Chapter 3: Affected Environment

The information in the "Affected Environment" chapter describes resources and values that may be changed if an action alternative is implemented. In addition to describing the resources, available data on existing conditions is included.

Natural Resources

Soils and Geology

Geology and Physiography

Gateway National Recreation Area (Gateway or the park) is spread out in three units in the boroughs of Brooklyn, Queens, and Staten Island, New York, and in Monmouth County, New Jersey. The park is generally considered part of the Atlantic Coastal Plain province. Coastal plain materials are from formations of sand and gravel characterized by a relatively high degree of weathering. Most of the park in New York City is covered by deposits from an ice age that began about 1.6 million years ago; Sandy Hook (in New Jersey) was not glaciated (NRCS et al. 2001). Stratification or layering is common in outwash deposits from glaciers and is displayed in metropolitan surface materials.

The park is generally considered part of the Atlantic Coastal Plain province. Coastal plain materials are from formations of sand and gravel characterized by a relatively high degree of weathering.

The area geology includes crystalline bedrock, sedimentary rocks, and igneous intrusive rocks. In many places, these are covered with human-deposited fill. The bedrock for the Jamaica Bay and Staten Island Units consists of Cretaceous age rocks, including the Raritan Formation, the Monmouth Group, and the Matawan Group, and in some places unconsolidated Cretaceous sediment of the Magothy Formation (Fisher et al. 1970, as cited in Edinger et al. 2008a). The surficial geology of these two units is primarily outwash sand and gravel with small amounts of till moraine at Fort Wadsworth and significant areas of artificial fill (e.g., at Floyd Bennett Field and Great Kills Park). The surficial geology of the Sandy Hook Unit is Holocene age (Stanford 2000, as cited in Edinger et al. 2008a). The original sedimentary and igneous rocks have been folded, faulted, and in some places melted and recrystallized during several cycles of mountain building. Although bedrock exposures are common in Manhattan and the Bronx, for the most part they are buried beneath younger deposits. Serpentine, a green metamorphic rock, forms the backbone and highest point on Staten Island (NRCS et al. 2001). Most of the park's landscapes are characterized by relatively flat to slightly undulating topography, with elevations ranging from sea level to less than 50 feet above mean sea level (NRCS et al. 2001).

Soils

The Jamaica Bay Unit contains the greatest proportion of tidal marsh inside the park, which is underlain in large part by poorly drained glacial outwash soils in the Ipswich series. In some areas, considerable amounts of organic materials have accumulated since the retreat of the glaciers. The unit also contains urban land, which is a mix of human-deposited materials (NRCS et al. 2001). For example, Floyd Bennett Field in the Jamaica Bay Unit was constructed on saltmarsh now covered by dredged materials, rubble, fly ash, and wastes (see "Soils and Geology" impacts common to both action alternatives section for more information) and in some cases paved to create space for runways, hangars, and historically for the railroad across Jamaica Bay. The Fountain Avenue and Pennsylvania Avenue former landfills occupy space on the northern edge of Jamaica Bay. Each is about 80 feet high and covers 100 acres of former saltmarsh habitat.

Areas covered by glacial outwash south of the terminal moraine on Staten Island include Miller Field and Great Kills Park. These are either sand or well-drained soils of the Bernardston series, the latter covering most of the park sites in the Staten Island Unit (Edinger et al. 2008a). Pockets of windblown sediment can also be found blanketing the surface in some areas. The red sand of Great Kills Park is human deposited from hydraulic dredging of glacial deposits from offshore sandbars (NRCS et al. 2001).

The Sandy Hook Unit is covered with beach sands and less well-drained depressions of the Hooksan series, as well as urban land and other human-deposited fills (Edinger et al. 2008a).

Shorelines and Coastal Processes

Although the three units of the park total only about 8,300 acres in land area (and a total of 21,680 acres of land and National Park Service [NPS]-managed waters), they include 75 miles of shoreline. The Sandy Hook Unit's shoreline on the Atlantic Ocean and Raritan Bay (to the west) covers more than 6 miles, but it is the park sites in the Jamaica Bay Unit that compose the majority of the park's shoreline (NRCS et al. 2001).

Coastal processes include marine processes such as tides, coastal currents, storm surges, and shoreline dynamics. These forces are some of the most significant drivers of geomorphological processes (which relate to the origin and development of landforms) at the park. Humans have also shaped landforms at the park, starting with historical uses such as agriculture and progressing to more recent ones such as urbanization, dredging and filling, diverting freshwater flows, and hardening of the shores with development and massive sand stabilization efforts.

Coastal Sediment Supply and Movement

Ocean shores at the park are fed by sediment carried along the coast by the longshore current in a process called littoral drift. Longshore transport provides material that contributes to a natural development of the barrier island profile, including the formation of offshore bars, beach slopes, beach berm, dunes, and foredune habitat. The strength of waves and currents, the angle at which waves strike the shore, tidal cycles, and the size and weight of sand grains the current carries all help define how and where the sediment will be deposited. At Gateway, the longshore current travels from east to west along Long Island and from south to north along the northern New Jersey coast. The dominant wave action is from the southeast, a function of prevailing winds and storms in the tropics and the South Atlantic. The sources of material carried by the longshore currents offshore of park sites vary as described below, but sources include Headlands in New Jersey and remnants of glacial moraines in New York Bay (see the "Marine Resources" section of this GMP/EIS for distinctions between New York Bay, New York Bight, and New York Harbor).

The amount of sediment input (sources), deposition (sinks), and transport out of the system is the sediment budget. Usually, the sediment budget is expressed in terms of some volume of sand gained or lost per year for a given area. Whether the sand is lost to an offshore sink, inland to a bay, or transported to the next area downdrift is not important to the potential for accretion (adding of sediment) or erosion (removal of sediment) of a coastline (Psuty et al. 2009). In general, most park sites at Gateway are experiencing a long-term negative sediment budget. However, there are portions of the park that are expanding while others are eroding; this is true of the Sandy Hook Unit, for example.

When natural conditions prevail, the topography of the ocean shoreline is a broad beach backed by a vegetated foredune. The beach, dunes, and island core exchange sediment with each other and with the nearshore environment in different measure during the seasons. Sand is moved from offshore to onshore at different times of year by a variety of mechanisms, including tides, waves, and storms. In general, sand is stored offshore in sandbars during storms and migrates back to the beach during quieter times. Coastal dunes accumulate sand in the upper margin of the beach; their growth depends on wind transport and water moved during storms. Foredunes are dynamic, and can become steepened or scarped when storms erode beaches, or be pushed inland by storm surge and sand transported by strong waves. Very strong storms such as hurricanes or nor’easters can transport sand across the spit and into bays in a process called “overwash,” or can cut a channel from ocean to bay, creating inlets and shoals in the bays. The back beach area is only flooded during winter storms and the highest spring tide surges. Winter coastal winds redistribute some of the sand to the back dunes, which can reach 20 to 30 feet above mean sea level in undisturbed areas.

Storms can cause the erosion or accretion of large quantities of sediment over a relatively short time. This was the case with Hurricane Sandy, which resulted in more than 160,000 cubic meters of sand moved across parking lots, roads, and buildings, and erosion substantial enough in some spots to uncover historic batteries and blockades that had been buried several feet deep.

Although sand transported by the longshore current can be sequestered naturally along the route—in inlets, for example—human activity also interrupts littoral drift. Dredging and stabilizing of inlets for navigation interrupts the magnitude of sediment transported; this is true of areas of Raritan Bay and Rockaway Inlet in the study area. Groin fields and jetties block and redirect longshore flows, resulting in the accumulation of material on the updrift side of these structures. The long-term impact of these structures varies based on local sediment transport regimes and on the size, effectiveness, and integrity of the structure. Whereas the structures that influence longshore transport are local, their impacts can be both local and regional in effect. More information on jetties and groins at specific park sites and their effects is presented below.

When a sediment budget is positive, the shoreline will migrate seaward; the opposite is true in a negative sediment budget, as the dune beach system will be displaced landward as sand is eroded and transported downdrift. As sea-level rise accelerates over time, the amount of sand in the sediment budget available for deposition will define an important element in the vulnerability of a coastline to increasing erosion and loss.

Storms can cause the erosion or accretion of large quantities of sediment over a relatively short time. This was the case with Hurricane Sandy, which resulted in more than 160,000 cubic meters of sand moved across parking lots, roads, and buildings, and erosion substantial enough in some spots to uncover historic batteries and blockades that had been buried several feet deep.

Coastal Processes at Park Beaches

The two major coastal landform components of Gateway are the barrier spits that compose Sandy Hook on the New Jersey coast and the Jacob Riis Park–Breezy Point stretch of the New York coast (Psuty et al. 2009). These are both products of the longshore transport of sand, which has extended the two barrier features toward Lower New York Bay. In other parts of the park, Plumb Beach was formed as a remnant of the eastern terminus of the Coney Island barrier, and Great Kills Park is located on the remnant of a barrier spit that formerly extended southwesterly along the ocean-facing margin of Staten Island.

Coastal Processes at the Jamaica Bay Unit

Rockaway Peninsula

Breezy Point Tip is the westernmost extension of the Rockaway Peninsula. East of Breezy Point Tip are two additional park sites that also lie on the Rockaway Peninsula: Fort Tilden and Jacob Riis Park. Each is supplied by eastern Long Island longshore transport of sediments originally deposited as glacial outwash. The Rockaway Peninsula is at the end of this sediment pathway, which transports sand along the south shore of Long Island at a rate of about 450,000 cubic yards/year (344,000 cubic meters/year) (Hess and Harris 1987, as cited in Psuty et al. 2009).

Breezy Point Tip is the westernmost extension of the Rockaway Peninsula. East of Breezy Point Tip are two additional park sites that also lie on the Rockaway Peninsula: Fort Tilden and Jacob Riis Park. Each is supplied by eastern Long Island longshore transport of sediments originally deposited as glacial outwash.

East of the park sites (i.e., further updrift in the longshore transport chain), sand is dredged at Little Rockaway Inlet and deposited downdrift to nourish beaches in the Rockaway communities. In addition, starting in 1975 and continuing to 2004, 17 million cubic yards (13 million cubic meters) of sediment were dredged from offshore to help supply these same beaches (USACE records; Yasso and Hartman 1976 and Neresian 1977, as cited in Psuty et al. 2009). Despite these beach nourishment efforts, a long and effective groin at the eastern end of Jacob Riis Park prevents longshore transport of sand to NPS-managed lands. Instead, a sand-starved, highly mobile beach profile exists at Jacob Riis Park, preventing the development of a stable foredune that could otherwise help reduce coastal erosion during storms. Further west, a foredune has formed at Fort Tilden despite riprap and wooden bulkheads along this site's entire length. At Breezy Point Tip, a jetty built in 1933 to prevent longshore transport from filling in the Rockaway navigation channel has resulted in the accretion of sand seaward for a distance of 2.8 miles. The accumulation has reached its maximum and filled the area between the point and the jetty, although an increase in height could occur (Psuty et al. 2009).

Hundreds of thousands of cubic yards of sand was blown and washed ashore by an 11- to 13-foot storm surge in each of these three areas during Hurricane Sandy in 2012, resulting in damage to buildings, roads, and other structures. Although dunes were overwashed and eroded at Breezy Point Tip and Fort Tilden, and buildings and facilities flooded and covered in sand at Jacob Riis Park, only debris removal was recommended to help restore coastal resources in NPS assessment documents (NPS 2012c). The exposure of wooden bulkheads at Fort Tilden is considered a human safety hazard and this area is closed to the public until an access plan is developed by the NPS. Although the rubble and debris trapped by the bulkheads and exposed after the hurricane is increasingly reburied by sand, it is considered part of the hazard. Sediment washed onto the upland area of Fort Tilden, including on roads and parking lots, was placed near dunes in protective berms (NPS 2012c).

Plumb Beach

Plumb Beach is an access point to the shore along the outer bay area of Rockaway Inlet. It is a remnant of the eastern end of the Coney Island barrier island and its associated tidal inlet delta, but it is isolated from the general barrier evolution by the western extension of the Rockaway Peninsula (Psuty et al. 2009). Plumb Beach is also separated from longshore sediment supply through the dredging of the navigation channel into Sheepshead Bay west of the site. The effect of these changes and the completion of the inlet jetty at Rockaway Point in 1933 to stabilize Rockaway Inlet has been to switch net sediment transport at Plumb Beach from westward to eastward (NPS 2010a). Creation of the Belt Parkway in the 1930s resulted in a large amount of fill placed on the shoal inland of Plumb Beach and the establishment of a reformed shoreline at the seaward margin of the fill (Psuty et al. 2009). Because there was no natural source of sand coming into this area, net erosion displaced the shoreline inland toward the Belt Parkway.

Several episodes of beach nourishment and riprap placement in the central portion of Plumb Beach, including efforts by both New York City Department of Parks and Recreation and the U.S. Army Corps of Engineers,were observed in aerial photo evidence, as was the severe erosion and loss of the existing pathway near the Belt Parkway in 1985 (Psuty et al. 2009). However, sand deposited in the central portion of the park site continues to be transported from west to east, adding to the eastward-extending spit. The western margin of Plumb Beach is stabilized with a bulkhead structure and an offshore breakwater of old tires that was constructed in the early 1980s to intercept incident waves and reduce the wave energy reaching the remaining beach.

Recognizing the need for more consistent intervention, the park and the USACE analyzed options for stabilization of the shoreline to protect the Belt Parkway in a 2010 planning document and environmental assessment (NPS 2010a) and began to implement the first phase in 2011 by adding 150,000 cubic yards of sand. The next phase of the project begins in 2013 and consists of the construction of two terminal groins and an offshore breakwater to help reduce wave energy and retain sand.

Coastal Processes in the Staten Island Unit

The three coastal areas of the park shoreline on Staten Island—Great Kills Park, Miller Field, and Fort Wadsworth—are each situated where glacial deposits are being reworked by waves and currents but little of the natural topography remains. Large amounts of beach nourishment and dredged sediment and multiple shore structures have altered these sites. Each site is eroded somewhat by longshore transport from the northeast moving southwest. Althougthe transport does not add sand to these sites because of updrift groins, it does create a depositional spit at Crooke’s Point on the western edge of Great Kills Park (Psuty et al. 2009).

Great Kills Park

Great Kills Park was constructed at least in part by excavation of sediment to create the Great Kills Park Harbor; dredged materials were used to build up the surrounding land, including a connection from the mainland to Crooke's Point Island. The cumulative effect of the groins deliberately installed to trap sediment from the longshore current was doubled when a very long outfall pipe installed in 1975 effectively stopped the remaining sediment from reaching Great Kills Park (Psuty et al. 2009). A jetty at Crooke's Point on the western edge of Great Kills Park keeps the harbor from filling in, but the beach immediately to the west (downdrift) is eroding. Sanitary landfills in the 1940s covered the saltmarsh behind the beach and increased its elevation by 35 feet. Nonetheless, the beach is a popular visitor destination. Portions of the Great Kills Park site north of the harbor have been closed recently due to the discovery of radon from medical waste in the early landfills.

The accreting Crooke's Point was at one point a sand spit, which was separated by a storm in the early 1900s to become an island. Crooke's Point was reconnected using the dredge material from the harbor, which was used to fill in the saltmarshes and three creeks.

Miller Field

The shoreline of Miller Field extends between two groins for about 2,000 feet (630 meters), about 1,600 feet (500 meters) of which is within park boundaries. The shoreline is completely composed of artificial fill and is manipulated by the placement of this fill and the sand-capturing ability of the two groins. Sand trapped by the groins and held by a sand dike is used to nourish this small beach (Psuty et al. 2009).

Fort Wadsworth

A beach on the seaward-facing side of Fort Wadsworth is a product of fill placed in the 1950s. The northern 250 feet (75 meters) is lined by riprap and bounded by an offshore breakwater. Otherwise, the beach gently slopes toward a sand dike. No new sand is being transported to this site; it is exposed to waves entering the bay between Sandy Hook and Breezy Point and will continue to erode over time.

Coastal Processes at the Sandy Hook Unit

Sandy Hook is located at the intersection of the New Jersey shore with the ancient valley of the combined Raritan and Hudson Rivers, now flooded as Raritan Bay. It extends in width from several hundred feet to a mile. Several saltmarshes lie along the western side of the spit. Sand dunes line its eastern side, protecting grasslands, shrublands, woodlands, and forest vegetation from overwash flooding during most storms. Although the barrier spit extends northward 11.2 miles from its origin at the coastal headlands in Monmouth Beach, only the distal end (farthest from shore) is part of the park. Sandy Hook derives its sediment from northerly transport along the New Jersey shoreline; the source of this sediment is eroding headlands immediately updraft of Sandy Hook, which is considered insufficient to maintain the current shoreline in the long term (NRCS et al. 2001). Sand that makes up the spit is transported north by longshore current along the New Jersey coast and the east side of Sandy Hook, and is supplemented by sediments derived from the Shrewsbury and Navesink River estuaries (USGS n.d.a). Plum Island, in Raritan Bay on the bayside of Sandy Hook, is a remnant of an old overwash fan formed by several intense storms that also separated Sandy Hook from the mainland in the 1800s (USGS n.d.a).

The supply and availability of sediment changes along the length of Sandy Hook, in some part due to its orientation but also because of built groins. Caldewell (1966, as cited in Psuty et al. 2009) estimated the volume of sand moved along the shoreline through longshore transport at about 500,000 cubic yards (382,000 cubic meters) per year. The southern portion of Sandy Hook is nearly north–south in its orientation, which means it is eroded by wave energy to a greater degree than it is fed by the longshore current. The natural source of sediment to supply the basal portion of Sandy Hook is more limited than for its northern portion (Psuty et al. 2009). About halfway into the NPS-managed lands, the shoreline changes to a north-northwest direction, where wave energy and deposition of sediment balance. This continues for 1.6 miles (2.5 kilometers), when orientation changes to due northwest, further lowering the wave energy and resulting in a positive sediment budget and accretion area north of Sandy Hook. Because there is a limited natural source of sediment to supply the basal portion of Sandy Hook, at times during the period from 1733 to 1900 it was detached from the mainland, making it an island. During this same time it has also reconnected to the mainland in two places—at the Highlands and at Long Branch, where it is connected now (Psuty et al. 2009).

This portion of the coast shows signs of erosion, both because sand supplies are inadequate to buffer continuous loss, and because of the presence of a 7.5-mile-long seawall and several groins. The groins were built over several decades in Monmouth Beach and Sea Bright south of the park, and the seawall was constructed from Monmouth Beach to the southern boundary of the park (NPS 2004c). Immediately north of the seawall, accelerated erosion developed after 1950 and increased through 1976 (Psuty et al. 2009), with loss rates that peaked at 230,200 cubic yards/year (176,000 cubic meters/year) (Psuty and Namikas 1991, as cited in Psuty et al. 2009). This area north of the seawall was dubbed the “critical zone” by Sherman et al. (1976, as cited in Psuty et al. 2009).

Although the town replenishes the sand on the beach side of the wall, it has been eroded away several times by strong storms (USGS n.d.a). In addition, the NPS has placed more than 5.2 million cubic yards (4 million cubic meters) of sediment in the vicinity of the critical zone since 1975 (Psuty and Ofiara 2002, as cited in Psuty et al. 2009). A 2004 environmental assessment of options to maintain the beaches in this portion of Sandy Hook (NPS 2004c) found that 1.5 million cubic yards of sand was needed every five to seven years, although beach nourishment efforts by Sea Bright and the U.S. Army Corps of Engineers (USACE) offset this estimate by about half. The source of sediment was identified in the environmental assessment as sand in the longshore, swash bars, and migratory shoals offshore of the northern accreting end of Sandy Hook (NPS 2004c), and a pipeline to transfer sand slurry from Gunnison Beach to the critical zone was put in place. The result of the slurry and beach nourishment has been to reduce the net rate of sediment loss and to increase available sediment in the critical zone.

In the northern part of Sandy Hook, a series of dune ridges representing earlier stages of accretion is now stranded inland as this portion continues to grow. In addition to the seawall and groins south of the park site, a few groins were built on what is now NPS-managed land at Sandy Hook. These structures, at Battery Gunnison and North Beach, are usually covered in sand and are not considered important in sand transport processes (Psuty et al. 2009).

As a result of the 2012 Hurricane Sandy, sand was blown or washed from the beaches west over much of the spit, covering vegetation and park facilities such as roads and parking lots. As noted above, this cross-peninsula transport of sand from the ocean to the interior and bay shoreline is a natural process resulting from storm surge that increases the elevation of dunes and sometimes of inland areas of the spit, making it more resilient to future storm events.

The bayshore at Sandy Hook also shows signs of erosion. At one point just north of Spermaceti Cove, the wooden posts of a seawall built in 1912 are now nearly 150 feet from the shoreline standing in bay waters. The NPS returned the 160,000 cubic yards of sand cleared from roads and parking lots at Sandy Hook to the beach.

Jamaica Bay and its saltmarsh islands form one of the most recognizable and striking features in New York City.

Shoreline of Jamaica Bay

Jamaica Bay and its saltmarsh islands form one of the most recognizable and striking features in New York City. Tidewater grasslands colonized postglacial outwash plains at the ends of many creeks and streams on Long Island to form these islands. In addition to the saltmarsh islands, many more hundreds of acres of "fringing marshes" once adjoined the mainland. Much of this habitat is now gone because of development, dredging, and pollution, as described below and in other sections of this GMP/EIS (see the "Wetlands and Floodplains" and "Vegetation" sections, for example). Benthic soils in the bay are more likely to be sandy in the western portion (east to the Rockaway Inlet) and silty in the eastern portion (NYCDEP 2007).

In 1878, the secretary of war and New York City began a major landscape modification to establish the bay as a major seaport. Broad channels were dug and the dredge spoils were used to fill in marsh areas and to create raised land for docks and piers. Later, marshland was filled in the construction of Floyd Bennett Field and what is now John F. Kennedy International Airport. The Marine Parkway Bridge, which connected Flatbush Avenue to the Rockaways, was completed in 1937, hastening the development of the protective barrier islands. Large landfills and sewage sludge disposal removed additional marshland. As a result, soils in the Jamaica Bay Unit, including those in the bay itself, are altered. The inorganic mass of marsh sediments has decreased in Jamaica Bay marshes since European settlement, while organic matter has increased over the same period (Peteet et al. 2004 and 2008, as cited in Rafferty, Castagna, and Adamo 2011). The upland areas adjacent to the marsh are largely underlain by urban fill or dredged materials. The primary sources of freshwater into the bay are four wastewater treatment facilities and numerous combined sewer overflow (CSO) pipes, although eight large and several smaller tributaries also empty into the bay. All of the tributaries have been altered by channelization and tend to have little or no freshwater flow other than that conveyed by the CSO and/or storm sewers (NYCDEP 2007). Combined with wastewater effluent, they have increased nitrogen loading by more than 400 percent in the last 110 years (Rafferty, Castagna, and Adamo 2011) and changed the composition of nutrients in bay soils. Total organic carbon, a measure of organic material in sediments, was greater than 3.5 percent across nearly 40 percent of bay soils tested in 1998, a condition associated with decreased abundance of benthic aquatic species and biomass (Hyland et al. 2000, as cited in NYCDEP 2007). Soils along the northern and eastern portions of Jamaica Bay were also found to be contaminated with heavy metals and pesticide and other hydrocarbon residues such as polychlorinated biphenyls (PCBs), dichloro-diphenyl-trichloroethane (DDT), and chlordane in studies conducted from the 1970s through the 1990s.

By the 1960s, when the true ecological value of the saltmarshes was realized, the original 25,000 acres of Jamaica Bay saltmarsh and surrounding freshwater wetlands had diminished to about 13,000 acres (USGS n.d.a). A panel of experts convened by the NPS in 2001 investigated possible causes and identified relevant research needs. The panel theorized that increases in wave energy from waves and tides, a sediment deficit from dredging, the westward extension of the Rockaway Peninsula and eight terminal groins reducing sediment movement from the ocean into the bay, and sea-level rise were possible contributors.

By the 1960s, when the true ecological value of the saltmarshes was realized, the original 25,000 acres of Jamaica Bay saltmarsh and surrounding freshwater wetlands had diminished to about 13,000 acres.

Air Quality

Introduction

Gateway is located in New York City, New York, and Monmouth County, New Jersey, and air quality in the park is typical of that found in an urban area. Ambient air quality is affected by stationary, mobile, and area source emissions. Six air pollutants are regulated by National Ambient Air Quality Standards (NAAQS) under the Clean Air Act and are called “criteria” pollutants. These include carbon monoxide (CO), nitrogen oxides (NOx), particulate matter (PM2.5 and PM10 combined), ozone, sulfur oxides (SOx), and volatile organic compounds (VOCs).

Air quality is an integrating resource that often affects numerous resources and values including the health of ecosystems, viewsheds, and visitor health and visitor experience.

National Ambient Air Quality Standards and Public Health

Carbon Monoxide

CO, a colorless and odorless gas, is produced in the urban environment primarily by the incomplete combustion of gasoline and other fossil fuels. In urban areas, approximately 80 to 90 percent of CO emissions are from motor vehicles. Because CO is a reactive gas that does not persist in the atmosphere, concentrations can vary greatly over relatively short distances. Elevated concentrations are usually limited to locations near crowded intersections, heavily traveled and congested roadways, parking lots, and garages (NYCPC 2012b).

Ozone, Volatile Organic Compounds, and Nitrogen Oxides

Ozone is formed through a series of reactions between NOx and VOCs that take place in the atmosphere in the presence of sunlight. Because the reactions are slow and occur as the pollutants move downwind, elevated ozone levels are often found many miles from sources of the precursor pollutants. The effects of NOx and VOC emissions from all sources are therefore generally analyzed on a regional basis. Both stationary and mobile sources contribute to the combined total of these pollutants. The total vehicle miles traveled by cars, shuttles, buses, and other vehicles that bring visitors to the park are all considered sources of mobile emissions (FHWA 2006).

In addition to being a precursor to the formation of ozone, nitrogen dioxide (NO2; one component of NOx) is also a federally regulated criteria pollutant. NO2 is formed from the transformation of nitrogen oxide (NO) in the atmosphere. This pollutant is mostly generated by large stationary point sources and has not traditionally been considered a local concern. However, with the promulgation of a new 1 hour average NAAQS for NO2, local mobile sources such as vehicle emissions have become more important to managing this pollutant.

Particulate Matter

PM is a broad class of air pollutants that includes particles of a wide range of sizes and chemical compositions, either as liquid droplets (aerosols) or as solids suspended in the atmosphere. Fine particulate matter (PM2.5) is smaller, less than or equal to 2.5 microns in size, whereas coarse particulate matter (PM10) is less than or equal to 10 microns. The constituents of PM are numerous and varied and they are emitted by a wide variety of sources (both natural and human-made). Natural sources include salt particles resulting from the evaporation of sea spray; windborne pollen, fungi, molds, algae, yeasts, rusts, bacteria, and material from live and decaying plant and animal life; and particles eroded from beaches, soil, and rock. Naturally occurring PM is generally greater than 2.5 microns in diameter. Major human-made sources include the combustion of fossil fuels (e.g., vehicular exhaust, power generation, boilers, engines, and home heating), chemical and manufacturing processes, construction and agricultural activities, ship traffic, and wood-burning stoves and fireplaces (NYCPC 2012b). PM10 is often part of dust, soot, and ash.

PM2.5 has the ability to reach the lower regions of the respiratory tract, delivering with it other compounds that adsorb to the surfaces of the particles, and is extremely persistent in the atmosphere.

Sulfur Oxides

SOx (primarily sulfur dioxide [SO2]) emissions are mostly associated with the combustion of sulfur-containing fuels (e.g., oil and coal). Monitored SO2 concentrations in New York City are lower than the current NAAQS, largely due to federal restrictions on the sulfur content in diesel fuel for on-road vehicles. Federal limits on stationary sources have also greatly reduced SO2 emissions in the east.

NPS Air Quality Conditions and Current Trends

The NPS Management Policies 2006 clarifies that the NPS will seek to "perpetuate the best possible air quality in parks" (NPS 2006a, section 4.7.1). This means establishing desired conditions for air quality that are consistent with the Clean Air Act, NAAQS, and other policy goals. Currently, the NPS focuses on three primary measures and associated desired conditions to evaluate natural resource-based air quality conditions in national parks: ozone concentrations, wet deposition of acidic compounds or nitrogen, and visibility.

Ozone

The NAAQS for ozone is set by the U.S. Environmental Protection Agency (EPA) and is based on human health effects. However, studies show that some plant species are more sensitive to ozone than humans are. Accordingly, the NPS Air Resources Division (ARD) recommends a desired condition for ozone that is lower than the human health-based NAAQS.

Currently, ozone conditions at Gateway are not meeting NPS ARD–recommended desired future conditions. The estimated ozone level from 2005–2009 at Gateway was 82.1 parts per billion (ppb), much higher than the reference condition of 60 ppb and a condition that warrants significant concern. Table 3-1 describes and assesses ozone conditions and trends at Gateway in more detail.

Deposition

Nitrogen and sulfur compounds deposited from air pollution can harm soils, vegetation, lakes, and streams through acidification or fertilization. Deposition is measured in kilograms per hectare per year (kg/ha/yr) of wet nitrogen or sulfur deposition. The NPS ARD–recommended desired condition for deposition is determined to be protective of all ecosystems based on current scientific understanding.

For 2005–2009, estimated wet sulfur deposition at Gateway was 5.2 kg/ha/yr, substantially higher than the reference condition of 1 kg/ha/year and one that warrants significant concern. Table 3-1 describes and assesses nitrogen and sulfur deposition conditions and trends at Gateway in more detail.

Visibility

Visibility is a measure of how far and how well a person can see a distant and varied scene. Pollutant particles in the atmosphere scatter and absorb light, creating a haze that impairs scenic views. The deciview (dv) metric measures visibility changes as perceived by the human eye (analogous to the decibel scale) and is used by the air regulatory community to track visibility conditions and trends. The Clean Air Act established a national goal to return visibility to "natural conditions" in Class I areas. Natural visibility conditions are those estimated to exist in a given area in the absence of human-caused visibility impairment (EPA-454/B-03-005). The NPS ARD recommends a visibility desired condition that is consistent with this Clean Air Act goal. Based on the Organic Act mandates, the NPS ARD recommends the same desired conditions for Class I and Class II parks. Gateway is a Class II park.

Currently, visibility conditions at Gateway are not meeting NPS ARD–recommended desired conditions and therefore warrant "significant concern" as indicated by the NPS ARD standards. For 2005–2009, estimated average visibility in Gateway was 12.0 dv above estimated natural conditions, whereas desired conditions are less than 2 dv above natural conditions. This is a condition status that also warrants significant concern. Table 3-1 describes and assesses visibility conditions and trends at Gateway in more detail. As detailed in the analysis of impacts on air quality in chapter 4 of this GMP/EIS, the great majority of pollutants, including those that affect visibility, come from sources outside the park.

Table 3-1. Air Quality Conditions and Trends at Gateway.

Indicators of Condition	Specific Measures	Condition Status/ Trend[a]	Rationale	Reference Condition
Ozone	Annual 4th-highest 8-hour concentration	● ↑	**Condition:** The estimated ozone level from 2005 to 2009 at Gateway was 82.1 parts per billion (ppb); therefore, condition status warrants significant concern. Gateway falls within a county designated by the EPA as "nonattainment" for the ground-level ozone standards of an 8hour average concentration of 75 ppb. A risk assessment that considered ozone exposure, soil moisture, and sensitive plant species concluded that plants at Gateway were at high risk for ozone damage. Ozone-sensitive plants in the park include quaking aspen *(Populus tremuloides)* and chokecherry *(Prunus virginiana).* **Trend:** During 2000–2009, ozone levels at Gateway monitor improved. **Confidence:** The degree of confidence at Gateway is high because there is a nearby or on-site ozone monitor.	NPS ARD Benchmarks: Resource is in Good Condition: ≤ 60 ppb Warrants Moderate Concern: 6175 ppb Warrants Significant Concern: ≥ 6 ppb
Deposition	Sulfur wet deposition	●	**Condition:** For 2005–2009, estimated wet sulfur deposition was 5.2 kilograms per hectare per year (kg/ha/yr)[b]; therefore, the condition status warrants significant concern. Although Gateway receives among the highest measured sulfur wet deposition of all monitored parks, a risk assessment evaluating ecosystem sensitivity ranked Gateway's ecosystems as having low sensitivity to acidification effects relative to all Inventory and Monitoring parks. Acidification effects include changes in water chemistry that impact aquatic vegetation, invertebrate communities, amphibians, and fish. **Trend:** No trend information is available because there are no on-site or nearby wet deposition monitors. **Confidence:** The degree of confidence at Gateway is medium because estimates are based on interpolated data from more distant wet deposition monitors.	NPS ARD Benchmarks: Resource is in Good Condition: < 1 kg/ha/yr Warrants Moderate Concern: 13 kg/ha/yr Warrants Significant Concern: > 3 kg/ha/yr

Table 3-1. Air Quality Conditions and Trends at Gateway (continued).

Indicators of Condition	Specific Measures	Condition Status/ Trend[a]	Rationale	Reference Condition
Deposition	Nitrogen wet deposition	🔴	**Condition:** For 2005–2009, estimated wet nitrogen deposition was 4.4 kg/ha/yr[b]; therefore, the condition status warrants significant concern. Gateway receives among the highest measured nitrogen wet deposition of all monitored parks. A risk assessment evaluating ecosystem sensitivity ranked Gateway's ecosystems as having moderate sensitivity to nutrient enrichment effects relative to all Inventory and Monitoring parks. Nitrogen deposition may disrupt soil nutrient cycling and affect biodiversity of certain vegetative communities, including wetland plant communities. **Trend:** No trend information is available because there are no on-site or nearby wet deposition monitors. **Confidence:** The degree of confidence at Gateway is medium because estimates are based on interpolated data from more distant wet deposition monitors.	NPS ARD Benchmarks: Resource is in Good Condition: < 1 kg/ha/yr Warrants Moderate Concern: 13 kg/ha/yr Warrants Significant Concern: > 3 kg/ha/yr
Visibility	Haze index[c]	🔴	**Condition**: For 2005–2009, estimated average visibility in Gateway was 12.0 dv above estimated natural conditions[d]; therefore, the condition status warrants significant concern. **Trend:** No trend information is available because there are no on-site or nearby visibility monitors. **Confidence:** The degree of confidence at Gateway is medium because estimates are based on interpolated data from more distant visibility monitors.	NPS ARD Benchmarks: Resource is in Good Condition: < 2 dv above natural conditions[d] Warrants Moderate Concern: 28 dv above natural conditions[d] Warrants Significant Concern: > 8 dv above natural conditions[d]

Sources: Kohut 2004; NPS ARD 2013; Sullivan et al. 2011a, 2011b.

[a] Interpolations of air quality monitoring data averaged over a five-year period (2005–2009) are used to evaluate conditions. Trend analyses are completed using 10 years (2000–2009) of data from on-site or nearby monitors.

