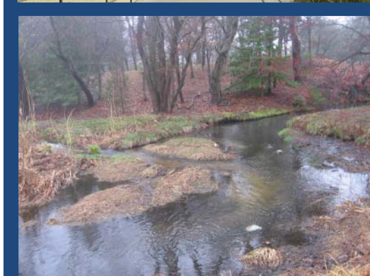
Wreck Pond

Monmouth County, NJ

Baseline Conditions Report



August 2016

Prepared in support of the
U.S. Army Corps of Engineers New York District
Wreck Pond Coastal Storm Risk Management Feasibility Study

Wreck Pond, New Jersey
Coastal Storm Risk Management Feasibility Study
Baseline Conditions Report
August 2016

Table of Contents

Figures

Tables

Appendices

1 Introduction

This baseline conditions report was prepared by the U.S. Army Corps of Engineers (USACE) New York District (CENAN) as part of the Wreck Pond Coastal Storm Risk Management Feasibility Study (Wreck Pond Study). This report is an update to the May 2016 report; text in this main report has been edited, though the technical appendices have not changed. In response to significant impacts sustained due to Hurricane Sandy, USACE undertook the Study to investigate potential coastal storm risk management solutions in communities surrounding Wreck Pond, Monmouth County, New Jersey. Concurrent with the Study, the Borough of Spring Lake and its partners designed a risk management project that could significantly reduce the risk of flooding due to coastal storms in the area. Funding was obtained by the Borough for its project in August 2015. Because the Borough project will negate the need for a Federal project potentially recommended by the Study, the Study was suspended in November 2015.

This report summarizes baseline investigations completed by USACE in support of the Wreck Pond Study. It details existing conditions at Wreck Pond and the surrounding communities; field investigations and data collection; future without-project conditions in the area; Study plan formulation; and potential authorities for future study. Detailed technical information about field investigations can be found in the appendices.

Requests for further information should be directed to: USACE New York District, Planning Division, Jacob Javitz Federal Building, 26 Federal Plaza, Room 2145, New York, New York, 10278.

1.1 Non-Federal Sponsor

The New Jersey Department of Environmental Protection (NJDEP) is the non-Federal study sponsor. A Feasibility Cost Sharing Agreement (FCSA) was executed with NJDEP on September 10, 2013 for completion of the Study at full Federal expense.

1.2 Study Authority & History

Coastal storm flooding, fluvial flooding, and ecosystem degradation are decades-long, interrelated problems in the Wreck Pond watershed. In response to these problems, the Committee on Transportation and Infrastructure of the United States House of Representatives adopted a resolution on October 26, 2005 that stated:

> *Resolved by the Committee on Transportation and Infrastructure of the United States House of Representatives, That the Secretary of the Army is directed to review the report of the Chief of Engineers on Sandy Hook to Barnegat Inlet, New Jersey, published as House Document 332,* 85th *Congress,* 2nd *Session, and other pertinent reports to determine whether modifications of the recommendations contained therein are advisable at the present time in the interest of navigation improvements, flood damage reduction, environmental restoration and protection, and related purposes, with*

special emphasis on Wreck Pond, Monmouth County, New Jersey, including Black Creek and associated waters.

In response to the authority, CENAN initiated a reconnaissance study in December 2009. The reconnaissance study focused on determining current field conditions and study criteria to determine whether any watershed-based opportunities for coastal storm risk management and flood risk management exist for continued Federal participation during detailed evaluation and construction. The CENAN completed a reconnaissance report in August 2000 that detailed its findings (USACE 2000). The report recommended further Federal investigation into the feasibility of developing a "comprehensive watershed management plan for the investigation of erosion and sediment reduction, streambank stabilization, ecosystem restoration, flood damage reduction, and related issues in the Wreck Pond Watershed study area." In a letter dated March 14, 2012, NJDEP expressed its intent to serve as the non-Federal sponsor for the recommended study, which is the subject Wreck Pond Study. Before a Feasibility Cost Sharing Agreement (FCSA) could be signed between the USACE and NJDEP, Hurricane Sandy severely impacted the region when it made landfall in New Jersey in October 2012. In response to the storm's impact, the U.S. Congress passed and the President signed into law the Disaster Relief Appropriations Act of 2013 (P.L. 113-2). The legislation provides the USACE supplemental appropriations to address damages caused by Hurricane Sandy, and to manage future flood risk in ways that will support the long-term sustainability and resiliency of the coastal ecosystem and communities, and reduce the economic costs, and to risks associated with large-scale flood and storm events. The Wreck Pond Feasibility Study was included in the Second Interim Report submitted by the Assistant Secretary of the Army for Civil Works to Congress (USACE 2013) as a study to be completed as part of USACE's response to Hurricane Sandy. A FCSA between the USACE and NJDEP was signed on September 10, 2013, and the Study was funded for completion with funds authorized by P.L. 113-2.

The Study complimented efforts by other Federal agencies, state agencies, non-profit organizations, and the community to manage flood risk and improve the ecology of the Wreck Pond watershed. To support the recovery and resilience of communities impacted by Hurricane Sandy, a number of Federal and state programs were set up to distribute funding to support projects that reduce the risk of damages from future storms. The Borough of Spring Lake, U.S. Fish and Wildlife Service, American Littoral Society, and others partnered to design a risk management project that will significantly reduce the risk of flooding due to coastal storms. The main feature of the project is a secondary outfall structure and pipe that will enhance and control tidal connection between Wreck Pond and the Atlantic Ocean. The Borough of Spring Lake applied for and received $3.85 million from the post-Sandy New Jersey Flood Hazard Risk Reduction and Resilience Grant Program in July 2015. Construction of the project began in late 2015 with funding from this grant and other sources. As described in Chapter 4, the Borough project could significantly reduce coastal flood risk to communities surrounding Wreck Pond, and thus will negate the need for a Federal project potentially recommended by the Study. After the construction contract was awarded, USACE decided to suspend its study in November 2015.

2 Baseline Conditions

This chapter summarizes existing conditions in the study area. It includes a discussion of data collection and modeling that was completed to fully understand the extent of current problems and conditions as of November 2015. Much of the data produced by USACE were used as inputs into engineering models that simulated future with and without-project conditions, the results of which are summarized in Chapter 3.

2.1 Study Area

The study area includes the tidally-influenced and surge-prone areas in and around Wreck Pond (Figure 1). The study area encompasses 0.56 square miles (356 acres) in the boroughs of Spring Lake, Spring Lake Heights, and Sea Girt, and Wall Township. It roughly follows the 100-year floodplain.

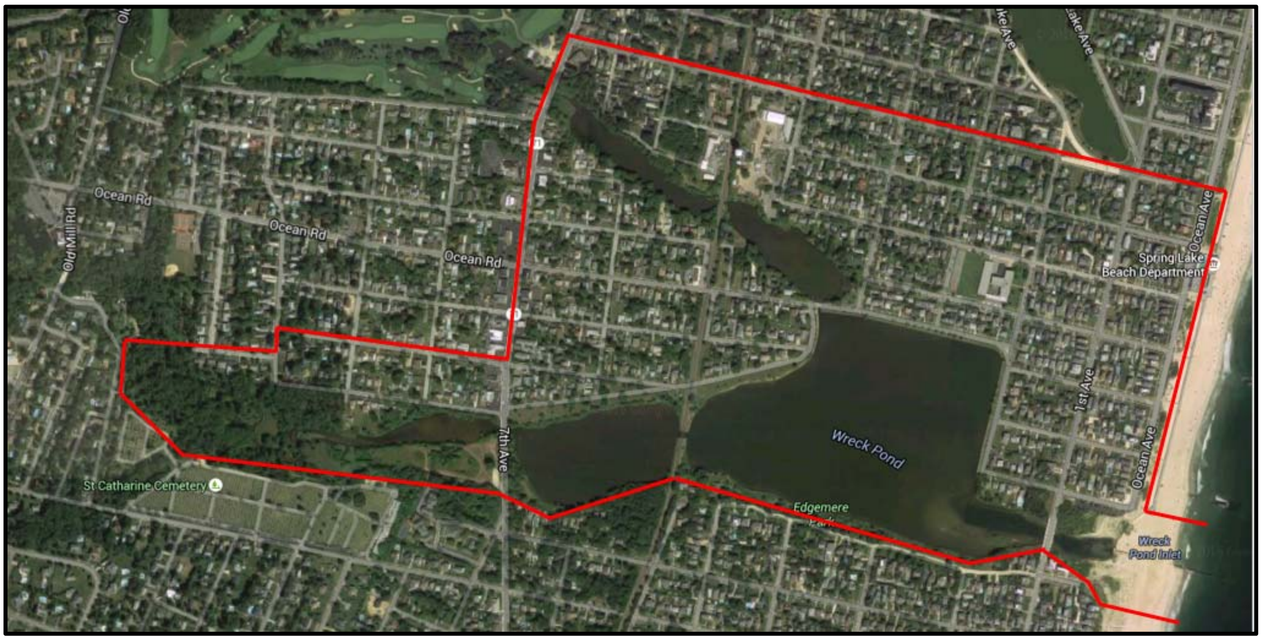


Figure 1: Wreck Pond study area.

Portions of the boroughs of Spring Lake, Spring Lake Heights, and Sea Girt, and Wall Township are included in the study area. The area is home to approximately 8,000 people, most of them full-time residents (US Census, 2010). Most residents have returned to the area after the devastation caused by Hurricane Sandy in 2012; residents and businesses continue their recovery. The study area includes the entirety of Wreck Pond, which is a tidally-influenced coastal lake with connection to the Atlantic Ocean. The pond is approximately 73 acres with tidal influence on the eastern portion. The eastern end of Wreck Pond contains an outfall structure that exchanges water with the Atlantic Ocean.

2.2 Physical Processes & Characteristics

Wreck Pond is a tidally-influenced pond located on the coast of the Atlantic Ocean. The Wreck Pond Brook watershed includes 8,174 acres in southern Monmouth County. The watershed is approximately 12.8 square miles, with its headwaters located in Wall Township, flowing east-southeast to discharge into Wreck Pond. Major tributaries to Wreck Pond within the study area include Wreck Pond Brook and Black Creek. The western boundary of the watershed is in Wall Township and extends east-southeast to Wreck Pond on the border of the Boroughs of Spring Lake and Sea Girt. The watershed also includes lands in the Borough of Spring Lake Heights and Wall Township. The major tributaries are Hannabrand Brook, Wreck Pond Brook, Hurley's Pond Brook, and Black Creek (Figure 2).

Figure 2: Wreck Pond watershed and sub-watersheds.

Although tidally influenced, Wreck Pond is classified by the State of New Jersey as FW2-NT habitat. Designated uses for FW-NT waters include: are designated as FW2-Non Trout (NT) or freshwater (FW) river not supporting trout spawning or maintenance. By definition, designated uses for FW2 waters include: 1. Maintenance, migration and propagation of the natural and established biota; 2. Primary contact recreation; 3. Industrial and agricultural water supply; 4. Public potable water supply after conventional filtration treatment and disinfection; and 5. Any other reasonable uses. Non-trout waters are those "not generally suitable for trout because of their physical, chemical or biological characteristics but are suitable for a wide variety of other fishes" (N.J.A.C. 7:9B 2008).

2.2.1 Tidal Connection of Wreck Pond to the Atlantic Ocean

Tidal influence of Wreck Pond is via a connection to the Atlantic Ocean through a 795-foot long and 7-foot diameter outfall. The western reaches of the pond are less saline than the eastern portions. A 7-foot diameter outlet pipe provides tidal exchange between the Atlantic Ocean and Wreck Pond (Figure 3 and Figure 4). The end of the outfall pipe is 600 feet offshore. The outlet also provides some flood risk reduction by controlling peak tides concurrent with peak flow from the watershed. It consists of two main structural parts: 1) the actual outfall culvert which is a 795 foot long, 7-foot diameter concrete pipe, and 2) the pond side outfall structure, which consists of sheet pile across the channel and sluice gates with weirs. This large concrete structure has six ports of varying dimensions and invert elevations which collect flow from the pond and discharge to a large chamber which is connected to the 7-foot diameter outfall pipe.

Figure 3: Wreck Pond outfall structure on September 9, 2013.

Figure 4: Wreck Pond outfall structure on September 27, 2014.

The outfall structure constrains the flushing of Wreck Pond. Inefficient movement of water causes increased flood risk to the community, and degradation of habitat and water quality within and around Wreck Pond. Significant rainfall events tend to quickly overload the capacity of the outfall pipe. Floodwaters move swiftly into Wreck Pond, where they overload the pond's storage capacity. Floodwaters quickly breach the pond's banks during such events. Local interests have taken to digging a temporary emergency spillway prior to and during storm events to mitigate flood damages. The outfall structure also limits fish passage between the pond and the ocean. It also contributes to impaired water quality due to lack of "flushing."

The outfall structure was damaged by Hurricane Sandy in October 2012. Between September 2013 and 2014, the outfall structure was reconstructed. Sluice gates and a second outfall were added to control the flow exchange between the pond and the ocean.

2.2.2 Freshwater Inflows

Freshwater inflows were computed using the HEC-HMS model of the Wreck Pond watershed. This HEC-HMS model was originally developed by the New Jersey

Department of Agriculture (NJDOA 2008) and was used for this study. The HEC-HMS model includes several streams, lakes and ponds within the watershed. The major tributaries are Wreck Pond Brook, Hannabrand Brook and Black Creek. These streams drain to Wreck Pond, which has tidal exchange with Atlantic Ocean. Hurley's Pond, Taylor Pond, Albert's Pond, Osborne's Pond, and Old Mill Pond are major waterbodies in the watershed.

