

Grading (upland)

- Unprotected Shoreline: Grade from UWL to elevation 6 ft NAVD for berm
- Other Areas: Grading as needed in upland for berm.

Access Path:

- Crushed shell walkway for public access; kayak launch Shore Road

PLANTING PLAN

AREAS OF NEW MARSH OR EXISTING OPEN SHORELINE:

Low Marsh: *Spartina alterniflora* (saltmarsh cordgrass) – three feet on center spacing from average low water to average tide level

High Marsh: *Spartina patens* (saltmeadow hay) – 12" spacing, start two rows below mean high water to 1.5 times average tide level. Intersperse with *S. alterniflora* for two rows; add other plants as appropriate

Riparian (as appropriate): Final plantings to be determined in conjunction with Spring Lake Borough for aesthetics and access. Existing trees to remain; supplemental trees may be planted in limited areas. Low-height shrubs to be planted area expected to include:

- *Morella pensylvanica* (Bayberry)
- *Rosa Virginiana* (Virginia Rose)
- *Baccharis halimifolia* (groundsel tree)
- Native plant mixture as understory

Mowed grass strip at the roadway for access/maintenance.as needed

AREAS OF EXISTING VEGETATION:

In areas already vegetated, to the extent feasible, remove invasive species and replant with natives. If infeasible, or not needed, supplement existing plantings as needed to enhance shoreline habitat.

PLANTING NOTES

1. Obtain nursery-grown plants guaranteed to be true to name and healthy upon delivery as per the final planting plan as to genus, species, variety and cultivar (as specified). Plants to be healthy, vigorous stock, free of disease, pests, eggs, larvae and defects.
2. Provide plants of sizes, grades as specified.
3. Where needed, topsoil to be provided to 2-4 inches as needed for plantings
4. Immediately prior to topsoiling, subsoil surface shall be scarified to six inches to ensure bonding between new topsoil and existing subsoil. Underground utilities to be delineated and no work done that would disturb any underground utilities.
5. Required Planting Dates and Methods

Wetland Plants

- *Spartina Alterniflora:* From last frost to end of September. Avoid late July and August due to high water temperatures. Plant rows, 5 feet apart, 2-3 feet on center per plug or as otherwise determined appropriate to the site.
- *Spartina patens:* From last frost to end of September. Avoid late July and August due to high water temperatures. Plant spacing should be between 18 and 36 inches.
- For planting plugs, create holes approximately 3 inches in diameter and deep enough to cover the roots using hand tool such as a dibble bar. Backfill around plugs and tap down to ensure no air pockets.

Upland Plants

- Planting periods and planting techniques as determined for each species by nursery or other plant provider

Seeding

Seeding to be performed b y applying seed uniformly by hand, centrifugal seeder, droop seeder, drill, cultipacker or similar. Alternative methods must be approved. Except for drilled seedings, seed shall be incorporated into the soil on the same day as seed is placed, (except for drilled seeding), tp a de[tj pf ¼ to ½ inch by raking or dragging. Depth of seed placement dependent on soil texture.

FIGURE 26
CONCEPTUAL BERM AND LIVING SHORELINE PLAN

WRECK POND
Spring Lake, Monmouth County, NJ

LSA
LEON S. AVAKIAN, INC.
Consulting Engineers
788 WAYSIDE ROAD
NEPTUNE, NEW JERSEY 07753
OFFICE: (732) 922-9229 FAX: (732) 922-0044

Najarian Associates
35 years
Professional Engineers, Land Surveyors & Planners • Scientists
One Industrial Way West, Eatontown, New Jersey 07724
(732) 389-0220 • Facsimile No. (732) 389-8546
Certificate of Authorization Certificate # 24GA27993300

DRAWN BY:	SCALE:	DATE:	DRAWING NO:	SHEET NO:
GRM/DJH	NTS	11/20/15		

APPENDIX B

PHOTOGRAPHIC ALBUM

EASTERN POND

Outfall to First Avenue Bridge

Lower Pond from First Avenue Bridge looking east.

Photo along northern shoreline looking west toward First Ave. Bridge

View of Northern shoreline of looking east to outfall

View of outfall structure post Sandy. Outfall pipe is within structure

Southern Shoreline looking west toward First Ave Bridge

Southern shoreline looking west toward outfall

EASTERN POND

First Avenue to Brown Avenue

View of Southern shoreline from First Ave. Bridge west to main part of Pond.