[b] Reporting units for wet deposition conditions and trends are different. Wet deposition trends are evaluated using pollutant concentrations in precipitation (micro equivalents/liter) so that yearly variations in precipitation amounts do not influence trends analyses. Wet deposition conditions are based on nitrogen and sulfur loading (kilograms per hectare per year) to ecosystems.

[c] Visibility trend and condition calculations are expressed in terms of a haze index in deciviews (dv); however, the benchmark metrics are different. Condition assessments are based on interpolation of the five-year average current visibility minus estimated average natural visibility, where average visibility is the mean of visibility between 40th and 60th percentiles. Visibility trends are computed from the haze index values on the 20 percent haziest days and the 20 percent clearest days, consistent with visibility goals in the Clean Air Act.

[d] Natural visibility conditions are those estimated to exist in a given area in the absence of human-caused visibility impairment. The Clean Air Act established a goal of restoring visibility in all Class I areas to natural conditions. Estimated annual average natural condition equals 8.1 dv at Gateway.

Condition Status		Trend in Condition		Confidence in Assessment	
🔴	Warrants Significant Concern	⇧	Condition is Improving	◯	High
🟡	Warrants Moderate Concern	⇔	Condition is Unchanging	○	Medium
🟢	Resource is in Good Condition	⇩	Condition is Deteriorating	◌	Low

NAAQS and Current Conditions

The New York Department of Environmental Conservation maintains an air quality monitoring system that includes the Jamaica Bay Unit. Data from the early 2000s indicate that the pollution levels for CO, NOx, and PM10 were below the NAAQS (FHWA 2006). The ozone concentrations exceeded the NAAQS for both the 1-hour and 8-hour averaging period. The PM2.5 concentration for the 24-hour averaging period met the NAAQS, but the annual concentrations continued to violate the standard. Table 3-2 shows measured concentrations at or near the park in assessment of the impacts of possible transportation methods at Jamaica Bay studied in 2005 and 2006 (FHWA 2006). For this table, data were taken from several sources, including Jamaica Bay Transportation Studies (FHWA 2006) and two recent New York City EISs (NYCPC 2012a, 2012b).

Table 3-2. Concentrations of Regulated Pollutants Compared to NAAQS.

Pollutant	Averaging Period	Concentration Measured at Gateway or Nearby	NAAQS (Federal Standard)
CO	8-hour	2.5 ppm	9 ppm
CO	1-hour	3.2 ppm	35 ppm
NO_x	Annual	47 µg/m^3	100 µg/m^3
NO_x	1-hour	126 µg/m^3	0.1 ppm or 188 µg/m^3
SO_2	1-hour	67.7 µg/m^3	0.075 ppm or 196 µg/m^3
Ozone	8-hour	0.086 ppm	0.075 ppm
Ozone	1-hour	0.116 ppm	0.12 ppm
PM_{10}	Annual	20 µg/m^3	50 µg/m^3
PM_{10}	24-hour	50–53 µg/m^3	150 µg/m^3
$PM_{2.5}$	Annual	16.3 µg/m^3	15 µg/m^3
$PM_{2.5}$	24-hour	36.5 µg/m^3	35 µg/m^3

Sources: FHWA 2006; NYCPC 2012a, 2012b.
CO = carbon monoxide; ppm = parts per million; NOx = nitrogen oxides;
µg/m3 = micrograms per cubic meter; SO2 = sulfur dioxide; PM10 = particulate matter ≤ 10 microns;
PM2.5 = particulate matter ≤ 2.5 microns

As mentioned in the “National Ambient Air Quality Standards and Public Health” section, the EPA has recently finalized a new 1 hour NO2 standard (February 29, 2012). The measured NO2 amount reported in table 3-2 is less than the new standard, but does not yet meet the criteria for attainment. This is because additional monitoring is required to determine whether concentrations are met over several years of data collection. Therefore, the EPA has designated the entire state of New York as “unclassifiable/attainment” for the new 1-hour NO2 standard.

The EPA also established a new 1-hour SO2 standard, replacing the 24-hour and annual standards, effective August 23, 2010. Based on the available monitoring data, all New York State counties had met the 1-hour standard as of 2011, but additional data were needed to make attainment designations.

Attainment

As noted in the "NPS Air Quality Conditions and Current Trends" section, Gateway is designated a Class II air quality area. This designation protects air quality by allowing only limited increases over baseline concentrations for NOx, SO2, and PM. These pollutants are characteristic of the EPA's New York-New Jersey-Connecticut Air Quality Control Region, an area that includes the park. Table 3-2 shows concentrations of pollutants and table 3 3 summarizes the air quality attainment status for the six criteria pollutants in the region. Those pollutants for which Gateway and the surrounding area meet the NAAQS are designated as "attainment" status. For those pollutants that are still above the levels allowed by the NAAQS, Gateway and the surrounding area is designated as "non-attainment," and for those pollutants for which the park and regional area had been in non-attainment but has improved to meet attainment standards, the park is listed as a "maintenance area."

Table 3-3. Gateway Air Quality NAAQS Attainment Status (2006).

Pollutant		Averaging Period	Attainment Status
CO		8-hour	Maintenance area
NO_x		Annual	Attainment
Ozone		1- and 8-hour	Non-attainment
PM	PM_{10}	Annual and 24-hour	Attainment
	$PM_{2.5}$	Annual and 24-hour	Non-attainment
Pb		Quarterly	Attainment
SO_2		Annual/24-hour and 3-hour	Attainment

Source: FHWA 2006.
CO = carbon monoxide; NOx = nitrogen oxides; PM10 = particulate matter ≤ 10 microns; PM2.5 = particulate matter ≤ 2.5 microns; Pb = lead; SO2 = sulfur dioxide

Gateway-specific CO Measurements

The Jamaica Bay Transportation Studies document (FHWA 2006) also measured CO, which is indicative of vehicle use, at Floyd Bennett Field and Jacob Riis Park and predicted how this would change over time assuming reasonably foreseeable future changes in EPA regulations and park compliance with the new regulations. At Floyd Bennett Field, the Federal Highway Administration found that 1-hour CO concentrations under the 2005 existing conditions ranged from 6.1 to 6.3 ppm (NAAQS is 35 ppm). The 2005 existing condition 8-hour CO concentrations ranged from 4.3 to 4.4 ppm (NAAQS is 9 ppm). Under the 2025 no-action alternative in the environmental assessment, the analysis predicted that the 1-hour CO concentrations would range from 5.8 to 6.0 ppm and the 8-hour CO concentrations from 4.1 to 4.2 ppm (FHWA 2006).

Jacob Riis Park 1-hour CO concentrations under the 2005 existing conditions ranged from 5.7 to 6.3 ppm. The 2005 existing condition 8-hour CO concentrations ranged from 4.0 to 4.4 ppm. Under the 2025 no action alternative in the environmental assessment (FHWA 2006), the predicted 1-hour CO concentrations would range from 5.4 to 5.8 ppm and the 8-hour CO concentrations would range from 3.8 to 4.1 ppm. The predicted CO scenario was similar at the adjacent Fort Tilden.

Water Resources

Groundwater

Groundwater is subsurface water stored in aquifers (bodies of permeable rock or sediment capable of storing or transmitting water) and is a primary source of freshwater for a variety of human uses, including drinking water, agriculture, and commercial or industrial use (NRCS et al. 2001). The Sandy Hook and Staten Island Units overlie the New Jersey Coastal Plain aquifer system (EPA 2010). One of its constituent aquifers, the Sandy Englishtown aquifer, is at or near the surface of the southern portion of Sandy Hook (Herman et al. 1998). The Jamaica Bay Unit lies over the Brooklyn–Queens System composed of the Upper Glacial, Jameco, Magothy, and Lloyd aquifers. The Upper Glacial aquifer, composed of glacial moraine deposits up to 300 feet thick, is exposed at the surface throughout all of Kings and Queens Counties and overlies the three lower aquifers, which are generally composed of sands and gravels (EPA 2012).

Natural recharge to both aquifer systems is primarily through surface water derived from precipitation that percolates through natural habitats or restricted porous urban surfaces such as lawns and parks.

Natural recharge to both aquifer systems is primarily through surface water derived from precipitation that percolates through natural habitats or restricted porous urban surfaces such as lawns and parks (EPA 2010; NYCDEP 2007). Some seepage also occurs from the bottoms of lakes, ponds, and streams; however, most freshwater sources in the watersheds surrounding Gateway have been filled, diverted into the storm sewer system, or altered by channelization (NYCDEP 2007). Natural discharge in the New Jersey Coastal Plain aquifer is primarily to the surface through streams and springs that ultimately flow into bays or the ocean. Some surface discharge also occurs in the Brooklyn–Queens aquifer; however, much of the groundwater that is not pumped for human uses discharges laterally into surrounding saltwater bodies (EPA 2012). Groundwater pumping reduces the rate and volume of freshwater discharge to surrounding saltwater bodies, which can lead to saltwater intrusion at the freshwater/saltwater interface (NYCDEP 2007), although this in not currently occurring in the aquifers supplying Gateway.

Brooklyn–Queens and New Jersey Coastal Plain aquifer systems underly park sites. Historically, the Brookly-Queen aquifer supplied fresh water to meet the expanding growth of the New York City area in the late 1800s and into the 20th century. Pumping groundwater in Brooklyn ended in 1947 over concerns from saltwater intrusion and fell to 10 million gallons per day in Queens as water from upstate New York was increasingly used (NYCDEP 2007). The New Jersey Coastal Plain aquifer system has experienced a regional decline which has resulted in saltwater intrusion into many of its aquifers (EPA 2010). The EPA has defined as the New Jersey Coastal Plain system as a sole-source aquifer (SSA), an administrative designation that requires the EPA to review certain proposed projects in the designated area to protect groundwater resources from contamination. Areas that receive an SSA designation must use the aquifer to supply at least 50 percent of its drinking water needs and demonstrate that alternate sources would be physically, legally, or economically infeasible to use. Much of the surface water that would normally recharge the aquifers is intercepted by the impervious surfaces of the highly urbanized watershed or channeled into storm sewers and CSOs that flow to the bays before they have an opportunity to percolate (USACE and PA 2009; NYCDEP 2007). Thus Gateway, with its open spaces, natural habitats, and soils with coarse particles that allow for rapid movement of water into the soil (NRCS et al. 2001), is an important resource for groundwater recharge to sustain the region's important aquifers.

Surface Water

More than half of Gateway's area is composed of 16,200 acres of surface water systems, including the Atlantic Ocean, estuarine wetlands and bays (Jamaica, Sandy Hook, and Lower New York Bays), creeks and tributaries, and freshwater wetlands and ponds (NRCS et al. 2001). Lower New York Bay provides deeper marine habitat, while Sandy Hook and Jamaica Bays have shallower waters, generally less than 20 feet deep (USACE and PA 2009). The characteristics of these water bodies are discussed in more detail in the "Marine Resources" section of this GMP/EIS. For much of the surface waters of the bays, including the extensive saltmarshes and mudflats, the most important hydrologic features are the semidiurnal tides of the bays and ocean (Edinger et al. 2008b). The Hudson and Raritan Rivers are the primary natural sources of freshwater to the regional estuary system, with the Navesink and Shrewsbury Rivers contributing locally to the Sandy Hook Bay estuary. However, Hudson and Raritan River flows have been reduced by upstream reservoirs, impoundments, and water treatment facilities. Contributions by natural tributaries, now mostly filled or diverted, have been replaced in importance throughout most of the region by outflows from water treatment plants, CSOs, and stormwater runoff, which cause localized increases in freshwater flow that reduce natural salinity gradients (USACE and PA 2009).

Dredging has increased the overall water volume in Jamaica Bay, for example, which was historically 11 feet deep on average but has increased to an average depth of 16 feet, in part from shipping channels and borrow pits up to 50 feet deep. This has resulted in an overall 350 percent increase in water volume (NYCDEP 1994, as cited in NYCDEP 2007). The deeper waters created by dredging act as a sediment sink (NYCDEP 2007), which has consequences for sediment accretion important to saltmarsh development throughout much of the region (USACE and PA 2009); however, in Jamaica Bay, factors such as excess nitrogen loading and phytotoxins (e.g., hydrogen sulfide [H_2S]) appear to be more important contributors to saltmarsh loss (Renfro et al. 2010). Shoreline alterations and dredged sediment sinks also affect natural flows and flushing, resulting in decreased water quality (USACE and PA 2009). Dredging and other engineering modifications in Jamaica Bay have also expanded tidal ranges to increase the maximum elevation of high tides, which is further amplified by rising sea levels (Swanson and Wilson 2008). These hydrological changes have contributed to saltmarsh losses in Jamaica Bay.

Compared to estuarine and marine waters, freshwater wetlands and ponds (deepwater habitats) as defined by Cowardin et al. (1979) are few in number at Gateway. Freshwater wetlands cover approximately 24 acres, including forested swamps, marshes, swales, and wetlands created as part of mitigation projects (Edinger et al. 2008b). Most permanent ponds in Gateway were created by artificial dredging. Three large permanent ponds were created in the Jamaica Bay Wildlife Refuge to improve wildlife habitat. The two largest ponds, East Pond (118 acres) and West Pond (45 acres), are artificially controlled by drainage valves to Jamaica Bay and have brackish water, whereas the smaller Big John's Pond is a dredged freshwater pond (NRCS et al. 2001). The West Pond was breached by the Hurricane Sandy storm surge and is currently freely mixing with saltwater from Jamaica Bay. Nike Pond, Round Pond, and North Pond are small permanent ponds at Sandy Hook. Other ponds at the park are seasonal and dry up during drought conditions; these ponds include one artificially created pond in Great Kills Park on Staten Island, and several in the Floyd Bennett Field, Fort Tilden, and Breezy Point sections of the Jamaica Bay Unit (NRCS et al. 2001).

Water Quality

Water quality in bays, estuaries, and tributaries has been gradually improving since the Clean Water Act and other environmental legislation spurred the implementation of regulations and abatement programs to control the discharge of contaminants and pollutants from municipal and industrial sources. The Staten Island and Sandy Hook Units have better water quality than Jamaica Bay because they receive a greater volume of freshwater from the Hudson and Raritan Rivers, resulting in greater mixing of freshwater and saltwater, which helps regulate pH and salinity, dilute contaminants, and lower bacterial counts. During the summer monitoring season, waters off Staten Island and Sandy Hook only occasionally exceed limits for bacterial counts set by state water quality standards (NPCA 2007a).

Water quality in bays, estuaries, and tributaries has been gradually improving since the Clean Water Act and other environmental legislation spurred the implementation of regulations and abatement programs to control the discharge of contaminants and pollutants from municipal and industrial sources.

In contrast, Jamaica Bay suffers from water quality issues because it is relatively enclosed. Tidal flushing is limited to the Rockaway Inlet, whereas freshwater flows are primarily contributed by urban runoff and sewer outflows. Overall, recent water quality trends in Jamaica Bay show improvement, including increased dissolved oxygen (DO) and decreased fecal coliform counts. However, the 240–340 million gallons per day of treated sewage effluent flowing into Jamaica Bay continues to be a major source of pollution, including treatment byproducts such as chlorine, and heavy metals and other contaminants that are not eliminated by water treatment facilities (NPCA 2007a). In addition, large rain events can overwhelm the sewer system capacity, resulting in untreated wastewater and raw sewage entering the bays of the Hudson-Raritan estuary system (USACE and PA 2009).

The four wastewater pollution control plants (WPCPs) that flow into Jamaica Bay are the most important source of nitrogen, phosphorous, silica, and carbon loads, while CSOs concurrently contribute the highest quantity of pathogens (e.g., fecal coliform) (NYCDEP 2007). Sewage effluent also carries the largest concentrations of nickel, zinc, copper, and cadmium, heavy metals that are not eliminated by treatment in WPCPs. Landfill leaching is a smaller source of heavy metals, and atmospheric deposition is the most important source of lead contamination (NPCA 2007a). Other contaminants include pharmaceuticals, soaps, floating debris (e.g., trash), and toxic runoff from the John F. Kennedy International Airport (USACE and PA 2009). Although WPCP and CSO outflows and other overland runoff are a well-understood source of pollution and contaminants, groundwater discharge into the estuary from subterranean zones of the surrounding aquifer system are another potential source of dissolved metals, nitrogen, and other compounds, and requires further study (Beck et al. 2009; Benotti et al. 2006).

Nitrogen and phosphorous are typically limiting nutrients in estuarine ecosystems, keeping algal growth in check. An estimated 36,600 pounds per day of nitrogen are discharged into

Jamaica Bay from WPCP outflows, accounting for 95 percent of the nitrogen load (NYCDEP 2007). Excess nutrient loading, a condition known as eutrophication, stimulates the growth of invasive plants and causes phytoplankton and algae blooms. Counts of chlorophyll a, a photosynthetic pigment produced by algae and used in water quality monitoring to indicate eutrophication, have been increasing in Jamaica Bay over time (NYCDEP 2007). High nitrogen levels can decrease root production in saltmarsh plants, decreasing their ability to accumulate organic material and hold sediments together and leading to saltmarsh loss as plants and sediments are washed away by the erosive force of storms (Rafferty, Castagna, and Adamo 2010; Kolker 2006, as cited in JBWPPAC 2006). High nitrogen levels also increase microbial decomposition, reducing the accumulation of organic matter and limiting the ability of saltmarshes to maintain an elevation that keeps pace with rising sea levels (Rafferty, Castagna, and Adamo 2010).

High nutrient loads from WPCP outflows are a major contributor to low DO levels in Jamaica Bay. DO ranges from 3.5 to 18.5 milligrams per liter (mg/L), sometimes falling below the 5.0 mg/L threshold specified by state water quality standards for waters suitable for recreation and fishing. Long periods of low DO can harm or kill larval fish and shellfish, and lead to odor problems from production of H2S gas in oxygen-deficient sediments. High concentrations of DO in the water column can also indicate poor water quality, and typically occur when algal blooms near the surface create very high to supersaturated DO concentrations as a byproduct of photosynthesis. While there is high year-to-year variability in measured DO concentrations, long-term monitoring suggests DO levels are trending toward improvement (NYCDEP 2007).

In addition to reducing infiltration and recharge of groundwater aquifers, the increase in hard or impervious surfaces from urbanization causes excess sediment to be conveyed by runoff. This sediment-laden runoff can reduce water clarity, impacting sensitive organisms and habitats including oyster reefs, eelgrass beds, fish, and aquatic invertebrates. Runoff can also increase erosion through scouring, which has deteriorated interior islands and shorelines over time (USACE and PA 2009). Water clarity in Jamaica Bay has declined by more than 20 percent over the past 30 years (JBWPPAC 2006).

Subaqueous Sediments

Contaminants dissolved or suspended in water adhere to organic compounds and settle into sediments. Before pollution regulations were put in place, large quantities of chemicals, including heavy metals, pesticides, PCBs, DDT, and dioxin, were discharged into the waters of Jamaica Bay, polluting the sediments of the bay and its wetlands. Contaminated sediments are difficult to remove; therefore, these “legacy chemicals” persist and exceed acceptable levels in many areas of the bay. In addition to these historical sources, chemicals from modern sources including industrial discharges, WPCP discharges, CSOs, stormwater runoff, non-point source discharges, landfill leachates, atmospheric deposition, and chemical and oil spills continue to contaminate Jamaica Bay sediments. Many chemicals that taint sediments are readily absorbed into animal fat cells, where they can accumulate to dangerous levels. As a result, consumption advisories are in place for some of the region’s fish and shellfish species (USACE and PA 2009).

Coastal wetlands and eelgrass beds, marine plant ecosystems once extensive throughout the estuary, perform a variety of water quality functions, including stabilizing sediments and retaining and recycling nutrients.

Wastewater discharge into Jamaica Bay and other estuarine waters includes trace organic compounds from contaminants such as household and industrial products, personal care products, pharmaceuticals, detergents, and pesticides. Some of these compounds and their chemical breakdown products have hormone-like properties (e.g., "estrogenic compounds") that disrupt reproduction, development, and other endocrine-mediated processes in aquatic organisms (Furlong et al. 2010; JBWPPAC 2006). These compounds can affect the reproduction of some fish populations by skewing the male-to-female sex ratios (Furlong et al. 2010); for example, winter flounder from Jamaica Bay, which also show reduced hatch rates and delayed development (McElroy 2006, as cited in JBWPPAC 2006). Water treatment processes can influence the amount of endocrine-disrupting trace organics discharged into bay waters. A recent study showed aerobic digestion of activated sludge removed 90 percent of estrogenic compounds, while anaerobic treatment of biosolids actually increased the amount of estrogenic compounds (Furlong et al. 2010). Because biosolids are sometimes used as a soil amendment, more research is needed to investigate groundwater discharge from biosolid-amended soils as a potential source of contamination (Furlong et al. 2010).

Coastal wetlands and eelgrass beds, marine plant ecosystems once extensive throughout the estuary, perform a variety of water quality functions, including stabilizing sediments and retaining and recycling nutrients. Coastal wetlands can capture and attenuate high levels of nitrogen, reducing the effects of eutrophication and nitrogen loading that contribute to low DO levels. Coastal wetlands can effectively capture up to 95 percent of chemical substances discharged into the saltwater ecosystem (Ringenary, pers. comm. 2013a). In addition to continued controls on municipal and industrial outflows, restoration of coastal wetlands and eelgrass beds is an essential component of effective water quality improvement plans in the region of Gateway (USACE and PA 2009). While eelgrass beds have been virtually eliminated from the Gateway's vicinity and are absent within the boundaries of the park, much of Jamaica Bay and the bayside coastal areas of Sandy Hook may provide suitable restoration sites (USACE and PA 2009). Wetland restoration projects could also expand the 1,200 acres of saltmarsh in Gateway, which are concentrated mostly in Sandy Hook and Jamaica Bays (Edinger et al. 2008b).

Wetlands, Floodplains and Flooding

New York City and the adjacent region of New Jersey are built around a complex of narrow rivers, estuaries, islands, and waterways that are strongly influenced by tides and weather. Much of the metropolitan region, including most of Gateway, is low in elevation and is at risk from strong storm surge flooding for both tropical systems and nor'easter cyclones (Colle et al. 2008). The complex coastal geometry and bathymetry surrounding the New York City metropolitan region can increase the water levels and create difficult coastal flood forecasts. Storm surge is enhanced in this region by the relatively shallow continental shelf and the southward bend in the coast from Long Island to New Jersey, which can funnel water toward the New York City harbor area when there are low-level easterly winds (Bowman et al. 2005, as cited in Colle, Rojowsky, and Buonaiuto 2010). Although coastal flooding from strong storms is most likely and potentially most damaging, the coastal marsh and back-bay areas of the region can also lead to localized flooding (Colle, Rojowsky, and Buonaiuto 2010).

Floodplains

Coastal Flooding—*Extreme Storms*

As demonstrated in October 2012 when Hurricane Sandy struck, the area is also vulnerable to flooding from hurricanes, although by the time Sandy made landfall in New York City, it had been downgraded to post-tropical cyclone status. Nonetheless, the cyclone brought winds of up to 85 mph and total rainfall of about 1 inch across the city. Some of the heaviest damage in the area was in the New York Harbor and included Gateway and other NPS properties (NPS 2013a). A combination of high tides, wind-blown waves, and the enormous circulation of the superstorm pushed water to a peak surge of nearly 14 feet (Fleshler and Nolin 2012). Its amplified wave height and reach, along with strong winds, pushed sand across roads, parking lots, and structures, flooded structures and destroyed machinery, and took beach sands with it as it receded, resulting in a patchwork of coastal erosion and inland areas covered in sand.

As demonstrated in October 2012 when Hurricane Sandy struck, the area is also vulnerable to flooding from hurricanes, although by the time Sandy made landfall in New York City, it had been downgraded to post-tropical cyclone status.

Hurricane Sandy is not an isolated event. For example, in 1992 a winter storm—or "nor'easter"—caused water levels at the southern tip of Manhattan to peak at about 8 feet above mean sea level (Colle, Rojowsky, and Buonaiuto 2008). Hurricanes have struck New York City, including memorable storms in 1821 and 1938 and several in the mid-twentieth century (NYCOEM 2013). A major hurricane could result in storm surges of 30 feet in some parts of the city (NYCOEM 2013). Sea-level rise may also be increasing flood risk in the region and along the entire coastline.

Although tropical cyclones like Sandy primarily flood coastal areas where the storm comes ashore, winter storms or nor'easters can cause much wider-ranging damage and major coastal erosion (Colle et al. 2010). Climatologists have found there is an average of 12 winter storms along the eastern coast of the United States each year. A 2000 study (Zhang et al., as cited in Colle, Rojowsky, and Buonaiuto 2010) found no significant trends in the number and intensity of these storms or accompanying large wave surge events over the last several decades, although variability occurs from year to year or even decade to decade.
Flooding from storm surge, high tides, and wind during Hurricane Sandy occurred in the following locations:

In the Jamaica Bay Unit (NPS 2012f):

- Flooding damaged the Canarsie Pier shoreline and the structures on the pier.
- Some of the islands in Jamaica Bay (east islands and hassocks) were flooded.
- Jamaica Bay Wildlife Refuge East and West Ponds were breached, and the West Pond remains breached.
- Lower-elevation vegetative communities were flooded.
- All of Fort Tilden was flooded from both the ocean and bay side with enough force to diminish dunes by several feet on the beach side.

Storm surge in the New York/New Jersey area usually varies from 0.5 to 1 meter, but has reached 2 meters, as it did in 1985 during Hurricane Gloria.

- In Fort Tilden, the Shore Road and fisherman's parking lot were covered in sand, and a significant portion of the road was reduced to rubble, indicative of high waves and strong winds from south to north.

- At Jacob Riis Park, coastal flooding removed a massive amount of beach, but winds also covered much of the park north of the beach in sand. Ocean waters flowed through the first floor of the bathhouse and protective dunes adjacent to it were destroyed.

In the Staten Island Unit (NPS 2012c):

- At Fort Wadsworth, the shoreline south of the Verrazano-Narrows Bridge was flooded, although steep grading helped protect the rest of the fort.

- Wind and storm surge carried sand to cover parking lots and block roads at Great Kills Park.

In the Sandy Hook Unit, considered by the NPS as the park unit mostly heavily affected by Hurricane Sandy (NPS 2012c):

- Flooding damaged most NPS infrastructure and rendered water and wastewater systems inoperable (NPS 2012d).

- Much of the interior areas of the cedar/holly forest were flooded, as were other interior areas of maritime shrub lands (NPS, pers. comm. 2013e). Dunes here normally protect these areas from overwash flooding during storms.

- In the vicinity of the Sandy Hook Visitor Center, structures were swamped by floods, destroyed by wind, and covered in sand.

- Roads were covered in sand and substantial loss of beach occurred in some areas (notably the area near Sea Gull's Nest).

Coastal Flooding—*Average Storms*

Storm surge in the New York/New Jersey area usually varies from 0.5 to 1 meter, but has reached 2 meters, as it did in 1985 during Hurricane Gloria. Fortunately, Gloria made landfall during a low tide cycle; as noted earlier, Hurricane Sandy came ashore during a high tide cycle. In analyzing storm surge for the years 1959 to 2007, Colle, Rojowsky, and Buonaiuto (2010) found 253 data points for storm surges between 0.5 and 0.6 meter and only 4 data points for storm surges greater than 1.5 meters. For these years, this study found between 0 and 14 minor (less than 1 meter) events and on average between five 5 and 7 per year. Wind direction was not correlated with the size of a storm surge, but wind speed was. Wind speeds associated with larger surge (greater than 1 meter) were 44 percent stronger than those for minor storm surge. High tide combined with storm surge and wind speed also increased flooding, and is associated with a coastal flood advisory and/or warning depending on the storm surge.

Wetlands

Localized Flooding in Wetlands

As noted earlier, localized flooding can occur in low-lying areas, such as wetlands or former wetlands. The Jamaica Bay Unit contains the largest proportion of tidal marsh in Gateway—a landscape that is naturally gently sloping and subject to tidal flooding. Although wetlands are low lying and can experience flooding, they are also important as floodwater storage areas, as well as for floodwater conveyance, wave attenuation, and erosion control (USDA et al. 2001). Gateway also has several fringing estuarine or saltmarsh wetlands subject to coastal or tidal flooding, and inland floodplains include the swamp white oak forest and parts of Floyd Bennett Field.

Wetland Ecosystems

Wetland ecosystems are characterized by saturation, with water as the dominant factor influencing substrate or soil development (hydric soils). Vegetation in wetlands is dominated by hydrophytes, or plants with physiological adaptations to saturated conditions. Wetlands are classified according to characteristics of their hydrology, soil, and vegetation (Cowardin et al. 1979).

Wetlands at the park are the natural legacy of Pleistocene glacial scouring, followed by thousands of years of dynamic coastal processes such as wave action, longshore currents, erosion, and sediment accretion. Human disturbances including historical land uses, dredge and fill activities of the bays and marshes, hard-edged constructed shorelines, ongoing urban development, sewage and wastewater outflows, and the introduction of nonnative, invasive species have altered the natural extent, function, and type of wetland habitats at Gateway, contributing to the overall “poor” rating of natural resource conditions at the park (NPCA 2007a). In addition to the value of wetlands in storing and conveying floodwater discussed earlier, wetlands also reduce erosion by protecting coastlines from wave action, improve water quality by removing sediments and contaminants, and provide habitat for fish, wildlife, and unique plant communities (NRCS et al. 2001). These ecosystem services are diminished when wetland systems are degraded, fragmented, or lost, spurring the effort by regional managing agencies including the NPS to mitigate and restore wetlands in the New York Harbor region (NYCDPR 2010; USACE and PA 2009; NYCDEP 2007; JBWPPAC 2006; NPS 2004d).

Wetlands at the park are the natural legacy of Pleistocene glacial scouring, followed by thousands of years of dynamic coastal processes such as wave action, longshore currents, erosion, and sediment accretion.

Wetland Types: Estuarine

Estuaries are nearshore aquatic habitats where ocean water mixes with freshwater runoff from the land (the watershed), creating a gradient of salinities (Lawrence, Roman, and Frame 2010). Fluctuating water levels, salinity gradients, mixing of warm and cold waters, and sediment and nutrient loads contribute to the productivity and biodiversity of estuarine ecosystems (Levinton and Waldman 2006). The hydrology, water chemistry, vegetation, and soil development in estuarine wetlands are affected by factors such as tides, wind and low-energy wave action, and mixing of saltwater with freshwater from runoff or precipitation (Cowardin et al. 1979). The Hudson and Raritan rivers and outflows from urban water treatment facilities are the primary sources of freshwater, sediment, and nutrients to the park's estuarine ecosystems (Lawrence, Roman, and Frame 2010).

Within the park, the significant estuarine areas are Jamaica Bay and Sandy Hook Bay (Lawrence, Roman, and Frame 2010), with some additional smaller areas along the coastline of the Great Kills section of the Staten Island Unit. Most of the over 11,700 acres of estuarine wetland communities within park boundaries are intertidal marshes and mudflats (Edinger et al. 2008b), including the numerous islands and "hassocks" (islands of peaty or mucky soil saturated by high tides) of the Jamaica Bay Wildlife Refuge (Rowan 2012). These wetlands range from North Atlantic high saltmarshes at the high-water mark, to North Atlantic low saltmarshes near open water in the regularly flooded intertidal zone, to North Atlantic Coast estuarine intertidal mudflats that are completely exposed only during low tides. Other tidally influenced wetlands, including salt panne marshes and brackish meadows, occur within the complex of saltmarshes and mudflats, whereas non-tidal wetlands such as coastal salt pond marshes occur in the splash zone on beaches and behind dunes.

North Atlantic Coast estuarine intertidal mudflats are saline habitats characterized by a silty mud substrate rich in organic matter, with moderate fluctuations in salinity and moisture due to low-energy wave action.

North Atlantic Coast estuarine intertidal mudflats are saline habitats characterized by a silty mud substrate rich in organic matter, with moderate fluctuations in salinity and moisture due to low-energy wave action. At the park, they are located at Great Kills in the Staten Island Unit and in Jamaica Bay at the Jamaica Bay Wildlife Refuge and Plumb Beach. Intertidal mudflats typically lack vegetation, although some are densely covered by sealettuce *(Ulva lactuca),* a green algae (Edinger et al. 2008b). Historically, mudflat vegetation was dominated by eelgrass, a species that is extirpated here but that once formed extensive beds throughout Jamaica and Sandy Hook Bays (Lawrence, Roman, and Frame 2010).

North Atlantic low saltmarsh, dominated by smooth cordgrass, is flooded twice daily by tides, allowing the development of deep, poorly drained soils, sometimes with thick organic deposits, ranging from mucky peat to mucky fine sandy loam in the Ipswich, Pawcatuck, and Sandy Hook series (Edinger et al. 2008b; NRCS et al. 2001).

Further inland, **North Atlantic high saltmarsh** vegetation is irregularly flooded by high and spring tides along the coastlines of the Sandy Hook Unit and the Breezy Point, Fort Tilden, Floyd Bennett Field, Canarsie Pier, and Jamaica Bay Wildlife Refuge sections of the Jamaica Bay Unit. Soils range from mucky peat to coarse sand in the Matunuck, Sandy Hook, Bigapple, Breeze, Ipswich, and Jamaica series, and the characteristic vegetation includes cordgrass and inland saltgrass (Edinger et al. 2008b; NRCS et al. 2001).

Cordgrass-dominated saltmarshes are maintained by annual accretion of sediment, anchored by the roots of vascular vegetation. These habitats are rapidly disappearing from the park, with losses as high as 50 acres per year. They erode or lose vascular vegetation and transform into mudflats due to a combination of factors including pollution, excess nutrient enrichment, reduced sediment deposition from dredging and constructed coastlines, and sea-level rise (NPS 2010b; NPCA 2007a). Since colonial times, an estimated 80 to 95 percent of the New York Harbor saltmarshes have disappeared (NRCS et al. 2001). In addition to rapid saltmarsh losses, many habitats have been invaded by a nonnative strain of common reed *Phragmites australis,* which responds to disturbance and forms dense colonies that exclude most other plant species. *Phragmites* is also present in much of the park's freshwater wetland habitat and covers about 1,120 acres of wetlands in the park (Mellander, pers. comm. as cited in Lawrence, Roman, and Frame 2010).

Approximately 12 acres of **salt panne** marshes occur in shallow, poorly drained depressions within or at the margins of high and low saltmarsh communities in Sandy Hook and Jamaica Bay. These impounded depressions are created by ice-scouring, rafting flotsam, peat compaction, mosquito ditch levees, or erosion of tidal creek banks. Evaporation during low tides results in hypersaline conditions, resulting in a prevalence of bare peat or muck substrate. Vascular plants are typically sparse or absent, although some pannes may be characterized by dense stands of salt-tolerant glasswort species (Edinger et al. 2008b). The mucky peat to finer-grained sandy soils were formed from deep sediments derived from the Sandy Hook, Matunuck, Hooksan, Bigapple, and Jamaica soil series (NRCS et al. 2001).