Wreck Pond Brook drains the central portion of the watershed, originating just north of Allaire Airport in Wall Township and flowing to the southeast. The main stem of the stream is about 7.6 miles long. The Wreck Pond Brook sub-watershed includes the largest watershed area about 6.8 square miles, which is more than half of the watershed area. The Brook flows through Kellers Pond, Hurley's Pond, Osborne Pond and Old Mill Pond.

Hannabrand Brook flows through the southern portion of the watershed. It is about 4 miles long and has a drainage area of about 2.9 sq. miles. Hannabrand Brook joins Wreck Pond Brook just downstream of Old Mill Road. The Brook then discharges into Wreck Pond. Black Creek, also known as the North Branch of Wreck Pond Brook, drains the northern portion of the watershed and is the shortest tributary at about 1.2 miles.

Rainfall data observed at Monmouth Executive Airport were used in the HEC-HMS model, resulting in stormwater discharges varying from 100 to 400 cubic feet per second (cfs) during the 30 day simulation period (May 30–June 29, 2014). The HEC-HMS results indicate that approximately 50 cfs of base flow enters Wreck Pond during intervals of no rainfall.

2.2.3 Water Quality: Sediment & Nutrient Loading

The impacts of storms and stormwater runoff on the pond have spiked over the past decade, as evidenced by the number of large, intense storms, including Hurricane Sandy that impacted the pond and its tributaries. Collectively, these factors have heightened the understanding of the pollutant and hydrologic loading dynamics of the pond and its watershed and the necessity to quantify, rank and prioritize the sources of sediment or nutrient loading to Wreck Pond. MapShed, a GIS-based tool, was utilized to quantify the pond's annual sediment and nutrient loads. The primary objective of the MapShed loading analysis was to identify, at a subwatershed level scale, the pond's major sources of sediment, phosphorus and nitrogen loading. Although MapShed is a relatively simplistic pollutant loading model, it is very robust and powerful in its scope and applicability to investigating the eutrophication and sediment in-filling factors affecting Wreck Pond. MapShed utilizes various land cover, climatic, topographic and hydrologic based GIS inputs to derive watershed loading estimates of sediments, nutrients and water. The model ascribes sediment inputs through land-based erosion and through the scour and erosion of stream channels. The MapShed modeling effort documented unique hydrologic characteristics of the pond linked to the higher runoff volumes that typically occur during the months of June, August and October. Elevated runoff volumes lead to streambank erosion and heightened sediment loading. The model documented that 50% of the pond's total annual sediment load can be attributed to streambank erosion. On a subwatershed basis, nonpoint source (NPS) loading of sediments and nutrients was shown to be highest, on a per unit area basis, from sub-watershed 7 (Figure 2). This sub-watershed is characterized by a greater percentage of cropland than any of the other Wreck Pond sub-watersheds. The data also show that nutrient loading from sub-watersheds 2, 3, and 8. An investigation was conducted to assess the magnitude and sources of sediment, phosphorus, and nitrogen loading to Wreck Pond from the watershed. MapShed was used for the analysis. Data sources including but not limited to watershed boundary, topographic data, land use/land cover, and soils information were used to estimate sediment loading. Detailed sediment inflow modeling methods, analysis and results are presented in Appendix E.

Total sediment contributions to Wreck Pond are highest at sub-watershed 7 with a per unit area contribution of 1.61 kgx1000/ha (1.43 lbsx1000/ac). The second highest contributor of total sediments per unit area is sub-watershed 5, which contributes 0.72 kgx1000/ha (0.64 lbsx1000/ac) of sediment. Both of these sub-watersheds have the greatest acreage of agricultural land. Streambank sediment erosion, per unit area, was highest for subwatershed 7, which contributes 0.21 kgx1000/ha (0.18 lbsx1000/ac), and second highest for sub-watershed 9, which contributes 0.17 kgx1000/ha (0.15 lbsx1000/ac) of sediment. Sediment contributions to Wreck Pond from the watershed, when modeled as an aggregate, are 0.83 kgx1000/ha (0.74 lbsx1000/ac) for total sediment and 0.41 kgx1000/ha (0.37 lbsx1000/ac) for streambank sediment.

Total nitrogen loading was greatest, per unit area, was generated by sub-watershed 7 with annual loading at 9.85 kg/ha (8.78 lbs/ac). Total phosphorus loading was also the greatest for sub-watershed 7 with an annual loading rate of 1.16 kg/ha (1.04 lbs/ac). The agricultural acreage of this sub-watershed is largely responsible for these higher loads. Sub-watershed 1, 5, and 7, each of which have substantial lands categorized as agricultural, do not directly drain to Wreck Pond proper. Rather, each of them drain to one of the pond's primary tributaries and pass through a constricted impoundment before feeding the pond. The hydraulic detention attributable to the pond's tributaries and the online impoundment upgradient of Wreck Pond likely lessen the direct impact of nutrient loading from these subwatersheds on the pond.

Long-term water quality data from the NJDEP and other agencies show that water quality in Wreck Pond has been negatively influenced by stormwater runoff and the filling in of the pond from sedimentation. Four public beaches in Spring Lake and Sea Girt have been impacted from discharge from the pond. Water quality monitoring along the coast has led to closure of the beaches due to excessing bacterial counts, or as a precautionary measure after heavy rainfall events. Heavy rainfalls have the potential to increase bacterial contamination nearshore because of discharge from the outfall pipe.

In 2006, the then-500-foot outfall pipe was extended by 300 feet to 800 feet in an effort to shunt discharge further offshore. Extension of the pipe and local efforts to decrease nonpoint source pollution improved water quality in the pond and at the public beaches.

In 2011, NJDEP developed the Wreck Pond Restoration Action Plan with local stakeholder input to address water quality in the Wreck Pond Watershed and the Sea Girt and Spring Lake beaches. Extensive water quality monitoring of the waters around Wreck Pond have been performed over several years. Due to improved water quality, the precautionary closing policy for the four public beaches in Spring Lake and Sea Girt was lifted in 2014. The beaches are currently monitored on a weekly basis from mid-May through mid-September.

2.2.4 Hydrodynamics

Hydrodynamic processes in Wreck Pond are largely determined by the flow exchange through the ocean outfall, and freshwater entering through surface runoff from the upland drainage area. The three-dimensional Estuarine, Coastal, and Ocean Model (ECOM) was used as the primary tool for hydrodynamic modeling. ECOM is a state-of-the-art, time-dependent, three-dimensional hydrodynamic model derived from the Princeton Ocean Model, developed by Alan F. Blumberg and George L. Mellor (1987).

The model was calibrated using data from sensors placed in Wreck Pond. The sensors provided temperature, salinity, and flow data (Figure 5). Data were obtained from the sensors during the simulation period, which was a 30-day interval covering May 30 through June 29, 2014. Appendix C contains a detailed explanation of existing conditions, hydrodynamic modeling procedures, theory and results.

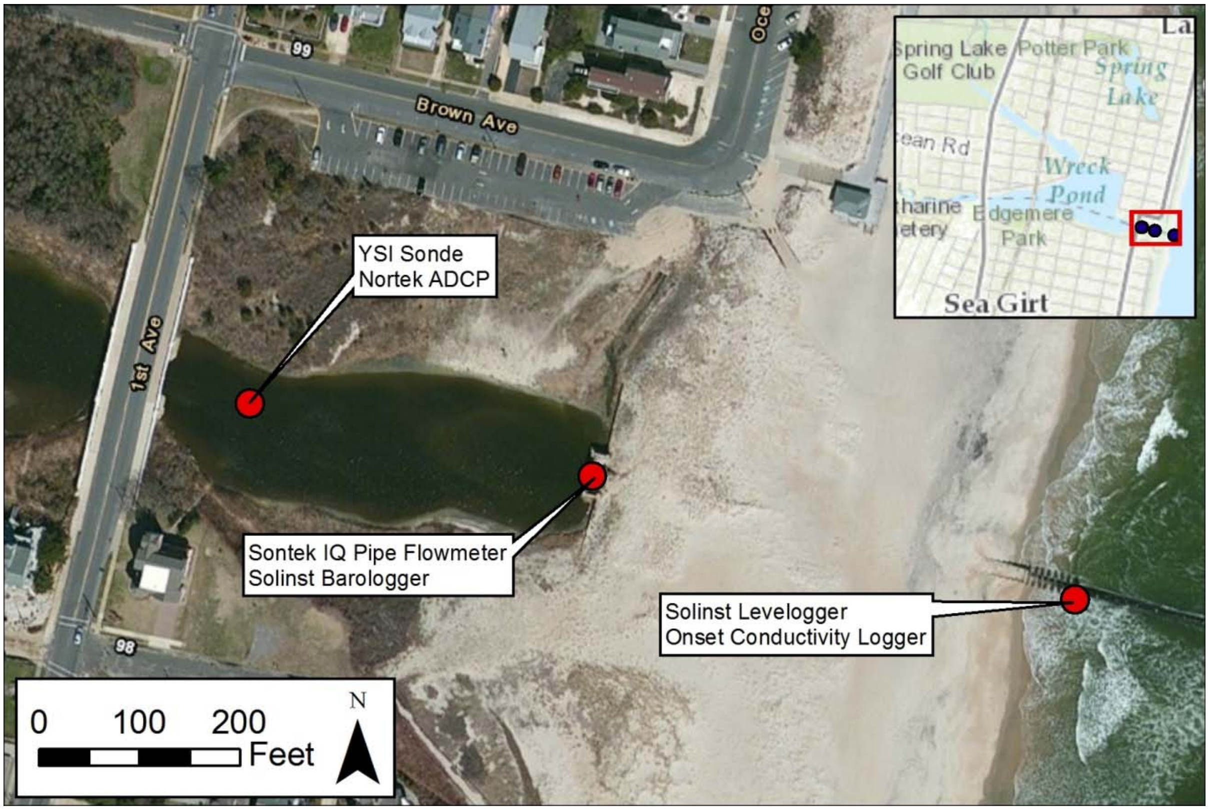


Figure 5: Hydrographic monitoring stations.

Other model inputs included:

- Atlantic Ocean water surface elevations
- Inflow from Wreck Pond Brook and Black Creek
- Inflow from stormwater runoff
- Meteorological conditions to compute wind stress and heat flux
- Ocean outfall rating curves

Existing conditions during the 30 day simulation period were modeled and compared to observed conditions. The hydrodynamic conditions with the proposed 8 by 5.5 foot box culvert at the Wreck Pond inlet were also modeled, and results are explained in Section 3.1. The observed water elevations are shown in Figure 6. Red lines indicate the observed water elevations in Wreck Pond (upper frame) and in the ocean (lower frame) and blue lines are model computed water elevations. The green line in the upper frame indicates the runoff (HEC-HMS results) from upland area entered the Wreck Pond system during the model simulation period. The results indicate that, on average, water levels inside Wreck Pond remain relatively flat compared to the ocean-side. Tidal water fluctuation in the pond is about 0.7 feet. Tidal range in the pond is much smaller compared to the tidal range of about 4.9 feet on the ocean side. The difference is due to the flow-limiting hydraulic capacity of the ocean outfall. This flow-limiting ocean outfall feature helps the low-lying areas on the perimeter of Wreck Pond from flooding during storm surge events. It should be also noted that during rainfall events (i.e., around days 10 and 15), both the observed and computed water elevations inside the pond do not show the impact due to rainfall runoffs. It appears that the existing ocean outfall can accommodate rainfall runoff flows as high as 400 cfs. While the limited flow exchange with the ocean is beneficial in reducing flooding due to storm surges in the ocean, it may pose adverse impact on water quality inside Wreck Pond and flooding due to high runoff events.

The velocity and flow of currents near the mouth of Wreck Pond were computed and compared with observations (Figure 7). The current velocities were less than 1 foot per second. Currents leaving the pond are dominant compared to entering currents. The weak currents are usually translated into a depositional environment for sediment introduced in the pond. With the limited flow exchange through the ocean outfall and weak currents, most of the sediment entering the pond will not be transported to the ocean through the outfall.

2.2.5 Salinity

Figure 8 shows the salinity variations within Wreck Pond. The two upper frames show the salinity distribution during high flow events and lower two frames show the salinity during low flow events. Salinity can vary from 0 parts per thousand (ppt) to as high as 30 ppt within Wreck Pond. Salinity can vary substantially in the vertical column (depth variation) despite shallow water depths. This may suggest that currents inside the pond are not strong enough to produce good mixing within the vertical column.

2.2.6 Bathymetry

Land and bathymetric surveys were conducted in June 2014 for the purpose of preparing a base map for the feasibility study and quantifying the volume of accumulated sediment within Wreck Pond. The pond was delineated into six reaches for the surveys (Figure 9). The land survey collected topographic data extending out 100 feet from the shoreline. The survey collected ground elevations, bulkheads and other walls, discharge pipes (stormwater) greater than 10 inches, stormwater inlets, roads and other structures. RTN (Real Time Network) GPS in conjunction with conventional survey techniques were used to establish survey control within the study area. From this control, additional traverses were run to establish survey control to perform required survey tasks. At each of the bridges sufficient data including both upstream and downstream face, low chords and high chords, and structure openings were collected to adequately define the opening. Location of the bulkheads showing the top and waterside toe was ascertained. The existing outfall structure, including the pipe from Wreck Pond to the ocean, was surveyed in detail. LiDAR and USACE beach profile data were used to supplement the base map for the hydrographic and topographic survey data. A seamless Digital Terrain Model (DTM) comprised of topographic survey, hydro survey, and LiDAR data was produced as the end product.