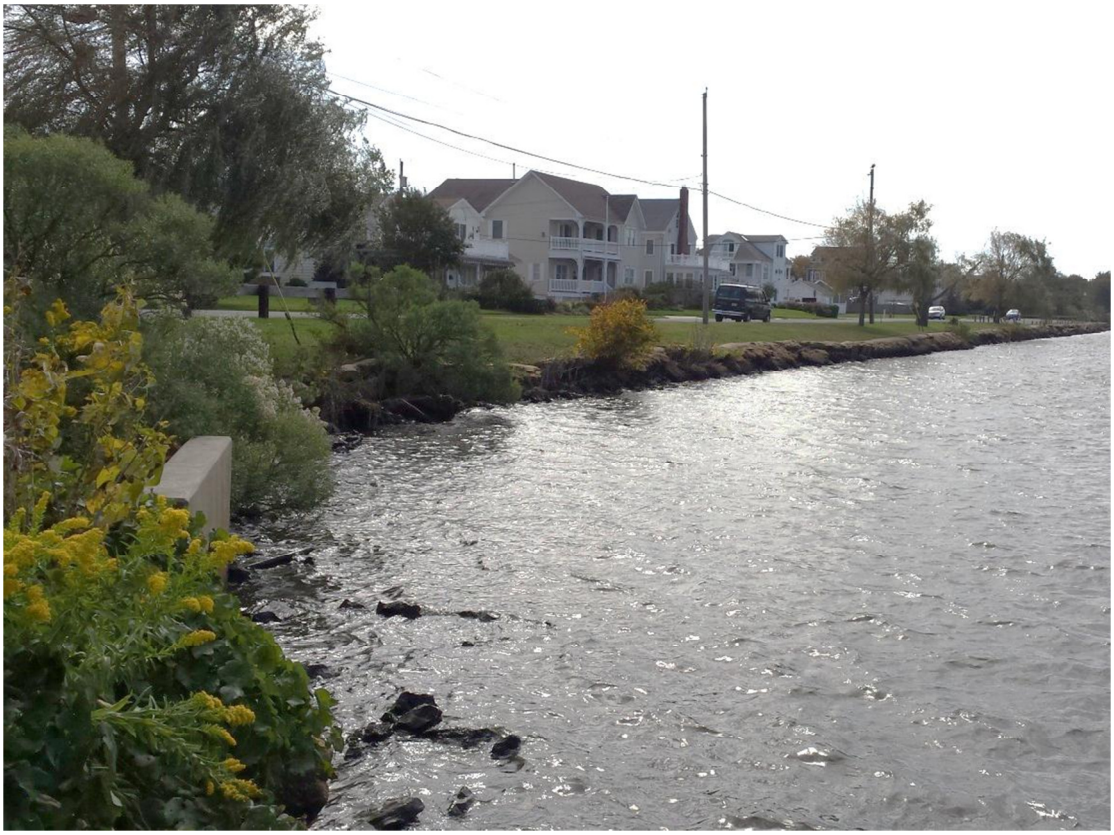
View of shoreline from Brown Ave west to main part of Pond

MAIN POND

Second Avenue and Ocean Road Shorelines

Shoreline along the southern part of Second Ave, looking North.

Northern portions of shoreline along Second Ave, looking to Ocean Road



Second Avenue Shoreline looking South

Outfall at Second Ave and Ocean Road

Corner of Pond with stormwater outfall visible. Corner Second and Ocean

Ocean Road Shoreline from corner of Second Ave looking west.

Vinyl bulkhead western part of Ocean Road shoreline

Stormwater Outfall Structure along the Ocean Road Bulkhead, with rock at base

MAIN POND

Shore Road Shoreline

Black Creek weir on Ocean Road at Shore Road

Rock Bulkhead on Shore Road, just south of Ocean Road, looking south

Shore Road Shoreline looking west at low tide

Shore Road Shoreline and Upland area, at higher tide, looking west

Shore Road shoreline and upland area looking east

Eastern part of Shore Road Shoreline , at low tide, September 2015, at outfall

Western end of Shore Road shoreline, looking southwest toward Railroad bridge

Railroad Bridge Area, upper end of main Pond

UPPER POND

Railroad Bridge to Route 71

View of vegetated shoreline, with grass upland

Shoreline view looking west toward Route 71

View from Route 71 Bridge to Railroad Bridge, looking east

View of northern shoreline from Route 71 Bridge

BLACK CREEK

Park at the corner of Ocean and 4th along Black Creek

View of Black Creek Shoreline, looking northeast from Ocean Road bridge

View of Black Creek shoreline from Ocean Road bridge, looking North-northwest

Black Creek shoreline at Prospect Ave. ROW east of Second St., looking northwest

Looking East toward Black Creek shoreline

View of a home along Black Creek with lawn to the shoreline