Between high saltmarshes or beaches and more upland communities, **brackish meadows** are wetland grasslands dominated by switchgrass and saltmeadow cordgrass that occur on freely draining, shallow, sandy peat overlying glacial till. Soil moisture is maintained by groundwater seepage and irregular tidal flooding, usually during spring tides or storm surges. Most of the 26 acres of brackish meadow occur in the Sandy Hook Unit, with some communities near Canarsie Pier in Jamaica Bay (Edinger et al. 2008b). Brackish meadows are considered imperiled in New York State and may be at high risk of extinction (Lawrence, Roman, and Frame 2010).

Less than 4 acres of one non-tidal estuarine wetland type, **coastal salt pond marsh,** occur in the Breezy Point and Floyd Bennett Field sections of the Jamaica Bay Unit, separated from the ocean by surrounding beaches, dunes, and maritime shrub lands. Overland flow and precipitation contribute freshwater, whereas storm overwash, tidal breaches, and seepage across the barrier beach provide an infrequent source of saltwater. Vegetation is most abundant in mudflat areas of the ponds that occasionally become exposed when water levels draw down. These mudflats are typically dominated by dwarf spikerush or smooth cordgrass (Edinger et al. 2008b).

Wetland Types: Palustrine

Palustrine wetlands are fed by freshwater sources including groundwater, overland runoff, and precipitation. They include all non-tidal wetlands, and wetlands in tidal areas that have less than 0.05 percent salinity derived from ocean salts (Cowardin et al. 1979). Historically, freshwater wetlands were extensive in the region as a result of the numerous drainage basins created by complicated glacial topography. However, 95 percent of these wetlands have been lost to centuries of urban development (Lawrence, Roman, and Frame 2010). Today, about 24 acres of freshwater and brackish palustrine wetlands remain in the park (Edinger et al. 2008b), including forested swamps, marshes and swales, wetlands along the margins of artificial ponds, and wetlands created as part of mitigation projects.

Three large **artificial ponds** in Jamaica Bay Wildlife Refuge were created to improve wildlife habitat diversity. East Pond (118 acres) and West Pond (45 acres) are brackish ponds overlying former saltmarshes that were impounded when shallow channels feeding the ponds were

Between high saltmarshes or beaches and more upland communities, brackish meadows are wetland grasslands dominated by switchgrass and saltmeadow cordgrass that occur on freely draining, shallow, sandy peat overlying glacial till.

filled with dredged sediments. Big John's Pond, between the two brackish ponds, is a smaller excavated freshwater pond that supports floating aquatic vegetation. Over time, the salinity of brackish water in East Pond and West Pond diminished to create a freshwater marsh community. Both East Pond and West Pond were breached because of storm surge from Hurricane Sandy. Although East Pond has been repaired, West Pond remains in a breached condition and open to tidal influence and Jamaica Bay. Water level in West Pond never exceeds that of high tide (NPS, pers. comm. 2013e; Rowan 2013).

Two unique wetland communities, **woolgrass marsh** and **mixed forb marsh,** have grown up in and around the ponds, particularly East Pond, and are not found elsewhere in Gateway. Artificial maintenance of East Pond regulates the hydrology of both irregularly flooded marshes. The 1 acre woolgrass marsh, dominated by eastern marsh fern with woolgrass bulrush and *Phragmites*, occurs on deep, poorly drained sandy soil in the Jamaica series. The 0.3-acre mixed forb marsh occurs on Jamaica gravelly sand and is characterized by a diverse assemblage of characteristic species including fox sedge, spotted joepyeweed, common boneset, and chairmaker's bulrush (Lawrence, Roman, and Frame 2010; Edinger et al. 2008b).

The **Northeastern Atlantic brackish interdunal swale** community occurs between coastal sand dunes on very deep sands in the Hooksan and Jamaica series. In Gateway, these swales are at Sandy Hook and in the Breezy Point section of the Jamaica Bay Unit. Hydrology and salinity levels vary due to the seasonally high groundwater table, sporadic tidal overwash, and salt spray. Vegetation is dominated by saltmeadow cordgrass with common threesquare and chairmaker's bulrush (Edinger et al. 2008b).

Similar to estuarine wetlands, most palustrine communities at Gateway have been invaded by an alien genotype of *Phragmites*. Japanese knotweed is another nonnative invasive species associated with disturbed areas that tends to form dense monocultures that exclude other plant species. The Japanese knotweed gravel bar wetland type occurs on fill derived from Greenbelt loam and Bigapple coarse sand. It can be found at Sandy Hook and in the Fort Wadsworth section of the Staten Island Unit (Edinger et al. 2008b).

Forested wetlands at Gateway include red maple/blackgum basin swamp and southern New **England red maple seepage swamp** vegetation associations, and swamp white oak forest. The 3 acre Southern New England red maple seepage swamp occurs only on the east side of East Pond in the Jamaica Bay Wildlife Refuge. Soils are Barren series sand transported to the site as fill, and the forest canopy is co-dominated by red maple and gray birch over a sparse understory (Edinger et al. 2008b). **Red maple/blackgum basin swamp** is an imperiled community with only 20 to 30 forests known in New York state, including one 0.3-acre patch in the north-central interior portion of the Sandy Hook Unit (Lawrence, Roman, and Frame 2010; Edinger et al. 2008b). This acidic, nutrient-poor wetland type dominated by blackgum occurs on very deep, poorly drained Jamaica sand (Edinger et al. 2008b).

The **swamp white oak forest** occurs only at Miller Field in the Staten Island Unit as a 12-acre remnant of undeveloped habitat surrounded by dense urban development (Lawrence, Roman, and Frame 2010). This forest occurs on very deep Pompton loam soils formed over glacial outwash that are seasonally flooded in late winter and may contain vernal pools (Rowan 2013; Edinger et al. 2008b). The site was likely wetter in the past before storm sewer diversions were built in the 1980s, and the resulting drier conditions may contribute to the decline of swamp white oak, which can compete with other trees due to its tolerance of seasonal flooding. The swamp white oak forest is managed as a wetland under the 1979 GMP, but the community does not meet the criteria for wetland classification because it does not have hydric soils. More research is needed to determine whether hydric soils occur and what the historical hydrological regime of this forest is (Rowan 2013).

Marine Resources

This section describes general characteristics of soils, water, vegetation, and wildlife that are key to understanding the marine zone, an area that includes ocean waters and benthic (bottom or subaqueous) habitat and onshore to the intertidal community. Backdune and more inland vegetation or wildlife that occupy these habitats are discussed in the "Vegetation" or "Wildlife" sections of the GMP/EIS. Gateway includes approximately 27,025 acres of coastal lands and waters in New York and New Jersey. Nearly two-thirds of the park is estuarine and ocean waters. Approximately 1,700 acres of these waters are ocean and another nearly 16,000 acres are estuarine. The park has about 75 miles of shoreline (including islands) parkwide, including 31 miles of ocean beaches (Lawrence, Roman, and Frame 2010).

Figure 3-1 New York Bight.

The marine habitats of Gateway lie primarily in the nearshore zone of the New York Bight (see figure 3-1), a great expanse of shallow ocean between Long Island to the north and east and the New Jersey coast to the south and west. The term "bight" is a mariner's term for a bend or curve in the shoreline, and the New York Bight is outlined by the east/west-trending coast of Long Island and north/south-trending coast of New Jersey, which create a right angle where they intersect (USGS n.d.b). The average salinity of ocean areas is about 32 parts per thousand (ppt), subject to input from extreme periods of flooding rains. Winter water temperatures can be below 37°F, while summer temperatures can exceed 77°F (USFWS 1997c). This coastal zone is dominated by tides that influence horizontal movement and transport of water, sand, and other sediments.

The New York Bay (see figure 3-2) lies generally north of the Bight and is divided into the upper and lower New York Bay. Sandy Hook and Breezy Point Tip frame the entrance to Lower New York Bay. New York Harbor lies at the mouth of the Hudson River, which feeds the Upper New York Bay. Although the mix of saltwater and freshwater in the harbor and upper bay vary seasonally, tidally, and during and after storm events, average flow from the Hudson River to the harbor is 683 cubic meters per second. High and low tides occur twice daily (NPCA 2007b).

Figure 3-2. New York Bay and Harbor.

The Nearshore Ocean Zone

The nearshore zone is defined as that area of open water from the mean low-water line offshore to the 66 foot depth contour line (USFWS 1997c). The nearshore zone of the New York Bight is located between the boreal waters of New England and the semitropical region to the south; this intersection of habitat types is important to marine species diversity. The New Jersey nearshore zone, which extends from Sandy Hook to Cape May, is characterized by a high-energy sandy beach to the north and an extensive estuary system protected by barrier islands to the south. The underwater topography includes scour troughs and ridges formed by storm currents (USFWS 1997c).

More than 100 species of marine and anadromous boreal, temperate, and semitropical migratory fish use this productive ecosystem as a feeding area (Frame, pers. comm. 2013a). A number of these species are commercially important or caught by sport fishers, including weakfish *(Cynoscion regalis),* striped bass *(Morone saxatilis),* summer flounder *(Paralichthys dentatus),* and winter flounder *(Pseudopleuronectes americanus).* Atlantic menhaden *(Brevoortia tyrannus)* also provide an important food source for marine wildlife, including fish, birds, and marine mammals. Anadromous species that use the Hudson or other coastal rivers to spawn include Atlantic sturgeon *(Acipenser oxyrinchus)*, blueback herring *(Alosa aestivalis),* and Atlantic tomcod *(Microgadus tomcod)* (USFWS 1997c). The shallow nearshore area off the park sites along the Rockaway Peninsula is habitat for the endangered Atlantic sturgeon and is an important recreational fishery (Lawrence, Roman, and Frame 2010).

Because Gateway's boundaries extend to one-quarter mile offshore, it is likely that most of its managed ocean waters are in the nearshore zone. Historically, these ocean waters and bottom were populated by diverse species of marine mammals and sea turtles, but today they are best known for recreational fishing (Lawrence, Roman, and Frame 2010). Marine mammals continue to use the nearshore habitat of the New York Bight, however, and a number of porpoises, seals, and whales migrate along the coast (USFWS 1997c). Seals also haul out on park sites, including Hoffman and Swinburne Islands, during the winter months (Ringenary, pers. comm. 2013b).

The "benthos" is collectively all the organisms that live on the bottom or in the bottom sediments. Invertebrates, including clams and other shellfish, crustaceans (crabs and lobster), annelids (worms), shrimp, gastropods, and echinoderms (e.g., starfish) occupy benthic habitat in the nearshore. Although a brief survey in 2009 recorded at least 42 species of benthic invertebrates at the park (Ecology and Environment Inc. 2009, as cited in Lawrence, Roman, and Frame 2010), other longer-term studies of the bight have recorded 699 species of benthic macrofauna (USFWS 1997c).

Farther out to sea and not usually within the one-quarter mile offshore considered to be park waters is the continental shelf ecosystem. This is a vast zone of shallow water, which in the New York Bight is adjacent to estuary systems that nurture or protect a number of fish species, contributing to the area's biodiversity (USFWS 1997c).

Like other aquatic systems, the nearshore marine environment is a ladder or pyramid of trophic levels of plants, herbivores, and carnivores, ultimately converting inorganic chemicals and the sun's energy into living matter. At each higher trophic level, total biomass decreases. The primary producers are plankton (small or single-celled plants or photosynthetic and cyanobacteria that serve as food for a number of animals), including zooplankton (very small, free-floating invertebrate animals), and filter-feeding benthic species. Zooplankton in turn serves as food for a wide spectrum of larger animals. Primary production is regulated by water temperatures and mixing, and there are sharp seasonal differences in plant growth and availability of phytoplankton (USFWS 1997c).

The center of Jamaica Bay is dominated by subtidal open water and extensive low-lying islands with areas of saltmarsh, intertidal flats, and uplands important for colonial nesting waterbirds.

Marine Environment at Gateway Park Sites

As noted above, the NPS manages waters out to one-quarter mile from its lands. These waters include the nearshore environments off lands on the Rockaway Peninsula (Breezy Point, Jacob Riis Park, and Fort Tilden), Plumb Beach, Sandy Hook and Raritan Bay, and the southeast shore of Staten Island, as well as Rockaway Inlet and Jamaica Bay. The geomorphology of beaches or shorelines at these sites is described in the "Soils and Geology" section of this chapter of the GMP/EIS.

Jamaica Bay and the Rockaway Inlet

Although Jamaica Bay is brackish (30 ppt or less salt) and not marine (greater than 30 ppt and less than 50 ppt salt), it is directly open to the Lower New York Bay and Atlantic Ocean via Rockaway Inlet and is discussed in this section because of the connection. Breezy Point Tip is located on the tip of the south edge of this inlet. Salinity in Jamaica Bay is 20–26 ppt. It is located adjacent to the confluence of the New York Bight and New York Bay where the right angle between the New Jersey and Long Island coasts intersect (USFWS 1997b). Freshwater input directly to Jamaica Bay is primarily from polluted sources, such as four wastewater treatment plants.

Historically, Jamaica Bay was shallow, averaging 11 feet deep on average. Because of dredging for shipping channels, and borrow pits to produce material to build up John F. Kennedy International Airport and other development, the average depth has increased to 16 feet (NYCDEP 1994, 2007). The center of Jamaica Bay is dominated by subtidal open water and extensive low-lying islands with areas of saltmarsh, intertidal flats, and uplands important for colonial nesting waterbirds. Because Jamaica Bay is located at the intersection of not only cooler ocean waters from the north and warmer currents from the south but also of the Hudson River–Raritan Bay estuary, it is considered part of a regionally important fish, wildlife, and plant habitat complex that also includes Breezy Point Tip (USFWS 1997b). Shorebirds, raptors and other land birds, waterfowl, and various migratory insects are concentrated near the coastlines. These migratory species are further massed into the remaining open space and waters of Jamaica Bay by the lack of habitat in surrounding urban land.

Atlantic ribbed mussels are a major biomass component of the park's saltmarsh and mudflats, and other shellfish species such as northern quahog (Mercenaria mercenaria), intertidal soft clam (Mya arenaria), and Atlantic surf clam (Spisula solidissima) occupy the nearshore and Rockaway inlet area.

Between them, the marine environments of Jamaica Bay and Breezy Point Tip support seasonal or year-round populations of over 200 rare or listed species, including 48 species of fish and 120 species of birds (USFWS 1997b). Listed species in the waters in and around these two park sites include Kemp's Ridley and loggerhead sea turtles *(Lepidochelys kempii, Caretta caretta),* piping plovers *(Charadrius melodus)*, seabeach amaranth *(Amaranthus pumilus),* and roseate terns *(Sterna dougallii).* Dozens of the species of fish found in Jamaica Bay (including many that are commercially important, such as winter flounder) use the bay as a nursery. A few islands in the bay support waterbird nesting colonies for species including glossy ibis *(Plegadis falcinellus),* great egret *(Ardea alba)*, snowy egret *(Egretta thula),* cattle egret (Bubulcus ibis), black-crowned night-heron *(Nycticorax nycticorax),* and tricolored heron *(Egretta tricolor).* The bay is also considered an important migratory stopover site for shorebirds; although these species use much of the bay, they focus on the intertidal areas during low tide and the East and West Ponds during higher tides for feeding. The benthic environment of Jamaica Bay provides habitat for many invertebrates, fish, and diving ducks. Sandy beaches and intertidal mud flats throughout Jamaica Bay and especially the beaches at Plumb Beach support a large population of horseshoe crabs *(Limulus polyphemus).*

Atlantic ribbed mussels are a major biomass component of the park's saltmarsh and mudflats, and other shellfish species such as northern quahog *(Mercenaria mercenaria),* intertidal soft clam *(Mya arenaria),* and Atlantic surf clam *(Spisula solidissima)* occupy the nearshore and Rockaway inlet area. Jamaica Bay hosts significant waterfowl concentrations, averaging about 11,000 birds in ground counts from 1980 to 1992. Species include greater scaup *(Aythya marila),* American black duck *(Anas rubripes),* brant *(Branta bernicla),* Canada goose *(Branta canadensis)*, and bufflehead *(Bucephala albeola).* Harbor seals *(Phoca vitulina)* are found in Jamaica Bay and at Breezy Point Tip, and humpback whales *(Megaptera novaeangliae)* and bottlenose dolphins *(Tursiops truncatus)* occasionally feed in the area adjacent to Rockaway inlet. Breezy Point Tip supports some of the largest nesting sites for rare or endangered shorebirds, including least terns *(Sterna antillarum),* black skimmers *(Rynchops niger),* roseate terns (very rarely), American oystercatchers *(Haematopus palliatus),* and piping plovers. It is also a concentration area for migratory shorebirds, raptors, waterfowl, and land birds, especially during summer and fall.

Raritan Bay including Sandy Hook and Staten Island

Parts of the Raritan Bay are brackish, receiving direct inflow from the Raritan, Shrewsbury, and Navesink Rivers and other small tributaries along the shoreline of Staten Island and New Jersey, as well as indirectly from the Hudson River through the New York Bay. Dredged channels in the bay are up to 35 feet deep, but otherwise the bay is shallow—less than 20 feet deep for the most part. The area is subject to a wide range of fluctuations in temperature, salinity, and DO (USFWS 1997a).

The Staten Island shoreline along Raritan Bay from New Dorp Beach to Tottenville includes beach and intertidal and subtidal mudflats extending about one-quarter mile from the shoreline. Great Kills Park includes large areas of disturbed marsh ingrown with *Phragmites* and coastal shrub thicket at Crooke's Point.

Sandy Hook divides Raritan and Sandy Hook Bays from the New York Bight. On its wide northern end it supports an extensive foredune vegetated with American beachgrass *(Ammophila breviligulata).* The western side of the spit consists of extensive tidal mudflats, sandflats, and saltmarsh dominated by low marsh cordgrass. There are more than 200 rare or listed species using the waters and shorelines of Raritan Bay and Sandy Hook, including piping plover, two species of sea turtles, and three whale species. More than 90 species of fish have been counted in Raritan Bay and Sandy Hook Bay, including brackish-water species like mummichog *(Fundulus heteroclitus)* and white perch *(Morone americana)* (USFWS 1997a). In the larger bay, ocean fish species as well as lobster *(Homarus americanus),* blue crab *(Callinectes sapidus),* and horseshoe crab are taken in a dredge fishery. Spawning habitat for horseshoe crab on Sandy Hook provides an important food source for migrating shorebirds, which are abundant. Like Jamaica Bay and Breezy Point Tip, Sandy Hook and Raritan Bays provide a variety of habitats for migrating and wintering waterfowl, waterbirds, and shorebirds, with counts of 20,000 birds per season in the summer and fall to 60,000 in the winter. Sandy Hook is also home to beach-nesting piping plovers.

Offshore of Staten Island lie Hoffman and Swinburne Islands, constructed in the 1800s using dredged sand, rock, and concrete. The islands were initially used to quarantine immigrants, but the buildings have since turned to ruins and grass was planted in the 1960s. In the absence of human disturbance, both islands have become wooded and are important habitat for colonial nesting waterbirds, wading birds, and seabirds. In 2007, Hoffman Island was home to 567 nests of seven wading bird species and 188 nests of herring gulls *(Larus argentatus)* and great black-backed gulls *(Larus marinus)* (Bernick et al. 2007, as cited in Lawrence, Roman, and Frame 2010). Adjacent Swinburne Island had 264 double-crested cormorant *(Phalacrocorax auritus)* nests and 310 gull nests. Swinburne and Hoffman Island are also used as a haul-out location for seals (Lawrence, Roman, and Frame 2010).

Vegetation at Ocean Beaches at Gateway Park Sites

Although the park manages nearshore ocean waters, no surveys or other information about vegetation in these marine areas is available. Besides this submerged habitat, only one vegetation association is considered by Edinger et al. to be truly marine; that is, it grows between the high tide line and the sea (Edinger et al. 2008b). This is the North Atlantic Coast estuarine intertidal mudflat, a vegetative community that covers over 9,000 acres of park lands and tidal areas. However, because they grow on the ocean side of the foredune (the first dune landward of the beach) or exist only where storm surge reaches, other vegetative communities are discussed along with the North Atlantic Coast estuarine intertidal mudflat in this section of the GMP/EIS. These are the North Atlantic upper ocean beach, North Atlantic coastal plain vine dune, northern beachgrass dune, beachgrass/panicgrass dune grassland, and overwash dune grassland.

The intertidal zone is the area between the land and sea that is covered by water at high tide and uncovered at low tide and is immediately landward of the nearshore zone. The intertidal areas in estuaries like Jamaica Bay include hundreds of acres of mudflats and low and high saltmarsh and are rich in food resources for a variety of wildlife. Ocean shores in the park are otherwise covered in beaches, most of them sandy and used for recreation.

North Atlantic upper ocean beach is the formal name of beach habitat just above mean high water. While this vegetation type is not considered rare and is found throughout the park, it nonetheless provides habitat for a number of protected plant and animal species.

Beaches are the most dynamic habitats in the park, changing continuously with the wind and tides and sometimes changing radically during hurricanes and nor'easters. Animals and plants that thrive on beaches are well adapted to its changing nature. The beaches on the Rockaways and at Sandy Hook are called "barrier beaches" because they lie on barrier peninsulas that are separated from the mainland by an estuary or bay. A description of the beaches and coastal processes in the park is available in the "Soils and Geology" section of this GMP/EIS.

In the descriptions of vegetation associations taken from Edinger et al. (2008b), the name of the association is in bold type.

North Atlantic coast estuarine intertidal mudflat is the only vegetation association (i.e., a community of associated plants) considered by Edinger et al. (2008b), the team that comprehensively inventoried park vegetation most recently, to be a truly marine or intertidal community. Intertidal mudflats cover more than 9,000 acres of park lands and waters, making it the most abundant of all vegetation associations at Gateway. This vegetation type is found on saline mudflats, is completely exposed at low tide, and is tidally flooded twice daily. The substrate consists of silt and mud that is rich in organic matter and poorly drained at low tide. It is subject to moderate fluctuations in salinity and moisture and is washed by low-energy waves. The mudflats are nearly devoid of vegetation, although the marine alga sealettuce *(Ulva lactuca)* can cover 40 percent or more of the exposed area. Smooth cordgrass *(Spartina alterniflora)* can occur sporadically, colonizing from adjacent low saltmarsh communities. This community occurs in the Great Kills Park section of the Staten Island Unit and the Floyd Bennett Field and Jamaica Bay Wildlife Refuge sections of the Jamaica Bay Unit.

North Atlantic upper ocean beach is the formal name of beach habitat just above mean high water. While this vegetation type is not considered rare and is found throughout the park, it nonetheless provides habitat for a number of protected plant and animal species. At the park, it is characterized by native plant species American searocket *(Cakile edentula)* and seaside sandmat *(Chamaesyce polygonifolia).* Rare plants include the federally threatened seabeach amaranth as well as the globally vulnerable seaside knotweed (*Polygonum glaucum)* and state imperiled sanddune sandbur *(Cenchrus tribuloides)* (Edinger et al. 2008b). Invasive plants include Russian thistle *(Salsola kali)*. Rare birds in this ocean beach area include piping plover, least tern, common tern, and black skimmer (Lawrence, Roman, and Frame 2010).

Foredune Habitat

Plants and animals that thrive in the foredune environment are well adapted to the winds and waves, and this dynamic environment promotes biological diversity. Vegetation upland from the beach and foredune is described in the "Vegetation" section of the GMP/EIS; marsh and wetland vegetation is described in the "Wetlands and Floodplains" section.

Edinger et al. (2008b), who described 35 vegetative communities at Gateway, named the plant association on active foredunes the **northern beachgrass dune** community. Although this vegetation grows on dynamic, active foredunes, it also occupies more protected interdune areas (Edinger et al. 2008b). The dominant grass is American beachgrass, but there may also be other grasses and forbs. Rare plants documented in this community at Gateway include sanddune sandbur and Oakes' evening primrose *(Oenothera oakesiana),* both of which are New York state-listed threatened plants. The northern beachgrass dune community is found along the upper edge of ocean beaches throughout the park.

The **beachgrass/panicgrass dune grassland** community at Gateway occurs on active foredunes, but in areas mostly outside the influence of storm tides and only in combination with the northern beachgrass dune community. While the beachgrass/panicgrass dune community is characterized primarily by bitter panicgrass *(Panicum amarum),* many other native plants such as American beachgrass, field sagewort *(Artemisia campestris),* and pink fuzzybean *(Strophostyles umbellata)* are also present. Several species of lichens of the genus *Cladonia* are found in this community. This community is globally imperiled, at a high risk of extirpation, with only an estimated 65–100 communities remaining. The vegetation is particularly vulnerable to trampling or off-road vehicle use because it is very fragile and does not easily recover from disturbance (Edinger et al. 2008b). In Gateway, beachgrass/panicgrass dune grassland is documented only at the northernmost end of Sandy Hook (Edinger et al. 2008b).

The **overwash dune grassland** is dependent on overwash sand that is deposited during storm surges. It is usually not more than a few acres in size and its highly ephemeral nature requires a large dune system to survive. It often is in a mosaic with the northern beachgrass dune community. In the park, overwash dune grassland is also found on dredge fill deposits, where it is dominated by saltmeadow cordgrass *(Spartina patens).*

The **North Atlantic coastal plain vine dune** community occurs on foredunes up to the crest, exposed to wind, salt spray, and occasional overwash by storm tides. Eastern poison ivy *(Toxicodendron radicans)* shrubs dominate at the park, often accompanied by native Virginia creeper *(Parthenocissus quinquefolia)* and nonnative, invasive Japanese honeysuckle *(Lonicera japonica).* The community is globally imperiled and at risk of extinction. The soil is Hooksan series sand, a substrate characteristic of the rarest plant communities at Gateway. The North Atlantic coastal plain vine dune community is found at Sandy Hook, Fort Tilden, and in the Jamaica Bay Wildlife Refuge (Edinger et al. 2008b).

Threats to the Marine Zone

The New York Bight is in a heavily urbanized watershed supporting the largest coastal population of people in the United States (USFWS 1997c). Major threats affecting the bight include coastal urbanization, wetland and coastal use modifications, ocean dumping and waste disposal, port development and maintenance, agricultural practices and development, transportation, energy production, marine mineral mining, and cumulative nonpoint sources of pollutants. The ocean area of the New York Bight has traditionally been used for the disposal of waste, including sewage sludge, dredged materials, chemical wastes, and radioactive materials. This use has degraded the habitats and associated organisms in the waters. Organic loading of riverine, estuarine, and coastal waters is an emerging problem.

Symptoms of this loading are the increasing prevalence of excessive algae blooms, shifts in algal species composition, high sediment biological oxygen demand at affected sites, and anoxic events in near coastal and estuarine waters. Domestic waste discharge and other household nonpoint source contaminants are major sources of the contaminant burden to the nearshore waters and benthos. Domestic waste includes fecal contaminants, heavy metals, agricultural runoff, leachate from landfills, highway and urban runoff, chemical and oil spills, and contaminated (with PCBs and polycyclic aromatic hydrocarbons [PAHs]) sediment movement in some of the riverine and bay areas. Atmospheric contaminants are another domestic nonpoint source (USFWS 1997c).

Urban sprawl and suburbanization have exerted tremendous pressure on the integrity and health of the coastal ecosystem, including those of Raritan Bay and its watersheds, as well as some of the upland and wetland buffer areas around the shoreline of Jamaica Bay. Intense demand for home sites, resorts, marinas, and commercial development has resulted in the loss of valuable wetland resources through filling, dredging, ditching, diking, and shoreline modification. Increased population intensifies recreational uses of the coastal areas, including the demands for boating facilities and access to the water (USFWS 1997b).

Sea-level rise and warming temperatures most experts attribute to climate change (NY Academy of Sciences 2010) are also forces that currently affect marine resources and would increasingly do so in the future. Sea level rise can increase shoreline erosion along beaches and in Jamaica Bay, inundate vegetation or nests of shorebirds or terrapins and cause saltwater intrusion into groundwater aquifers that then contaminate fresh or brackish water habitat (Columbia University 2009). Warming temperatures increase evaporation of brackish or freshwater habitat and are known to be associated with increased competitive advantage of invasive vegetation.

Mining for sand and gravel, as well as exploration and production drilling for oil or minerals of the outer continental shelf, affect marine biota and their habitats. Sand and gravel mining can result in loss of benthic organisms that live in the sediment; mining modifications of the substrate in the plume area can sometimes be measured in miles. Oil spills and spills of other hazardous materials are a major threat to marine waters in the area. Deep borrow pits in areas of minimal flushing can have decreased DO and may become seasonally or permanently anaerobic where mixing does not occur regularly (USFWS 1997b, 1997c).

Extensive recreational use of Gateway beaches has resulted in disturbance of wildlife like nesting birds and has increased demand for parking, access, and other facilities that could further disturb wildlife or eliminate habitat (USFWS 1997a).

The nonnative, invasive Japanese sand sedge *(Carex kobomugi)* is an aggressive, invasive colonizer of dunes on the beaches of the North Atlantic Coast. It successfully outcompetes native grasses and herbs such as American beachgrass, field sagewort, and seaside goldenrod. It grows on dynamic, shifting sand dunes, usually beyond the influence of storm tides. Edinger et al. (2008b) report it only at Sandy Hook, where it has a large enough presence to be classified as a separate vegetative community and is spreading exponentially (Lawrence, Roman, and Frame 2010).

Vegetation

Vegetation at the park is classified by its location and present assemblage of species. Many of these plant communities are highly altered due to urban influences; approximately 45 percent of Gateway's 700 identified plant species are nonnative to the New York City maritime environment (Frame, pers. comm. 2013b). Generally, the beaches and mudflats at the park are not vegetated, or if they are, coverage is sparse. Adjacent to the intertidal area or beach are the dunes, which begin with the foredune. The processes that form and shape the dunes are described in the "Soils and Geology" section of this chapter of the GMP/EIS. Behind the foredune are the dunes and interdunes (swales between the dunes), where the vegetation includes more than 260 native vascular plants, including 12 that are rare (NPCA 2007c). Moving farther inland and away from the influence of salt spray and wind, dune vegetation gives way to shrubs and then to maritime forest. On the inland side of beaches, such as along the western side of Sandy Hook and throughout Jamaica Bay, are expansive saltmarshes composed primarily of grasses *(Spartina)*, as well as sandy hills and shores.

On the inland side of beaches, such as along the western side of Sandy Hook and throughout Jamaica Bay, are expansive saltmarshes composed primarily of grasses (Spartina), as well as sandy hills and shores.

Vegetation at Gateway has been surveyed recently (Edinger et al. 2008b) and classified into 35 associations. Of these, 20 are maintained by maritime influence including strong salt spray, high winds, and coastal processes such as dune deposition, shifting, and overwash. Edinger et al. (2008b) divides these maritime communities into marine associations, estuarine associations, and terrestrial associations. Most of the remaining communities are classified as human-modified associations.

Marine, intertidal beach, and foredune vegetation associations are discussed in the "Marine Resources" section of this chapter. These include the North Atlantic Coast estuarine intertidal mudflat, the North Atlantic upper ocean beach, North Atlantic coastal plain vine dune, northern beachgrass dune, beachgrass/panicgrass dune grassland, and overwash dune grassland.

Estuarine associations are those that grow in habitat that is semi-enclosed but with access to open ocean or tidal flows and that are at least occasionally diluted by freshwater runoff. Seven estuarine vegetation associations grow at the park, including brackish meadow, mid-Atlantic salt shrub, North Atlantic low saltmarsh, North Atlantic high saltmarsh, salt panne, coastal salt pond marsh, and Northeastern Atlantic brackish interdunal swale. These associations are discussed in the "Wetlands and Floodplains" section of this chapter of the GMP/EIS.

The grasslands, shrublands, and forests of terrestrial maritime communities, as well as human-modified associations, are the focus of this section of the document, although maps and descriptions of park sites in the last subsection include a synopsis of the types and conditions of all vegetation. Terrestrial maritime associations described by Edinger et al. (2008b) include North Atlantic Coast backdune grassland, northern beach heather dune shrubland, northern bayberry dune shrubland, northern tall maritime shrubland, mid-Atlantic maritime salt shrub, maritime red-cedar woodland, maritime holly forest, and successional maritime forest. Terrestrial maritime vegetation associations are made up of "salt-pruned" trees and shrubs with contorted branches and wilted leaves; they also usually have a dense vine layer. Often, they grow in narrow bands parallel to the shoreline (Edinger et al. 2008b). Descriptions of each of these associations are taken primarily from Edinger et al. (2008b). Human-modified associations (whose descriptions are also primarily from Edinger et al. 2008b) are discussed in the "Invasive Species and Human-modified Associations" subsection.

Terrestrial Maritime Vegetative Communities

Backdune Associations

North Atlantic Coast Backdune Grassland. This community occurs in a natural setting on deep, stabilized sands of old interdunes and backdunes. It can also occur in disturbed settings following clearing of maritime shrubland and other backdune communities or on sandy dredge spoil. The substrate can be fine sand, coarse sand, gravelly fine sand, or (less commonly) loamy sand. Soils are derived from various natural and nonnatural sediments, including household landfills capped with sand, sandy dredge fill, eolian (windblown) and marine sediments, and sandy fill mixed with demolished construction debris. The vegetation of this association is variable and depends on landscape setting and land-use history. It is dominated by gray clubawn grass *(Corynephorus canescens)* in more disturbed settings and by little bluestem *(Schizachyrium scoparium).* This association occurs in the Great Kills Park section of the Staten Island Unit, in the Sandy Hook Unit, and in all sections of the Jamaica Bay Unit.

Northern Beach Heather Dune Shrubland. This is a dwarf shrubland association that occurs in well-developed sand dune systems on stable secondary dunes. Conditions are xeric; plants must be adapted to low moisture, high surface temperature, and high light intensity. The substrate is fine sand in the Hooksan series. The natural setting for this community is in flat openings within northern tall maritime shrubland, maritime red-cedar woodland, and mid-Atlantic maritime salt shrub. At Gateway, it can also be found in a disturbed setting surrounded by Japanese black pine *(Pinus thunbergii)* forest. This dwarf shrubland is characterized by woolly beachheather *(Hudsonia tomentosa)* occurring with other low-growing shrubs, including eastern red cedar *(Juniperus virginiana)*, beach plum *(Prunus maritima),* flameleaf sumac *(Rhus copallinum),* Japanese black pine, northern bayberry *(Myrica pensylvanica),* and black cherry *(Prunus serotina).* This association occurs in the Sandy Hook Unit and in the Fort Tilden and Floyd Bennett Field sections of the Jamaica Bay Unit. Northern beach heather dune shrubland is globally vulnerable and at risk of extinction.

Northern Bayberry Dune Shrubland. This association occurs on protected slopes and hollows of dry, stabilized maritime backdunes. The substrate is coarse to fine sand consisting of very deep, excessively drained soils formed in eolian sands, sandy marine sediments, or sandy dredge spoils. The vegetation of this dense, short maritime shrubland is dominated by northern bayberry with flameleaf sumac. Northern bayberry dune shrubland is at risk of extinction in New York State (Edinger et al. 2008b, as cited in Lawrence, Roman, and Frame 2010). This association occurs in the Sandy Hook Unit and in the Breezy Point, Fort Tilden, Floyd Bennett Field, Canarsie Pier, and Jamaica Bay Wildlife Refuge sections of the Jamaica Bay Unit.