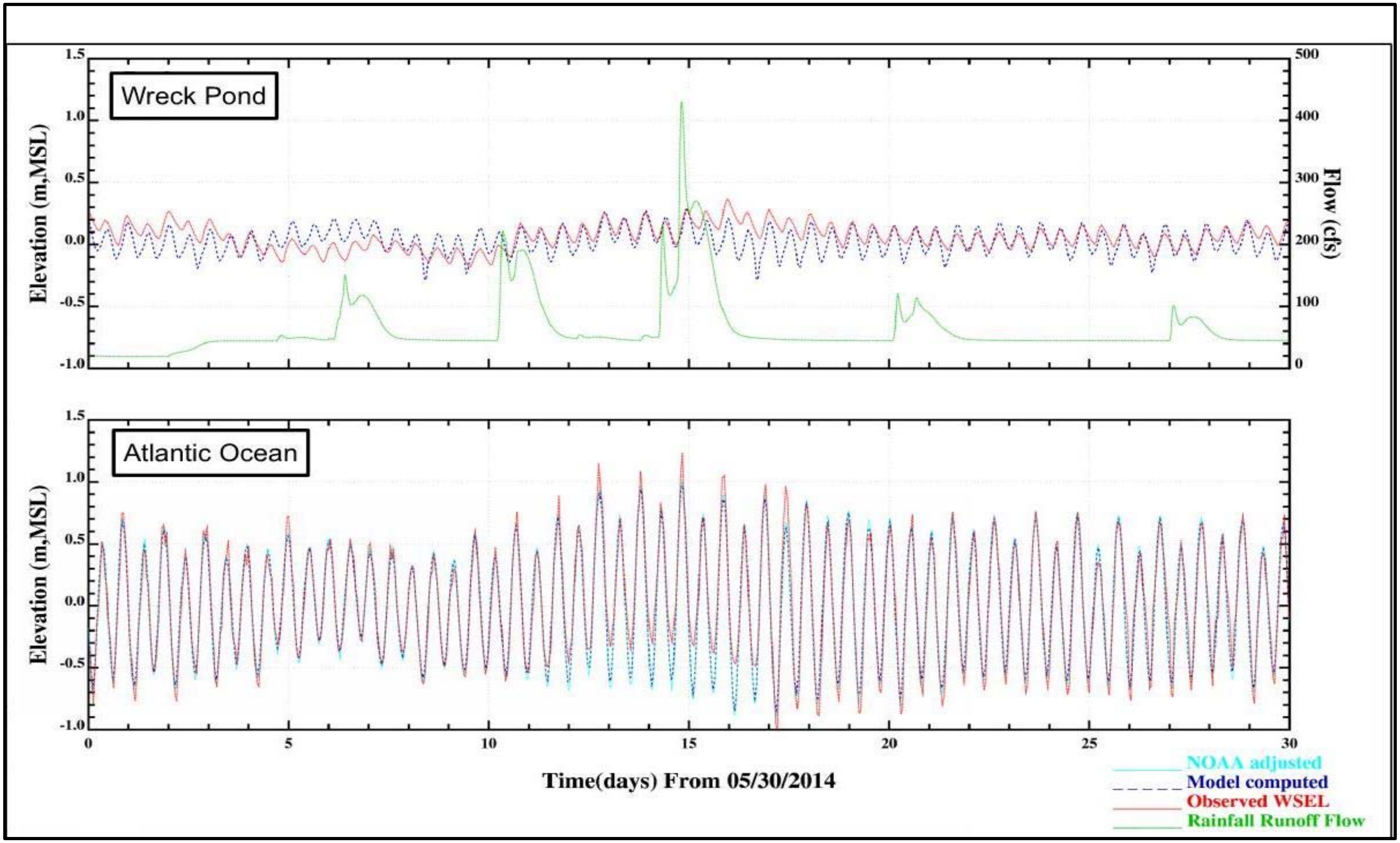


Figure 6: Comparison of water elevations under existing outfall conditions.

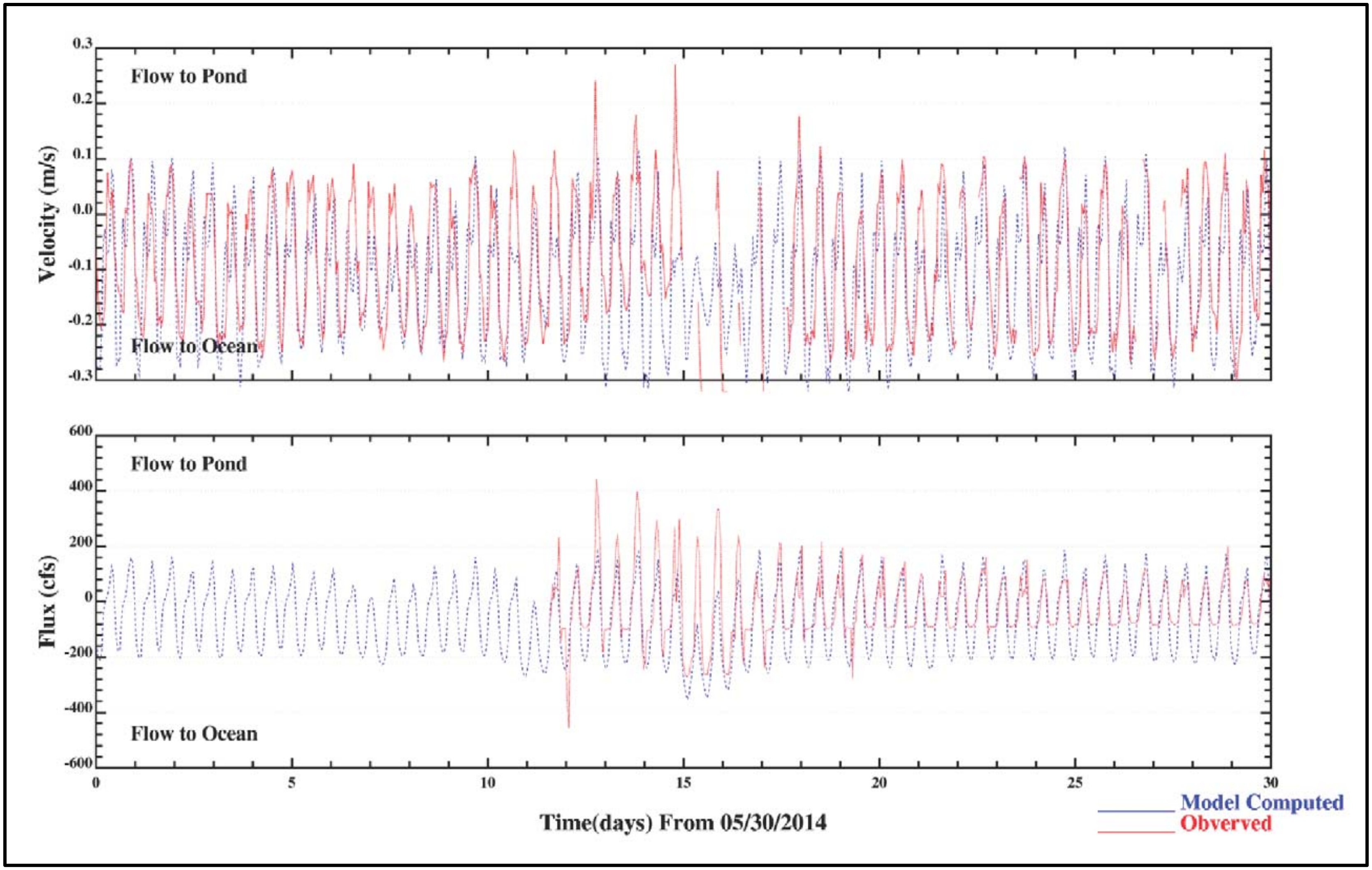


Figure 7: Currents near the Wreck Pond inlet.

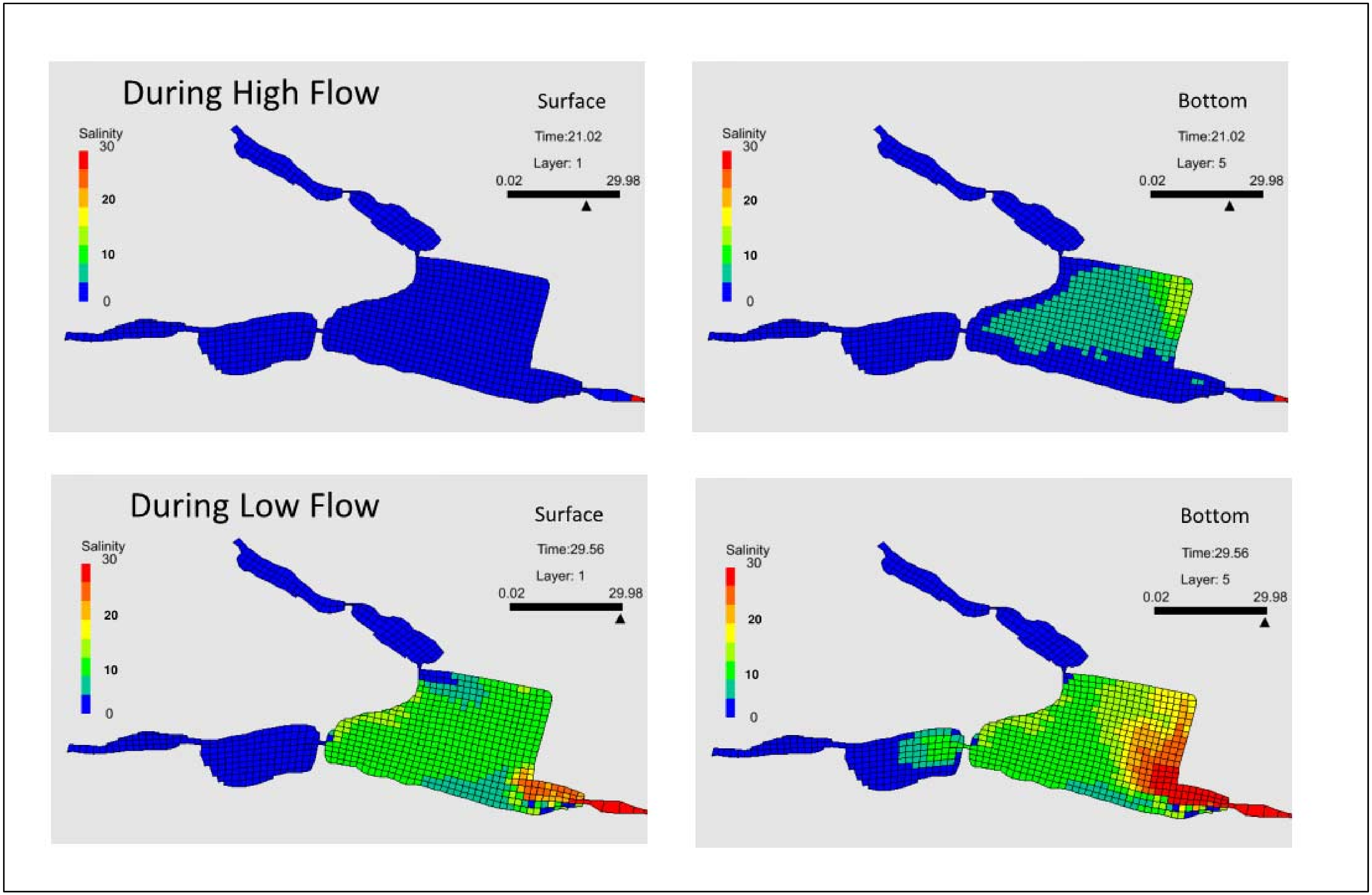


Figure 8: Salinity Distribution during high flow (upper frames) and low flow (lower frames) conditions.

To tie in the land survey to the bathymetric survey to be completed, automated water elevation data collectors were installed in each of the subject pond sections. The bathymetric survey was conducted over a period of 5 days (June 16 through 20, 2014). Due to shallowness of the pond, an echo-sounder was not used. Instead, a 10-foot calibrated pole was utilized. A pole graduated every 0.2 feet (US Survey feet) with red marks on pole, and yellow marks at every 1-foot interval was used to penetrate the sediment. To provide horizontal control a Trimble GPS data-logger was used. The calibrated rod was lowered into the water until it reached the top of the sediment (TOS). Depth in feet was observed and recorded within the GPS unit. The pole was pushed into sediment to point of refusal at the estimated bottom of the unconsolidated sediment (BOS). Depth in feet was observed and recorded on the data logger.

Figure 9: Survey study reaches.

As shown in the bathymetric survey map (Figure 10), Wreck Pond and the smaller open water areas up Wreck Pond Brook and Black Creek are consistently very shallow, with depths at one or two feet. The only deep spots are at the extreme east edge of Wreck Pond (approximately 8 feet) and in the channel leading to the inlet to the ocean (7 feet).

Figure 10: Bathymetry of Wreck Pond.

Following the completion of the bathymetric survey, the GPS data and timestamps were calibrated with the water level data collectors and the spot elevations collected were then converted to the land survey datum (NAVD88). Following the completion of processing the raw field data, GIS was used to develop bathymetric data, including volume of sediment, average thickness and elevation contours of top of sediment and estimated bottom of sediment. A summary of the bathymetric survey statistics can be found in Table 1.

Table 1: Bathymetric survey statistics.

Reach	Size	Volume of Sediment
A	1.5 acres	6,067 cubic yards
B	57.7 acres	407,453 cubic yards
C	14.2 acres	63,924 cubic yards
D1	6.3 acres	51,108 cubic yards
D2	5.3 acres	27,846 cubic yards
E	4.0 acres	18,850 cubic yards

2.2.7 Geotechnical Data

Ten borings were progressed within Wreck Pond; nine were within the main Wreck Pond, and one within the Black Creek branch of Wreck Pond to the north. The borings were progressed to depths of at least 12 feet below the top of sediment. In general, Wreck Pond contains a variable thickness layer of organic silt with varying quantities of sand, underlain by poorly graded sands that pre-date the pond and are part of the underlying geologic parent materials.