Northern Tall Maritime Shrubland. This community is usually very dense and often occurs inland of northern bayberry dune shrubland in sheltered settings. The substrate is most commonly coarse to fine sand originating from marine sediments, eolian deposition, or dredge fill. Vegetation is dominated by northern bayberry, flameleaf sumac, black cherry and many associates, including autumn olive *(Elaeagnus umbellata),* multiflora rose *(Rosa multiflora),* white poplar *(Populus alba),* and others. Vines are commonly draped in and over shrubs. This association occurs in the Sandy Hook Unit; the Great Kills and Miller Field sections of the Staten Island Unit; and in all sections of the Jamaica Bay Unit.

Mid-Atlantic Maritime Salt Shrub. This shrubland usually forms an ecotone between high saltmarsh and adjacent upland vegetation, but it also occurs in patches on areas of slightly higher elevation within maritime dunes. It occurs above mean high tide but can be flooded by storm tides. The substrate is primarily fine sand to mucky, fine, sandy loam consisting of very deep, excessively drained to very poorly drained soils formed in eolian sands, sandy marine sediments, dredge fill, or thick sandy deposits with a thin organic surface layer. This tidal shrubland is dominated by a fairly dense cover of Jesuit's bark *(Iva frutescens)* and eastern baccharis *(Baccharis halimifolia).* Associated tall and short shrubs include northern bayberry, flameleaf sumac, and black cherry. This association occurs in the Sandy Hook Unit and in all sections of the Jamaica Bay Unit.

Maritime Forests

Maritime forests are situated on barrier islands and peninsulas, which are subjected to wind-driven salt spray and occasional inundation by storm-driven ocean surges. Stands may represent seral stages of the barrier island forest, perhaps held in stasis for a century or longer by specific site conditions, including soil depth or nutrients, temperature, or intense storms. Much of the barrier island forest along the New Jersey and New York coasts has been lost to urban development, and two types of barrier island forest—maritime red-cedar woodland and maritime holly forest—are globally imperiled. In the park, both of these occur only at Sandy Hook, on the deep, non-glacial sediments of Hooksan soil series.

Maritime Red-cedar Woodland. This association occurs on inactive old sand dunes in association with maritime holly forest or maritime dunes or on the upper edge of low saltmarsh. Most commonly, the substrate is fine sand consisting of very deep, excessively drained soils formed in eolian sands or sandy marine sediments. The community has also formed on sandy dredge spoils. Tall shrubs and saplings are moderately abundant (nearly 30 percent cover) and consist of a mix of species, many of which are also represented in the canopy. This maritime woodland community has an open canopy (just over 50 percent cover) that is strongly dominated by eastern red cedar. The most abundant associated canopy species are black cherry, American holly *(Ilex opaca),* and common hackberry *(Celtis occidentalis).* Occasionally, individual trees will also extend up above the canopy into a sparse emergent layer. Additional tree species are Japanese black pine, blackjack oak *(Quercus marilandica),* black oak *(Q. velutina),* northern red oak *(Q. rubra),* black locust *(Robinia pseudoacacia),* and red maple *(Acer rubrum).* In Gateway, this association is only found in the Sandy Hook Unit. It is globally imperiled and considered to have a high risk of extinction.

Maritime forests are situated on barrier islands and peninsulas, which are subjected to wind-driven salt spray and occasional inundation by storm-driven ocean surges. Stands may represent seral stages of the barrier island forest, perhaps held in stasis for a century or longer by specific site conditions, including soil depth or nutrients, temperature, or intense storms.

Maritime Holly Forest. The rarest association in the park is the maritime holly forest, which is located only on the west shore of Sandy Hook. At 231 acres, it is the largest one of only two known occurrences in the world, with the other, coincidentally, located on NPS land at Sunken Forest on Fire Island National Seashore. This association occurs on old, inactive dunes with undulating topography. Some patches show evidence of past fire in charred stumps and multi-trunked American holly. The substrate is a variable mix of loamy/organic sand and medium sand with a covering of litter and duff. Soils within this community are in the very-deep-to-bedrock and excessively drained Hooksan series formed in eolian sands or sandy marine sediments. Maritime holly forest at Gateway is strongly dominated by American holly with black cherry, eastern red cedar, common hackberry, red maple, and common serviceberry *(Amelanchier arborea).* Holly trees at Sandy Hook range in age from 15 to 162 years old (Forrester et al. 2004, as cited in Lawrence, Roman, and Frame 2010). Holly survival is very high, particularly relative to co-occurring species like black cherry or American hackberry, as is its reproductive success in the park (Lawrence, Roman, and Frame 2010). The maritime holly forest at Sandy Hook is considered the finest example of this vegetative community in the world (Art 1992, as cited by Lawrence, Roman, and Frame 2010). It is globally imperiled and at high risk of extinction. The height of the trees, the low profile of the dunes, and a coastline geography that heightens storm surges all make the Sandy Hook maritime holly forest highly susceptible to storm damage (Forrester et al. 2008, as cited in Lawrence, Roman, and Frame 2010). The Sandy Hook holly forest has experienced strong winds that caused blowdowns and gaps approximately 11 times since 1788 (Boose et al. 2001, as cited in Lawrence, Roman, and Frame 2010), including from Hurricane Sandy in 2012, which caused flooding but no significant blowdown of trees noticeable in the immediate aftermath. Large numbers of holly trees appear now to be dead, apparently from being flooded for an extended period of time (Lane, pers. comm. 2013). Longer-term changes may have occurred, but they are yet unknown (Rowan 2012, as updated by NPS 2013e).

Successional Maritime Forest. This maritime forest community occurs most often on stabilized backdunes, generally leeward of secondary maritime dunes or in protected hollows. It can also be found farther inland in association with tall maritime shrubland. Substrates are somewhat poorly drained to excessively drained, coarse to fine sands originating from marine- or eolian-derived sand or sandy dredge fill. The somewhat open tree canopy (to 50 feet [15 meters] tall) of this successional maritime forest is strongly dominated by black cherry with common hackberry. Associated canopy species include red maple, American holly, white poplar, black locust, and lesser amounts of eastern red cedar, Japanese black pine, and eastern cottonwood (Populus deltoides). This association occurs in the Sandy Hook Unit, in the Great Kills Park section of the Staten Island Unit, and in the Fort Tilden, Floyd Bennett Field, Canarsie Pier, and Jamaica Bay Wildlife Refuge park sites of the Jamaica Bay Unit. The present plant composition in the North Forty of Floyd Bennett Field is very diverse (Greller 1984 and Wijesundara 1997, as cited in Lawrence, Roman, and Frame 2010), with 125 plant species in three separate forest communities, including successional maritime forest. This association is considered rare.

Invasive Species and Human-modified Associations

Much of the natural vegetation at the park has been disturbed or altered by humans, either historically or recently (NRCS et al. 2001). Forests have been cut for use as firewood or building materials, and formerly forested lands have been converted to pasture or agricultural uses. Saltmarshes have been filled to create tracts of housing or other development or dredged for substrate on which to build them. Floyd Bennett Field, Jamaica Bay Wildlife Refuge, and Great Kills Park all contain land that was created from material dredged from what are now park waters and neighboring bays or marine environments as well as from areas outside park boundaries (NRCS et al. 2001). In addition, as described in the "Soils and Geology" section of this chapter of the GMP/EIS, humans have altered shoreline dynamics along the length of Sandy Hook and most of Breezy Point to change the availability of sand, which not only supports beach vegetation but is moved inland by water and wind to supply inland and even nearshore saltmarsh habitats.

Nonnative plants are common throughout the park, composing from one-third to nearly all species at some park sites (NPCA 2007c). Although some nonnative plants became established as a result of disturbance and disruption of native habitats by the historical activities described above, others were deliberately planted. Much of the Staten Island Unit is landscaped, for example, using nonnative species such as bluegrass *(Poa pratensis).* Other nonnative species, like Russian or autumn olive *(Elaeagnus angustifolia, E. umbellata),* red chokeberry *(Aronia arbutifolia),* and buckthorn *(Rhamnus frangula),* were planted to supplement wildlife habitat, especially for migratory birds (NPCA 2007c).

Like many other eastern locations, several Japanese species have found habitat at the park, including Japanese sand sedge, Japanese honeysuckle, Japanese black pine, and Japanese knotweed *(Polygonum cuspidatum).* The Japanese sand sedge is an invasive colonizer of dunes of the North Atlantic Coast and successfully outcompetes a number of native dune species, including American beachgrass. An alien strain of *Phragmites* (common reed; *Phragmites australis)* has infested fresh and brackish wetland communities so that it now covers an estimated 1,120 acres, or nearly 5 percent of the park lands and waters (Mellander, pers. comm. 2005, as cited in Lawrence, Roman, and Frame 2010).

Human-modified Vegetation Associations

Human-modified vegetation associations include early successional woodland/forest, Japanese black pine forest, Japanese sedge maritime dunes, little bluestem old field, northeastern modified successional forest, northeastern old field, and reed/grass tidal marsh. Very small patches of two additional associations—hardwood plantation and Japanese knotweed gravel bar—also grow in the park but are not described in this GMP/EIS because of the limited area they occupy. Much of the Japanese black pine in the park has been lost to disease.

Early Successional Woodland/Forest. This successional shrubland or open woodland or forest includes northern hardwoods occurring in various settings following disturbance such as clearing, fragmentation, and deposition of fill material. The substrate is coarse sand formed from sandy dredge fill. The community often occurs in a mosaic with other disturbed or successional communities, such as successional maritime forest and reed/grass tidal marsh, or even with paved areas. In the forests or woodlands, the open canopy is composed of a mix of early-successional species, including white popular, quaking aspen *(Populus tremuloides),* gray birch *(Betula populifolia),* and black cherry. The shrubland expression of this community is characterized by a dense layer of tall shrubs that are strongly dominated by white poplar, with northern bayberry and black cherry. This association occurs in the Great Kills Park section of the Staten Island Unit and in the Fort Tilden, Floyd Bennett Field, Canarsie Pier, and Jamaica Bay Wildlife Refuge sections of the Jamaica Bay Unit.

Japanese Black Pine Forest. This association occurs on old, inactive, undulating dune deposits; some patches may be natural and others were probably planted intentionally. The substrate is well-drained, sandy fill, which can be moist below 4–6 inches (10–15 centimeters), covered by a layer of pine needles, duff, and loamy sand. Nonnative Japanese black pine is the dominant canopy and subcanopy tree of this vegetative community, with black cherry the only documented associated tree species. Shrub cover is sparse and usually shorter than 3.3 feet (1 meter) in height. This association occurs in the Sandy Hook Unit and in the Fort Tilden, Floyd Bennett Field, and Jamaica Bay Wildlife Refuge sections of the Jamaica Bay Unit. As noted above, most of the park’s Japanese black pine has been lost to disease.

Japanese Sedge Maritime Dunes. This association occurs on coastal sand dunes with sandy, unstable substrates with no soil profile development. Eolian processes cause active sand deposition and erosion. The sand substrate is usually visible, and litter accumulation from plant debris is nearly absent. This community occurs on foredunes that receive the force of wind and salt spray, but it is generally beyond the influence of most storm tides. Vegetation is dominated by nonnative Japanese sedge in association with (and outcompeting) typical maritime dune species, including field sagewort and American beachgrass. This association is limited to the Sandy Hook Unit, New Jersey.

Little Bluestem Old Field. This association occurs on coarse sand to sandy loam and consists of well-drained to somewhat poorly drained soils formed in sandy dredge fill and loamy fill over sandy sediments. The vegetation association occurs in disturbed areas and is generally maintained by mowing. Adjacent communities include northern tall maritime shrubland, northern bayberry dune shrubland, northeastern old field, and North Atlantic Coast backdune grassland, as well as parking lots and airstrips. This successional vegetation is dominated and characterized by little bluestem. Associated species vary widely according to land-use history and adjacent vegetation; they can include weeping lovegrass *(Eragrostis curvula),* purple lovegrass *(E. spectabilis),* gray clubawn grass, or a host of other grass or forb species. This association occurs in the Great Kills section of the Staten Island Unit and the Fort Tilden, Floyd Bennett Field, and Spring Creek sections of the Jamaica Bay Unit.

Northeastern Modified Successional Forest. This is an early-successional woody vegetative community that occurs on sites that have been cleared of vegetation or otherwise heavily modified. The environmental characteristics of sites where this vegetative community grows in the park are highly variable. Substrates can range from coarse sand derived from sandy dredge fill to loam that developed over either glacial till or loamy fill material. Vegetation is characterized by dominance of successional and/or invasive species in all layers. The tree canopy and subcanopy are composed of a mix of species, including tree of heaven *(Ailanthus altissima),* black locust, white mulberry *(Morus alba)*, and black cherry. In the park, this association occurs on artificial, newly created uplands, such as the species-rich forest in the North Forty area of Floyd Bennett Field, and is present in all three units of Gateway.

Northeastern Old Field. This association occurs in an extremely variable assortment of sites, from mowed fields to disturbed maritime dunes. Substrates range from coarse sand and sandy loam to mucky peat. The vegetation of these successional old fields is extremely variable and depends on past and current land use as well as surrounding vegetation. The herbaceous layer is often dominated by common wormwood *(Artemisia vulgaris)* with a variety of grasses and forbs. This association occurs in the Great Kills section of the Staten Island Unit and in the Fort Tilden, Floyd Bennett Field, and Canarsie Pier sections of the Jamaica Bay Unit.

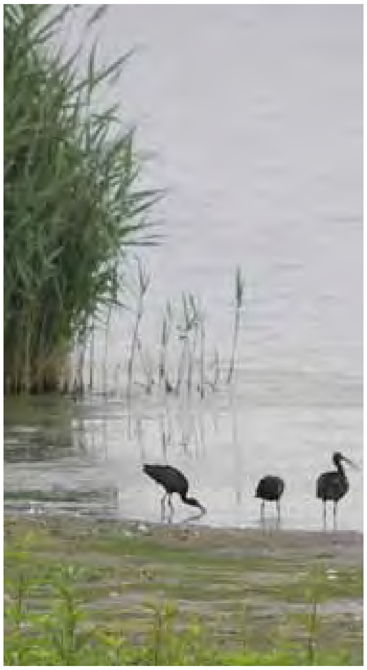
Reed/Grass Tidal Marsh. This association is often adjacent to and commonly intermingled with mid-Atlantic maritime salt shrub. It occurs in a range of tidal wetland habitats, and substrates range from coarse to fine sand or (less often) mucky peat or mucky, fine, sandy loam. Soils can be derived from eolian sands or dredge fill. The association is characterized by dense stands of Phragmites, which tends to grow in colonies of tall, stout, leafy plants, often to the exclusion of all other vascular plant species. This association occurs in the Sandy Hook Unit, the Great Kills section of the Staten Island Unit, and in all of the sections of the Jamaica Bay Unit.

Rare or Unique Vegetation

Rare, state-listed species or species listed as threatened or endangered under the federal Endangered Species Act are discussed in the “Species of Special Concern” section in this chapter of the GMP/EIS.

Of the vegetation associations described here and in the “Marine Resources” and “Wetlands and Floodplains” sections in this chapter of the GMP/EIS, several are locally and/or globally vulnerable or imperiled. Those communities ranked S1 (5 or fewer occurrences) or S2 (6–20 occurrences) by the New York and/or New Jersey Heritage Programs include the following:

- American holly forest—S1 New York and New Jersey; G1
- Successional maritime forest—S1, S2 New Jersey
- Maritime red-cedar forest—S1 New York and New Jersey
- Northern bayberry dune shrubland—S1, S2 New Jersey
- Beachgrass/panicgrass dune—S1, S2 New Jersey
- Northeastern Atlantic brackish interdunal swale—S1, S2 New York and New Jersey



- Brackish meadow—S1, S2 New York
- Coastal salt pond marsh—S1, S2 New York
- North Atlantic upper ocean beach—S1, S2 New Jersey

North Atlantic upper ocean beach also supports several listed species, including seaside amaranth (a New York endangered and federal threatened plant), sanddune sandbur (a New York threatened plant), piping plover (a New York endangered and federal threatened bird), seaside knotweed (a New York rare plant), black skimmer (a New York bird of special concern), and common tern (a New York threatened bird).

Northern beachgrass dune supports species of special concern as well, including sanddune sandbar and Oakes' evening primrose (a New York threatened plant).

Globally rare associations that occur at the park include the following:

- American holly forest—S1 New York and New Jersey; G1
- North Atlantic coastal plain vine dune—G1, G2
- Successional maritime forest—G2, G3
- Maritime red-cedar woodland—G2

G1 (5 or fewer occurrences) indicates the association is critically imperiled globally because of rarity, habitat, or biology; G2 (6–20 occurrences) indicates it is globally imperiled because or rarity, habitat, or biology; and G3 (21–100 occurrences) indicates it is rare and local throughout its range. A ranking of G1, G2, or G3 indicates the community or species is vulnerable to extinction.

Vegetation at Park Sites

A recently prepared assessment (Rowan 2012) of plant communities across the park is summarized in these sections to show their current condition. Updates on conditions after Hurricane Sandy were provided by NPS staff (February 2013). When an additional source is used, it is cited.

Jamaica Bay Unit

Plumb Beach. Plumb Beach has beach and dune areas, as well as saltmarsh and upland shrub/forest communities. The shrublands are in poor condition from foot traffic, which has worn several pathways into this area between the bike path and the dunes or saltmarsh. Although the marsh supports native saltmarsh species with no apparent invasive species, it is highly disturbed in many places. Many areas of the dunes are no longer vegetated due to heavy foot traffic and social paths that crisscross them. Coastal erosion at the western end of the beach periodically threatens the bike path and the Belt Parkway. An effort by the USACE, New York City Department of Parks and Recreation (NYCDPR), and NPS to nourish the beach on the west shoreline added 150,000 cubic yards of sand, which helped it withstand the storm surge from Hurricane Sandy. The east shoreline was not substantially eroded by Hurricane Sandy and remains in relatively good condition.

Floyd Bennett Field/Bergen Beach. Floyd Bennett Field consists of filled saltmarshes between former Jamaica Bay islands and what was once a shallow embayment. Bergen Beach is also a filled saltmarsh. Much of the planted lawns in the center and on the southeastern side of Floyd Bennett Field are now reverting to grasslands. This is a result of a partnership between the New York City Audubon and the NPS in the 1980s and 1990s to create habitat for grassland birds on 140 acres of Floyd Bennett Field. The grasslands provide butterfly and some bird habitat. Very large areas of Floyd Bennett Field, including grasslands on the southeastern side of the site, as well as Bergen Beach and shoreline of Dead Horse Bay between Plumb Beach and Floyd Bennett Field, are dominated in large part by a nonnative, invasive genotype of *Phragmites*. Hardened areas of the Floyd Bennett Field coastline associated with development alternate with eroding mudflats or sandy beaches. Bergen Beach is heavily used, especially by horses, as indicated by bare areas of sand. Many of these paths, as well as an area where restoration of a wetland was attempted, are flooded and at negative grade. Other than some erosion on the north shoreline of Floyd Bennett Field, this area was not substantially affected by Hurricane Sandy.

Canarsie Pier Coastal Area. This portion of Jamaica Bay includes the pier, Fountain Avenue and Pennsylvania Avenue former landfills, and Spring Creek Park and stretches for several kilometers of coastal frontage between them. Much of this land area is now filled, but it once was tidal freshwater or saltwater marsh. The shoreline is now largely dominated by *Phragmites*, particularly in Spring Creek Park. Vegetation here and elsewhere in these park sites shows evidence of heavy use, including bare areas and a network of social trails. Hurricane Sandy resulted in some flooding of the areas east and west of Canarsie Pier. Although the pier was overwashed by storm surge, it did not experience structural damage. The Fountain Avenue and Pennsylvania Avenue former landfills were not affected substantially by the storm.

Frank Charles Memorial Park. This very small community park is vegetated with recreational fields, lawns, and shrubs in the upland and has some saltmarsh and mudflat/intertidal communities interspersed with a cobble/gravel coastline. The site is affected by CSOs (a combination of stormwater and wastewater collected when treatment plants are at capacity) and heavy use. Vegetation here was not substantially affected by Hurricane Sandy.

Hamilton Beach Park. This very small community park is bisected by the Rockaway subway line and is affected by effluent from treated wastewater from an adjacent outfall pipe. Some areas of the park shoreline support saltmarsh vegetation, but it is dominated by *Phragmites*. This site was not substantially affected by Hurricane Sandy.

Jamaica Bay Fast Islands. “Fast” islands are those with dry land; fast islands in Jamaica Bay include Canarsie Pol, Ruffle Bar, Little Egg, and Subway Islands. These islands are primarily human created from dredge spoils, sand, and gravel added to saltmarshes. Upland areas include maritime shrublands and dunes. Intertidal zones are saltmarsh and beach, and there are some freshwater wetlands on the islands. *Phragmites* has invaded some of Canarsie Pol. Habitat on the fast islands is diverse, and a variety of animal species use it. Some of these islands were flooded by storm surge during Hurricane Sandy. Longer-term impacts from the flooding are yet unknown.

Jamaica Bay Hassocks. "Hassocks" are islands that are submerged at a minimum of once a month during the spring high tide; most are submerged twice each day by normal tides. Vegetation is nearly all low or high saltmarsh, although some shrubs or trees grow where fill material keeps them out of the brackish water. *Phragmites* has adapted to grow in higher salinities than it would in other areas at many park sites, but it cannot survive in saltmarshes and so has not invaded the hassocks. The hassocks are an important habitat for wildlife. Like the fast islands, hassocks in Jamaica Bay were flooded by storm surge during Hurricane Sandy.

Jamaica Bay Wildlife Refuge. The land area of this park site was created by filling and excavating various areas, including marsh islands, sand beaches, and submerged habitat in the northern portion of Jamaica Bay. Portions of Grassy Bay, Rulers Bar Hassock, Goose Pond Marsh, Goose Pond, Big Egg Marsh, Broad Creek Marsh, and three other unnamed islands were reconfigured to create the refuge land and water masses. As described in the "Wetlands and Floodplains" section in this chapter of the GMP/EIS, two large water bodies were artificially created at the refuge—both with the intention of making freshwater habitats. A third water body, Big John's Pond, is an excavated freshwater pond covered with floating aquatic vegetation during the warm season. Over time, the salinities of the ponds have changed. A woolgrass marsh and a mixed forb marsh both grow near the ponds (see "Wetlands and Floodplains" in this chapter for more information). The refuge also supports brackish and saltwater wetlands, as well as shrubland, woodland, dunes, and beaches. *Phragmites* covers a large area along the edges of the water bodies on the refuge.

Jacob Riis Park. This park site on the Rockaway Peninsula is bounded to the north by Jamaica Bay and to the south by the Atlantic Ocean. The land area is mostly developed for parking lots and recreational uses; a large beach and dune system on the ocean side is unvegetated. A small area of the northeastern side of the site supports a maritime shrubland; otherwise, vegetation is planted lawn. Hurricane Sandy substantially overwashed and eroded the dunes.

Fort Tilden. Much of the vegetation at this park site, particularly in the back fort area (following Hurricane Sandy), is in relatively undisturbed condition. Plant communities include shrublands and forest, as well as old field associations. Before Hurricane Sandy, dunes were vegetated with North Atlantic coastal plain vine dune association species, including eastern poison ivy and Virginia creeper. However, the storm substantially affected the bayshore and the ocean shore of Fort Tilden. Primary and secondary dunes on the ocean side were eroded and the dune vegetation lost over much of the park site.

Breezy Point. Breezy Point Tip is the terminus of the Rockaway barrier island. The habitat is a unique and relatively undisturbed combination of exposed beach and foredune with secluded backdune and a variety of wetland types, including palustrine, coastal salt pond marsh, brackish interdunal swales, and salt panne pools.

Staten Island Unit

Because of the location of the Staten Island Unit, Hurricane Sandy blew directly onshore rather than alongshore as it did at many other park sites. As a result, extensive flooding and loss of trees and habitat for other vegetative communities took place.

Fort Wadsworth. The shoreline of Fort Wadsworth is located along the New York Harbor at the western terminus of the Verrazano-Narrows Bridge. The bridge terminus is hardened, but otherwise the shoreline is undeveloped near the fort. A beach lies along one shore; the other is vegetated with shrub and successional forest species (Edinger et al. 2008b). Vegetation is characterized by dominance of successional and/or invasive species in all layers. The tree canopy and subcanopy are composed of a mix of species, including nonnative tree of heaven, black locust, white mulberry, and black cherry. Much of this vegetation was blown down or removed by winds and waves during Sandy. Upland of the shore, vegetation is primarily planted lawns, shrubs, and trees.

Miller Field. Most of Miller Field is either planted lawn or developed, although a line of dunes faces the ocean. However, a rare relict swamp white oak forest grows in the farther inland portion of the site. In addition to a few swamp white oaks, the site supports pin oak *(Quercus palustris),* northern red oak, and other tree species. The understory is populated with a suite of invasive species, including multiflora rose, Japanese honeysuckle, and garlic mustard *(Alliaria petiolata).* These species particularly occur along disturbed sites such as the multitude of pathways through the forest. Although Hurricane Sandy did not affect the forest, it did diminish and flatten the dunes.

Great Kills Park, Including Crooke's Point and Associated Coast. The "Soils and Geology" section in this chapter describes natural coastal processes, human-caused changes to them, and historical efforts to alter the configuration and elevation of this part of the park. The beach at Crooke's Point naturally accumulates sand, and vegetation in this area includes that typical of upper ocean beach. Crooke's Point includes overwash habitat and dunes vegetated with American beachgrass along its shore, as well as inland associations such as successional maritime forest and northern tall maritime shrubland. Much of Crooke's Point is covered in invasive vines, the removal of which is a target of an NPS partnership project with volunteers and NYCDPR. Mudflats and vegetation as described in the" Marine Resources" section in this chapter of the GMP/EIS for North Atlantic Coast estuarine intertidal mudflat occupies a portion of the coast at Great Kills Park. In Great Kills, *Phragmites* dominates the majority of the area, particularly north of the Great Kills Harbor and along the northern NPS property line, although additional successional forests grow west of this infestation.

Hoffman Island and Swinburne Island. Hoffman Island is a 14-acre and Swinburne Island a 4-acre artificial island; each was each previously developed and ruins of the buildings remain. The islands are wooded with a variety of deciduous trees and shrubs. Island shores are stone bulkheads and nonnative plant species are common, as are open areas from former human use (Frame, pers. comm. 2013b).

Sandy Hook Unit

The Sandy Hook Unit is unique at Gateway in that it is a larger continuous and contiguous park site. The vegetation is described by habitat type rather than location.

Beaches and Dunes. Dunes at Sandy Hook are vegetated with species (described in the "Marine Resources" section in this chapter of the GMP/EIS), including American beachgrass, American searocket, seaside sandmat, and bitter panicgrass, typical of the upper ocean beach, beachgrass dune, beachgrass/panicgrass dune, and dune shrubland communities. The swales of the dunes are often brackish and support vegetation dominated by saltmeadow cordgrass, although Japanese sedge maritime dune species, including Japanese sedge, has invaded many of the dunes. Sandy beach in the northern end of the island is accreting and the extensive foredune here is vegetated with American beachgrass (USFWS 1997a). Extensive areas of backdune habitat also occur toward the northern end. Beaches at the southern end of Sandy Hook are narrow for reasons described in the "Soils and Geology" section in this chapter. Hurricane Sandy caused extensive damage to NPS facilities and infrastructure through strong winds and a 13-foot storm surge. Sand movement from dunes and beaches was extensive, with overwash moving sediment from the dunes and beaches across the peninsula to cover the unit's main access road with drifts as much as 8 feet deep. Unvegetated dunes were particularly vulnerable.

Hurricane Sandy caused extensive damage to NPS facilities and infrastructure through strong winds and a 13-foot storm surge. Sand movement from dunes and beaches was extensive, with overwash moving sediment from the dunes and beaches across the peninsula to cover the unit's main access road with drifts as much as 8 feet deep.

Grassland Vegetation. Although most of the Fort Hancock area is developed, Rowan (2012) noted a relatively undisturbed area of grassland in the vicinity, indicating that it was in good condition and provided habitat for insects, butterflies, and ground-nesting birds.

Internal Shrublands, Woodlands, and Forests. Red cedar and holly forests cover about half of the Sandy Hook Unit. In some areas of these forests, springs or possible bogs or wet depressions occur. From the backdunes to the highest and most interior part of Sandy Hook, shrublands grow that are typical of the successional maritime forests described previously, dominated by bayberry, beach plum, and tree of heaven (USFWS 1997a). The backdune and interior maritime shrublands are relatively intact but have been invaded in some cases by Japanese sedge. Although the interior maritime shrublands were flooded by the storm surge associated with Hurricane Sandy, trees remained standing for the most part and long-term impacts are yet unknown.

Bay Coasts, Including Spermaceti and Horseshoe Coves and Plum Island. The bay side of Sandy Hook consists of extensive mudflats, sandflats, and saltmarsh dominated by smooth cordgrass. There are a few small inland brackish marshes or intertidal areas; many of these, as well as much of the bay shorelines, are dominated by *Phragmites*. Spermaceti and Horseshoe Coves have Phragmites along the shorelines in some cases, as does the interior wetland of Plum Island. Horseshoe Cove shows both erosion and accretion in some locations, which may be due to the presence of a battery that acts like a jetty to collect sand on one side. The Hurricane Sandy storm surge increased the erosion of these shorelines.

Wildlife

Other sections of this GMP/EIS describe the meeting of currents, waters, and climate from the north and south in the vicinity of Gateway. Jamaica Bay and Breezy Point on one side and Sandy Hook on the other frame the entrance into New York Bay and Harbor. Park sites in the Jamaica Bay Unit receive an influx of migrating species from the east–west-oriented coastline of New England and Long Island and the Sandy Hook and Staten Island Units from the north–south coastline of the mid-Atlantic coast. This intersection, along with the influence of substantial inflow of freshwater primarily from the Hudson River, concentrates species migrating between the New York Bight portion of the North Atlantic and the Hudson/Raritan Estuary in both directions, and makes for a regionally significant wildlife habitat (USFWS 1997c).

Despite the generally urbanized nature of the region, Jamaica, Raritan, and Sandy Hook Bays encompass important breeding and juvenile nursery habitat for fish. These estuaries and adjacent terrestrial habitat are also important for nesting, foraging, and roosting birds, including waterfowl, shorebirds, colonial-nesting waterbirds, and seabirds like gulls and terns. Upland sites in this area provide rare habitat in the area for grassland bird nesting and foraging and butterfly concentrations (USFWS 1997b). Habitat at Sandy Hook includes ocean beaches populated by listed plant and animal species; inland rare dune, shrub, and forest habitat; and the estuarine shoreline that faces the Raritan and Sandy Hook Bays. This section of shoreline is exposed to intertidal and subtidal influences and is considered important to shellfish and marine, estuarine, and anadromous fish, as well as for its significant migratory and wintering waterfowl concentrations (USFWS 1997a). Like Jamaica Bay, the shoreline provides important fish nursery areas, and its wetlands and uplands provide migratory and wintering spots for waterfowl, shorebirds, waterbirds, and landbirds like songbirds and raptors. The shore is also used as nesting and foraging areas for terrapins. Portions of the Staten Island shoreline also provide wildlife tidal mudflat, dune, and some remnant freshwater wetland and forest habitat.

The park is continually inventorying its wildlife species, and as of 2010 had found 326 bird species, 101 fish species, 30 mammal species, 25 reptile and amphibian species, and over 500 invertebrates, including aquatic macroinvertebrates, butterflies, moths, dragonflies, beetles, and other insects (Lawrence, Roman, and Frame 2010). At least 73 bird species nest in the park.

Mammals

The most common mammals at the park include opossum *(Didelphis virginiana),* raccoon *(Procyon lotor*), eastern cottontail *(Sylvilagus floridanus),* eastern gray squirrel *(Sciurus carolinensis),* white-tailed deer *(Odocoileus virginianus),* red fox *(Vulpes vulpes),* and species of rats, mice, and voles including white-footed mouse *(Peromyscus leucopus)* and meadow vole *(Microtus pennsylvanicus).* Migratory bats found at the park include little brown *myotis (Myotis lucifugus),* silver-haired bat *(Lasionycteris noctivagans),* red bat *(Lasiurus borealis),* and hoary bat *(Lasiurus cinereus)* (USFWS 1997b). Although not rare in the region, small

Despite the generally urbanized nature of the region, Jamaica, Raritan, and Sandy Hook Bays encompass important breeding and juvenile nursery habitat for fish. These estuaries and adjacent terrestrial habitat are also important for nesting, foraging, and roosting birds, including waterfowl, shorebirds, colonial-nesting waterbirds, and seabirds like gulls and terns.

mammals are rare in the urban core of the city and serve as an important food base for the hawks and owls feeding on the islands and shorelines of Jamaica Bay and elsewhere in the park.

As noted in the "Marine Resources" section of this chapter, dolphins, whales, and seals sometimes travel in park-managed waters. Harbor seals are winter visitors to Sandy Hook, Great Kills Harbor, Hoffman and Swinburne Islands, Jamaica Bay, and the Rockaway Inlet area and use local docks, the jetty at Breezy Point Tip, and other locations as haul-out areas. The endangered humpback whale occasionally feeds in New York Bay adjacent to the inlet, and bottlenose dolphins and endangered sperm whales *(Physeter macrocephalus)* have been noted as strandings in the area (USFWS 1997b).

Although the area that is now the park did at one time have larger land mammals, including elk, black bear, and beaver in the 1600s, these and a dozen other mammalian species are now locally extinct (NRCS 2001).

The wildlife group for which the park is best known is birds, particularly the waterbirds, seabirds, shorebirds, and waterfowl that frequent its estuarine and coastal shorelines.

Birds

The wildlife group for which the park is best known is birds, particularly the waterbirds, seabirds, shorebirds, and waterfowl that frequent its estuarine and coastal shorelines. The park is visited annually by 34 species of migratory shorebirds (Harrington, pers. comm. n.d.).

Jamaica Bay, for example, averages mid-winter ground counts of birds at about 11,000, with a peak (during the years from 1980 to 1992) of 36,000 (USFWS 1997b). The migratory and mid-winter concentrations of waterfowl in the Raritan/Sandy Hook Bay complex (which includes both Sandy Hook and the park sites on the shore of Staten Island) average over 60,000 birds (USFWS 1997c).

Breezy Point and Sandy Hook support some of the highest concentrations of beach-nesting birds in the entire New York Bight coastal region, including threatened piping plovers and other rare bird species, such as least terns, black skimmers, and common terns, discussed in the "Species of Special Concern" section of this chapter. Other nesting waterbirds at Breezy Point include great black-backed gull, herring gull, and American oystercatcher. The gulls, terns, and oystercatchers nesting at these park sites feed throughout Rockaway Inlet and Jamaica Bay.

Breezy Point and Sandy Hook are also concentration areas for other migratory shorebirds, waterfowl, and raptors and other landbirds, especially during the summer and fall migrations. The raptor banding station at Breezy Point banded 2,414 raptors during the period from 1978 to 1987 and sighted 15,715 raptors. The most numerous species sighted were American kestrel *(Falco sparverius)* and sharp-shinned hawk (Accipiter striatus), with a total of 9,244 and 4,373 birds, respectively, sighted during that period (USFWS 1997b). Spring hawk counts at Fort Hancock on Sandy Hook average nearly 5,000 birds, with the same two species dominating (USFWS 1997c). Other species consistently sighted include Cooper's hawk *(Accipiter cooperii),* northern harrier *(Circus cyaneus)*, osprey *(Pandion haliaetus),* peregrine falcon *(Falco peregrinus),* and merlin *(Falco columbarius).*

Jamaica Bay's islands, because they are somewhat isolated from predation, support large numbers of colonial-nesting waterbirds as well as a variety of migratory species. At least 326 species of birds have been sighted at Jamaica Bay on its islands and at the wildlife refuge, including confirmed breeding by 62 of those species (USFWS 1997b). A mixed-breed heronry on Canarsie Pol includes a variety of nesting waders, including glossy ibis, great egret, snowy egret, cattle egret, black-crowned night-heron, and tricolored heron. A smaller heronry no longer active occurred on Ruffle Bar in 1995. Although no wading birds nested here in recent years, Canarsie Pol also has nesting by the state-listed threatened common tern, as well as by great black-backed gull, herring gull, and American oystercatcher. Common terns occur on several other islands in the bay, including Jo Co Marsh and Silver Hole Marsh, with smaller numbers at Duck Creek Marsh, East High Meadow, Ruffle Bar, and Subway Island. An average of about 1,000 common terns and a maximum of 1,630 common terns nested on the combined seven colonies in Jamaica Bay between 1984 and 1996 (USFWS 1997b).

Laughing gulls *(Larus atricilla)* recolonized Jamaica Bay in 1979; over 99.9 percent of nesting by this species in the state of New York from 1979 to 2007 was associated with the colony at Joco Island in the park. As of 2008, an estimated 1,280 nests were active at this site (Washburn, Lowney, and Gosser 2012).

Ospreys also nest in the Jamaica Bay Unit and elsewhere in the park. Approximately 18 osprey pairs nest in Jamaica Bay, 14 pairs at Sandy Hook, and 1 pair on Staten Island.

Clapper rails *(Rallus longirostris)* and common moorhens *(Gallinula chloropus)* nest in the saltmarshes. American oystercatchers nest at several islands in Jamaica Bay; they also have nested along the airport shoreline. A variety of other birds breed on the islands and uplands in the bay, including one of only two New York State sites for, and the northernmost nesting extent of, the boat-tailed grackle *(Quiscalus major).* Shorebirds known to breed in or around Jamaica Bay include killdeer *(Charadrius vociferus),* American oystercatcher, willet, spotted sandpiper *(Actitis macularia),* upland sandpiper, and American woodcock *(Scolopax minor).*

In addition to providing wintering and nesting habitat, Jamaica Bay is one of the most important migratory shorebird stopover sites in the New York Bight region, especially during fall migration (July to November). The shorebirds use much of the bay during the migration stopovers, but tend to focus on the intertidal areas during low tide and move to East and West Ponds on Ruler's Bar Hassock during higher tides. The water in East Pond is artificially lowered after July 1 each year. From 1981 to 1990, there was an average of 27 and a maximum of 36 shorebird species counted at the East and West Ponds in the Jamaica Bay Wildlife Refuge during the fall. The most abundant shorebirds during that period were black-bellied plover *(Pluvialis squatarola),* semipalmated plover *(Charadrius semipalmatus),* greater yellowlegs *(Tringa melanoleuca),* ruddy turnstone *(Arenaria interpres),* sanderling *(Calidris alba),* semipalmated sandpiper *(Calidris pusilla),* least sandpiper *(Calidris minutilla),* dunlin *(Calidris alpina),* and short-billed dowitcher *(Limnodromus griseus).* Jamaica Bay is also important during spring migration (March to June) on the ponds for several of these same species, as well as red knot *(Calidris canutus).* Hunting is prohibited in the park by virtue of its New York City location, which may contribute to the high numbers of individual ducks and duck species. In one year-round survey of birds at Jamaica Bay, 263,000 individuals of 32 species were recorded (USFWS 1997b).

The combination of geographic location and configuration coupled with productive bay wetlands, flats, and waters in Raritan and Sandy Hook Bays make this another important migratory staging area in the park for many species of waterfowl on the Atlantic Flyway.

The combination of geographic location and configuration coupled with productive bay wetlands, flats, and waters in Raritan and Sandy Hook Bays make this another important migratory staging area in the park for many species of waterfowl on the Atlantic Flyway. Peak migration occurs in late October, but November aerial counts in New Jersey waters still average nearly 45,000 birds (USFWS 1997c). The number of horned grebes *(Podiceps auritus),* as well as common and red-throated loons *(Gavia immer, G. stellata),* during migration is regionally significant. Especially notable are the overwintering scaup concentrations, primarily greater scaup, which have increased in this area recently and are an important component of the Atlantic Flyway population. Other significant species populations include Canada geese in the Raritan River and the Navesink system, American black ducks, canvasbacks *(Aythya valisineria),* mallards *(Anas platyrhynchos),* and brant, along with lesser numbers of bufflehead, oldsquaw *(Clangula hyemalis),* mergansers (primarily red-breasted mergansers *[Mergus serrator]*), common goldeneye *(Bucephala clangula),* and American wigeons *(Anas americana).* These waterfowl are not evenly distributed but rather tend to concentrate along the southern Raritan Bay and Staten Island shorelines, where moderate-sized flocks of scaup and American black ducks and smaller groups of brant occur.

Shrublands and woodlands can offer important feeding or resting habitat for songbirds (or "passerines") in the park, such as sparrows, warblers, and other perching species. As noted above, grasslands at Fort Hancock on Sandy Hook and open areas at Breezy Point support very large spring raptor migrations as well.

Grasslands at Floyd Bennett Field became habitat for certain open-country bird species after the airfield was decommissioned in 1950, and stayed that way until the last few decades, when open areas began to transition into shrub and forest. In 1985, a portion of Floyd Bennett Field was cleared and mowed to create grasslands; about 140 acres are still maintained using these techniques. This area is unique in that it is a large grassland in the urban area of New York City, supporting feeding and resting grassland species that are not seen elsewhere in the city. In addition, several birds have or now use this habitat for nesting, including grasshopper sparrow *(Ammodramus savannarum),* horned lark *(Eremophila alpestris),* eastern meadowlark *(Sturnella magna),* upland sandpiper, savannah sparrow *(Passerculus sandwichensis),* northern harrier, American kestrel, and common barn owl *(Tyto alba).* Use of this area by grasshopper sparrows (a state-listed species) increased significantly in average abundance between 1984 and 1992. Since 1996, however, there have been no grasshopper sparrows nesting at Floyd Bennett Field.

Overwintering grassland birds at Floyd Bennett Field include northern harrier, rough-legged hawk (Buteo lagopus), American kestrel, common barn owl, short-eared owl *(Asio flammeus),* horned lark, eastern meadowlark, and savannah sparrow. The bobolink *(Dolichonyx oryzivorus)* is a regular migrant visitor in the grasslands. Grassland birds, especially upland sandpipers, also use the grassland habitat along the runways at John F. Kennedy International Airport (USFWS 1997b).

The bird community at park sites in the Staten Island Unit is most varied at Great Kills Park, including Crooke's Point. Wintering horned larks, snow buntings *(Plectrophenax nivalis),* and Lapland longspurs *(Calcarius lapponicus)* occupy shoreline habitat, and purple sandpipers *(Calidris maritima),* ruddy turnstones *(Arenaria interpres),* and gulls visit jetties at Crooke's

Point and north of the tidal flats at Great Kills Park (Audubon New York 2013). Fall migrants are numerous and include red-shouldered hawk *(Buteo lineatus),* rough-legged hawk, and northern harrier, as well as numerous warblers, vireos, orioles, and flycatchers. Shorebirds, wading birds, and waterfowl including herons, ibis, and egrets occupy seasonal ponds after heavy rains. Bank swallows *(Riparia riparia)* nest in cliffs southeast of the parking lot.

Reptiles and Amphibians

Species of reptiles in the park include the estuarine northern diamondback terrapin *(Malaclemys terrapin),* seven species of turtles in the terrestrial maritime environment and freshwater wetlands, six species of snakes, and several sea turtles that swim offshore. The eastern hognose snake *(Heterodon platyrhinos)* has recently been reintroduced to portions of the park (Tanacredi and Badger 1995, as cited in NRCS 2001). An additional eight species of amphibians include salamanders, newts, toads, and frogs, including the northern spring peeper *(Pseudacris crucifer),* reintroduced as a food source for the eastern hognose snake. In addition to the eastern hognose snake and spring peeper, several other reptiles and amphibians have been introduced specifically to the Jamaica Bay Wildlife Refuge area of the park. These include Fowler's toad *(Bufo woodhousii fowleri),* gray treefrog *(Hyla versicolor),* green frog *(Rana clamitans),* spotted salamander *(Ambystoma maculatum),* redback salamander *(Plethodon cinereus),* northern brown snake *(Storeria dekayi dekayi),* smooth green snake *(Opheodrys vernalis),* eastern milk snake *(Lampropeltis triangulum triangulum),* northern black racer *(Coluber constrictor constrictor),* snapping turtle *(Chelydra serpentina),* eastern painted turtle *(Chrysemys picta picta),* and eastern box turtle *(Terrapene carolina carolina).*

Although northern diamondback terrapins and eastern box turtles are not listed, they are considered species of management concern by the park and are discussed in more detail in the "Species of Special Concern" section in this chapter of the GMP/EIS.

Sea turtles use the area offshore of several park sites, and loggerhead sea turtles have occasionally been reported coming on shore in the Jamaica Bay or Breezy Point areas (USFWS 1997b).

Fish

Over 100 species of finfish and shellfish have been counted in park-managed waters, with 90 reported in fisheries hauls in the Raritan and Sandy Hook Bays. The most abundant fish species in the Raritan Bay complex are those tolerant of lower salinities and so require an estuarine habitat like that provided off the Staten Island and east Sandy Hook shorelines. These species include mummichog, hogchoker *(Trinectes maculatus),* weakfish, winter flounder, summer flounder, striped bass, sea bass *(Dicentrarchus punctatus), scup (Stenotomus chrysops),* and spot *(Leiostomus xanthurus).* Commercial fisheries exist for American shad *(Alosa sapidissima),* American eel *(Anguilla rostrata),* and American lobster. Blue crabs and horseshoe crabs are taken in a dredge fishery. Species of clams, oysters, and mussels populate the bays, although they are closed to direct-market harvest of shellfish due to pollution (USFWS 1997c; Yuhas 2003, New York Department of Environmental

Conservation website: **http://www.dec.ny.gov/regs/4014.html#12837;** consulted June 17, 2013). Sandy Hook Bay has been re-classified as a special restricted area (following resolution of water quality issues related to Hurricane Sandy), which mean shellfish taken from here can be sold after depuration in clean water tanks (NJ DEP Marine Water Monitoring website: **http://www.state.nj.us/dep/bmw/sandymonmouth.html;** consulted June 17, 2013).

Waters in Jamaica Bay and ocean-fronting park sites on the Rockaway peninsula are home to an estimated 81 species of finfish and shellfish (USFWS 1997b). The majority of species collected in Jamaica Bay, including the commercially important winter flounder, are juveniles using it as a nursery area. Juvenile Atlantic silverside *(Menidia menidia)* composed over 60 percent of all species caught in a seining survey of the bay in 2002 (USACE 2010). Mummichog, Atlantic menhaden, striped killifish *(Fundulus majalis),* and Atlantic silverside compose a prey base in the bay for feeding fish and birds. Recreational landings include scup, bluefish *(Pomatomus saltatrix),* and American eel, many of which are caught in Raritan and Sandy Hook Bays.

Waters in Jamaica Bay and ocean-fronting park sites on the Rockaway peninsula are home to an estimated 81 species of finfish and shellfish.

Essential Fish Habitat

The regional fisheries management councils, with assistance from the National Oceanic and Atmospheric Administration (NOAA)–Fisheries, are required under the Magnuson-Stevens Fishery Management and Conservation Act to delineate essential fish habitat for all managed species to minimize adverse effects and identify actions to enhance and conserve habitat for these species.

Several of the species listed below are currently in danger of overfishing or are currently overfished, (NOAA websites: **http://www.nero.noaa.gov/hcd/STATES4/ConnNYNJ.htm,** consulted June 14, 2013):

- Whiting *(Merluccius bilinearis)* - eggs, larvae and juveniles at Rockaway Beach, Jamaica Bay; eggs, larvae, juveniles and adults off Sandy Hook.

- Red hake *(Urophycis chuss)* - eggs, larvae and juveniles at Rockaway, Jamaica Bay, Sandy Hook and Staten Island

- Winter flounder *(Pseudopleuronectes americanus)* - all life stages at all park units

- Windowpane flounder *(Scophthalmus aquosus)* - all life stages off Staten Island, Sandy Hook and western Jamaica Bay; juveniles and adults in eastern Jamaica Bay.

- Yellowtail flounder *(Limanda ferruginea)* - eggs and larvae off Sandy Hook

- Atlantic sea herring *(Clupea harengus)* - juveniles and adults offshore of Sandy Hook and western Jamaica Bay; adults in eastern Jamaica Bay; larvae, juveniles and adults off Staten Island

- Monkfish *(Lophius americanus)* – eggs and larvae off Sandy Hook and western Jamaica Bay; eggs, larvae and juveniles in eastern Jamaica Bay.

- Bluefish *(Pomatomus saltatrix)* – juveniles and adults in Jamaica Bay, off Staten Island; all life stages offshore Sandy Hook

- Atlantic butterfish *(Peprilus triacanthus)* - all life stages in eastern Jamaica Bay; larvae, juvenile and adults in western Jamaica Bay and Rockaway beaches, offshore Staten Island; juveniles offshore Sandy Hook

- Atlantic mackerel *(Scomber scombrus)* – all life stages in eastern Jamaica Bay; juveniles and adults in western Jamaica Bay and offshore Staten Island

- Summer flounder *(Paralichthys dentatus)* – larvae, juveniles and adults offshore Staten Island and in western Jamaica Bay/Rockaway quadrant; juveniles and adults in eastern Jamaica Bay and offshore Sandy Hook.

- Scup – all life stages in western Jamaica Bay/Rockaway and offshore Staten Island; juveniles and adults offshore Sandy Hook and eastern Jamaica Bay.

- Black sea bass *(Centropristis striata)* - juveniles and adults at Staten Island, western Jamaica Bay/Rockaway, offshore Sandy Hook; juveniles in eastern Jamaica Bay.

- Ocean quahog *(Artica islandica)*- adults found offshore of Sandy Hook

- King mackerel *(Scomberomorus cavalla)* - all life stages offshore of Staten Island, Sandy Hook, Jamaica Bay/Rockaway

- Spanish mackerel *(Scomberomorus maculatus)* - all life stages at all park units

- Cobia *(Rachycentron canadum)* - all life stages at all park units

- Sand tiger shark *(Carcharias Taurus)* - larvae at all park units

- Dusky shark (*Carcharhinus obscurus*)- larvae and juveniles offshore Staten Island and Sandy Hook; larvae in Jamaica Bay.

- Sandbar shark *(Carcharhinus plumbeus)* – larvae and adults offshore Staten Island; larvae, juveniles and adults at other park sites.

- Tiger shark *(Galeocendo cuvieri)* - larvae offshore Sandy Hook and eastern Jamaica Bay

- Bluefin tuna *(Thunnus thynnus)* - juveniles offshore Sandy Hook

- Skipjack tuna *(Katsuwonus pelamis)* - adults offshore Sandy Hook

The mudflat at Plumb Beach supports other invertebrates, including mud snails and Atlantic ribbed mussels (Geukensia demissa), which provide biomass for horseshoe crabs and a variety of birds.

Invertebrates

Aquatic invertebrates are plentiful in the shallow waters of Jamaica Bay. The muddy sediment of the eastern and northern portions of the bay and sandy soils of the southern and western side support a diverse assemblage of benthic species, measured at 121 in a 1983 survey (USFWS 1997b). Amphipod crustaceans such as marine worms supply food for waterfowl and adult winter flounder. The mudflat at Plumb Beach supports other invertebrates, including mud snails and Atlantic ribbed mussels *(Geukensia demissa),* which provide biomass for horseshoe crabs and a variety of birds. Horseshoe crabs in turn lay abundant eggs, which feed many migrating bird species, and in particular sustain the state-listed red knot, a species that must have this food source to successfully complete its migration to the arctic. Sandy soils offshore of park sites support many mollusks and crustaceans, including northern quahog, soft clam, and Atlantic surf clam. The biodiversity, however, is much impoverished compared with what it must have been before the loss of eelgrass beds and oyster reefs.

Terrestrial invertebrates are largely unsurveyed in the park, although studies of butterflies in the 1990s recorded over 50 species (Tanacredi and Badger 1995, as cited in NRCS et al. 2001). American holly at the park is the host for the rare butterfly, Henry's elfin *(Callophrys henrici),* which has been recorded breeding and overwintering in the Raritan Bay/Sandy Hook area (Lawrence, Roman, and Frame 2010). A slightly more recent survey of Jamaica Bay Wildlife Refuge (USFWS 1997a) counted 54 species of butterflies and skippers at the refuge and in surrounding uplands. This survey noted regular use by several rare butterfly and skipper species, including checkered white *(Pieris protodice),* white-m hairstreak *(Parrhasius m-album),* Appalachian azure *(Celastrina neglectamajor),* tawny emperor *(Asterocampa clyton),* and saltmarsh skipper *(Panoquina panoquin)* (USFWS 1997a). More than 489 moth species have been photo-identified in and around Jamaica Bay (S. Walter, pers. comm. n.d.)

Wildlife in Park Sites

An informal survey of park wildlife types completed by Rowan (2012) was used to compile the following assessments of current wildlife status at park sites.

Jamaica Bay Unit

Plumb Beach. Plumb Beach habitat is composed mostly of native species, and the beach is in relatively undisturbed condition in the eastern portion of the site. The only notes made by Rowan include the presence of horseshoe crabs and the potential for recreational fishing. Although shorebird habitat may be available, the heavy use of the area makes nesting unlikely.

Floyd Bennett Field. Open areas of grasslands, meadow, and possible wet areas, including Phragmites, offer habitat for birds, small mammals and their predators (primarily birds), and deer. Rowan noted that feral cats or dogs as well as resident Canada geese are likely present. Grasslands may be used by butterflies, bluebirds, and other grassland or meadow species.

Canarsie Pier Coastal Area, Including Horseshoe Bay, Fountain Avenue and Pennsylvania Avenue Parks, Spring Creek Park Site. The majority of this area is highly disturbed, although mudflats in some areas may support horseshoe crabs. Feral dogs and cats, which may prey on shorebirds or small mammals, are likely present.

Frank Charles Memorial Park. Rowan (2012) did not notice any wildlife and indicated it was likely quite sparse because the park site is small and heavily used.

Hamilton Beach Park. Mudflats at this park site likely support a few invertebrate species. Feral pets are likely present.

Jamaica Bay Fast Islands. The wildlife community on the fast islands, and in particular Canarsie Pol, is important, with wading-bird rookeries and other bird nesting and breeding areas. In addition to its isolation from predators of ground- or colonial-nesting birds, the existing woodland provides habitat for roosting birds.

Jamaica Bay Hassocks. Wildlife at the hassocks is primarily aquatic because these islands are submerged by the tides. Invertebrates and shellfish, crustaceans, waterfowl, seabirds, and shorebirds live and feed in the saltmarsh at lower tide.

Jamaica Bay Wildlife Refuge. The combination of estuarine, saltmarsh, and freshwater habitat provides support for a multitude of migratory bird species, many of which are rare, threatened, or endangered at the state or federal level. The open waters of the refuge ponds support large flocks of resident Canada geese and gulls.

Jacob Riis Park. Although the dune area of this park site could support some wildlife species, habitat is limited by the near absence of vegetation.

Fort Tilden. Habitat in the beach intertidal and splash zone could be home to an abundant assemblage of marine invertebrates. Grasslands and shrublands provide habitat for passerines, including sparrows, warblers, and other species. Fort Tilden is known for raptor migrations between March and May, including many rare or unique species such as northern harriers and ospreys.

Breezy Point Tip. The tip of Breezy Point is excellent shorebird and marine bird/waterfowl habitat. It also is used by terrapins for nesting and is home to surf clams and other invertebrates on relatively undisturbed beach intertidal habitat. Upland dune and shrub habitat is used by a variety of songbirds and waterfowl for feeding, nesting, and resting.

The tip of Breezy Point is excellent shorebird and marine bird/ waterfowl habitat. It also is used by terrapins for nesting and is home to surf clams and other invertebrates on relatively undisturbed beach intertidal habitat.

Staten Island Unit

Fort Wadsworth. Wildlife in Fort Wadsworth would be those species able to live in woodlands and shrublands that are not native to the area. Shoreline areas may support sparse wildlife, although beaches slope quickly to deep water.

Miller Field. The swamp white oak forest may provide habitat for a few woodland birds, although heavy use likely keeps wildlife from permanently residing here.

Great Kills and Crooke's Point. Although Rowan did not observe wildlife, she did note that the wetlands, saltmarsh, and mudflat habitat near shrublands is likely to provide some habitat for native species.

Hoffman and Swinburne Islands. These islands are used by herons, ibis, egrets, and other waterbirds in a mixed-species rookery for nesting.

Sandy Hook Unit

Beaches. Rowan indicated that the sparse natural vegetation at Sandy Hook means the beach or foredune wildlife community is less abundant than it could be. Extensive maritime shrublands behind the foredunes may provide habitat for a variety of passerines. As described in the "Species of Special Concern" section in this chapter of the GMP/EIS, abundant shorebird nesting, including for several listed or unique species, takes place on the beaches of Sandy Hook.

Fort Hancock. Grasslands and old fields near the fort support butterflies and other insects, and offer nesting and feeding opportunities for ground-nesting passerines. Small mammals likely occupy the area as well, which contributes to its value as a raptor migration stopover in the spring (USFWS 1997a).

Internal Shrublands and Woodlands. Internal shrublands and woodlands, including the maritime holly forest, can be important roosting or nesting habitat for birds. These habitats include historical nesting by great blue herons *(Ardea herodias)* and black-crowned night-herons, and currently host ospreys and several species of passerines (USFWS 1997a). Horseshoe and Spermaceti Coves. These coves provide saltmarsh, mudflat, and other habitats important for marine birds and waterfowl.

Species of Special Concern

This section of the GMP/EIS lists plants and animals that are named under the federal Endangered Species Act or a state (New York or New Jersey) Endangered Species Act and are referred to as "listed" species throughout the rest of this section. This section also includes species of park management concern, a category that can include rarity, its ecological niche, or need for management because it is invasive, overabundant, a nuisance or a disease vector for example. Where a species is both listed and of management concern to the park, it is described in more detail. Because federally listed species are of particular management concern to the NPS as a federal agency, they are the focus of separate subsections.

Plants

Table 3-4 shows plants that are state or federally listed and that grow in the park. Vegetation associations are described in the "Vegetation" section in this chapter of the GMP/EIS; some of these are considered imperiled in New York or New Jersey, or globally. Although many more plants are listed as threatened or endangered on the New York or New Jersey lists, the species in table 3-4 are the ones whose presence has been verified at Gateway. Information for the descriptions and status is taken from the New York Natural Heritage Program website (http://www.acris.nynhp.org), New Jersey Endangered and Nongame Species Program, and personal communications with NPS staff.

Table 3-4. State or Federally Listed Plant and Animal Species Known to Occur at Gateway.

Scientific Name	Common Name	Listing
Birds		
Accipiter cooperii	Cooper's hawk	SL
Accipiter gentilis	Northern goshawk	SL
Accipiter striatus	Sharp-skinned hawk	SL
Ammodramus henslowii	Henslow's sparrow	SL
Ammodramus maritimus	Seaside sparrow	SL
Ammodramus savannarum	Grasshopper sparrow	SL
Asio flammeus	Short-eared owl	SL
Asio otus	Long-eared owl	SL
Bartramia longicauda	Upland sandpiper	SL
Botaurus lentiginosus	American bittern	SL
Buteo lineatus	Red-shouldered hawk	SL
Calidris canutus	Red knot	SL
Caprimulgus vociferus	Whip-poor-will	SL
Charadrius melodus	Piping plover	FT, SL
Chlidonias niger	Black tern	SL
Chordeiles minor	Common nighthawk	SL
Circus cyaneus	Northern harrier	SL
Cistothorus platensis	Sedge wren	SL
Dendroica cerulea	Cerulean warbler	SL
Dolichonyx oryzivorus	Bobolink	SL
Eremophila alpestris	Horned lark	SL
Falco peregrinus	Peregrine falcon	SL
Gavia immer	Common loon	SL
Haliaeetus leucocephalus	Bald eagle	SL
Icteria virens	Yellow-breasted chat	SL
Ixobrychus exilis	Least bittern	SL

Table 3-4. State or Federally Listed Plant and Animal Species Known to Occur at Gateway (continued).

Scientific Name	Common Name	Listing
Lanius ludovicianus	Loggerhead shrike	SL
Laterallus jamaicensis	Black rail	SL
Melanerpes erythrocephalus	Red-headed woodpecker	SL
Nyctanassa violacea	Yellow-crowned night-heron	SL
Nycticorax nycticorax	Black-crowned night-heron	SL
Pandion haliaetus	Osprey	SL
Passerculus sandwichensis	Savannah sparrow	SL
Podilymbus podiceps	Pied-billed grebe	SL
Pooecetes gramineus	Vesper sparrow	SL
Rallus elegans	King rail	SL
Rynchops niger	Black skimmer	SL,
Sterna antillarum	Least tern	SL,
Sterna dougallii	Roseate tern	FE, SL
Sterna hirundo	Common tern	SL,
Strix varia	Barred owl	SL
Vermivora chrysoptera	Golden-winged warbler	SL
Invertebrates		
Cicindela dorsalis dorsalis	Northeastern beach tiger beetle	FT, SL
Fish		
Acipenser brevirostrum	Shortnose sturgeon	FE, SL
Acipenser oxyrhynchus	Atlantic sturgeon	FE
Reptiles		
Caretta caretta	Loggerhead turtle	FT, SL
Chelonia mydas	Green turtle	FT, SL
Dermochelys coriacea	Leatherback turtle	FE, SL
Eretmochelys imbricata imbricata	Hawksbill turtle	FE, SL
Lepidochelys kempii	Kemp’s Ridley sea turtle	FE, SL
Terrapene carolina carolina	Eastern box turtle	SL
Mammals		
Balaenoptera borealis	Sei whale	FE, SL
Balaenoptera musculus	Blue whale	FE, SL
Balaenoptera physalus	Fin whale	FE, SL
Eubalaena glacialis	Northern right whale	FE, SL
Megaptera novaeangliae	Humpback whale	FE, SL
Myotis sodalis	Indiana bat	FE, SL
Phocoena phocoena	Harbor porpoise	SL
Physeter macrocephalus	Sperm whale	FE, SL

Table 3-4. State or Federally Listed Plant and Animal Species Known to Occur at Gateway (continued).

Scientific Name	Common Name	Listing
Plants		
Amaranthus pumilus	Seabeach amaranth	FT, SL
Bidens laevis	Smooth bur-marigold	SL
Cenchrus tribuloides	Sanddune sandbur	SL
Chenopodium rubrum	Red pigweed	SL
Cuscuta polygonorum	Smartweed dodder	SL
Cyperus flavescens var. *flavescens*	Yellow flatsedge	SL
Cyperus lupulinus ssp. *lupulinus*	Hop sedge	SL
Cyperus retrorsus	Retrorse flatsedge	SL
Cyperus schweinitzii	Schweinitz’s flatsedge	SL
Digitaria filiformis	Slender crabgrass	SL
Eupatorium leucolepis var. *leucolepis*	White-bracted boneset	SL
Eupatorium torreyanum	Fringed boneset	SL
Galium concinnum	Shining bedstraw	SL
Glaux maritima	Sea milkwort	SL
Juniperus horizontalis	Creeping juniper	SL
Lycopus rubellus	Gypsy wort	SL
Magnolia virginiana	Sweetbay magnolia	SL
Oenothera humifusa	seabeach evening-primrose	SL
Oenothera laciniata	Cut-leaved evening-primrose	SL
Oenothera oakesiana	Oakes’ evening-primrose	SL
Polygonum glaucum	Seabeach knotweed	SL
Quercus phellos	Willow oak	SL
Solidago sempervirens var. *mexicana*	Seaside goldenrod	SL
Suaeda linearis	Narrow leaf sea-blite	SL

Sources: NPS n.d.h; NYDEC n.d.a, n.d.b, and n.d.c; NJDEP 2010, n.d.a, and n.d.b.
SL = state listed; FT = federally threatened; FE = federally endangered

Many of the state-listed plants at the park are either saltwater or freshwater wetland or marsh species. These include smooth bur-marigold *(Bidens laevis),* a state threatened plant that is found primarily in freshwater and tidal mudflats; red pigweed *(Chenopodium rubrum),* found along the coast in wet interdunal swales, rocky beaches, and the shores of coastal ponds and saltmarshes; smartweed dodder *(Cuscuta polygonorum)*, which grows in wet meadows and moist shores and riverbanks; and gypsy wort *(Lycopus rubellus),* found in marshes and flooded swamps. High saltmarsh listed plants include a subspecies of seaside goldenrod *(Solidago sempervirens var. mexicana)* and narrow leaf sea-blite *(Suaeda linearis),* although these species are also found in grasslands (goldenrod) or interdunal swales and beaches (sea-blite). Woodland or palustrine wetland state-listed species found at the park include shining bedstraw *(Galium concinnum),* found in hardwood forests and along the banks or swampy ground next to streams; sweetbay magnolia *(Magnolia virginiana)*, which grows in red maple palustrine wetlands; and willow oak *(Quercus phellos),* which occupies floodplain forests, as well as grasslands or roadside forests where the soil is moist.

The remaining state-listed plants grow on the open sandy areas of the park's coastline, including the upper beach, foredune, and more inland dunes. These include sanddune sandbur *(Cenchrus tribuloides)*, a dune species found at Great Kills Park; creeping juniper *(Juniperus horizontalis),* an evergreen shrub that occupies wetland shores and stream banks in addition to dunes; cut-leaved and Oakes' evening-primrose *(Oenothera laciniata, Oenothera oakesiana),* which grow on dry sandy soils on dunes or along roadsides; seabeach knotweed *(Polygonum glaucum),* which occupies beach and adjacent dune and saltmarsh habitat and has been found in the Sandy Hook Unit of the park; southern arrowwood *(Viburnum dentatum var. venosum),* a species that grows on dry, sandy, coastal habitat including dunes and old fields; slender crabgrass *(Digitaria filiformis),* which grows on sandy disturbed areas near the coast; two species of boneset (white-bracted, *Eupatorium leucolepis var. leucolepis,* and fringed, *E. torreyanum),* which grow in sandy, open habitats including weedy or shrubby roadsides, grasslands, and dunes; and four flatsedges. The flatsedges have been collected from wet sandy sites, beaches, roadsides, and additional areas where the sand is windblown or otherwise mobile. They include yellow flatsedge *(Cyperus flavescens var. flavescens),* hop sedge *(C. lupulinus ssp. lupulinus),* retrorse flatsedge *(C. retrorsus),* and Schweinitz's flatsedge *(C. schweinitzii).*

Many of these state-listed species are ranked S1 or S2 in the state, which means there are fewer than 5 (S1) or 20 (S2) known occurrences statewide.

Many of these state-listed species are ranked S1 or S2 in the state, which means there are fewer than 5 (S1) or 20 (S2) known occurrences statewide. The rarest (S1) species include smartweed dodder, yellow flatsedge, retrorse flatsedge, slander crabgrass, white-bracted boneset, shining bedstraw, creeping juniper, gypsy wort, sweetbay magnolia, cut-leaved primrose, willow oak, seaside goldenrod, and narrow leaf sea-blite.

Although the park does not have specific management goals for any of these state-listed species, it does work toward restoring maritime vegetative communities and many of the species that are rare in the park live in those communities. These include red maple *(Acer rubrum),* red and black chokeberry *(Aronia arbutifolia, A. melanocarpa),* common hackberry *(Celtis occidentalis),* American holly *(Ilex opaca),* eastern red cedar *(Juniperus virginiana),* northern bayberry *(Myrica pensylvanica),* black cherry *(Prunus serotina),* and several species of oak (pin *[Quercus palustris],* white [Q. alba], scarlet *[Q. coccinea],* northern red *[Q. rubra],* black *[Q. velutina]*, and chestnut oak *[Q. prinus]).* The park also lists restoration of the estuarine eelgrass community as of management concern (NPS 2013f).

Federally Listed Plant Species – Seabeach Amaranth

Seabeach amaranth is the only federally listed plant species occurring at the park. Seabeach amaranth *(Amaranthus pumilus)* is a federally threatened species listed in 1993 and is considered endangered by both New York and New Jersey. It is an annual vascular plant that inhabits upper beaches and overwash areas, primarily at the accreting end of barrier spits like Sandy Hook. It occupies a narrow beach zone that lies at elevations from 0.2 to 1.5 meters above mean high tide. Without overwash to maintain the open, sparsely vegetated habitat required by the species, it can be outcompeted by other plants and eliminated.

Seabeach amaranth has been lost over much of its former range on the east coast, primarily from development and stabilization of barrier island beaches. Coastal storms are considered the single most important natural limitation on the abundance of seabeach amaranth and have both positive effects from habitat creation and negative ones from flooding. The primary nonnatural threat is alteration of habitat from beach erosion and shoreline stabilization (NPS 2004f). Seabeach amaranth was considered extirpated from the state by 1913 until 2000, when it was rediscovered. In 2005, a large population of more than 3,000 plants was found at Sandy Hook; this population remains the largest in New Jersey.

Populations of seabeach amaranth at any given site are extremely variable (Weakley and Bucher 1992, as cited in NPS 2007a) and can fluctuate by several orders of magnitude from year to year. The primary reasons for the natural variability of seabeach amaranth are the dynamic nature of its habitat and the effects of stochastic (random) factors such as weather and storms on mortality and reproductive rates. Although wide fluctuations in species populations tend to increase the risk of extinction, variable population sizes are a natural condition for seabeach amaranth and the species is well adapted to its ecological niche. While the numbers of plants has varied state to state as well, the U.S. Fish and Wildlife Service (USFWS) notes a geographic shift of the largest populations from North Carolina to New York (NPS 2007a).

In addition to the large Sandy Hook population, sites in the Jamaica Bay Unit support seabeach amaranth. Numbers are lower in these park sites; 2007 counts indicated Breezy Point Tip contained 123 plants; Fort Tilden, 11; and Jacob Riis Park, 8 (NPS 2007b). The lower number of plants at Jacob Riis Park is associated with the removal of fencing used to attempt protection of piping plover (Charadrius melodus) nests, because these two species often occur together. The number of plants at Breezy Point Tip grew from 123 in 2007 to 862 plants in 2009, illustrating the variability in the population from year to year (NPS 2009d).