To corroborate the bathymetric survey discussed below, two transects of the survey were overlain on the boring logs to create interpretive cross sections of the accumulated sediment and underlying parent materials. Overall the borings corroborate the survey findings, with the exception of boring B-4, located near the eastern end of Wreck Pond. In this boring 4 feet of sandy sediment was encountered overlying 7 feet of sandy organic silt. It is apparent in this location that the top stratum of sandy sediment was likely the result of deposition of sands as a result of the storm surge during Hurricane Sandy. This finding reveals that the total accumulated sediment volume in Wreck Pond is likely to exceed over the calculated amount in the bathymetric survey.

2.3 Fish & Wildlife Resources

Ecological communities within the study area include sand beach, dunes, sandy shoals, tidal wetlands and open water. The tidal wetlands found within the study area provide valuable habitat for numerous aquatic and terrestrial species. Coastal marshes are some of the most productive ecosystems on earth, providing foraging and nesting habitat for waterfowl and wading birds, and spawning and nursery habitat to juvenile fish and shellfish (USFWS 2005). The beach, dune and sandy shoal communities provide habitat for shore nesting and foraging species, including migratory shore birds. The diverse mosaic of habitats in and around Wreck Pond makes it a significant coastal resource for many aquatic and terrestrial species including several state and federally listed threatened and endangered species. However, limited connectivity, poor water quality and sedimentation issues have led to habitat degradation in the pond's recent history.

The study area has been known to be utilized by anadromous fish species, including alewife (*Alosa pseudoharengus*), blueback herring (*Alosa aestivalis*), and catadromous species such as the American eel (*Anguilla rostrata*). A fall fish survey conducted in 2014 by the American Littoral Society indicates that young of year alewife are present within the pond or its upstream reaches (NJDEP and Monmouth County 2014).

Wreck Pond is included in the North Shore Coastal Ponds Complex Important Bird Area (IBA) designated by the National Audubon Society. IBA's are sites that support habitat necessary for breeding, overwintering or migration and the goal of the IBA Program is "to stop habitat loss by setting science-based priorities for habitat conservation and promoting positive action to safeguard vital bird habitats."

The National Audubon Society considers the North Shore Coastal Pond Complex as a breeding and foraging site for Least Terns and Piping Plovers and a wintering site for waterfowl species such as northern shoveler (*Anas clypeata*), American wigeon (*Anas Americana*), redhead (Aythya Americana), common goldeneye (*Bucephala clangula*), common merganser (*Mergus merganser*), brant goose (*Branta bernicla*) and American black duck (*Anas rubripes*) and gulls species including Bonaparte's (*Chroicocephalus philadelphia*), ring-billed (*Larus delawarensis*), herring (*Larus argentatus*), and great black-backed (*Larus marinus*) (National Audubon Society 2015).

The open water community is currently connected to the Atlantic Ocean via the outfall pipe. The aforementioned fish survey conducted in 2014 determined the presence of young of year alewife (*Alosa pseudoharengus*) within the pond and its upstream reaches, indicating that the outfall allows for some passage for migratory catadromous and anadromous fish species. In addition to alewife, the survey identified twenty-one other fish species, six crab species, two species of shrimp, one species of clam and one species of jellyfish that are all typically found in brackish and saline ecosystems, within Wreck Pond (NJDEP and Monmouth County, 2014).

2.3.1 Federal and State Endangered & Threatened Species

A review of the U.S. Fish and Wildlife Service's (USFWS) Information, Planning and Conservation System, the New Jersey Geo-web was conducted to identify potential of Federal and State threatened, endangered and special concern fish, wildlife and plant species within the study area (Table 3).

A review of the New Jersey GeoWeb database indicates documented use of Wreck Pond by great blue heron, least tern, yellow-crowned night heron, osprey (*Pandion haliaetus*), and black-crowned night heron for foraging (NJDEP December 11, 2015).

The piping plover and least tern are beach nesting species. Beach habitat is located within the study area along the coast of the Atlantic Ocean near the existing outfall location. A survey conducted by the NJ Division of Fish and Wildlife in 2002 to document least tern nesting productivity recorded the presence of 21 adults, 12 nests and nine young fledglings within the Wreck Pond Area (NJ Division of Fish and Wildlife 2002). The NJ Division of Fish and Wildlife documented the occurrence of one pair of nesting plovers in the Wreck Pond in 2009 and 2012 (Pover and Davis 2015).

Table 2: Federal and State-listed Endangered, Threatened and Special Concern Species within the Wreck Pond study area.

Latin Name	Common Name	Federal Status	State Status
Bird Species			
Calidris canutus	Red Knot	Threatened	Not Listed
Charadrius melodus	Piping Plover	Threatened	Endangered
Sternula antillarum	Least Tern	Not Listed	Endangered
Nyctanassa violacea	Yellow-crowned night heron	Not Listed	Threatened
Pandion haliaetus	Osprey	Not Listed	Threatened
Nycticorax nycticorax	Black-crowned night heron	Not Listed	Threatened
Area Herodias	Great blue heron	Not Listed	Special Concern
Reptile Species			
Glyptemys muhlenbergii	Bog Turtle	Threatened	Endangered
Plant Species			
Amaranthus pumilus	Seabeach Amaranth	Threatened	Endangered
Helonias bullata	Swamp Pink	Threatened	Endangered
Rhynchospora Knieskernii	Knieskern's Beaked-Rush	Threatened	Endangered

In addition, bird surveys conducted from 2009-2010 within the National Guard Barracks in Sea Girt, which is located approximately one mile southwest from Wreck Pond, identified the presence of 16 State listed Endangered, Threatened and Special Concern species (Table 4). Due to the proximity of the National Guard Barracks to Wreck Pond, it can be presumed that the species utilize the Study Area (USACE 2011).

Bat surveys conducted at the National Guard Barracks in 2009-2010 utilizing acoustic methods to identify bat calls indicated the presence of the eastern red bat (*Lasiurus borealis*) and hoary bat (*Lasiurus cinereus*) which are both listed as State Special Concern. Both species are known to inhabit forests, forest edges and typically roost in deciduous trees. Given that it is presumed that these species could utilize the forested area located immediately upstream of Wreck Pond (USACE 2011).

Eastern bog turtle habitat consists of palustrine emergent wetlands consisting of cool, shallow, slow-moving water, deep soft muck soils, and tussock-forming herbaceous vegetation (NYSDEC 2015). Potential habitat may be found within wetlands with freshwater inputs located in the western portion of the study area.

Table 3: State Listed Endangered, Threatened and Special Concern Species Observed at Sea Girt National Guard Training Center

Latin Name	Common Name	State Status
Falco peregrinus	Peregrine falcon	Endangered
Passerculus sandwhichensis	Savannah sparrow	Threatened
Falco sparverius	American kestrel	Threatened
Accipiter cooperii	Cooper’s hawk	Special Concern
Accipiter striatus	Sharp-shinned hawk	Special Concern
Actitis macularious	Spotted sandpiper	Special Concern
Calidris alba	Sanderling	Special Concern
Calidris pusilla	Semiplamated sandpiper	Special Concern
Egretta minimus	Little blue heron	Special Concern
Egretta thula	Snowy egret	Special Concern
Haematopus palliates	American oystercatcher	Special Concern
Numenius phaeopus	Whimbrel	Special Concern
Plagadis falcinellus	Glossy ibis	Special Concern
Sterna hirundo	Common tern	Special Concern
Sturnella magna	Eastern meadowlark	Special Concern
Taxostoma rufrum	Brown thrasher	Special Concern

Seabeach amaranth habitat consists of overwash flats, lower foredunes, and upper strands of non-eroding beaches (landward of the wrackline), and sometimes bay-side beaches, inter-dunal areas and sand or shell material deposited for beach replenishment or as dredge spoils (USFWS 2015a). Potential habitat for this species may be located along the beach of the Atlantic Ocean within the study area.

Swamp pink also occurs in wetlands that are perennially saturated, but not inundated by floodwater (USFWS 2015c). Habitat for this species may be present within the western most portion of the study area where NJDEP identified tidal freshwater wetlands within the Wreck Pond Brook.

Knieskern’s beaked-rush is an early successional species found in wet and disturbed areas such as gravel and clay pits, mowed road sides, utility and railroad rights-of-way, wheel ruts and muddy swales (USFWS 2015b). Habitat for this species may occur throughout the study area as wetlands and disturbed areas are present.

2.3.2 Benthic Community & Water Quality

Benthic sampling involving the collection of sediment data, supporting in-situ water quality and benthic infauna samples from Wreck Pond and Deal Lake, approximately eight miles north of Wreck Pond, was conducted in September 2014. Deal Lake was used as the reference waterbody for this study. All sampling stations within Wreck Pond were taken within the tidally influenced portion of the pond (Figure 11) as were all of the Deal Lake sampling stations.

Sediment samples taken in Wreck Pond primarily consisted of organic sand/silt while Deal Lake was comprised of an organic rich, reduced silty material. Based on water quality samples, Wreck Pond had a higher specific conductance and salinity, and is more affected by tidal inflow than Deal Lake; thus making it more of a saline ecosystem. Both waterbodies had pH and dissolved oxygen levels considered supportive of a variety of fish and benthic species.

The benthic community within Wreck Pond is dominated by a variety of marine worms (polychaete) with the majority comprising of tube building deposit feeders (Nereidae, Lumbrineridae and Spionidae). The predominance of these species is conducive to the organic sandy/silt composition of the pond’s sediments. Ostracods, a type of shrimp, were also fairly common, being collected in six of the eight samples. Very few clams (Gemma gemma) were collected. The propensity of polychaetes and ostracods in Wreck Pond indicates that Wreck Pond is brackish in nature which is supported by the in-situ water quality data.

The benthic community within Deal Lake was dominated by pollutant tolerant organisms (that is organisms capable of existing under anoxic, environmentally stressed conditions). In addition, the invertebrate community was found to be far less diverse and in many samples, much lower total numbers than samples collected from Wreck Pond. Furthermore, the Deal Lake benthic assemblage was represented by a greater number of pollution tolerant species and by a fewer number of mollusks and ostracods.

Thus, the benthic community of Wreck Pond was determined to be more robust and representative of a less stressful environment than the benthic community of Deal Lake. The primary factors that appear responsible for these differences are the more reduced nature of the Deal Lake sediments, the sandier nature of the Wreck Pond sediments, and the greater rate of tidal exchange and overall volumetric flushing of Wreck Pond as compared to Deal Lake. The Water Quality and Benthic Sampling Report is included in Appendix A.

Wreck Pond Sampling Stations

Deal Lake Sampling Stations

Figure 11: Benthic sampling stations.

2.3.3 Wetlands

Federal and State definitions of wetlands are similar, identifying wetlands as “those areas that are inundated or saturated by surface or groundwater at a frequency and duration sufficient to support, and that under normal circumstances do support, a prevalence of vegetation typically adapted for life in saturated soil conditions.” As defined above, wetlands generally include swamps, marshes, bogs, and similar areas.

A review of the NJ Geo-web and the U.S. Fish and Wildlife Service (USFWS) National Wetland Inventory Maps indicated a deciduous wetlands complex approximately 21 acres in size, a 1.5 acre coastal wetland dominated by *Phragmites* sp., and a two acre freshwater tidal marsh just upstream of Wreck Pond along Wreck Pond Brook (Figure 12). In addition, the mapping resources indicated approximately 5 acres of vegetated dune communities along the shoreline on the eastern side of the pond.

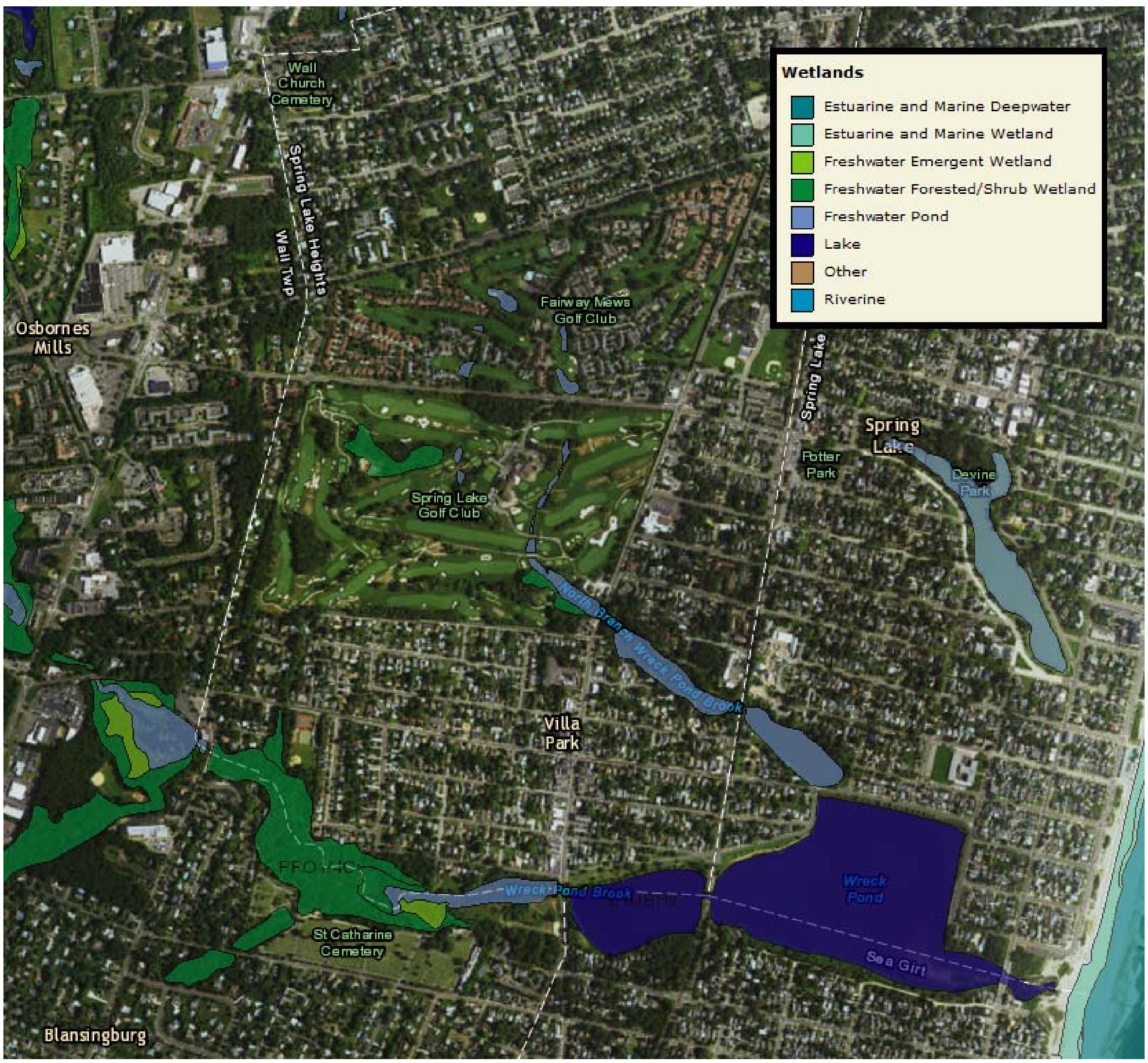


Figure 12: USFWS National Wetlands Inventory (accessed April 2016).

2.3.4 Cultural Resources

Limited research was carried out at the New Jersey State Museum and the New Jersey State Historic Preservation Office to identify historic properties and districts within the project's Area of Potential Effect (APE) and inside a 1-mile buffer area surrounding the APE. The research was conducted in accordance with Section 106 of the National Historic Preservation Act of 1966, as amended, Section 101(b)(4) of the National Environmental Policy Act of 1969, and the Advisory Council Procedures for the Protection of Cultural Properties (36 CFR Part 800).

Table 4 lists seventeen National Register of Historic Places (NRHP) listed or eligible historic properties and districts on file at the New Jersey State Historic Preservation Office, as well as four archaeological sites on file at the New Jersey State Museum that are within a 1-mile area surrounding the APE. The New York and Long Branch Railroad Historic District (ID#4354) is the only resource of the seventeen that is within the study area. The Missouri Pavilion, located in the vicinity of the pond to the south of Black Creek, is listed in the Monmouth County Historic Sites Inventory. A complete cultural resources investigation has not been carried out for this study area and therefore, there is a potential for additional cultural resources to exist within the study area.

Table 4: Cultural resources within 1 mile of the study area.

Name	Address	Description/Status	NJHPO/State Museum Report #
Manasquan Main Street Historic District	Parts of Main, South, Broad, Pearce and Barker and Woodland, Curtis, Virginia, Marcellus and Morris Avenues, Monmouth Co.	Eligible	E125
Blansingburg School Historic District	Sea Girt and Old Mill Road, Monmouth Co.	Eligible	E125
Frederick A Duggan First Aid Center (Spring Lake First Aid Squad Building)	311 Washington Avenue, Spring Lake Borough, Monmouth Co.	Listed on the National and State Register	N/A
Martin Maloney Cottage	101 Morris Avenue, Spring Lake, Monmouth Co.	Listed on the National and State Register	N/A
Western World Shipwreck	Protected	Eligible (HPO Opinion)	Mon A94
St. Andrews Methodist Church	Spring Lake Borough, Monmouth Co.	Eligible (Certificate of Eligibility)	Mon A94A

Name	Address	Description/Status	NJHPO/State Museum Report #
St. Catherine's Catholic Church	215 Essex Ave, Spring Lake, NJ	Eligible (Certificate of Eligibility)	Mon A94A
Holy Trinity Episcopal Church	Monmouth and Third Avenue, Spring Lake, Monmouth Co.	Listed on the National and State Register	Mon A94A
Hunter Cottage (AKA Devlin Guest House)	101 Chicago Boulevard, Sea Girt Borough, Monmouth Co.	Eligible (Certificate of Eligibility)	Mon A94A
New York and Long Branch Railroad Historic District	Manasquan Twp., Monmouth Co.	Eligible (HPO Opinion)	N/A
Quarters One/Shearman/Mount Stockton Farmstead Site	Sea Girt National Guard Quarters, Monmouth Co.	Eligible (HPO Opinion)	Mon AA865/ State Museum 28-MO-407
Old Mill	Old Mill Road at Pond Road, Monmouth Co.	Eligible (HPO Opinion)	E125
Wildthyme	1116 Atlantic Avenue, Monmouth Co.	Eligible (HPO Opinion)	E125
Brown-Bennett Orchards Historic District	Route 35 and Church Street on Meeting House Road	Eligible (HPO Opinion)	E125
Outcalt-Morris House	Sea Girt Avenue West of Rt. 35, Wall Twp.	Eligible	E125
Friends Meeting House	Meeting House Road and Atlantic Ave., Monmouth Co.	Eligible	E125
Morris-Forsyth Home	1300 Sea Girt Avenue	Eligible	MON E125
Osbornes Mills Historic Structures	Protected	Undetermined	State Museum 28-Mo-30
Unnamed Historic House Foundations	Protected	Undetermined	State Museum 28-MO-196
Sea Girt Prehistoric Site	Protected, Monmouth County	Undetermined	State Museum 28-MO-283
Historic Debris Concentration Area	Protected, Sea Girt, NJ	Undetermined	State Museum 28-Mo-408

2.3.5 Hazardous, Toxic, and Radioactive Waste

Ten borings were progressed within Wreck Pond: 9 within the main Wreck Pond, and 1 within the Black Creek branch of Wreck Pond to the north. The sediment sample analytical results were compared to NJDEP Ecological Screening Criteria (ESC), Lowest Effects Level (LEL) concentrations. The LELs are concentrations at which adverse benthic impacts may begin to occur and are the most conservative comparison criteria. The LELs are not promulgated standards; they are concentrations that when exceeded require further evaluation. Laboratory analysis results were also compared with the ESC Severe Effects Level (SEL) concentrations. The SELs are contaminant concentrations that indicate severe impacts to the benthic community in most cases. Appendix D summarizes exceedances of the LELs and SELs for contaminants in each sample.

The samples collected from the sand below the accumulated sediment in Wreck Pond did not contain any contaminants at concentrations above the LELs. A sample of this material was not collected from Black Creek. Given that the underlying sand does not have concentrations of contaminants above the LELs, this material is suitable benthic habitat in regards to contaminants.

The accumulated sediment in Wreck Pond contains concentrations of metals, pesticides and polycyclic aromatic hydrocarbons (PAHs) above the LELs but below the SELs. The accumulated sediment in Black Creek contains concentrations of arsenic and chromium above the LELs but below the SELs.

Sixteen contaminants including seven metals, eight PAHs and one pesticide were detected in the accumulated sediment at concentrations above the LELs but below the SELs. Exceedances of the LELs means the presence of these contaminants warrants further evaluation. It does not mean that impacts on benthic organisms have occurred. The types and concentrations of contaminants in the accumulated sediment are very typical in developed areas in New Jersey. The accumulated sediment may be suitable benthic habitat as the SELs were not exceeded, however further evaluation would be required. The analytical results were also compared to NJDEP Residential Direct Contact Soil Remediation Standards (RDCSRS). The RDCSRS are not applicable to the sediment in place within the pond, however it may be applicable if the material is dredged and placed upland. Only three marginal exceedances of the RDCSRS were reported in the samples.

2.4 The Community

The study area encompasses the southern-most portion of the Borough of Spring Lake; the northern-most portions of the boroughs of Spring Lake Heights and Sea Girt; and some of the southeastern portion of Wall Township. The boroughs are home to approximately 8,000 people, most of them full-time residents (US Census 2010). The communities are largely middle class, with a large portion of the population employed, above the poverty line, and living with family. Most residents have returned to the boroughs after the devastation caused by Hurricane Sandy in 2012. Residents and businesses continue their recovery.

According to the 2010 U.S. Census, there were 2,993 people, 1,253 households, and 829.5 families residing in the borough. Of the 1,253 households in Spring Lake, 22.6% had children under the age of 18 living with them, 56.8% were married couples living together, 7.7% had a female householder with no husband present, and 33.8% were non-families. Approximately 31% of all households were made up of individuals, and 19.1% had someone living alone who was 65 years of age or older. The average household size was 2.38 and the average family size was 3.01. The median age in the borough was 51.9 years. The per capita income for the borough was $71,661. About 2.2% of families and 2.8% of the population were below the poverty line, and 2.0% of those age 65 or over.

In Spring Lake Heights, there were 4,713 people, 2,316 households, and 1,202 families residing in the borough at the time of the 2010 U.S. Census. Of the 2,316 households, 17.1% had children under the age of 18 living with them, 40.3% were married couples living together, 9.5% had a female householder with no husband present, and 48.1% were non-families. Approximately 41.7% of all households were made up of individuals, and 21.4% had someone living alone who was 65 years of age or older. The average household size was 2.03 and the average family size was 2.82. The median age was 49.6 years. The per capita income for the borough was $43,370. About 1.1% of families and 6.4% of the population were below the poverty line, including 3.0% of those under age 18 and 5.7% of those age 65 or over.

The Wreck Pond Brook Watershed Regional Stormwater Management Plan Committee, Wreck Pond Technical Advisory Committee, and several other groups and committees comprised of a number of Federal, state, and local agencies have formed to develop a comprehensive approach to the restoration of the Wreck Pond Watershed. The NJDEP prepared the Wreck Pond Restoration Action Plan, which was last updated in December 2015, and obtained funding to conduct watershed restoration and water quality studies. In addition, NJDEP created a website to facilitate the exchange of information regarding the watershed.

2.5 Problems in the Study Area

Many of the water resource problems in the Wreck Pond watershed are interrelated, and so too are potential opportunities and solutions. For example, the main cause of flooding problems in the communities surrounding Wreck Pond (restricted tidal exchange, decreased storage capacity in Wreck Pond) have also caused ecosystem degradation in the system. The following is a summary of the four main water resource problems in the study area.

Though the main focus of the Wreck Pond study was to reduce damages caused by flooding from hurricanes and coastal storms, the study team could not ignore exploring potential remedies to fluvial flood risk and ecosystem degradation, as the problems and opportunities in the study area are interrelated. That is, actions that may reduce coastal storm flood risk may help reduce fluvial flood risk and restore the ecosystem. It is also important to note that Wreck Pond has experienced environmental quality issues including significant loss of aquatic and wetland habitat, eutrophic waters and degraded habitat for fish, birds, and invertebrates.

2.5.1 Coastal Storm Flooding

Significant flooding occurs when coastal storms such as tropical storms, nor’easters, and hurricanes overtop the beach and inundate the boroughs of Spring Lake, Sea Girt and Spring Lake Heights. Constricted flow in the pond due to the inefficient outfall pipe exacerbates flooding, as water slowly drains back to the ocean. Most flooding during extreme events occurs near the beachfront and pond within the 100-year floodplain (Figure 13).

Hurricane Sandy was the most recent coastal storm that affected the area. It inundated the study area with approximately 6 feet of surge (10.9-foot NAVD88 recording at the Shark River National Oceanic and Atmospheric Administration [NOAA] gage). The surge generally extended to the north and west of the pond and Wreck Pond Brook (Figure 14). The storm had a return period between 100 and 200 years at Spring Lake. The outfall structure was damaged and the dune was breached by the storm, which exacerbated flooding in the area. The December 1992 nor’easter also severely flooded the area, with almost $800,000 (1992 value) in damages sustained by homeowners.

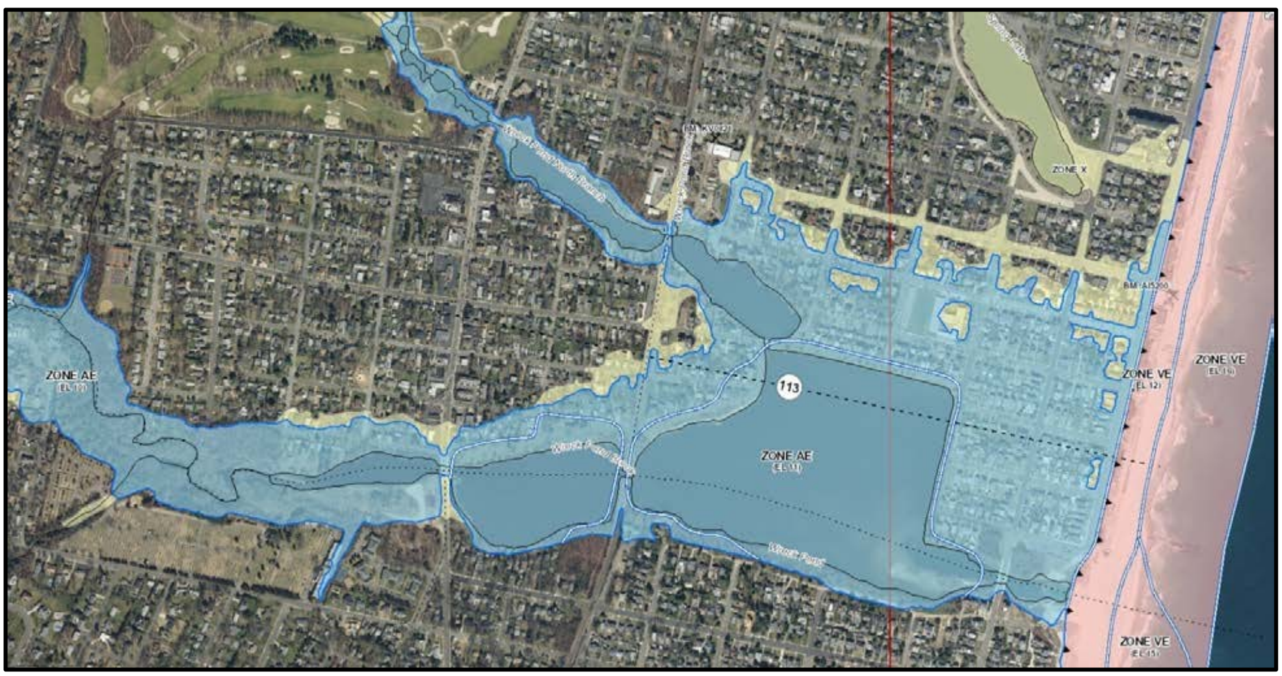


Figure 13: Preliminary Flood Insurance Rate Map showing 100-year floodplain (Federal Emergency Management Agency [FEMA], January 2015).