The recovery goals for the park for seabeach amaranth are a long-term average population of at least 2,000 plants and a five-year minimum population of no fewer than 1,000 plants (NPS 2009e). To help in meeting these goals, the park takes the following actions:

- Erecting symbolic fencing (string and post) around plants to create a 10-meter buffer to reduce loss from trampling by visitors

- Keeping habitat for this species available by prohibiting dense planting of other vegetation

- Collecting and storing seabeach amaranth seeds to repopulate in case of catastrophic events or population declines

- Evaluating the potential for, and planting seeds in, suitable areas of the park
- Monitoring the presence and condition of all known populations in the park

Invertebrates

Terrestrial invertebrates are largely unsurveyed in the park, although studies of butterflies in the 1990s recorded over 50 species (Tanacredi and Badger 1995, as cited in NRCS 2001). American holly at the park is the host for the rare butterfly, Henry's elfin *(Callophrys henrici),* which has been recorded breeding and overwintering in the Raritan Bay/Sandy Hook area (Lawrence, Roman, and Frame 2010). A slightly more recent survey of Jamaica Bay Wildlife Refuge (USFWS 1997b) counted 54 species of butterflies and skippers at the refuge and in surrounding uplands. This survey noted regular use by several rare butterfly and skipper species, including checkered white *(Pieris protodice),* white-m hairstreak *(Parrhasius m-album),* Appalachian azure *(Celastrina neglectamajor),* tawny emperor *(Asterocampa clyton),* and saltmarsh skipper *(Panoquina panoquin)* (USFWS 1997b). While only the checkered white butterfly is state listed, each is considered a species of concern by New York.

The park has identified aquatic invertebrates horseshoe crab (Limulus polyphemus), hardshell clam or quahog (Mercenaria mercenaria), and common oyster (Crassostrea virginica) as species of management concern with the objective of increasing the park population of all three. The rare white checkered butterfly is also of management concern at the park, with an increased population as a goal. Eelgrass and oysters are considered key extirpated species (along with Atlantic bay scallop *[Argopecten irradians])* of the original estuarine benthic communities of Jamaica Bay's littoral zone (NPS 2010b).

Federally Listed Invertebrate Species – Northeastern Beach Tiger Beetle

This species is listed as threatened under the federal Endangered Species Act and as endangered in New Jersey.

The northeastern beach tiger beetle *(Cicindela dorsalis dorsalis)* is a predatory species that forages for insects, lice, and fleas in the sand of the intertidal zone. Adults also scavenge dead crabs and fish. Populations of tiger beetles normally experience very high larval mortality and dramatic year-to-year, two- to threefold fluctuations in abundance, sometimes resulting in local extinction. Weather factors such as flood tides, hurricanes, erosion, and winter storms; mortality due to predators and parasites; and recreational beach use all contribute to the population declines (NPS 2004f).

Early records indicate that the northeastern beach tiger beetle occurred in "great swarms in July" along coastal beaches from Martha's Vineyard south to New Jersey and on both sides of Chesapeake Bay in Virginia and Maryland. Ideal habitat for the adult beetles and their larvae are wide, undisturbed, dynamic, fine sand beaches. The most important consideration, however, is limited use and disturbance by vehicles and humans; northeastern beach tiger beetles are so sensitive to human disturbance, for example, that a recent management document (NPS 2007a) recommended prohibiting all but emergency NPS off-road vehicle use from tiger beetle areas and limiting human use to fewer than 50 people per week during the summer and fall, and then only as walkers along the water's edge.

Disturbance from vehicular traffic and foot traffic has resulted in the extirpation of the beetle from New York State, particularly from the beaches of Long Island, where it had once been prevalent. Although it was not present in the park in recent times, it was reintroduced to the northern section of Sandy Hook in 1994 using larvae from the Chesapeake Bay. Additional reintroductions of larvae to the park have continued through 2006 (NPS 2007a). NPS monitors this species in coordination with the USFWS though annual surveys. Adult populations are estimated to be around 500 individuals according to annual surveys, although the population size varied dramatically from 1994 to 2003, with a low of 18 in 1996 to a high of 955 in July 2000 (NPS 2004f).

A recent management plan for the park's listed species identifies several measures intended to minimize human disturbance or improve habitat. These include establishing a protection zone at North Beach of Sandy Hook, minimizing NPS vehicle use in beetle larva habitat, removing invasive vegetation that diminishes beetle habitat, and exploring beach nourishment in additional areas of Sandy Hook to cover riprap or other structures and restore habitat (NPS 2009e). No tiger beetle adults or larvae have been reported from other areas of Sandy Hook except the reintroduction areas on North Beach. Recent inventories suggest the population may have once again died out (Avrin, pers. comm. 2013).

Fish

The park has not identified any fish species as of management concern (NPS 2009f, NPS 2013f). Only two listed species are known to occupy park-managed waters; both are federally listed and are described below.

Federally Listed Fish Species

Both the Atlantic sturgeon *(Acipenser oxyrinchus)* and shortnose sturgeon *(Acipenser brevirostrum)* are listed as federally endangered fish species using the marine and estuarine environment offshore of the park. Both are demersal and anadromous, migrating from the marine environment to freshwater to spawn during late winter–early summer in the lower sections of rivers. Juvenile sturgeons remain in freshwater for their first summer before migrating to estuaries in winter. Juveniles remain in the freshwater-estuary system for three to five years before migrating to the nearshore marine environment as adults. Migration into the marine environment has only recently been documented for the shortnose sturgeon (NOAA 2013). Atlantic sturgeons have been found in surveys and recreational landings in Jamaica Bay (NPS 2010b).

Reptiles and Amphibians

One amphibian, the eastern spadefoot toad *(Scaphiopus holbrookii),* is a species of special concern and a species of management concern for the park (NPS 2009f). It is not listed as threatened or endangered, but is rare. This species is found in pine or associated forests, such as the red cedar forest in the park. It is ranked S2 (between 6 and 20 occurrences) and is managed at the park for increased population.

Several federally listed sea turtles (leatherback *[Dermochelys coriacea],* hawksbill *[Eretmochelys imbricata imbricata],* Kemp's Ridley *[Lepidochelys kempii],* and loggerhead *[Caretta caretta])* named in table 3-4 may swim in NPS-managed coastal waters and may occasionally come ashore in the park. However, because no actions in any alternative are expected to affect marine species, they are not discussed further.

Four reptiles are of management concern at the park. While each is a species of concern, none is state or federally listed. The park is managing for increases in population for three of the species—spotted turtle *(Clemmys guttata),* eastern hognose snake *(Heterodon platyrhinos),* and eastern box turtle *(Terrapene carolina carolina)*—and for increased nesting success for the fourth, northern diamondback terrapin *(Malaclemys terrapin).*

The eastern hognose snake occupies sandy areas and feeds on toads and frogs. The park has reintroduced this species to some areas. Although it is not a listed species, it is ranked as S3 (between 21 and 100 occurrences) and is considered a regional species of concern in the northeastern United States (NYDEC 2013a). Both the spotted turtle and the terrapin are semiaquatic; spotted turtles are found in wet woodlands, freshwater marshes and wet meadows, whereas the terrapin is a brackish-water species. Jamaica Bay provides important breeding habitat for terrapins, as well as providing habitat for the largest northern diamond back terrapin population in the northeast (NPS 2010b). Ruler's Bar Hassock and Little Egg Island, as well as dunes south of the Jamaica Bay visitor center (USFWS 1997c), are known nesting sites in the park. Within the Jamaica Bay Unit, 11 other sites have suitable upland habitats for nesting; however, development in these areas limits access and use (NPS 2010b). Of these 11 potential nesting areas, 5 are located along developed portions of the Jamaica Bay north shoreline. Other nesting areas include Dubos Point (outside the park) and Floyd Bennett Field (USFWS 1997c). Both the terrapin and the spotted turtle are of statewide concern and are ranked S3. The eastern box turtle is a land turtle that occupies deciduous forests with a moist forest floor. It is also ranked S3 in New York and is of regional concern in the northeastern United States.

Birds

All state-listed birds at the park are managed to increase occurrence or increase nesting populations. Federally listed birds in the park include piping plover and roseate tern *(Sterna dougallii),* discussed separately below.

Breezy Point Tip, Sandy Hook, and Jamaica Bay are each important habitats for listed and/or rare shorebirds, waterbirds, wading birds, and seabirds. At Sandy Hook, piping plover and least terns *(Sterna antillarum)* nest, red knots *(Calidris canutus)* rest and feed, roseate terns feed, and ospreys *(Pandion haliaetus)* nest. As noted in the "Wildlife" section in this chapter of the GMP/EIS, migrations are substantial at these locations, with birds concentrating along the shorelines of park sites and adjacent areas. Migratory hawks number in the thousands at Sandy Hook and Breezy Point Tip, with several state-listed species, including sharp-shinned hawk *(Accipiter striatus),* northern harrier *(Circus cyaneus),* and Cooper's hawk *(Accipiter cooperii)* among those sighted at both Sandy Hook and Breezy Point Tip, and osprey and peregrine falcon *(Falco peregrinus)* additionally recorded at Breezy Point Tip. Approximately 25 osprey pairs nest in the Jamaica Bay Unit of the park, 14 pairs at Sandy Hook, and 1 pair on Staten Island. Fourteen pairs of ospreys have nested at the Jamaica Bay Wildlife Refuge and Breezy Point Tip in recent years (USFWS 1997b; NPS 2009d; Frame and Avrin, pers. comm. 2013). Overwintering grassland birds at Floyd Bennett Field include raptor species northern harrier, red-shouldered hawk *(Buteo lineatus),* and short-eared owl *(Asio flammeus),* as well as grassland species horned lark and savannah sparrow *(Passerculus sandwichensis).* Listed grassland birds that have been confirmed nesting at Floyd Bennett Field include horned lark, upland sandpiper *(Bartramia longicauda),* savannah sparrow, and northern harrier (USFWS 1997b). Grasshopper sparrows *(Ammodramus savannarum)* nested in the grasslands at Floyd Bennett Field between 1984 and 1992, but nests have not been found in recent years. Bobolinks *(Dolichonyx oryzivorus)* have also been seen during migration at Floyd Bennett Field. Several of these species also use grasslands along the runways at John F. Kennedy International Airport adjacent to Jamaica Bay.

Jamaica Bay islands are largely isolated from disturbance and predation and as a result support large numbers of nesting waterbirds and diverse populations of migratory birds throughout the year. A heron rookery on Canarsie Pol supported many nesting wading birds, including state-listed black-crowned night heron *(Nycticorax nycticorax)* as well as other species of heron, ibis, and egrets. Canarsie Pol has also been the site of nesting by common terns *(Sterna hirundo)* and American oystercatchers *(Haematopus palliatus),* an unlisted species of special concern in New Jersey ranked as S3 with 21–100 occurrences in New York. A smaller heronry occurred on Ruffle Bar in 1995. Common terns occur on several other islands in the bay, including Jo Co Marsh and Silver Hole Marsh, with smaller numbers at Duck Creek Marsh, East High Meadow, Ruffle Bar, and Subway Island. An average of about 1,000 common terns and a maximum of 1,630 common terns have nested on the combined seven colonies in Jamaica Bay since 1984 (USFWS 1997b). Seaside sparrow *(Ammodramus maritimus)* and least bittern *(Ixobrychus exilis)* have also been spotted in the Jamaica Bay Unit.

The bay itself has a variety of habitats, including mudflats, saltmarsh, and sandy shorelines, that are important to shorebirds and other water-dependent species. Twenty-two species of shorebirds are currently found in the Jamaica Bay estuary; historically, 44 species had been identified here. Shallow-water areas also provide fishing habitat for foraging wading birds, including nine species of herons (NYCDEP 2007). Both the federally endangered roseate tern and threatened piping plover nest or have attempted nesting in Jamaica Bay habitat, as have common terns, pied-billed grebes *(Podilymbus podiceps),* peregrine falcons, and northern harriers (NYCDEP 2007).

Nesting by several state-listed shorebirds either currently takes place or has taken place in the recent past in locations at Breezy Point Tip. Common tern nesting numbers have varied from 30 in 1988 (when monitoring first indicated nesting) to more than 4,000 in 1994. In recent years, it has diminished steadily, from 1,990 in 2006 to 324 in 2009 (NPS 2007a, 2009d). This may be a function of increasingly dense vegetation in some Breezy Point nesting areas. Least tern nesting has also been variable at Breezy Point Tip, although it has declined fairly steadily since numbers peaked in 1991 at 1,128 to 18 in 2009. Although 18 is a low number, it represents a substantial increase over the 0 nesting birds at the site in the years 2005–2008 (NPS 2009d). Black skimmers *(Rynchops niger),* a species of special concern listed as S2 by the state of New York and a species of management concern for the park, have apparently ceased nesting at the Breezy Point Tip, given that no nests have been discovered since 2002, although 750 nesting black skimmers were recorded just two years earlier (NPS 2009d). With the scouring effect of Hurricane Sandy in removing shrublands and dense coastal vegetation, it is possible that several or all of these shorebird species will once again nest at Breezy Point Tip. Species recorded at Jamaica Bay and not noted above include bald eagle and yellow-crowned night heron *(Nyctanassa violacea).* Very rarely observed species here include northern goshawk *(Accipiter gentilis),* black rail *(Laterallus jamaicensis),* king rail *(Rallus elegans),* roseate tern, black tern *(Chlidonias niger),* long-eared owl *(Asio otus),* and red-headed woodpecker *(Melanerpes erythrocephalus)* (Davis n.d.).

Bird species recorded at Floyd Bennett Field and not noted otherwise in this section include vesper sparrow *(Pooecetes gramineus);* this species has been seen only rarely in the area (NPS n.d.f).

The park takes multiple measures to protect and enhance habitat for several of its listed birds. These fall into a few main categories, which include increases in program staffing, minimizing human disturbance, managing predators, enhancing and restoring habitat, education, and monitoring. For some species, fireworks or NPS vehicles used on the beach are also issues; a recent management plan (NPS 2009e) lists actions to keep these activities from unduly disturbing nesting birds. The majority of these measures are aimed at sustaining and improving the park's existing piping plover nesting population, but these same actions assist other protected species that live or breed in the same vicinity, such as northeastern beach tiger beetles, least terns, seabeach amaranth, common terns, seabeach knotweed, and seabeach evening-primrose *(Oenothera humifusa),* a state-listed plant in New Jersey. These measures are discussed in more detail in the piping plover subsection below. A few measures to improve conditions for intertidal mudflat or estuarine species such as terrapins, black rails, American bitterns, red knots, horseshoe crabs, and American oystercatchers were also identified in the park's *Shoreside Threatened and Endangered Species Beach Management Plan* (NPS 2009e). Measures include better signs and enforcement for recreational use at Spermaceti and Horseshoe Coves and Plum Island at Sandy Hook to protect habitat for these species; evaluating the potential for restoration of bayside habitats, including the possible removal of shoreline stabilization structures; and *Phragmites* removal.

Federally Listed Birds

Roseate terns *(Sterna dougallii)* are listed as endangered under the federal Endangered Species Act and by both New York and New Jersey. This species nests almost exclusively on rocky or saltmarsh islands where predation pressure is lower than on mainland sites. Colonies are often located close to shallow-water locations where the terns can fish. Roseate terns are threatened by the loss of breeding habitat to development, rising sea level and related storm surge, human disturbance, and predation. A few roseate terns have nested in the park, but recent surveys at Breezy Point Tip did not show any breeding roseate terns here after 1999. Breeding numbers have always been low, peaking in 1998 at six (NPS 2009d).

Piping plovers *(Charadrius melodus)* are small shorebirds listed as threatened under the federal Endangered Species Act. Piping plovers at the park are part of the Atlantic Coast population, one of three population segments listed in the country. No critical habitat has been identified or proposed for this population (NPS 2004f).

Plovers arrive at the park nesting beaches in mid-March; nests are established above the high tide line on coastal beaches, on sandflats at the end of barrier spits, in washover areas cut into dunes, and on suitable dredge material. Access to feeding areas such as bayside flats, inlets, ephemeral pools, and the intertidal beach are important to productivity and survival of chicks. If these access routes from the nest are vegetated, chicks are less able to detect hidden mammalian predators. Eggs can be laid any time from early April to late July and chicks may be present from mid-May until late August. The productivity goal for the mid-Atlantic population established by the USFWS is 1.5 chicks per nesting pair for five years, a goal the park population has not reached on average. There is also extreme variability in nesting success for plovers; productivity at Sandy Hook has ranged from 0.36 chicks per pair to as high as 1.94 in the years 1991 to 2003 (NPS 2004f). Weather and predation, particularly by the park's red fox (Vulpes vulpes) population, is implicated as the cause of the very low number of 0.36 chicks per pair fledged at Sandy Hook in 1997.

Breeding by piping plovers also occurs at park sites along the Rockaway barrier spit, including at the Surf Club, West Beach, Fort Tilden, and Jacob Riis Park. In 2009, the number of chicks fledged per pair ranged from an average low of 0.25 at Jacob Riis Park to a high of 2 at the Surf Club location. Historical data show that nesting at Breezy Point Tip has also been variable, with the number of chicks fledged per pair fluctuating from a high of 1.89 in 2006 to 0.68 in 2009 (NPS 2009d).

The park now constructs predator-resistant fencing around nests to keep foxes, feral cats, opossums, and raccoons from capturing chicks at the nest site. The park also traps potential predators and depending on available staff time can catch quite a few in a given nesting season. For example, 15 cats, 10 opossums, and 10 raccoons were trapped in 2007 at the Breezy Point Tip. Foxes are also caught at the Sandy Hook sites. Crows and gulls also prey on plover eggs and chicks, and the park takes measures such as destroying gull nests in the vicinity of nesting plovers. In recent years, the park has begun to suspect that nesting American oystercatchers may be contributing to piping plover nest abandonment (NPS 2009d).

Recreational activities can be a source of direct mortality and harassment of nesting plovers. Plovers that flush because of human disturbance leave eggs or chicks exposed to predation and excessive temperatures. High concentrations of beachgoers can also keep plovers from using otherwise suitable habitat (NPS 2004f). The park monitors some of the violations by recreationists who enter beaches where posted signs indicate the area is closed. In Breezy Point Tip, even occasional monitoring noted 115 visitors in the closed area, including with pets or motor vehicles.

Once hatched, chicks almost immediately leave the nest and move along the beach and to other areas to feed. This places them outside park-fenced areas and increases their vulnerability to predation or to pedestrian or beach vehicle traffic. Although most of the park is closed to over-sand vehicle traffic, over-sand vehicles are allowed during non-nesting times at Breezy Point Tip and park rangers use them for emergencies and to patrol beaches.

The park has established six protected areas on Sandy Hook. In these areas, no over-sand vehicles are permitted except for NPS law enforcement and emergency use; dogs are prohibited from March to September; and predators are monitored. Exclosures are placed around all plover nests.

The *Shoreside Threatened and Endangered Species Management Plan for the Sandy Hook Unit* (NPS 2009e) noted that, in addition to the USFWS recovery goal of 1.5 chicks per pair on average for five years, the park has set goals of an average nesting population at Sandy Hook of 51–65 pairs for five years, and annual predation losses at or below 15 percent. To help in meeting these goals, the park has proposed additional measures beyond those already established. These include a 100-meter buffer from nests; prohibiting all vehicles, including NPS vehicles, except in emergencies; prohibiting kite flying and kite surfing within 650 feet of protected areas; expanding protection zones if needed; increasing the intensity of predator monitoring and management; removing any attraction for predators, such as trash and fish offal; trapping and relocating foxes and using lethal control when necessary; allowing fireworks only outside the breeding season; prohibiting beach raking between April and December; and the use of signs, meetings, and other education and interpretation media to inform visitors of pet, trash, and closure policies.

Mammals

Several marine mammals that may use park-managed waters are listed. These include sei *(Balaenoptera borealis),* blue *(Balaenoptera musculus),* fin *(Balaenoptera physalus),* humpback *(Megaptera novaeangliae),* and northern right whales *(Eubalaena glacialis),* as well as the state-listed harbor porpoise *(Phocoena phocoena).* All of the whale species are both state- and federally listed as endangered. Humpback whales occasionally feed in New York Bay adjacent to the Rockaway Inlet (USFWS 1997c) and sei, humpback, and sperm whales *(Physeter macrocephalus)* have been noted swimming in Raritan Bay. The park does not have a management objective for any of these species except for the harbor porpoise, where the park has stated a desire to increase the predictability of its seasonal occurrence. None of the actions in any of the alternatives would change conditions for these species or impact them in any way. They are therefore not considered part of the affected environment and are not discussed further in this GMP/EIS.

Indiana bat *(Myotis sodalis)* is a federally and state-endangered species that hibernates in caves and mines during the winter. Its roosts consist of trees, both living and dead. In New York, there are 10 hibernation areas for Indiana bats that appear to be stable. Thirteen maternity and bachelor colonies are also known to be present in the state, although some of these are threatened by increasing development. The total count in New York has recently increased from 13,000 to 40,000 bats, largely because of improvements in counting methods and the discovery of new hibernation areas. A recent (January 2013) survey of listed species in New Jersey indicated that the Indiana bat was not present at Gateway (USFWS 2013).

Cultural Resources

Introduction

For management purposes, the NPS recognizes five categories of cultural resources: archeological resources, historic structures, cultural landscapes, ethnographic resources, and museum collections. Because no effects to ethnographic resources are anticipated from the proposed actions analyzed in this GMP/EIS, that topic has been dismissed and is not discussed further. For this document, the park has chosen to present cultural landscapes in the context of historic districts. The following description of these resources is gleaned primarily from NPS-28: *Cultural Resource Management Guideline* (NPS 1998a).

Archeological resources are the remains of past human activity and records documenting the scientific analysis of these remains. They are typically buried, but may extend aboveground. These resources are commonly associated with pre-contact peoples but also may be products of more contemporary societies. At Gateway, the vast majority of archeological resources fall into this latter category.

Structures include such things as buildings, bridges, roads, forts and associated earthworks, monuments, ruins, and other manufactured objects that extend the limits of human capability. The manufacture and use of structures provide humans the ability to live in harsh climates and in areas far removed from where they work and live.

Historic districts are defined as resources that possess a significant concentration, linkage, or continuity of sites, buildings, structures, or objects united historically or aesthetically by plan or physical development (NPS 1990a).

Cultural landscapes are defined as a geographic area, including both natural and cultural resources, associated with a historic event, activity, or person. Cultural landscapes are listed in the National Register of Historic Places (National Register) when their significant cultural values have been documented and evaluated within appropriate thematic contexts and physical investigation has determined that they retain integrity. They are classified in the National Register as sites or districts or may be included as contributing elements of larger districts (NPS 1998a).

Museum collections are described as assemblages of objects, works of art, historical documents, and/or natural history specimens collected/maintained so they can be preserved, studied, and interpreted for public benefit.

In the following description of existing conditions, the effects on Gateway's cultural resources from Hurricane Sandy in the fall of 2012 must be mentioned. These storm-related effects range from detectable/not substantial to considerable in scope, much of which was dependent on the location of the resources. The most significant damage occurred to resources located immediately along the coastlines, particularly in the Sandy Hook Unit and along Jamaica Bay (Jacob Riis Park, Fort Tilden, Breezy Point Tip), which sustained considerable wind and water damage. Preliminary damage assessment efforts immediately after the storm focused primarily on the historical cultural resources of the park and typically included descriptions of severe erosion and sand redeposition, flooding, and wind damage. Damage assessments are ongoing. The following represents general descriptions of typical storm damage to cultural resources in the park:

- Erosion/exposure of buried resources (e.g., Battery Kessler at Fort Tilden Historic District)

- Flooding/storm surge (e.g., seawall at Battery Weed, Fort Wadsworth Historic District; Jacob Riis Park/bathhouse/associated facilities, Jacob Riis Park Historic District; Fort Hancock and Life Saving Station at Fort Hancock and Sandy Hook Proving Ground National Landmark Historic District, also referred to as Fort Hancock and Sandy Hook Proving Ground)

- Sand deposition (e.g., Jacob Riis Park facilities, Jacob Riis Park Historic District; roads located within Fort Hancock and Sandy Hook Proving Ground National Landmark Historic)

- Wind damage to a variety of structures throughout the park

Many of the park's impacted cultural resources are either listed in or eligible for listing in the National Register. Comprehensive damage assessments are underway and will provide specific information on the condition of any damaged historic properties. Preliminary damage assessments led the park to believe that the National Register status of the majority of the park's resources will be retained.

Cultural Resource Context for Gateway

The cultural resources of the park represent tangible manifestations of humans interacting with their environment and with each other throughout time, up to the present day. To understand the effects of the alternatives on the cultural resources of Gateway, a summary context is presented below. Much of this information is gleaned from archeological overview and assessment documents prepared for Gateway (NPS 2009a, 2011a, 2011b, 2011c). The information provided is intended to be a brief summary of cultural context of the study area; please refer to the documents referenced for additional detail.

Pre-Contact to Contact Context

Because the coastal areas of the park would have provided pre-contact inhabitants with a variety of important natural resources and transportation routes, it is reasonable to assume that undiscovered, buried cultural resources reflecting earlier lifeways may still exist. The potential for such discoveries varies by location and the history of natural and human impacts.

The pre-contact human use of the New York/New Jersey area dates back approximately 12,000 years. Although human history is known to vary locally and regionally within a defined area, it is generally believed that the major pre-contact periods for the Gateway area (as defined by existing material culture assemblages) are as follows:

- Paleo-Indian (ca. 12,500–10,000 years BP)
- Archaic (ca. 10,000–2,700 years BP)
- Woodland (ca. 2,700 years BP to European Contact, ca. AD 1600)

It is believed that Paleo-Indian cultures used the coastal areas of New York and New Jersey by exploiting the megafauna and tundra environment of the Late Pleistocene. It is theorized that inhabitants of the area lived in small, mobile bands whose movements were dependent on proximity to resources.

It is believed that Paleo-Indian cultures used the coastal areas of New York and New Jersey by exploiting the megafauna and tundra environment of the Late Pleistocene. It is theorized that inhabitants of the area lived in small, mobile bands whose movements were dependent on proximity to resources. Their subsistence patterns likely included the use of both animal and vegetable resources. Lithic tools characteristic of the period (distinctive fluted points, scrapers, knives, etc.) suggest that hunting, butchering, and animal processing were an important part of the subsistence strategy. Evidence of Paleo-Indian use of the study area is sparse. Although an isolated projectile point was located in Great Kills area of Gateway (NPS 2011a) and other manifestations of Paleo-Indian use of the general region are evident, no Paleo-Indian sites have been recorded within the park boundaries.

The Archaic period is subdivided into Early, Middle, and Late stages and, in general, is characterized by adaptation to a post-Pleistocene climatic transition. This is reflected by a variety of resource procurement strategies as the more temperate conditions of the Holocene began to prevail. Human use of the study area during this period suggests diverse hunting and gathering activities, likely employed by small, mobile social groups. Human reliance on a wide variety of flora and fauna is apparent, as are a variety of technological innovations (groundstone tools, gouges, knives, net-sinkers, etc.) (JMA 1978). During the later part of the Archaic period, settlement patterns appear to be associated with seasonal resource availability. Although manifestations of human occupation of northern New Jersey and the New York Harbor during the Archaic period have been recorded, no archeological sites dating definitively to this period have been recorded in the study area.

The Woodland period is also divided into Early, Middle, and Late stages and, in general, is characterized by considerable technological changes (e.g., production/use of ceramics), more intensive subsistence practices, an increasing trend toward sedentism (living in one place), larger settlements, changes in social organization, and long-distance trade. Technological advances in tool making are represented by a variety of distinctive projectile point styles and pottery. Woodland sites in and around the study area reflect more intensive and continuous use and occupation of the area, with a reliance on shellfish and a variety of other floral and faunal resources. Coastal shell middens have "preserved evidence of a variety of shellfish, fish, white-tailed deer, turtle, and other small mammals as well as bone and stone tools and ceramic types" (NPS 2011c, 9). The effects of the introduction/use of pottery significantly improved the efficiency of food preparation and storage, and pottery styles become more stylized and distinctive in the later part of the Woodland period. Horticulture based on maize, beans, and squash becomes apparent during the Late Woodland times, and is often associated with increased social complexity. Village sites near permanent rivers and other water sources were likely occupied year-round, while smaller occupations farther from the coast were used for seasonal hunting and gathering activities. Several sites dating to the Woodland period have been identified within the study area and are characterized by the presence of ceramic sherds (fragments), lithic artifacts, and shell middens indicative of the period (NPS 2011b, 2011c).

The Contact period, beginning around AD 1600, marks a time when indigenous groups were making contact with Europeans along coastal areas of the Northeast. At that time, many indigenous people of the area were living in year-round villages and seasonal camps.

The Contact period, beginning around AD 1600, marks a time when indigenous groups were making contact with Europeans along coastal areas of the Northeast. At that time, many indigenous people of the area were living in year-round villages and seasonal camps. Archeological evidence of their activities includes shell middens, shellfish-processing sites, cemeteries, and forts/trade houses. Numerous communities of Munsee-speaking Delaware Indians are documented in early records written during the first decades of Dutch contact and through archeological evidence. People speaking what Van der Donck later called the Manhattan language lived on the islands of New York Harbor, along the lower Hudson River estuary, and on the shores of Long Island opposite Staten Island (Grumet 2009). At the time of contact with Europeans, at least 13 separate groups of Native Americans were known to reside in the coastal portions of the study area. All of these groups were associated with the larger Algonquian-speaking people of the Lenape (Delaware) cultural group. Prior to contact, human cultures of the area were characterized by a wide diversity of cultural adaptation representing change over thousands of year. The exploration of the Lower Hudson River and the early 17th century fur trade resulted in very rapid Dutch colonization of the area, which brought about a dramatic change in the population, economy, social organization, and material culture of local indigenous groups. Disease, warfare with Dutch settlers, and land loss were the major factors bringing about change in indigenous population levels and ways of life. As access to food, farmland, and resource-collecting areas was being restricted by Europeans, the indigenous peoples who did survive moved inland. The Native American occupation of the area was largely supplanted by European colonization by the time the Dutch handed over New Netherlands to Great Britain in 1664. Contact period settlements typically include small amounts of European goods (metal kettles, glass beads, bottles, etc.) intermixed with larger amounts of indigenous-material cultural items. Several Contact period sites are known to have existed in the area around Gateway, but none have been recorded in the park.

General Historical Context

The following historical context of the study area is focused on presenting information related to cultural resources that have the potential to be affected by proposed park actions, with emphasis on those defined in this GMP/EIS as "fundamental." Fundamental resources are defined as those considered vital to maintaining the park's purpose and significance. Other cultural resources not considered fundamental are included and presented more broadly.

This summary is not intended to provide a comprehensive narrative on the history of Gateway. Rather, it is designed to provide a summary of the people and events that played a role in the major historical themes of the park: namely, those related to maritime, military, and aviation history. These historical influences have significantly shaped the history of the area and many resources, dating from the Revolutionary War to the Cold War, reflect this.

The historical development of the Gateway area is one involving diverse coastal, island, marsh, and aquatic environments. The structure of settlements, land use, industry, transportation, and landscape modification is complex and closely linked to the development of the entire region. By the mid-17th century, a number of small European settlements existed along the New Jersey and New York coastlines. Like the Native Americans, early settlers made use of the wide range of coastal natural resources—fish, shellfish, and wildlife—for food, and by the mid-19th century, such resource-harvesting endeavors were commercialized. Agriculture was also a major economic activity of settlers in the area, resulting in the need for processing mills. Among others, the Dutch and British established permanent early settlements in the harbor area.

Throughout historical times, the New York Harbor has served as one of the most convenient and active deep-water ports on the eastern seaboard. Surrounded by land favorable for urban development, the harbor consequently became commercially important to the Dutch, the British, and the Americans, eventually supporting New York City. Consequently, defensive strategies have been implemented for centuries to protect the harbor from assault and capture. Early earthwork fortifications, first built by the Dutch and British to repel ground forces and enemy vessels, later gave way to U.S. artillery emplacements and fortifications surrounding the harbor that were designed to destroy enemy vessels and protect local residents. During the last half of the 20th century, defensive structures and weapons related to the Nike Missile Program played a role in the national defense system.

The following summarizes the major historical themes represented at Gateway. Although addressed separately, there is considerable overlap among them. In the discussion, the use of the term “historic districts” refers to historic districts listed in the National Register.

Maritime History

The first recorded European observations of the New York Harbor were made by the Italian explorer Giovanni De Verrazano in 1524. In the early 17th century, explorers had discovered that the natural harbor of New York and the adjacent Hudson River Valley provided wide-reaching access into the region's interior. From the Colonial period to the mid 19th century, early development in the harbor area focused on maritime safety, transportation and trade, and temporary defensive fortifications designed to protect maritime interests and provide harbor defense. The ship-building industry dates to the 17th century in the harbor area and continues today. European development grew rapidly along the coastal areas of what is now New Jersey and New York, and by the 19th century harbor traffic was extensive (ferries, barges, schooners, clippers, steamships, etc.). As the importance of the harbor for commerce and transportation increased through the years, its defense became imperative and resulted in a variety of temporary and permanent fortifications along the perimeter of the harbor (NPS 2011b) (see "Military History").

Structures dedicated to ship navigation and lifesaving are well represented in the maritime cultural record of the area. The Sandy Hook Lighthouse, a National Historic Landmark, was first illuminated on June 11, 1764, generated by 48 oil-fueled lamps.

Structures dedicated to ship navigation and lifesaving are well represented in the maritime cultural record of the area. The Sandy Hook Lighthouse, a National Historic Landmark, was first illuminated on June 11, 1764, generated by 48 oil-fueled lamps. Today it is the oldest continuously operating lighthouse in the United States and the only surviving one of the 11 lighthouse buildings dating to the Colonial period. The Elm Tree Light, a contributing structure at Miller Army Airfield Historic District, has undergone several transformations. A 1797 map marks an elm tree that was considered a mark for vessels coming and going from New York in the late 18th century. Evidence of it also shows on 1826 and 1850 maps. Although it was not certain that a beacon was actually hung in the tree in these earlier times, there was some kind of light noted in 1852. The current Elm Tree Light was constructed by the U.S. Coast Guard in 1939 to replace an earlier tower that had served as a mark for sailing vessels in the late 18th century (Wren 1974; NPS 1979a). The first Fort Tompkins lighthouse was replaced in 1893 with a new light constructed on the top of Battery Weed (see below) to provide better protection of the shipping lane through the Narrows. The light was visible for 14 nautical miles. The light was decommissioned in 1965 (Olmsted Center for Landscape Preservation 2008).

In the late 17th century, harbor pilots were guiding vessels through the channels of New York Harbor, playing a critical role in preventing shipwrecks and strandings. One archeological site, a former tavern on Sandy Hook, is associated with harbor pilots and s listed in the National Register for its potential to yield information about harbor pilots, among other things. Buoys marking harbor channels existed as early as 1778. In 1889, an electric generator on the north end of Sandy Hook served five buoys in Gedney Channel (NPS 2009a).

Organized lifesaving efforts are known to have existed in the harbor area by the 19th century, with lifeboats stationed at various localities around the harbor (e.g., Rockaway Inlet and others spaced between Sandy Hook and Little Egg Harbor) (PBS&J 2009). During this era, lifesaving stations were also being constructed that would prove crucial for saving shipwreck victims. The Sandy Hook Life Saving Station No. 1, built in 1848 near the tip of Sandy Hook, no longer exists. The extant Spermaceti Cove Life Saving Station (1894) was constructed about 1,000 feet from the No. 1 station and was identified as Station No. 2 (see below for additional information). The station was decommissioned in 1949 as an active U.S. Coast Guard Station and has served as a visitors' center for the park since 1974. Additional lifesaving stations built in 1855, 1872, and 1891 on Sandy Hook no longer exist. There is also mention of a former mid-19th century lifesaving station being located in the Fort Tilden area (NPS 2011c), with the possibility that archeological evidence of it may still be present (Linck 1981).

Lifesaving stations were staffed with volunteers and adhered to no regulations, standards of practice, or reporting requirements. In 1878, the lifesaving system was officially named the U.S. Life Saving Service, which would include paid surfmen and the construction of new stations. Between 1871 and 1914, the service “aided 28,121 vessels, and rescued or aided 178,741 persons, while only 1,455 people lost their lives” (NPS n.d.a, 4). In 1915, the U.S. Life Saving Service merged with the U.S. Revenue Cutter Service to become the U.S. Coast Guard (NPS n.d.a; PBS&J 2009). The U.S. Coast Guard Station is currently located at the northwest end of Sandy Hook. The Spermaceti Cove Life Saving Station on Sandy Hook is an extant example of these structures.

Military History

Seacoast fortifications along the New York Harbor area date to the early days of discovery and colonization of the New Jersey and New York coastlines. Since the Colonial period, the defense of New York Harbor was considered critical for commerce and the defense of the United States. The fortifications included a variety of forts and batteries dating back to the late 18th century and continuing through the Cold War era. Technological advances in weaponry and construction techniques through time resulted in greatly improved fortifications, some of which were built over earlier, outdated structures. The following describes the evolution of the defense systems represented in the New York Harbor areas of Gateway.

Seacoast fortifications along the New York Harbor area date to the early days of discovery and colonization of the New Jersey and New York coastlines. Since the Colonial period, the defense of New York Harbor was considered critical for commerce and the defense of the United States.

First System Defenses

Since the early 18th century, there have been attempts to defend and protect the coast and harbor areas of New York and New Jersey. The first system of defense dates to 1794 when it seemed the United States might be drawn into European wars following the French Revolution (New York City, Landmarks Preservation Commission 1974). Fortifications (batteries, forts) dating to the Revolutionary War and the War of 1812 are mentioned in historical literature, but little evidence of them remains (NPS 2009a). One example, described as a crude defensive structure, is said to have been constructed in the current Fort Wadsworth area and was designed to protect the Narrows area of the harbor (Black 1983).

Second System Fortifications, 1807–1815

Conflicts on the seas arose between the United States and Great Britain in the early 19th century, initiating a new defense program characterized by open batteries built of earth and wood and casemated masonry structures. These structures were centered in the New York Harbor area, particularly the inner harbor close to and on Manhattan. The fortifications were used in the War of 1812 and were built to defend against enemy vessels such as the British ship HMS Victory. The cannons had the ability to fire on enemy ships up to 1 mile away (NPS 2013a). A temporary fortification on Sandy Hook—Fort Gates—included a wooden stockade and blockhouse, constructed in the general area of the current Fort Hancock. Archeological evidence of the fort was likely disturbed by grading and excavating for later building foundations, etc. (NPS 2009a).

Third System Fortifications, 1817–1867

Third System fortifications in the harbor area were characterized by elaborate enclosed masonry structures and were equipped with numerous smoothbore iron cannons that could fire up to 3 miles, a significant improvement over second system defense weapons. These fortifications were also used during the Civil War against potential enemies. Examples of these fortifications are Battery Weed and Fort Tompkins at Fort Wadsworth and the fort at Sandy Hook (which was never completed) (NPS 1984a, n.d.b).

Endicott-era Defenses, 1890–1910

Weaponry developed during the Civil War and after had advanced significantly, making masonry forts and smoothbore cannons obsolete. In 1885, the U.S. government convened the Endicott Board to create a new system of defense. The board, led by Secretary of War William C. Endicott, studied existing U.S. and European weapons technology and submitted a report to President Grover Cleveland in 1886 calling for a comprehensive defense system to protect the United States' most important ports and harbors from naval attack. The defenses were to consist of "high-powered guns and mortars mounted on concrete emplacements; submarine mine-fields; floating batteries and torpedo boats; and rapid-fire guns to protect the minefields" (NPS 1984a, 60). The batteries featured "breech-loading guns made of steel, mounted on 'disappearing' carriages that were designed to recoil behind a parapet wall during reloading, protecting the defenders" (NPS n.d.b, 5).

Table 3-5. Endicott- and Taft- Era Batteries, Fort Hancock, and Sandy Hook Proving Ground.

Battery Name	General Description	Approximate Date of Construction
Potter	Large-caliber gun battery; two 12-inch disappearing-carriage guns	1891
Granger	Large-caliber gun battery; two 10-inch counterweight disappearing-carriage guns	1896
Nine-Gun	Large-caliber gun battery	1902
Mills	Large-caliber gun battery	1917
Kingman	Large-caliber gun battery	1917
Mortar	Large-caliber gun battery, prototype for future gun batteries of the Endicott system	1890
Engle	Rapid-fire gun battery, one 5-inch gun on pedestal mount	1898
Morris	Rapid-fire gun battery, four 3-inch guns on pedestal mount	1904
Urmston	Rapid-fire gun battery, four 15-pounders and two 3-inch guns on pedestal mount	1899–1904
Gunnison	Rapid-fire gun battery, two 6-inch counterweight disappearing-carriage guns	1904
Peck	Rapid-fire gun battery	1902
Arrowsmith (Ruin)	Three 8-inch disappearing-carriage guns	1908

Endicott era = 1890–1905; Taft era = 1907–1945

Weaponry included guns with ranges of 7 to 9 miles. High-velocity guns were able to fire projectiles four times heavier and to ranges two to three times greater than earlier weaponry (NPS n.d.b). The use of these long-range guns on enemy ships in the harbor allowed United States Navy vessels the necessary time to reach the enemy. Some Endicott-era defenses remained in use until 1945. Extant examples within Gateway include fortifications at Fort Hancock and Sandy Hook Proving Ground and Fort Wadsworth (NPS 1984a, 1985) (see tables 3-5 and 3-6). Construction during this time at Fort Hancock and Sandy Hook Proving Ground resulted in the demolition of prior defensive fort structures. There is also evidence that ordnance and munitions, both fired and disposed of, related to military operations at Fort Hancock and Sandy Hook Proving Ground are still present on the ground and in the waters adjacent to the Fort (Panamerican Consultants 2001).

Table 3-6. Endicott-Era Batteries, Fort Wadsworth Historic District.

Battery Name	General Description	Approximate Date of Construction
Duane	Five 8-inch counterweight disappearing-carriage guns	1895–1897
Catlin	Six 3-inch rapid-fire guns	1902–1904
Bacon	Two 3-inch rapid-fire guns	1899
Turnbull	Six 3-inch rapid-fire guns	1902–1903
Barbour	Two 6-inch counterweight disappearing-carriage guns, two 4.7-inch rapid-fire guns	1898
Hudson	Two 12-inch counterweight disappearing-carriage guns, one 6-inch counterweight disappearing-carriage gun, one 4.7-inch rapid-fire gun	1898-1899
Mills	Two 6-inch counterweight disappearing-carriage guns	1899–1900
Upton	Two 10-inch counterweight disappearing-carriage guns	1896–1899
Dix	Two 12-inch counterweight disappearing-carriage guns	1902
Barry	Two 10-inch counterweight disappearing-carriage guns	1897–1899
Richmond	Two 12-inch counterweight disappearing-carriage guns	1898–1899
Ayers	Two 12-inch counterweight disappearing-carriage guns	1900–1901

Endicott era = 1890–1905

New York Harbor Defenses, 1907–1945

As was the case with earlier defense systems, many of the Endicott-era defenses were eventually replaced with newer weapons and technology. In 1905, the Taft Board—headed by Secretary of War William Taft—proposed improving the Endicott defenses and adding fortifications to possessions newly acquired in the Spanish-American War (NPS 2006c). Beginning in 1907, Taft-era improvements to existing fortifications included general electrification, telephone communications, searchlights, and motorized ammunition hoists (Layton and Foulds 2010). Observation posts and plotting rooms were used to refine information on target direction and bearing and speed of enemy ships with great accuracy (please refer to “Fort Tilden Historic District—Battery Harris, Battery Construction 220, Battery Kessler, and Nike Missile Launch Site”). This information was then relayed to artillery guns crews for their use in targeting the enemy.

Within a short period (by 1915), it became apparent that the disappearing-carriage guns in use were not sufficient to defend against the longer-range firing capabilities of new battleships. As a result, construction was begun on new large-caliber gun batteries with high-angle gun carriages that had a range of over 20 miles (compared with the 7- to 8 mile range of counterweight-carriage guns). The high-angled carriages on rotating platforms allowed a 360-degree field of fire (Layton and Foulds 2010).

Following World War I, the need to defend against air attacks became apparent, which resulted in additions to the area's defense system including rapid-fire anti-aircraft guns and the use of camouflage techniques. During the post–World War I period and the World War II period, new 16-inch gun batteries were constructed. During the latter period, existing 12- and 16 inch barbette guns were armored with thick concrete enclosures, covered by tons of sand, and camouflaged with natural vegetation. This was intended to render them virtually invisible from the air and impervious to most aerial bombs.

Being waged with airpower, World War II used strategies dramatically different from those used in earlier conflicts. Aircraft carriers became extremely important and radar developed by the U.S. Army on Sandy Hook was employed to provide early warning of approaching enemy aircraft. Examples incorporating Taft-era improvements include structures at Fort Hancock and Sandy Hook Proving Ground and Fort Wadsworth (NPS 1984a, 1985) (see table 3-5).

Nike Missile Defense System, 1954–1974

After World War II, the coastal artillery was abandoned and anti-aircraft guns remained as the only defense for the coastline and harbor. However, the limited capabilities of this defensive strategy—jet planes were able to fly higher and faster than the guns' capabilities—led to the development of the Nike Air Defense Missile (Nike Missile). Between the Cold War years of 1954 and 1974, 19 Nike Missiles encircled the New York Harbor area. The Nike Missile defense strategy required soldiers to be stationed at either the missile launch areas or the radar sites (Integrated Fire Control Area); soldiers lived at the sites and worked 24-hour duty shifts.

The Ajax was the first Nike Missile employed with the capability of destroying a target at 30 miles. The Hercules, with a range of over 96 miles and the ability to carry a nuclear warhead, began to replace the Ajax around 1958. All Nike batteries were disarmed in 1974 in compliance with the Strategic Arms Limitation Talks (SALT) treaty signed by the United States and the Soviet Union.

Nike Missile installations are still evident at Gateway at Fort Hancock and Sandy Hook Proving Ground and Fort Tilden. Both maintained two missile batteries, each with underground magazine storage rooms and large elevators that raised/lowered missiles (NPS 1984a, U.S. Department of the Interior 2009).

Aviation History

Both commercial and military aviation were quickly evolving after World War I. The early history of aviation in the United States is well represented in several Gateway facilities dating back to the early 20th century, including Floyd Bennett Field, Miller Army Airfield, and the Rockaway Naval Air Station (now the site of Jacob Riis Park).

Floyd Bennett Field

New York City opened its first municipal airport in 1931 with the dedication of Floyd Bennett Field. The new state-of-the-art airport was located on Barren Island and was named for a Congressional Medal of Honor recipient and navy pilot, Floyd Bennett. Rated highly by the Civil Aeronautics Board, it included concrete runways, an administration building/terminal, and Hangar Row, consisting of four identical rectangular two-bay aircraft hangars. Floyd Bennett Field was a popular site with aviators seeking to break records, and numerous transcontinental and transatlantic flights used the facility as a start or end point during the 1930s. In 1938, Howard Hughes and his crew, starting and ending their flight at Floyd Bennett Field, completed an around-the-world flight—14,791 miles in 3 days, 19 hours, 8 minutes and 10 seconds—to gather navigational data (NPS 2010c). The interest in these aviation records reflected the public's interest in aviation and contributed to improving both piloting skills and technology (NPS 1978).

New York City opened its first municipal airport in 1931 with the dedication of Floyd Bennett Field. The new state-of-the-art airport was located on Barren Island and was named for a Congressional Medal of Honor recipient and navy pilot, Floyd Bennett.

In 1933, Floyd Bennett Field was the second busiest airport in the country. Unfortunately, very little of the traffic was commercial and the lack of revenue was problematic. In 1939, Municipal Airfield 2 (later renamed LaGuardia Airport) opened. Unable to compete with LaGuardia and Newark Airports, the city sold Floyd Bennett Field to the United States Navy in 1941. During World War II, it was renamed Naval Air Station, New York. The navy expanded the facilities from 387 acres to 1,288 acres and continued to operate the field for 30 years (NPS 2010c).

The navy already had an established presence at Floyd Bennett Field, where pilots and ground crews from a Naval Air Reserve Squadron trained throughout the 1930s. A U.S. Coast Guard Air Station was also established at Floyd Bennett Field in 1936 (NPS 2010c). During World War II, "neutrality patrols" were established to protect the convoys of ships carrying war materials from New York to Great Britain. These patrols, involving PBY Catalinas (flying boats) and other naval patrol aircraft, flew from Floyd Bennett Field and other naval air stations to offer protection to convoys from German U-boats.

The navy's later interest in the helicopter for use in air-sea rescue operations resulted in the establishment of the first helicopter pilot and mechanic training facility in the world at Floyd Bennett Field in 1943. The ability to take off and land vertically would prove invaluable in rescuing downed servicemen in areas inaccessible to other aircraft. The airborne rescue capabilities of the helicopter were proven, and the first associated rescue equipment was developed and tested at Floyd Bennett Field (NPS 2010c, 2011c).

Floyd Bennett Field was redesignated as a Naval Air Reserve Training Station in 1946. In 1950, it was redesignated as the Naval Air Station, New York. In 1971, the navy deactivated the field and soon after, Gateway took over the management of the field. Today, the Ryan Visitor Center (which originally served as the historic passenger terminal) has been renovated to reflect the Golden Age of Aviation in the 1930s. It provides visitors with information and educational exhibits related to the period when Floyd Bennett Field served as New York City's municipal airport. Volunteers with the Historic Aircraft Restoration Project use Hangar B at Floyd Bennett Field to work in the preservation of historic aircraft and interpret them for the public (NPS 2010c) (see the "Other Important Cultural Resources" section in this chapter for additional information on Floyd Bennett Field).

Miller Army Airfield (Miller Field)

When completed in 1921, Miller Field included, among other structures, a concrete seaplane ramp, a sod runway, two landplane hangars, and two seaplane hangars (NPS 1979a). From 1923 to 1940, the New York National Guard's 102nd Observation Squadron was the major air unit at Miller Field. During this period, both military and civilian aircraft used the airfield. It was the home of the only Air Coast Defense Station on the East Coast during World War II when seacoast guns and observation towers were added. During the 1950s and 1960s, Miller Field was used by a variety of military aircraft (NPS 2013b). Other entities that used Miller Field from the 1950s through its closing in 1969 included the Civil Air Patrol, the National Guard, and U.S. Army Reserve troops. It was the last grass runway in New York City when it was deactivated by the army in 1969 (NPS 1979a).

Miller Field was also the site of several early experimental tests by private aircraft manufacturer Remington-Burnelli. In the spring of 1929, the American Aeronautical Corporation assembled and tested two Italian seaplanes—the SS-55 twin-hulled Savoia-Marchetti flying boat and the S-62 Savoia-Marchetti flying boat—at the airfield (NPS 1979a).

In 1973, when Miller Field was transferred to the NPS, about 24 structures existed at Miller Field; all were deteriorated. The landplane hangar was demolished in 1976, and the site was converted to paved areas and playing fields laid out over parts of the old airfield (see "Miller Army Airfield Historic District, Hangar No. 38" in the "Other Important Cultural Resources" section for additional information on Miller Field).

Rockaway Naval Air Station

The Rockaway Naval Air Station was located on undeveloped New York City park land and included 21 buildings in 1918. These included hangars for servicing HS-2 flying boats, for housing blimps, and for housing Navy-Curtiss flying boats, as well as a variety of other aviation-related structures. In 1919, one of the four Navy-Curtiss flying boats that departed from the air station completed the first transatlantic flight "totaling 3,936 miles in 53 hours, 58 minutes" (NPS 2011c, 25). Today, Jacob Riis Park, part of Gateway, occupies the location of the earlier Naval Air Station.

Fundamental Resources

Coastal Defense Resources

Fort Hancock and Sandy Hook Proving Ground National Historic Landmark District—Fort Hancock Parade Grounds, Endicott/Taft-era Batteries, and Nike Launch and Radar Sites

The information presented below is summarized primarily from the Fort Hancock and Sandy Hook Proving Ground National Historic Landmark District nomination form (NPS 1984a), the Fort Hancock and Sandy Hook Proving Ground Historic District nomination form (NPS 1980a), and the Cultural Landscape Report for Fort Hancock (NPS 2006b); please refer to these documents for additional detail.

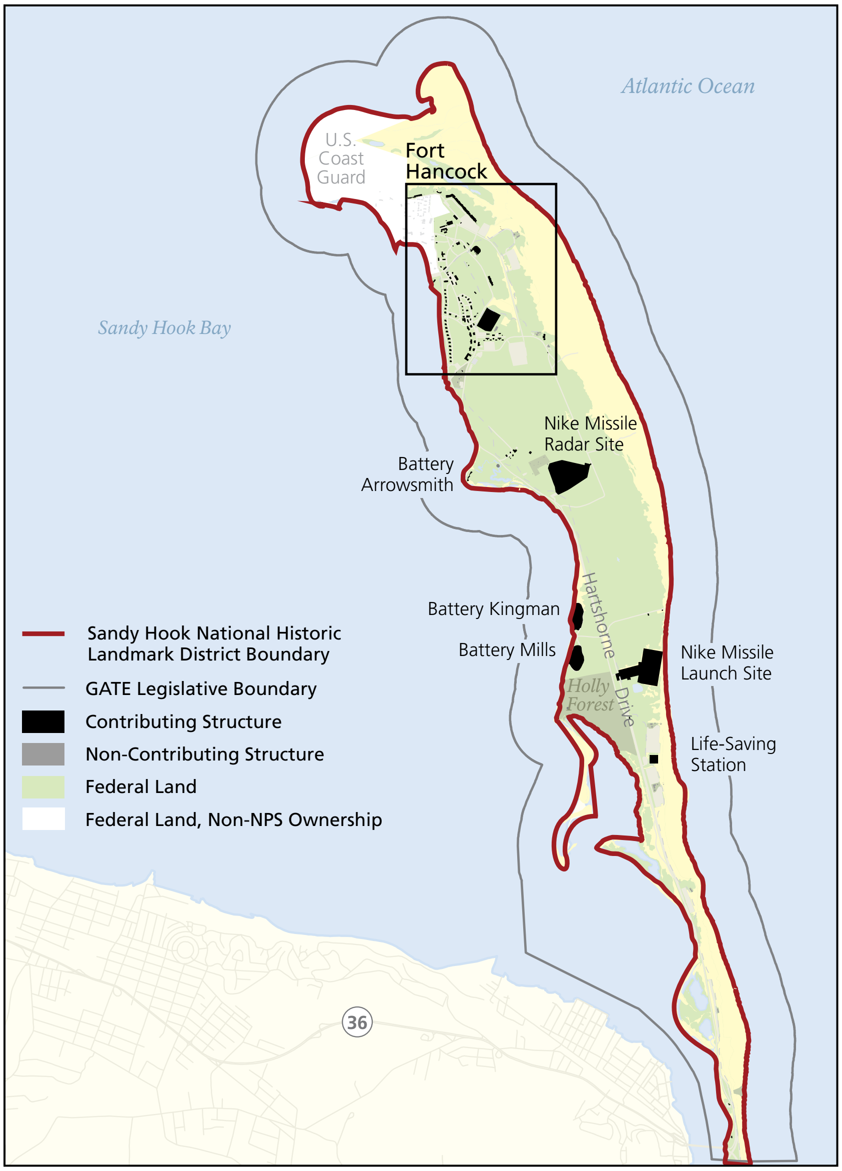
Fort Hancock is in the Fort Hancock and Sandy Hook Proving Ground National Historic Landmark District in the Sandy Hook Unit of Gateway (figure 3-3). Originally defined as including the more heavily developed northern area of Sandy Hook, it was listed on the National Register in 1980 as a historic district (NPS 1980a). In 1982, the district was designated as a National Historic Landmark, with boundaries encompassing the entire Sandy Hook peninsula, including all NPS, U.S. Coast Guard, U.S. Army, and State of New Jersey property. It also includes the Sandy Hook Lighthouse—also listed as a National Historic Landmark—and the Spermaceti Cove Life Saving Station, listed separately in the National Register (see below). The district also contains approximately 110 significant historic buildings and 16 batteries dating from the last quarter of the 19th century through the first half of the 20th century. The district reflects the history of the U.S. Army's Ordnance Department Proving Ground and Fort Hancock Military Reservation, both vital defense installations protecting New York City from 1895 through the Cold War era. It also played a significant role in the development of radar systems and the radar equipment that would eventually be located on Sandy Hook (NPS 1984a). For nearly 80 years, the fortifications at Fort Hancock and Sandy Hook Proving Ground contributed to the protection of the United States' most important harbor and its largest city, New York (NPS 1984a).

Two separate periods of significance exist for the district. The first period is associated with the Sandy Hook Proving Ground (1874–1919), and the second is related to the theme of coastal defenses associated with Fort Hancock and Sandy Hook Proving Ground (1859–1974) (figure 3-3). Nearly all the structures in the district contribute to its significance. A few examples in Fort Hancock and Sandy Hook Proving Ground include Officers' Row, the enlisted men's barracks, the mess halls, post headquarters, post hospital, bachelor officers' quarters, Sandy Hook Light, and the Spermaceti Cove Life Saving Station, among others (see NPS 1984a for complete listing).

The Sandy Hook Proving Ground operated from 1874 to 1919 and is considered the most significant part of the district, playing a key role in weapons development by the United States. The test facility, located on the northeast edge of the Fort Hancock cantonment, became one of the U.S. Army's most important facilities. Four structures—the Proof Battery, the Brick House, the Powder Magazine, and the Chemistry Lab—exist today as the most important of the remaining buildings in the proving ground (NPS 1984a). Three are managed by the park; the fourth (the chemistry lab) is managed by the U.S. Coast Guard.

As major technological advances in weaponry were occurring around the world, the proving ground played a vital role in the testing of experimental guns and carriages for the seacoast defenses of the country. All the big guns and mortars and their carriages "mounted in the Nation's Endicott and Taft period coast fortifications from early 1890s through World War II were developed at Sandy Hook and many of them were proved there" (NPS 1984a, 7). The proving ground was deactivated in 1919 when improvements in weapons technology made the short test field at Sandy Hook too small (NPS 2009c).

Figure 3-3. Fort Hancock and Sandy Hook Proving Ground National Historic Landmark District.



Source: NPS 2013b.

In 1886, the Endicott Board called for a comprehensive defense system to project the country's most important ports and harbors from attacks from the sea (see "Military History"). Under this and later programs, Sandy Hook evolved into one of the most important complexes guarding the approaches to the New York Harbor. Once the construction of the Endicott defenses was underway at Sandy Hook, permanent facilities for a garrison were needed. The site of Fort Hancock was selected and plans for an initial 34 buildings were drawn. The site was cleared and graded and a parade was laid out with the officers' quarters arranged along a linear alignment on the western edge of the parade. The enlisted men's barracks were constructed on the eastern side. The buildings are centered on two open space areas—the parade ground and the athletic field (Layton and Foulds 2010; NPS 1984a). Many of the more than 100 buildings at Fort Hancock share stylistic similarities—distinctive buff brick and Classical Revival ornamentation—and are grouped to take advantage of views of Sandy Hook Bay to the west. The initial buildings were completed around 1899 and construction at the fort continued at a steady pace up to 1918, when it began to slow. Today the fort is composed primarily of the buildings erected at the turn of the century (NPS 1984a).

Figure 3-4. Example of Endicott-Era Battery: Battery Peck, Open Battery Commander's Station, Circa 1905-1910, Looking Southeast.

Source: NPS 2010c, 113.

The Fort Hancock and Sandy Hook Proving Ground National Historic Landmark District sustained considerable damage from Hurricane Sandy. Fort Hancock structures experienced flooding (in basements) and many have substantial damage to porches, piers, and columns and will need stabilization. Ninety percent of the structures within Fort Hancock need electrical repair, including Officers' Row House #1, "History House." Roof damage is evident on many structures and sand and debris covered many of the parking areas, roads, and driveways. Numerous trees were blown down. Infrastructure and equipment were lost throughout the area. Erosion/damage around some Endicott-era fortifications and the Nike Missile Launch Site was noted. The museum collection housed at Fort Hancock was at considerable risk and was moved to Fort Wadsworth to ensure its preservation (IMT 2012a, b).

The large, open parade ground is one of the most distinctive features of the Fort Hancock landscape. It is defined by "the architecture of Officers Row, the linear row of senior officers' quarters that back onto the Parade Ground and face Sandy Hook Bay" (NPS 2006b, 16). The parade ground also contributes heavily to the spatial relationship of the landscape, which is central to the historical character of the Fort.

The Sandy Hook Endicott- and Taft-era batteries associated with Fort Hancock and Sandy Hook Proving Ground are presented in table 3-5. For summary information on Endicott/Taft-era batteries, please refer to "Military History."

The boundaries of battery sites extend beyond the aboveground masonry batteries and include "engineered slopes in front of the masonry structures, and battery service areas to the rear of the masonry structures" (Layton and Foulds 2010, 3). This design was an attempt to make the structure indistinguishable from the surrounding landscape at a distance.

All the Fort Hancock and Sandy Hook Proving Ground batteries have experienced some degree of deterioration and loss of integrity. In the case of Battery Arrowsmith, built in 1908, the battery is considered to be in an "extremely ruinous state and coastal storms continue to break apart the remaining structure and the peninsula upon which it sits" (Layton and Foulds 2010, 318). In 1995, gun decks were demolished by the USACE, leaving only about 30 percent of its original structure intact. Still, it is believed that the ruins convey a "sense of the structure's size and shape and is thus contributing" to the district as a ruin (NPS n.d.e).

Figure 3-5. Looking West at Target Tracking Radars, Fort Hancock and Sandy Hook Proving Ground, Control Area No. 1, Nike Radar Site, Circa 1962.

Source: Layton and Foulds 2010.

In the 1950s, Nike Missile installations—a response to the threats of the nuclear age—were placed on Sandy Hook. The launch area (14.69 acres) consisted of the "launching complex where missiles were stored in underground silos and a radar tracking and control station with equipment for acquiring targets, tracking targets, and tracking the flight of outbound missiles" (Layton and Foulds 2010, 471). The Nike Missile installation at Fort Hancock and Sandy Hook Proving Ground was one of only a few dual battery sites built in the United States that featured two rows of missile launchers and two related groups of radar. Construction was completed on the launch site in 1955 and on the radar site in 1956 (Layton and Foulds 2010).

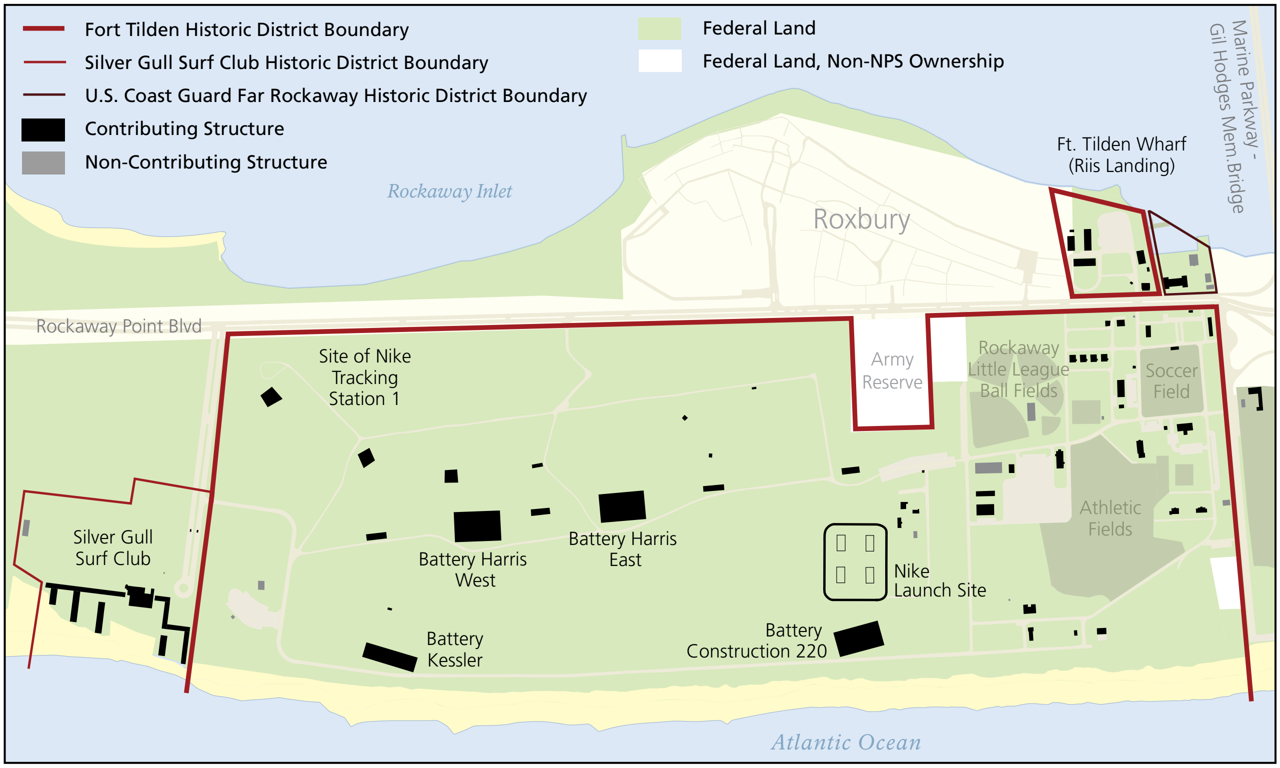
The launch area site is bound by a perimeter fence. On the surface, “double steel doors through which the missile would have passed and the missile launch elevator apparatus are evident” (NPS 1984a, 23). The silos contain no missiles today. The two tracking station towers to the north of the launch site include concrete radar towers and several support buildings (NPS 1984a). Currently, the radar site is interpreted for visitors.

Fort Tilden Historic District—Battery Harris, Battery Construction 220, Battery Kessler, and Nike Missile Launch Site

Located on the Rockaway Peninsula, the fort area was recognized in the early 19th century as a strategic location in the harbor (figure 3-6). Established in 1917, Fort Tilden complemented Fort Hancock and Sandy Hook Proving Ground and Fort Wadsworth as part of the “outer defense system for New York City and the harbor from World War I through the Cold War era” (NPS 1984b, 3). Coordination between Fort Tilden and Fort Hancock and Sandy Hook Proving Ground allowed for the efficient use of “seacoast artillery, anti-aircraft artillery, submarine mining and observation” in these efforts (NPS 1984b, 3). Fort Tilden is believed to illustrate a reorganization of the traditional coastal defense systems and was an integral part of a highly specialized strategy by the army to protect New York Harbor from sea and air attacks.

The fort consists of three areas: the post (administration) area, the fortification area, and Fort Tilden wharf area (Riis Landing) (figure 3-6). The post area reflects the administrative life of the fort (barracks, recreation, etc.). The primary early Taft-era fortifications at Fort

Figure 3-6. Fort Tilden National Register Historic District.



Tilden were Battery Kessler, Battery Construction 220, and Battery Harris (Selvek 2005) (figure 3-6). Later, during the Cold War years, a Nike Missile Launch Site and tracking station were installed.

The post area of Fort Tilden was located on the east quarter of the fort (figure 3-6) and included a number of structures built over several decades. They include the chapel (1941), the recreation building with dance floor (1941), the permanent brick barracks building (1938–1939; later converted to a hospital annex, and subsequently used as a headquarters), the theater (1941), two officers' quarters (1938; WPA construction, two-story, brick, with one-story garage), the double NCO quarters (1918–1919, the oldest permanent structure at the fort), the parade ground (early 1940s), the motor repair shop (1941), an ordnance building (1937–1938; replaced earlier World War I structure), the engineers' office (built soon after World War I), and the engineers' storehouse (1923–1924). The wharf dock (just north of the post area) existed prior to the fort being established and has undergone repairs through the years. This was a critical component of the fort because everything that was shipped to the facility had to come by way of the wharf (NPS 1980b). (Please see additional information on Fort Tilden wharf area provided in "Coastal Defense Support Structures.") Today, several modern playing fields exist in the post area of the fort (figure 3-6).

Battery Construction 220 and Battery Kessler were both constructed along the coastline of the fort. Battery Construction 220 was built in approximately 1917 and was outfitted with two 6-inch guns, separated by about 210 feet. Battery Kessler, originally known as "West Battery," consisted of two 5-inch guns mounted on a circular platform (NPS 1984b).

Constructed in approximately 1922–1924, Battery Harris is located slightly inland and to the north of Battery Construction 220 and Battery Kessler. It is characterized the technical improvements in military weapons at the time (Selvek 2005) (figure 3-6). In 1941, the two guns (16-inch gun placements) were roofed over by concrete casemates, approximately 850 feet apart. They were covered with earth and sand, resembling two oval hills. Together, these structures compose Battery Harris. There is a circular concrete hood projecting over the southern aperture of each gun emplacement. Due to their long range and power, the two guns represented an important factor in the defense of New York Harbor (NPS 1984b).

At the beginning of the Cold War period (1945–1974), a new surface-to-air missile defense program (Project Nike) was developed. The systems were installed at Fort Tilden and Fort Hancock and Sandy Hook Proving Ground. At Fort Tilden, this included the construction of "four magazine double Nike batteries" located at the eastern end of the fort, which were operational by 1955 (Selvek 2005, 47) (figure 3-6). Two missile-tracking stations were constructed at the western end of the fort, with two additional ones to follow. By 1967, the Nike technology had become obsolete and the Fort Tilden installation was decommissioned. By this time, the fort was slowly being shut down as a military installation (Selvek 2005).