Figure 14: Extent of Hurricane Sandy flooding (FEMA MOTF Model, accessed March 2015).

2.5.2 Fluvial Flooding

Fluvial, or riverine flooding, occurs when excessive rainfall over an extended period of time causes a waterbody to exceed its capacity. During periods of heavy rainfall, the Wreck Pond Brook watershed is overloaded with stormwater. Most stormwater ultimately travels to Wreck Pond, then to the Atlantic Ocean. The outfall constricts the flow of water, and stormwater cannot efficiently move to the ocean. This causes water to “back up” in the pond and sometimes into homes surrounding the pond. Flood damage caused by Hurricane Irene in 2011 was typical of fluvial flooding, during which about 200 homes surrounding the pond were flooded. Storms in October 2005 also caused flood damage in the area. Flooding resulted from rain of 11.58 inches over a period of 3 days.

2.5.3 Economic Damages from Storms

A wealth of data is available on flood damage in the study area. These include FEMA National Flood Insurance Program claims and designations, tax assessments, FEMA Stafford Act Public and Individual Assistance administered by FEMA and New Jersey Office of Emergency Management (NJOEM), New Jersey Agency information, and municipal data.

There are approximately 655 residential structures, 14 commercial structures, and one private school in the study area. Most residential structures are two-story single-family homes. There are 277 residential structures and 12 commercial structures (43 percent of total structures) located within the 100-year floodplain in the study area. Significant damage was widespread in Spring Lake and Spring Lake Heights after recent coastal storm events, including Hurricane Sandy (2012), Hurricane Irene (2011), and nor’easters in October 2005 and December 1992. Over $19,000,000 in claims has been paid by NFIP since 1978 in Spring Lake, Spring Lake Heights, and Sea Girt (Table 5).

Table 5: NFIP Claims from recent storm events.

Storm Event	Total Claims Paid
Hurricane Sandy (October 2012)	$11,540,030
Hurricane Irene (August 2011)	$ 772,629
October 2005 Nor’easter	$ 4,130,836
December 1992 Nor’easter	$ 781,602
All other storm events since 1978	$ 1,854,758

It is important to note that of these four major flood events, two were primarily fluvial flood events and two were coastal flood events. The area is and remains susceptible to both coastal and fluvial flooding.

To support the economic analysis, evidence of damage due to storm surge in the study area was gathered. In lieu of annual damages, evidential data is provided here. The work provides an accounting of damages due to Hurricane Sandy and other coastal storm events. The data provides a picture of the location and extent of coastal storm damages.

A flood damage assessment limited to available historical damage data in the study area was undertaken. Sources of information obtained included FEMA's National Flood Insurance Program claims, and based on Hurricane Sandy damage: Monmouth County property tax reassessments, damage to New Jersey Transit infrastructure and a list of demolition permits from the New Jersey Department of Community Affairs. USACE evaluated the decline in building assessment values and flood insurance claims, and made the following findings: Hurricane Sandy accounted for 60% of flood insurance claims since 1978; the decline in building values accounted for both flood and wind damage, and further investigation would be needed to separate the damage categories; property tax assessment, and specifically the building value, varies through time as structures are repaired or replaced; monetary damage to New Jersey Transit infrastructure in the study area was limited to $50,000, but did not include interruption in service to the public. Further data collection and study, not completed at this time, would be necessary to determine the full damages realized in the study area by Hurricane Sandy and other past and future events. Most of the damage in the boroughs caused by Hurricane Sandy was localized in the study area (Figure 15). Many of the homes claimed the maximum coverage offered by NFIP ($250,000 for building property, $100,000 for personal property). In addition, many homeowners received FEMA Personal Assistance funds for storm-related losses.

Figure 15: NFIP Hurricane Sandy claims paid by block.

2.6 Existing and Planned Water Resource Projects

There are a number of existing and planned water resource projects in the study area that provide various benefits to the community (Figure 16). The projects include:

- USACE Sandy Hook to Barnegat Section I Beach Erosion Control and Coastal Storm Risk Management Project (constructed)
- Outfall structure (constructed)
- Black Creek weir at Ocean and Shore Roads (constructed)
- Stormwater infrastructure (various completion)
- Borough of Spring Lake Wreck Pond second outfall structure project (currently under construction)
- Temporary emergency spillway (open during storm events; all actions post-Sandy)
- Pond dredging actions (various small demonstration projects completed by Monmouth County)
- Living shoreline (proposed)

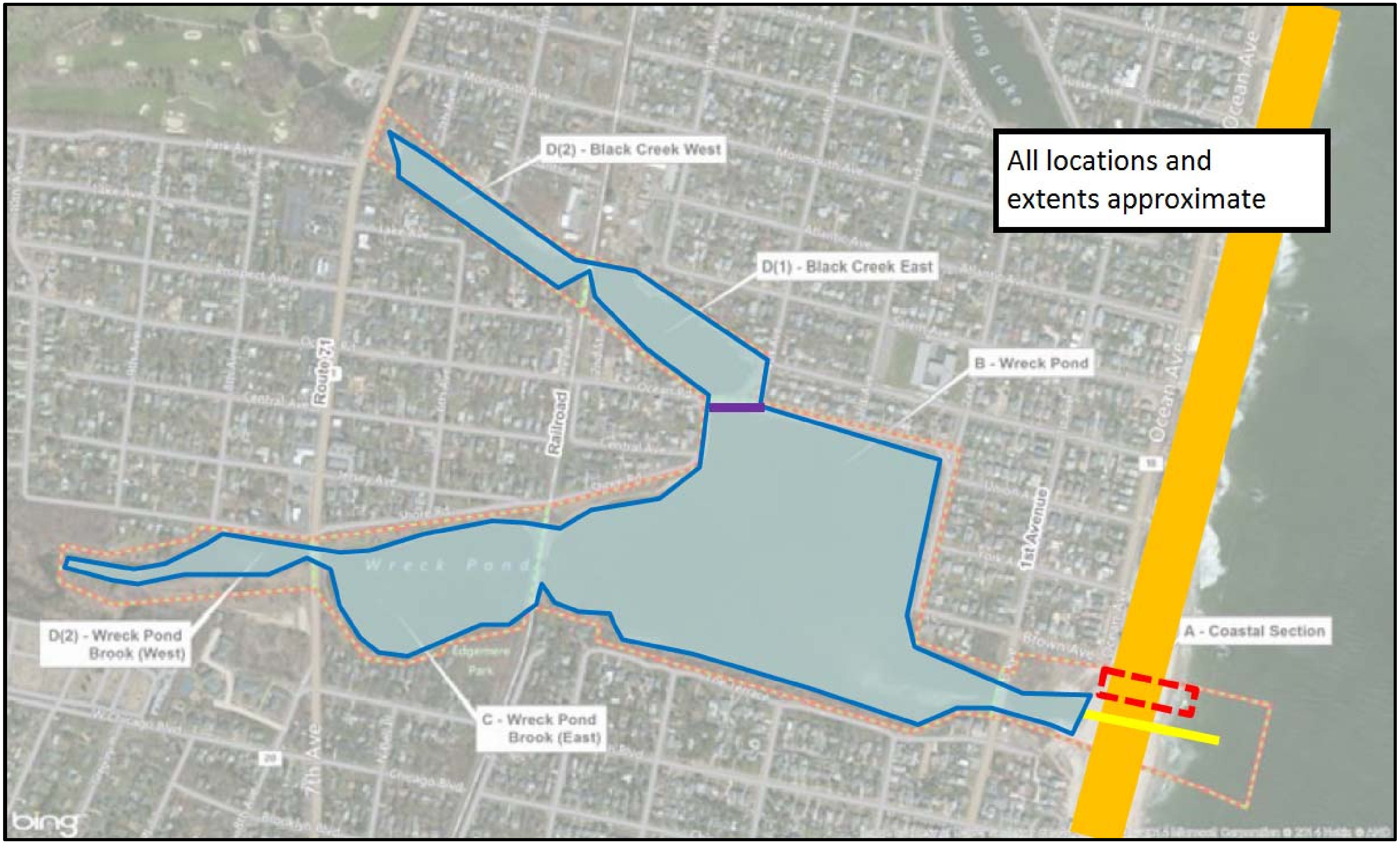


Figure 16: Existing water resource projects. The extent of Wreck Pond is shown in blue. USACE beach nourishment project (orange), outfall pipe (yellow), Black Creek weir (purple), and temporary emergency spillway (red). Pond dredging in various locations in the pond. Stormwater infrastructure at various locations.

3 Future Conditions

The future without-project condition consists of those future conditions most likely to prevail in the absence of the proposed project. The future-without project conditions were developed using the field data and modeling results detailed in Chapter 2, as well as the following sources:

- FEMA National Flood Insurance Program Claims (source: NJDEP)
- Tax Assessments (source: Monmouth County)
- Demolition permits (source: NJ Department of Community Affairs)
- Sea Level change projections (source: USACE)

This chapter mirrors that of Chapter 2, though the scope and detail of the future without-project analysis was limited: 1) to the Study's purview (i.e., coastal storm risk management), and 2) by time (the Study was suspended prior to completion). The analysis didn't consider in detail future conditions for the following resources:

- Freshwater Inflows
- Bathymetry
- Federal and State Endangered & Threatened Species
- Benthic Community & Water Quality
- Wetlands
- Cultural Resources

When the Study began, there were no plans in place for a second outfall. The assumptions for future conditions were revisited when planning began for a second outfall structure. The USACE assumptions were updated to include the secondary outfall structure project that is currently under construction; operation is expected to begin by the end of 2017. Designs were obtained from the Borough's engineer, and its dimensions and operation were considered during analysis. Modeling was provided for both with- and without-project, assisting in the design of the outfall.

3.1 Physical Processes & Characteristics

3.1.1 Tidal Connection of Wreck Pond to the Atlantic Ocean

The Borough of Spring Lake is currently constructing an 8 by 5.5-foot box culvert, and associated closure structure, and pipe extending to the Atlantic Ocean. These features will increase tidal connection of Wreck Pond to the Atlantic Ocean. In particular, the features will modify existing hydrodynamics and salinity regimes, which are described in detail in Section 3.1.3 and 3.1.4.

3.1.2 Water Quality: Sediment & Nutrient Loading

Elevated runoff volumes lead to streambank erosion and heightened sediment loading. The model documented that 50% of the pond's total annual sediment load can be attributed to streambank erosion. Because of this, efforts taken solely to intercept and treat stormwater runoff using conventional stormwater management techniques (including manufactured treatment devices; MTDs) may not in itself alleviate future sediment infilling of the pond, especially in the western most portions of the pond. Rather, a more comprehensive approach is needed; specifically one that both decreases the rate and volume of stormwater discharged to the streams and repairs eroded stream channels. These repairs could include restoration of riparian corridors and reconnection of the streams with their floodplains.

When viewing the watershed as a whole it becomes obvious that stormwater management and stream restoration is critical in minimizing sediment transport to Wreck Pond. Agricultural sources are probably best addressed through agricultural best management practices such as winter cover cropping and the repair and re-establishment of riparian buffer zones. The instability of the pond’s tributaries suggests that the streams have become disconnected from their floodplains, a common occurrence in urbanized watersheds due to development related encroachments into riparian areas and floodplains. While reconnection of the streams and their floodplains may be difficult to achieve given the history and extent of watershed development, doing so would likely prove beneficial in terms of reducing localized flooding problems, improving the stability and ecological functionality of the streams and decreasing sediment loading to the pond. The decommissioning of the pipe that once connected Spring Lake and Wreck Pond was beneficial to Wreck Pond and likely decreased the pond’s annual nutrient load by approximately 15%.

3.1.3 Hydrodynamics

The effects of the box culvert were evaluated using the calibrated hydrodynamic model, ECOM, to understand the impacts of the outfall within Wreck Pond. Figure 17 shows the water surface elevation within the pond in existing (red) and in proposed (blue) conditions. Existing conditions water surface elevation reflects flow through the existing 7-foot diameter pipe and the proposed conditions reflect the flow through the existing 7-foot diameter and the 8 by 5.5-foot box culvert currently under construction. For this simulation, both the culverts are assumed to be in the fully open condition. The results in Figure 17 indicate that the new culvert will increase tidal exchange and increase the range of water surfaces. The new culvert will increase the range in water surface elevations in Wreck Pond by approximately 0.5 to 1.5 feet. On high flow conditions (day 15, approximately 400 cubic feet per second), water surface elevation within the pond can go as high as 2.5 feet NAVD 88. However, it is believed that this water level increase on Day 15 is due to the increase water level in the ocean during a storm event not by the high rainfall runoff from upland area. In addition, the pond surface elevation decreases by a similar amount during the simulation period. This change in the range of tidal water elevations (from less than 0.7 feet to more than 1.5 feet) may expose the pond sediment during low tides (twice a day) in wide areas. Since most of the Wreck Pond is less than 2 feet below Mean Sea Level (MSL), the change of tide range over 1 foot will have significant impact on the tidal exchange in the pond. Figure 18 shows the comparison of exposed area under existing (shown in dark green shade) and proposed (shown in light green shade) ocean outfalls during typical tidal conditions. From the graphic, it can be concluded that if both the existing and the proposed outfall are left in open condition, it is possible to expose significant low areas within the pond.

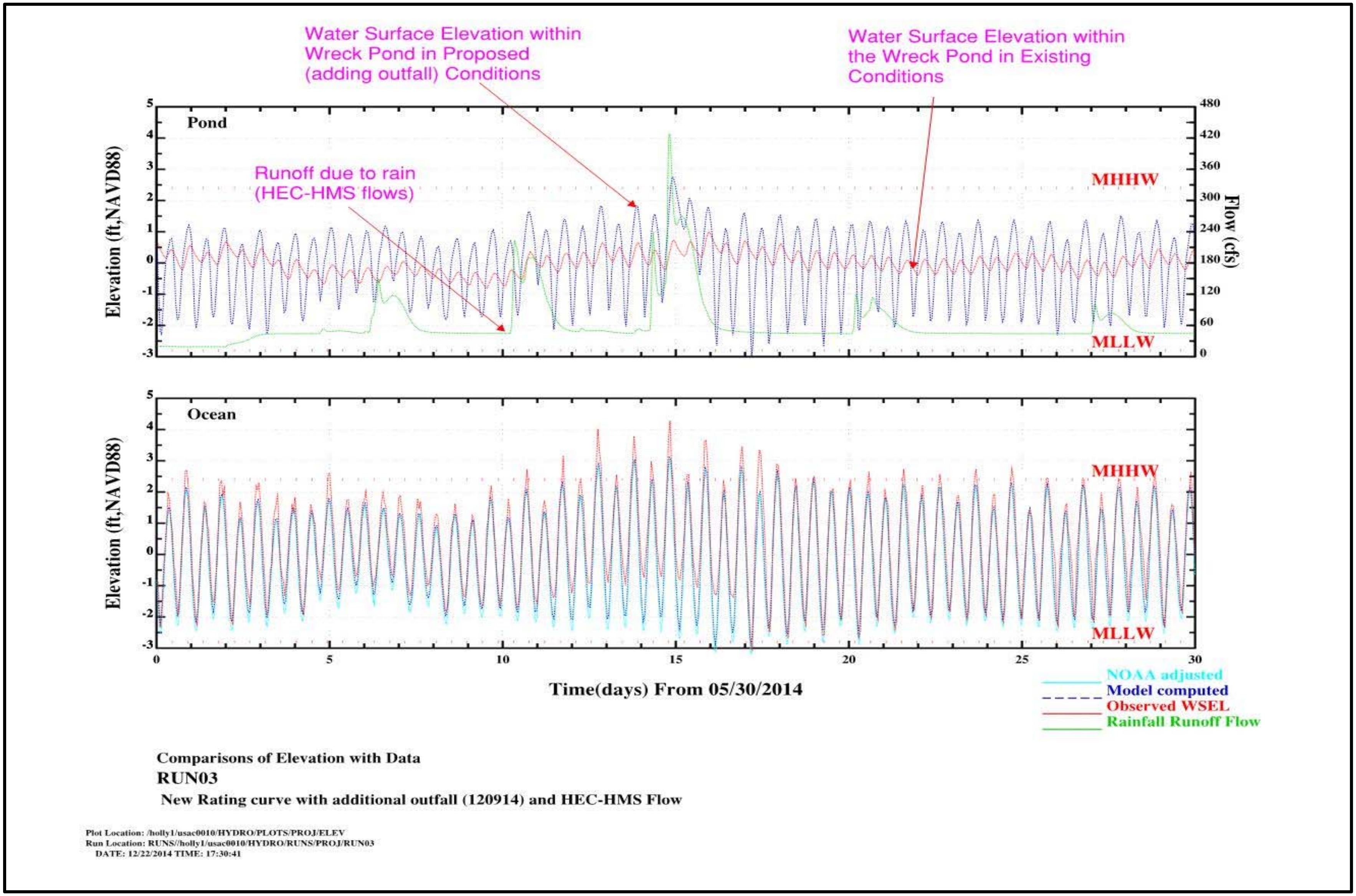


Figure 17: Water surface elevation variations with and without the Borough of Spring Lake's secondary outfall structure project in place.

Figure 18: Potential exposed area.

3.1.4 Salinity

The increased exchange produced by the proposed outfall, will increase salinity. Figure 19 shows the locations of salinity comparison at three different locations in the study area:

- West Point, which is upper end of Wreck Pond,
- East Point, which is the main water body section of Wreck Pond, and
- Near the ocean outfall

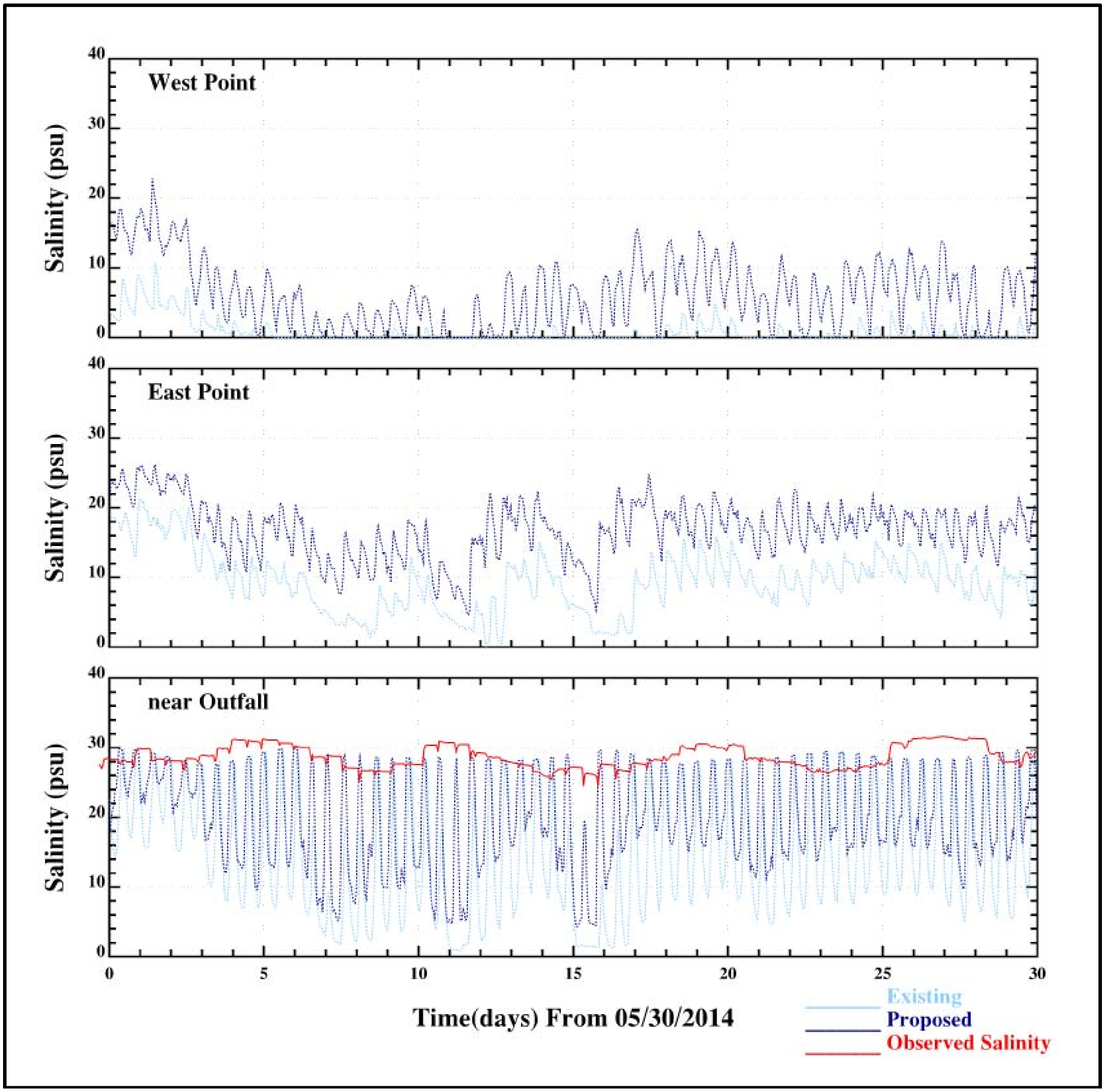


Figure 19: Salinity under existing and future conditions.

3.1.5 Geotechnical Data

Geotechnical analyses from boring data included slope stability analysis. This analysis primarily investigated the stability of the underlying sandy stratum to calculate the maximum allowable slope if additional depth was desired beyond the original pond bottom. The sediment layer above is highly unstable and would have both low compressive or shear strengths.

Due to the very low strength of this accumulated material, any loading of this material would create mud-waves (lateral displacement of sediment) due to high deformation and displacement. The relatively high organic and moisture content of the accumulated sediment would also not provide adequate qualities for use of the material as structural fill for beneficial use, if dredged and disposed of off-site. Therefore, it is recommended that any approach to the restoration of Wreck Pond not rely on the ability of the sediment to hold a slope of any greater than 20:1 and, even that slope would not necessarily maintain consistency over time due to the potential flowing nature of the materials. It is not recommended that any structural materials such as rock or other structure added to Wreck Pond be designed to sit atop the accumulated sediment.

The underlying sands, on the contrary, are of a medium dense to dense consistency with no organic content. For the various slopes analyzed, it was found that a slope of 2.5 to 1 would be considered stable. A slope of 3 to 1 would provide a more acceptable factor of safety. This material is of sufficient stability to allow flexibility for developing various dredging plans.

The analysis also recommends that any excavation would be accomplished at least 10 feet from a shoreline to reduce a slope's exposure to surface wave action, and not impact adjacent structures such as bulkheads.

It is finally noted that these recommendations do not account for hydraulic impacts to the pond's substrate such as erosion and scour that may occur as a result of wave, storm surge or general water circulation patterns.

3.2 Fish and Wildlife Resources

The new outfall will enhance connectivity between the Atlantic Ocean and Wreck Pond, thereby increasing fish passage. But sedimentation from the interior drainage area may continue, as there are no current projects to limit the sediment inflow. Eventually, the pond depth would decrease and aquatic habitat may be significantly reduced. While sedimentation could minimize aquatic species habitat, it may increase the size of the sediment island that already exists in the pond, providing additional habitat for birds and terrestrial species.

3.2.1 Hazardous, Toxic, and Radioactive Waste

Data suggested that for future dredging activities, exposure of the underlying sand subsequent to dredging would not produce an unacceptable ecological risk as concentrations of contaminants in this material are below the respective LELs. Further, from a contaminant perspective, upland placement of dredge spoils is a viable alternative and the material may be able to be used beneficially if it is a viable method of disposal.

3.3 Coastal Storm Flooding and Sea Level Rise

The study area will continue to be subject to the effects of coastal storms. Inundation due to storm surge is expected to increase gradually over time along the New Jersey coast in direct relation to sea level change. Based on long-term trends measured in the area, sea level is projected to rise between 0.64 (low scenario) and 2.57 feet (high scenario) over the 50-year period of analysis (at the Sandy Hook NOAA gage) (Figure 20). This may result in more frequent and higher stages of flooding along the coast (Table 6).

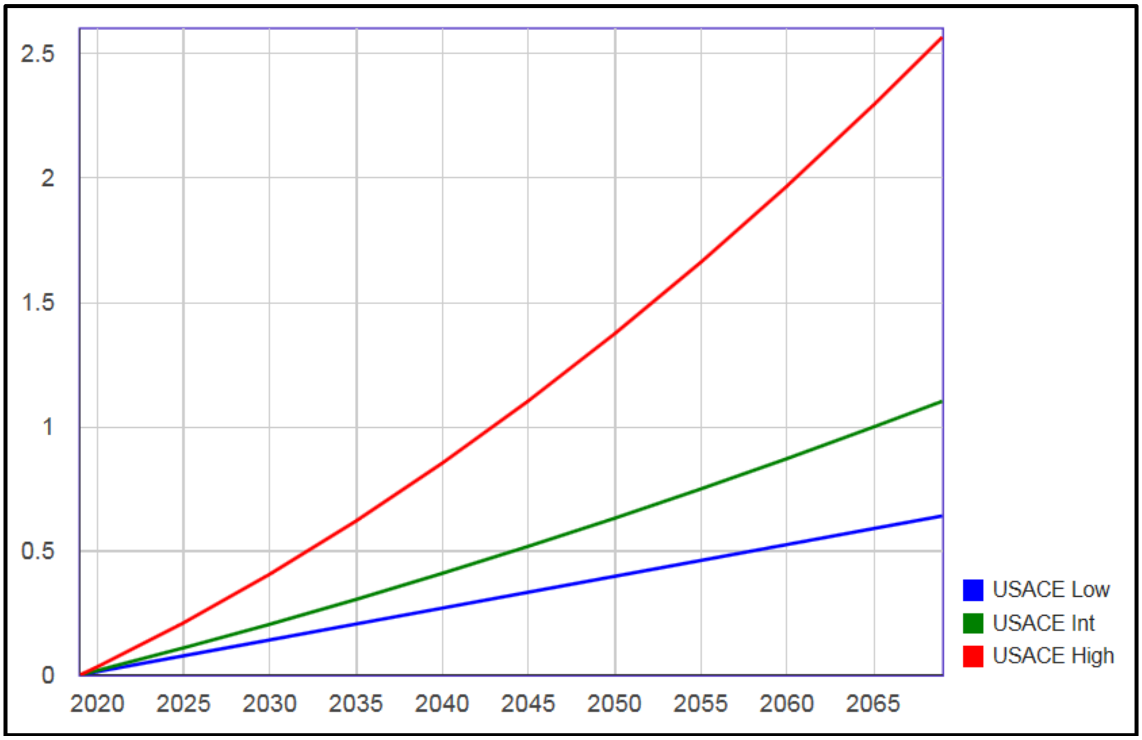


Figure 20: Predicted sea level change over the period of analysis (2019–2069), as calculated using procedures in ER 1100-2-8162.

Table 6: Water surface elevations and projections (not including wave run-up).

		Sea Level Change Projections by Scenario		
Scenario (Year)	**NAVD88 (feet)**	**Low**	**Intermediate**	**High**
1	4.48	5.12	5.58	7.05
2	5.36	6.00	6.46	7.93
5	6.45	7.09	7.55	9.02
10	7.20	7.84	8.30	9.77
20	7.92	8.56	9.02	10.49
50	8.97	9.61	10.07	11.54
100	10.02	10.66	11.12	12.59
200	11.37	12.01	12.47	13.94
500	13.14	13.78	14.24	15.71

Operation of the secondary outfall structure project, which is currently under construction, could significantly reduce the effects of coastal storm flooding in the study area. The borough's secondary outfall structure system is expected to reduce damages due to coastal storm flooding in the study area if operated in concert with the gates. Without closure of the gates prior to a storm event, flood risk may increase. Floodplain management regulations and building retrofits by homeowners will further mitigate some potential future damages. The effects of the system was evaluated using the hydrodynamic modeling to understand its potential effects to water levels within Wreck Pond. Modeling shows the water surface elevation within the pond in existing (red) and in proposed (blue) conditions. Existing conditions water surface elevation reflects flow through the existing 7-foot diameter pipe and the proposed conditions reflect the flow through the existing 7-foot diameter and the 8 by 5.5-foot box culvert currently under construction. For this simulation, both the culverts are assumed to be in the fully open condition (Figure 17).

The results in the plot indicate that, compared to the existing conditions, water surface elevations within Wreck Pond increased by approximately 0.5 to 1.5 feet during the simulation period. During high flow conditions, the pond water surface elevation can go as high as +2.5 feet NAVD 88. During low flow conditions, the pond water surface elevation can decrease to +0 feet NAVD88 (approximately 30 days starting from May 30, 2014).

4 Coastal Storm Risk Management Plans Considered

As with all USACE feasibility studies, potential water resource solutions were formulated for the Wreck Pond Study to support the Federal Objective of water and related land resources planning. The Federal Objective is to contribute to National Economic Development (NED) consistent with protecting the Nation's environment, in accordance with national environmental statutes, applicable executive orders, and other Federal planning requirements. Alternative plans were formulated to alleviate problems and take advantage of opportunities in ways that contribute to study planning objectives and, consequently, to the Federal objective.

USACE began investigating a range of coastal storm risk management solutions. Plan formulation is the process of building alternative plans that meet planning objectives and avoid planning constraints. Alternative plans are a set of one or more management measures functioning together to address one or more planning objectives. A management measure is a feature or activity that can be implemented at a specific geographic site to address one or more planning objectives. They can be used individually or combined with other management measures to form alternative plans.

4.1 Study Goals & Objectives

A study goal based on problems and opportunities was developed to help create and evaluate alternative plans. It is the overarching intent of the project. The period of analysis for this study was 2019 to 2069.

Goal: Manage the risk of storm surge flooding and associated damages in the study area.

Plans are formulated to achieve planning objectives. Planning objectives and constraints are inexorably linked to problems and opportunities. A planning objective states the intended purposes of the planning process. It is a statement of what solutions should try to achieve. Objectives provide a clear statement of the study purpose.
In support of the goal, the planning objectives were to:

- Manage the risk of damages due to storm surge in the study area through 2069.
- Encourage a resilient and sustainable risk management solution in the study area through 2069.

4.2 Risk Management Measures Considered

The study team considered a number of measures that could provide risk management to the communities in the study area. A management measure is a feature or activity that can be implemented at a specific geographic site to address one or more planning objectives. They can be used individually or combined with other management measures to form alternative plans. Measures were being developed to address coastal flood problems and capitalize on opportunities. They were derived from a variety of sources including prior studies, the public scoping process, and the team.

The following measures were considered:

- Modification of Existing Outfall Pipe
- Construction of New Outfall Pipe
- Surge Gate
- Floodwalls
- Levees
- Pumps
- Dune
- Nonstructural Measures
- Modification of Existing Drop Structure(s)
- Dredge Wreck Pond and/or Its Tributaries
- Natural and Nature-Based Features
    - Wetland Restoration/Creation
    - Living Shorelines
    - Installation of In-Water Structure(s)

Modification of Existing Outfall Pipe: The existing outfall pipe connecting the Wreck Pond and Atlantic Ocean is designed to exchange flow between the Pond and the Ocean. In addition, the outfall structure extends away from the beach and into the ocean to lessen the bacterial contamination of near shore waters.

Construction of New Outfall Pipe: A new outfall pipe could enhance the tidal exchange and better control pond levels, when paired with gates. The increased flow capacity would allow faster drainage, reducing fluvial damages. A new outfall pipe could be located to the north or south of the existing outfall pipe, and would extend away from the beach.

Surge Gate: A gate may be placed within a new or existing outfall structure. A sluice or similar gate could be effective in regulating flow in and out of the pond. The gate could block surge during storm events, reducing flooding in and around the pond.

Floodwalls: Floodwalls generally consist of cantilevered steel sheet pile extending below the river mud line, installed as close as possible on the water side of existing bulkheads. The floodwalls would generally tie off the alignment into high ground.

Levees: Levees generally consist of a trapezoidal shaped mound of earth with 1V:2.5H vegetated side slopes. Levee sections could be utilized in lieu of the inland floodwalls or landward of the existing shorefront bulkhead or beachfront.

Pumps: Pumps would remove water from the study area. Water would likely be pumped into the Atlantic Ocean.

Dune: A sand dune could be constructed within the footprint of the Sandy Hook to Barnegat Section I Beach Erosion Control and Coastal Storm Risk Management project. The team would coordinate with the Sandy Hook to Barnegat team to ensure consistency with the project.

Nonstructural Measures: A combination of nonstructural flood damage reduction features, including dry floodproofing, wet floodproofing, structure elevation, ringwall construction, rebuilding, acquisition, and evacuation will be considered.

Modification of Existing Drop Structure(s): Modifying the drop structure between Wreck Pond and Black Creek (reducing the height, eliminating the weir etc.) may allow better flushing between the two water bodies, and enhancing habitat.

Dredge Wreck Pond and/or Its Tributaries: Dredging could remove the existing sediment within the pond. This would increase the storage capacity of the pond, but would require the use of pumps and gates to provide any significant flood damage reduction. In-water habitat could be enhanced once the water depths are restored within the pond.

Natural and Nature-Based Features: These features include a spectrum of measures, ranging from those that exist due exclusively to the work of natural process to those that are the result of human engineering and construction.

- Wetland Creation: Wetland creation would involve re-grading and planting areas exposed to periodic tidal inundation. Clean fill would be added to create optimal slopes for wetland vegetation. Species that improve habitat would be planted within the high and low marsh areas determined by mean high (MHW) and mean tide (MTL) levels.
- Living Shorelines: These shorelines would mimic natural shorelines, and would be planted with native vegetation.
- Installation of In-Water Structure(s): The installation of in-water structures would include reef balls and other hard structures that would provide habitat for macro-invertebrates such as bivalves and crustaceans as well as fish species chosen to utilize the area for foraging.

4.2.1 Screening of Measures

Screening is the ongoing process of eliminating measures that will no longer be considered based on planning criteria. Criteria are derived for the specific planning study, based on the planning objectives, constraints, and the opportunities and problems of the study area. Management measures were retained for further consideration based on their ability to meet the following measures **screening criteria**:

1. **Does the measure meet objectives?**
   The team used Storm Damage Reduction and Resilience Functions detailed in the NACCS January 2015 report. The NACCS quantified the ability for typical coastal storm risk management measures to provide flood reduction and resilience. The NACCS Flooding Function and Resilience (Adaptive Capacity) Function Ratings were used to screen measures.
2. **Does the measure avoid constraints?**
   The project constraints (physical constraints, impacts to existing CSRM projects, and consistency with the Green Acres Program) were considered.

3. **Is the measure feasible to design and construct?**
   The team considered limitations to design and construction of the project. This screening didn't account for public acceptability of a measure. Potential plans will continue to be coordinated with the sponsor and the public.

The screening process is summarized in Table 7. The study was terminated prior to formulation of a final array of plans.

Table 7: Preliminary Screening of Measures

Measure	Objective 1: Manage the risk of damages due to storm surge[1]	Objective 2: Encourage a resilient and sustainable solution[2]	Avoid constraints	Feasible to design and construct	Carried forward for further consideration	Reason
Modification of Existing Outfall Pipe	High*	Low*	Yes	Yes	Yes	Could create more efficient drainage of pond
Construction of New Outfall Pipe	High*	Low*	Yes	Yes	Yes	Could create more efficient drainage of pond
Surge Gate	High	Low	Yes	Yes	Yes	Could prevent storm surge inundation
Floodwalls	High	Low	Maybe – physical constraints	Yes	Yes	Could prevent storm surge inundation
Levees	High	Low	No	No	No	Space for construction not sufficient
Pumps	Medium*	Low*	Yes	Yes	Yes**	Could remove floodwaters
Dune	High	High	No	No	No	Impacts to the existing Sandy Hook to Barnegat CSRM project
Nonstructural Measures	Low - High	Low - High	Yes	Yes	Yes	Could remove structures from the floodplain or provide flood proofing

Table 7: Preliminary Screening of Measures

Measure	Objective 1: Manage the risk of damages due to storm surge[1]	Objective 2: Encourage a resilient and sustainable solution[2]	Avoid constraints	Feasible to design and construct	Carried forward for further consideration	Reason
Modification of Existing Drop Structure(s)	Medium	Low	Yes	Yes	No	Would not meet Objective 1
Dredge Wreck Pond and/or its Tributaries	Low*	High*	Yes	Yes	No	Would not meet Objective 1
Natural and Nature-Based Features	Low	High	Maybe – physical constraints	Yes	No	Would not meet Objective 1

[1] Based on North Atlantic Coast Comprehensive Study (NACCS) Flooding Function Rating (*measure not evaluated by the NACCS)
[2] Based on NACCS Resilience (Adaptive Capacity) Function Rating (*measure not evaluated by the NACCS)
** In combination with other measures

5 Public Coordination

The study team coordinated extensively with the sponsor, resource agencies, and the public during the study. The team attended many of the monthly Wreck Pond Brook Watershed Regional Stormwater Management Plan Committee meetings, and has been part of the Wreck Pond Technical Advisory Committee since 2009.

In addition to the monthly updates to the Wreck Pond Brook Watershed Regional Stormwater Management Plan Committee, a public meeting specific to the study was held by CENAN and NJDEP on December 15, 2014. The purpose of the meeting was to update concerned residents and project stakeholders with watershed initiatives completed by NJDEP, inform meeting attendees about the progress of the feasibility study including coastal storm risk management measures that would be evaluated, and to request feedback from interested parties regarding flooding concerns that they would like the project to address. The public meeting memorandum containing a summary of the public meeting is included in Appendix F.

6 Potential USACE Authorities for Future Study

At the beginning of the study, modifying and/or adding additional outfall from Wreck Pond to Atlantic Ocean, in combination with tide gates, was considered to be a viable option to reduce coastal storm damages, to reduce fluvial flood damages and to achieve coastal risk reduction benefits within the study area. As the study progressed, USACE learned that the Borough of Spring Lake and its partners received a grant to construct an additional outfall structure and pipe. USACE and the Borough team worked together and shared information so as to not duplicate efforts. Ultimately, a design was completed and awarded for construction of the second outfall structure. Hydraulic modeling showed that the Borough's secondary outfall structure, which includes sluice gates, would significantly reduce the risk of coastal storm flooding in the study area. Because of this, other coastal risk reduction measures investigated as part of the Study would not provide sufficient economic justification. Funding was announced in July 2015 and after award for a construction contract of the Borough's project, USACE decided to suspend its Study in November 2015.

The Borough's new outfall will enhance connectivity between the Atlantic Ocean and Wreck Pond, thereby increasing fish passage. However, the Borough's project will not address other environmental problems – specifically, sedimentation in Wreck Pond and degradation of its shoreline. Sedimentation from the interior drainage area could continue to make the pond shallower every year. There are no current projects to limit the sediment inflow. There are plans to enhance the Wreck Pond shoreline, though to date no major funding has been allocated for action. Opportunities for ecosystem restoration at Wreck Pond remain. The USACE could potentially undertake a feasibility, with appropriate local sponsor participation and cooperation, to investigate potential ways to restore Wreck Pond. Such a study could examine the condition of the ecosystem and determine the feasibility of restoring degraded ecosystem structure, function, and dynamic processes to a less degraded natural condition. The following programs and authorities could be used by USACE and a non-Federal sponsor to undertake an ecosystem restoration feasibility study.

<u>General Investigations</u>: Congress could provide USACE with appropriate funding, based on the findings of the 2010 reconnaissance report. A separate authorization to implement a project would be needed prior to construction. The non-Federal sponsor would share the study and construction costs with the Federal Government. Such a study would be cost shared 50-50 by USACE and the non-Federal sponsor. The Federal share of the cost of construction would be 65% of the total cost, with no limit.

<u>Continuing Authorities Program Aquatic Ecosystem Restoration</u>: The USACE is authorized by Section 206 of the Water Resources Development Act of 1996 to carry out small aquatic ecosystem restoration projects that will improve the quality of environment, are in the public interest, and are cost-effective. Such a study would build off of the recommendations made in the 2010 reconnaissance report. The study would be cost shared 50-50 by USACE and the non-Federal sponsor, after the first $100,000 in study cost. The first $100,000 in study cost is Federally-funded. The Federal share of the cost of construction would be 65% of the total cost, and limited to $10,000,000.

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