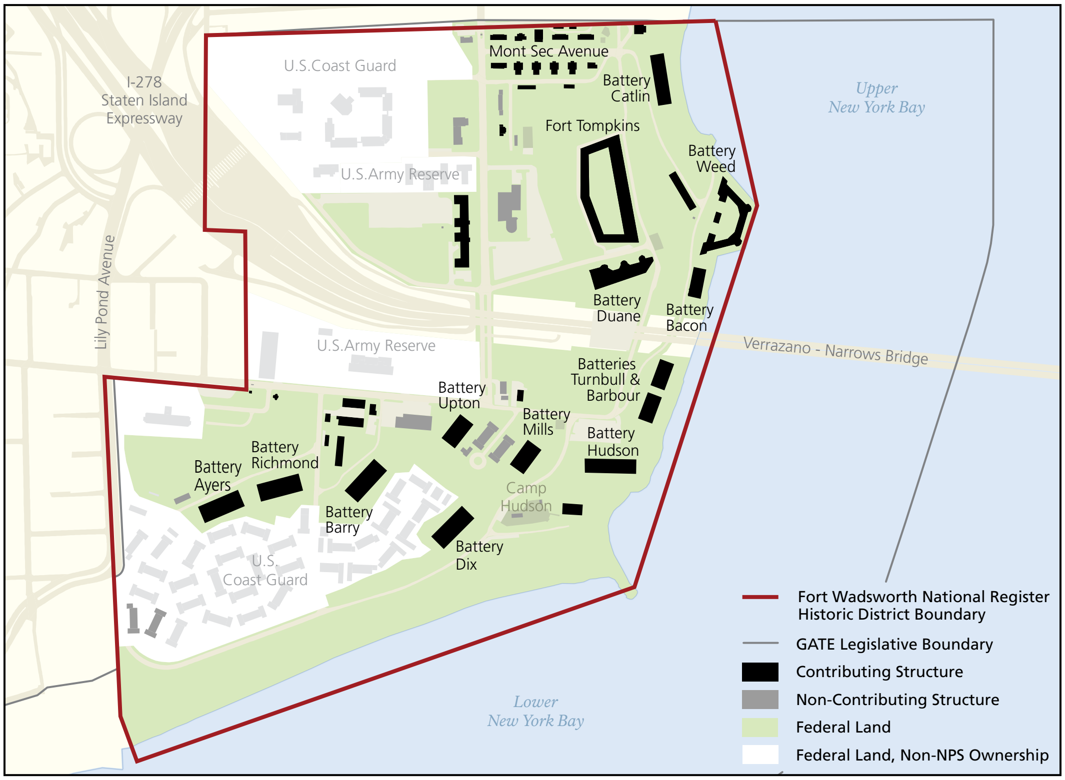
Fort Tilden experienced considerable flood and wind damage from Hurricane Sandy and many contributing features of the historic district were heavily impacted (officers' and enlisted men's buildings, Battery Kessler, small-scale features, etc.). Numerous trees were also downed (IMT 2012c).

Fort Tilden Historic District is considered significant because of its role in the defense network designed to protect New York Harbor. It was determined eligible by the Keeper of the National Register of Historic Places for its association with military history from 1916 to 1967. Contributing resources include the surviving Taft-era gun emplacements and associated structures from World Wars I and II, surviving features associated with the Nike-Ajax and Nike-Hercules missiles, and significant surviving operational, administrative, housing, wharf, and transportation components (U.S. Department of the Interior 2009). All of these elements retain sufficient integrity to contribute to the "significance of the district as an integrated 20th century coastal defense installation" (U.S. Department of the Interior 2009, 47). (Please refer to NPS 1984b, U.S. Department of the Interior 2009, and Selvek 2005 for greater detail on Fort Tilden.)

Fort Wadsworth Historic District—Battery Weed, Fort Tompkins, Torpedo-storage Building, and Endicott-era Batteries

The Fort Wadsworth Historic District is characterized by resources primarily associated with the coastal defense system that has contributed to the protection of New York Harbor for some 200 years (figure 3-7). The site is remarkable for the conspicuous bluff that rises to about 150 feet from the coastline. Damage from Hurricane Sandy in 2012 has left some of these slope areas unstable/unsafe (IMT 2012d). Battery Weed lies at the toe of the slope; Fort Tompkins is located at the highest point (figure 3-7). Both represent major third system fortifications listed on the National Register and retain much of their historic character (NPS n.d.b). The district also includes a number of other batteries and numerous military-

Figure 3-7. Fort Wadsworth National Register Historic District.



Source: NPS 2013b.

related resources ranging in time from the early 1800s to the 1990s, 12 of which have been determined eligible for the National Register (NPS 1985) (see below). It encompasses elements ranging from the post–Civil War period to the Endicott period. A most notable change from its original state is the increased vegetation (mature trees) that now exists; the original fortifications and batteries were covered with low-lying grass to allow for optimal visibility (NPS n.d.b). Management of Fort Wadsworth was transferred to the NPS from the United States Navy in 1994. The U.S. Coast Guard and U.S. Army Reserve also own and occupy a portion of Fort Wadsworth.

According to the National Register nomination form for Wadsworth (NPS n.d.b), important components of the fort include the following:

- Civil War–era fortifications (Battery Weed and Fort Tompkins), including the surrounding open space
- Battery Duane, Battery Catlin, Battery Turnbull, Battery Bacon, Battery Barbour, Battery Hudson
- Torpedo-storage building (Building 147)
- Seawall and dock
- Unrestricted view of New York Harbor
- Hillside below Fort Tompkins and above Battery Weed
- Hudson Road wall from Fort Tompkins turnout to head of Battery Weed Road
- Rail network between the torpedo-storage building and Battery Weed (NPS n.d.b, 9)

Fort Tompkins is located on the site of two earlier fortifications—one British (1779), the other built by the state of New York (1814, never completed). It was originally constructed as support for Battery Weed. What is evident today at Fort Tompkins dates to about 1859, when construction of the granite and brick fort began (construction was completed in 1876). It is a five-sided structure with one side overlooking Battery Weed and the harbor entrance (figure 3-7). The well-preserved fort is believed to be an outstanding example of the third system military architecture (NPS n.d.b) (see “Military History”). Fort Tompkins is also recognized as a Landmark Site by the New York City for its “special historical, aesthetic interest and value as part of the development, heritage and cultural characteristics of New York City” (New York City, Landmarks Preservation Commission 1974, 2).

Many of the existing batteries at Fort Wadsworth are located on the sites of earlier fortifications. Battery Weed, begun in 1847, is one of the earliest structures that remains intact at the fort and was constructed on the site of the former Fort Richmond, a water battery (Black 1983). Battery Weed’s construction involved the use of granite blocks in a half-hexagon shape and included a central parade ground (figure 3-8). At the time of its completion (1861–1864) it included 116 cannons, three tiers of casemates, and a fourth barbette tier, each with gun emplacements. Access to the tiers is via circular granite staircases. A seawall follows the perimeter of Battery Weed and at one time functioned as the exterior side of a moat that once surrounded the battery. The seawall is constructed of granite blocks similar in appearance to the construction materials of the battery. Damage to Battery Weed from Hurricane Sandy in 2012 included loss of fencing and damage to the seawall (IMT 2012d).

Figure 3-8. Battery Weed Looking Northeast Across the Narrows Toward Brooklyn (2006).

Battery Weed was garrisoned by a large force from the Fifth Regiment New York Volunteer Artillery. It represents "an important example of a multi-tiered casemated fort—one of only three 4-tiered forts built—belonging to the Third System of American seacoast fortifications" (NPS n.d.b, 5). It is believed to retain a high degree of integrity. Battery Weed is also recognized as a Landmark Site by the New York City for its "special historical, aesthetic interest and value as part of the development, heritage and cultural characteristics of New York City" (New York City, Landmarks Preservation Commission 1967, 2).

Twelve Endicott-era batteries constructed between 1895 and 1904 at Fort Wadsworth have been determined eligible for the National Register (table 3-6). Of these 12, 6 were reconstructed from existing works (rebuilt and renamed) (NPS 1985). Constructed of concrete, granite, and extensive earthworks, these batteries were designed to replace the third system defenses that were unable to defend against new military strategies and weaponry. The number of guns mounted in each battery varied. Their current conditions also vary and most are considered "generally in a state of deterioration" (NPS n.d.b, 6). (For more detail on individual batteries, please refer to NPS n.d.b. For additional information on Endicott-era batteries, please refer to "Military History."). Damage to these resources associated with Hurricane Sandy in 2012 included loss of fencing at Battery Duane, collapse of stone walls and unstable earthworks at Battery Hudson, numerous downed trees, and erosion and scouring around many other coastal batteries/earthworks (e.g., Battery Bacon) (IMT 2012d).

The Endicott-era torpedo-storage building was constructed on the hillside behind Battery Weed between 1892 and 1894 (figure 3-7). It served as the storage area for torpedoes or submarine mines that protected the harbor. The structure is a rectangular, two-story building with a corrugated roof constructed of granite and brick. The southeast portion of the building was substantially damaged by fire in the 1980s, causing a partial roof collapse. Mitigation measures were taken, but the damaged section remains in a deteriorated state; the northern portion of the structure remains "fairly intact" (NPS n.d.b, 7).

Maritime Resources

Sandy Hook Lighthouse

The Sandy Hook Lighthouse (also known as Sandy Hook Light) is designated as a National Historic Landmark. It is also located within the boundaries of the much larger Fort Hancock and Sandy Hook Proving Ground National Historic Landmark District (figures 3 8, 3 19). Construction on the light began sometime in 1761, with the first lighting in 1764, marking the beginning date for its period of significance. It was the fifth lighthouse to be built in America and now stands as the oldest continuously operating light tower in the nation.

During the Revolutionary War, the Americans extinguished the light so as not to aid the British. The British soon returned it to service and it has remained lit ever since with the exception of a temporary blackout periods during World War II. In addition to its shining beacon, the lighthouse communicated with lookouts on Staten Island during the day by flying various colored shapes from the tower, indicating inbound vessels (NPS 1971).

Figure 3-9. Sandy Hook LIghthouse and Keeper's Quarters.

Source: NPS 2013b.

The lighthouse was built by Isaac Contro and can be described as an octagonal structure, nine stories (103 feet) tall, and tapered from a base diameter of 29 feet to a 15-foot diameter at the top level. It is constructed of bricks on a masonry foundation and its walls are 7 feet thick at the base. It includes 13 windows and a circular iron staircase to the upper levels. A ladder allows access through the vaulted ceiling to the beacon itself, which is protected by a glass and steel cupola. The 45,000-candlepower beacon is approximately 4 feet wide by 8 feet high and is housed in a thick circular glass lens. Graphic depictions of the light in the late 1870s and early 1880s include, among other things, the keeper's quarters, a fenced yard, a second house (probably for an assistant keeper), a farmyard, and a possible chicken coop (Bianchi 2006). Restoration work was completed on the lighthouse in 2000.

Just southwest of the light structure sits the former lightkeeper's house—a two-and-a-half story frame house with hip and gable roof constructed in the early 1880s (figure 3-9) (NPS 1971). The original exterior has not changed substantially except for the addition of asbestos shingles. The interior of the house was renovated by the Coast Guard in 1980 (NPS 1984a); a more recent renovation by the Sandy Hook Foundation occurred in 2000. While the Sandy Hook Unit sustained considerable damage from Hurricane Sandy in 2012 (see Fort Hancock and Sandy Hook Proving Grounds, above), the lighthouse and keeper's quarters do not appear to be damaged.

Spermaceti Cove Life Saving Station

The Spermaceti Cove Life Saving Station was listed in the National Register in 1981 and represents one of only three individual resources recognized within the larger Fort Hancock and Sandy Hook Proving Ground National Historic Landmark District (figure 3-10). It is considered significant due to its association with the earliest federally sponsored efforts (through the U.S. Life Saving Service and U.S. Coast Guard) to save life and property from shipwrecks and its distinctive characteristics of a particular period and type of construction (Lee 2008). It was constructed in 1894 and, at the time, was located 800 yards from the ocean. Since then, that distance has been reduced to 150 feet (NPS 1981a).

Figure 3-10. Spermaceti Cove Life Saving Station, East Elevation.

Source: Lee 2008.

The station was one of at least 28 Duluth-type stations constructed for the U.S. Life Saving Service, which are characterized by "three building sections that form the station; a one-and-a-half story Main Block; a one-story Boat Room; and a four-story Watch Tower" (Lee 2008, 4). The Spermaceti Cove Life Saving Station, described as a one-and-one-half story structure with a two-bay boathouse on one end and a four-story tower on the front with a pyramid roof facing the ocean, exhibits strong Craftsman influence. The boathouse has double doors facing the sea. The front porch was enclosed in the 1930s. Other than the porch, the entire structure is shingled. (Please refer to the National Register nomination form (NPS 1981a) for greater architectural detail.) Effects of Hurricane Sandy on the structure in 2012 included flooding on the first floor and basement (IMT 2012e), the loss of the porch, and damage to some exhibits.

Between 1894 and 1949, the U.S. Life Saving Service conducted numerous rescues from this structure. The Spermaceti Cove Life Saving Station was one of the six to eight original New Jersey U.S. Life Saving Service sites. In 1949, the lifesaving station was decommissioned by

the U.S. Coast Guard and later housed administrative offices for the New Jersey State Park on Sandy Hook. Since 1974, it has served as one of Gateway's visitor centers and remains an important example of late 19th century New Jersey coastal utilitarian architecture (NPS 1981b).

Other Important Cultural Resources

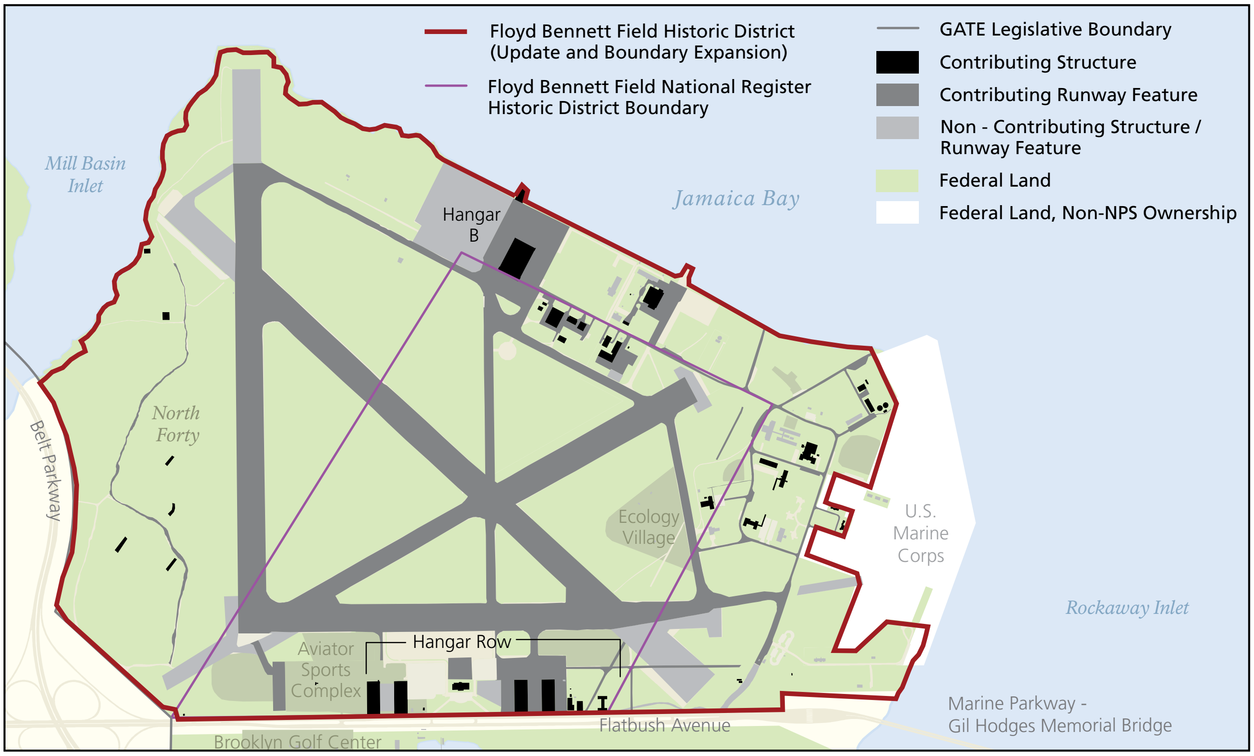
Floyd Bennett Field Historic District

Floyd Bennett Field Historic District was originally listed on the National Register in 1980 (figure 3-11). Its period of significance (1931–1941) was related to its involvement in the evolution of aviation history and municipal airport construction. According to the original National Register nomination, the original complex of steel frame and brick hangars and support building at Floyd Bennett Field still retains the "architectural design and historic cohesion of an early municipal airport" (NPS 1978, 3). A recent determination of eligibility expands the district's boundaries and period of significance. The revision to the period of significance ranges from 1928 to 1945 to incorporate important historical themes not addressed in the original documentation. The district's boundaries have been revised to include all lands east of Flatbush Avenue and south of the Shore Parkway, with the exception of the U.S. Department of Defense land used as a Marine Corps Reserve Center (NPS 2010c). These expanded boundaries conform to federally owned lands administered by the NPS that are historically associated with Floyd Bennett Field and the Coast Guard Air Station Brooklyn (NPS 2010c).

The expanded district is significant for its role in early aviation history. "In the 1930s it was the starting point and terminus for many record-breaking continental and intercontinental flights and important air races in the 'Golden Age' of U.S. aviation history" (NPS 2010c, 1). Its significance also lies in its role during World War II when the navy operated the field as Naval Air Station New York, one of the most vital "home front" navy installations, "ferrying more naval aircraft from regional assembly plants to the West Coast for deployment in the Pacific Theater than any other facility" (NPS 2010c, 1). The district is also significant for its architecture and engineering. Much of Floyd Bennett Field's original structure and setting—hangars, administration building, runways, and taxiways—is still evident and it is one of the few municipal airports that still reflects the pioneering of the aviation industry (NPS 2010c). Hangar B, the largest structure at the field, was completed in 1941 to house seaplanes and currently houses the Historic Aircraft Restoration Project volunteer group and numerous historic aircraft. Hangar B sustained roof damage and broken windows and is in need of stabilization as a result of Hurricane Sandy in 2012 (IMT 2012g).

The historic district's National Register significance lies not only in its association with aviation history and municipal airport construction but also in its association with individuals significant in early aviation (NPS 2010c). The former air terminal at Floyd Bennett Field is currently being used as the Ryan Visitor Center. (Please refer to NPS (2010c) and the "Aviation History" section above for additional information on Floyd Bennett Field Historic District.)

Figure 3-11. Floyd Bennett Field National Register Historic District.



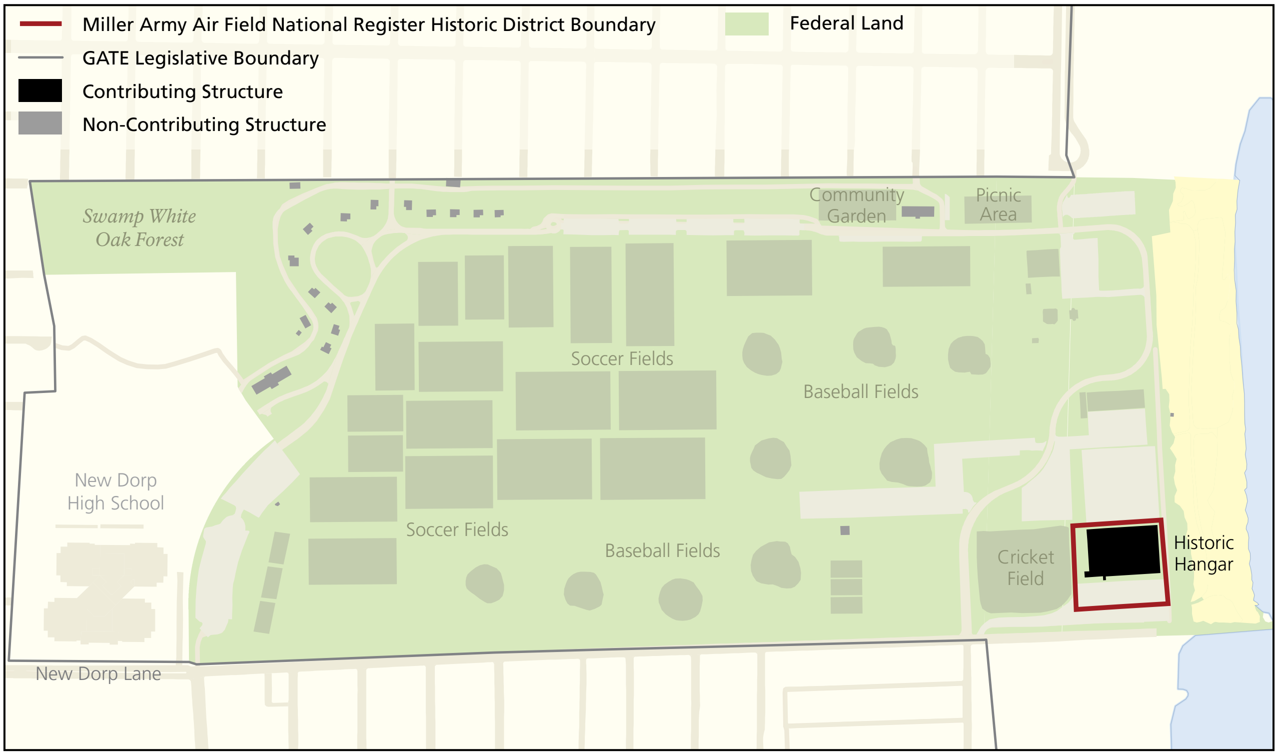
Miller Army Airfield Historic District, Hangar No. 38

Miller Field was established in 1919–1921 as a 180-acre army airfield (figure 3-12). It originally consisted of 38 structures including two double hangars, the most important buildings at the field. The flying field originally encompassed 80 acres, centered on a sod runway running diagonally across the field. When the park acquired the field in 1973, about 24 buildings and structures remained, all in deteriorated condition. The landplane hangar (Building 33) was demolished in 1976 and replaced with paved areas and fenced playfields. Former residential buildings have been renovated for park purposes and do not meet National Register criteria; the runway is no longer distinguishable because of its use as playing field (NPS 1979a). The area nominated was restricted to the double seaplane hangar (Hangar No. 38) and the Elm Tree Light, a total of about 3 acres (NPS 1979a).

Hangar No. 38, constructed in 1920 at Miller Field, is important because of its association with early aviation history (see the "Aviation History" section in this chapter). It was viewed as a part of the Hangar Group of Buildings, which included a variety of support structures (aero repair shop, boiler house, aero storehouse, etc.). It was constructed of a steel frame and stucco walls and consisted of two side-by-side bays. Several additions were made by the Works Progress Administration (WPA) of the Roosevelt administration in 1935–1939. The significance of Hangar No. 38 is its direct association with early aviation history and the history of air coast defenses of New York (NPS 1979a). Hangar No. 38 sustained considerable damage from Hurricane Sandy in 2012 (IMT 2012f).

The Elm Tree Light, an octagonal concrete beacon tower, stands near Hangar No. 38. It was constructed by the Coast Guard in 1939 to replace an earlier tower that served as a mark for sailing vessels in the late 18th century and was abandoned in 1924. The significance of the Elm Tree Light lies in its direct association with the early lighthouse service (NPS 1979a). Miller Field continues to be used by team/league sports teams, bikers, and for self-guided nature tours.

Figure 3-12. Miller Army Airfield National Register Historic District.



Jacob Riis Park Historic District—Bathhouse Pavilion, Central Mall Building

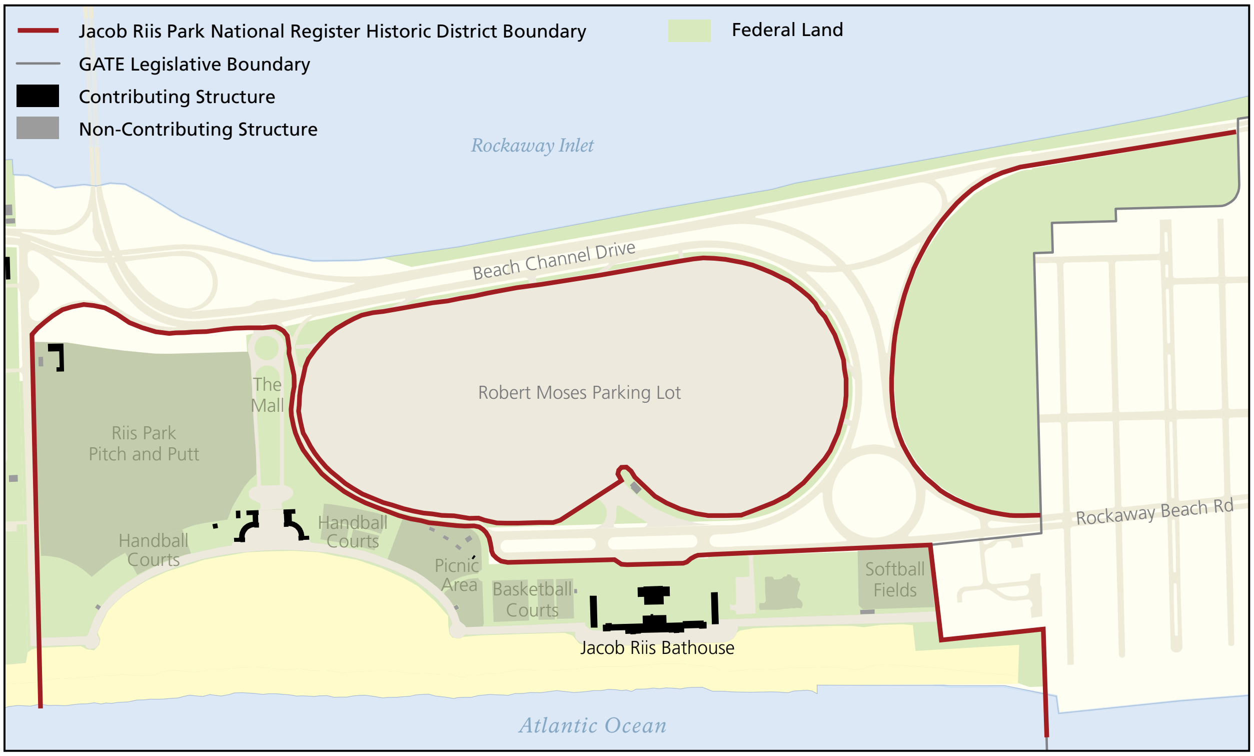
The Jacob Riis Park Historic District, listed in 1981, is considered an “excellent, though greatly deteriorated, example of … municipal recreational planning the 1930s” (Olmsted Center for Landscape Preservation 2002, 2) (figure 3-13). Its historical significance derives from its association with New York City’s Commissioner of Parks, Robert Moses, as well as it being a notable work of landscape architecture. The park was completed through the WPA and is associated with this important social and government program (NPS 1979b). The park landscape has lost much of its integrity and has not been well maintained (Olmsted Center for Landscape Preservation 2002). In 2012, Hurricane Sandy resulted in heavy wind and water damage to Jacob Riis Park facilities, including flooding; broken windows; blown out walls, sand deposition in the bathhouse; missing ceramic tiles in the bathhouse; and sand and other debris deposited in structures and across the landscape. The brick courtyard wall was destroyed and heavy erosion is evident along the boardwalk (IMT 2012h).

The 220-acre Jacob Riis Park occupies a mile-long section of the Rockaway Peninsula and provides a variety of recreational activities. The park's three significant recreational buildings were constructed between 1932 and 1937.

The original bathing pavilion—commonly known as the bathhouse—is the dominant feature of the park. The T-shaped, one-story brick masonry structure was completed in 1932. In 1936–37, it was enlarged by a long, two-story addition on the south side of the structure. The entrance to the bathhouse is located on the north wall. The front of the bathhouse is faced with a long arcade supported by pillars and topped with two octagonal turrets (NPS 1979b).

The mall focuses on a crescent-shaped extension of the boardwalk. The twin central mall buildings—constructed of brick and tile masonry—face each other at the southern end of the mall. Constructed in 1936–1937, both are two-story, square buildings, flanked by one-story wings, and connected to a rectangular, single-story wing to the south by a single-story, semicircular wing. Both have flat concrete roofs, concrete cornices, and concrete floors (NPS 1979b).

Figure 3-13. Jacob Riis National Register Historic District.



In addition, a broad promenade plaza adjacent to the original bathhouse was opened in 1932. During an expansion of the original park in 1936–1937, a continuous walkway (the length of the beach) was created, connecting all areas of the park. Both the promenade and boardwalk are considered integral elements of the park and contribute to its historic significance (Lane, Frenchman, and Associates 1992). Another striking feature of the park is the 72-acre parking lot located north of the bathhouse. With a 12,000–14,000 car capacity, it was believed to be the largest in the world at that time (NPS 1979b). The parking lot still retains its original integrity and is a contributing element to the district. (Please refer to NPS 1979b; Lane, Frenchman, and Associates 1992; and the Olmsted Center for Landscape Preservation 2002 for greater detail on the Jacob Riis Park Historic District.)

The history of the park's defensive military fortifications and weaponry is manifested in some of the most notable cultural resources in the park.

Coastal Defense Support Structures

The history of the park's defensive military fortifications and weaponry is manifested in some of the most notable cultural resources in the park. Places like Fort Wadsworth, Fort Tilden, and Fort Hancock and Sandy Hook Proving Ground, with their associated gun batteries and weaponry, have played critical roles in the history of the country, and particularly in the protection of New York Harbor (refer to discussions about the specific forts). The mission of the forts was to provide support for the soldiers manning the gun batteries. The support that these facilities required to function efficiently cannot be understated and included an important array of services, personnel, and facilities. Often, these forts resembled small towns, including such things as housing, hospitals/medical facilities, bakeries, post exchanges, schools, chapels, theaters, mess halls, transportation facilities, recreation areas, and so on. Many of these support structures still exists today in Gateway. A discussion of a few notable examples follows.

Parade Ground, Fort Tilden

The parade ground at Fort Tilden was built around 1941 with assistance from the WPA. In order to construct it, 11 World War I cantonment buildings were destroyed (NPS 1980b). The parade ground is about 3 acres in size and was designed as the primary ceremonial area at the fort. The WPA placed a steel, 75-foot-high flagpole at the northeast corner of the parade ground near the main fort's entrance; the flagpole was lost during Hurricane Sandy in 2012. The flagpole was set in a cut stone with inscriptions of the installation, organization, and U.S. Army Coast Artillery insignia (NPS 1980b). Plans called for the parade ground to be seeded and landscaped. It was bound by tree-lined roadways and enclosed by structures to the west, north, and south (Selvek 2005). The parade ground contributes to the significance of the Fort Tilden Historic District.

Fort Tilden Wharf Area (Riis Landing), Fort Tilden

The wharf area is located immediately to the northeast of the Fort Tilden post area (figure 3-6). It consists of an area approximately 10 acres in size and was historically considered part of the post. It contained the "main dock, warehouses, maintenance facilities and administration buildings, with rail lines connecting from the main dock through the post area to the fortifications" (Selvek 2005, 2). Although the wharf area contained 19 buildings during the World War II period, only 8 structures remain today, and only pilings remain from the main dock. In the early 2000s, a new ferry dock and parking lot were constructed as part of the Riis Landing redevelopment project. The project included the adjoining complex of buildings once used as the U.S. Coast Guard Station Rockaway (Selvek 2005).

Mont Sec Avenue, Fort Wadsworth

Fort Wadsworth's Mont Sec Avenue was the primary location of officers' housing at Fort Wadsworth from the 1870s to the present day (figure 3-7). The houses consist of ten duplexes and one single-family residence. These houses retain their original form and much of their original detail, both exterior and interior, with the exception of synthetic shingles. One—Mont Sec House—has had its interior restored to its 1890s appearance. One duplex, originally the quarters for the post surgeon and other medical officers, was originally clapboard but is now brick-faced with a mansard roof. Five brick duplexes (Buildings 101, 102, 106, 107, 110) and one residence (Building 115) were constructed by the WPA in the 1930s. Garages behind the houses served the multiple residences (NPS n.d.b).

Fort Wadsworth's Mont Sec Avenue was the primary location of officers' housing at Fort Wadsworth from the 1870s to the present day.

An associated fort street—New York Avenue—runs perpendicular to Mont Sec Avenue and has served as the main street of Fort Wadsworth since the mid-19th century. Although development in the area has dramatically modified the street in the last half of the 20th century, historically important structures that remain today along New York Avenue include the entry gate and gatehouse, the WPA-era former officers' quarters, and the former barracks (NPS n.d.b).

Officers' Row, Fort Hancock, Fort Hancock and Sandy Hook Proving Ground

Eighteen two-and-a-half story structures built along Hartshorne Drive between 1898 and 1899 served as officers' housing at Fort Hancock. Basically identical, all the buildings are constructed of buff-colored brick, chosen because it was less porous than traditional red brick (figure 3-3). The houses are among the most distinctive buildings at Fort Hancock due to the "cohesive architectural ensemble that survives as originally designed" (NPS 2006b, 19). Few alterations have been made to the structures and their surface appearance remains relatively unchanged. Single-car garages were added to some of the houses (Buildings 6–16) in the 1930s. Necessary maintenance has included repairs to leaking roofs, defective flashing, deteriorated brick mortar, faulty gutters/downspouts, decay on wood window sashes/frames, etc. The park manages Building 1 (Officers' Row House #1) as the "History House." Another building (Building 18) is currently used by the American Littoral Society (NPS 1984a; Ehrler, pers. comm. 2013).

Many of the historic structures along Officers' Row experienced damage from Hurricane Sandy in 2012. This included basement flooding and substantial damage to porches, piers, and columns that will require stabilization. Ninety percent of the structures within Fort Hancock need electrical repair, including Officers' Row House #1, "History House" (IMT 2012b). For additional detail, please refer to storm effects discussion above for Fort Hancock and Sandy Hook Proving Ground ("Fundamental Resources").

Other Historic Districts

The Silver Gull Beach Club, the Breezy Point Surf Club, and the Far Rockaway Coast Guard Station have been determined eligible for the National Register by the New York State Historic Preservation Office.

Silver Gull Beach Club Historic District

The Silver Gull Beach Club Historic District is located on the Atlantic Ocean shorefront, immediately west of Fort Tilden, on the Rockaway Peninsula. The historic district includes approximately "7.5 acres of relatively flat land that is surrounded on three sides by undeveloped coastal land covered with dense low brush. It is bordered on the south by the Atlantic Ocean, where a wide sandy beach provides uninterrupted vistas to the east and west" (NPS n.d.c, 1).

The district is an oceanfront cabana complex containing a total of 15 contributing (1 site, 7 buildings, 7 structures) and 10 non-contributing (5 buildings and 5 structures) resources. The district's contributing resources include a large clubhouse, 4 court buildings, a pool court, an activity building, recreational facilities, and both paved and unpaved parking areas. The 12,000-square-foot, one-story clubhouse is the central building of the cabana complex. The Silver Gull Beach Club sustained substantial storm damage from Hurricane Sandy in 2012. Cabanas, the pool, and surrounding concrete were destroyed. Large sections of beaches were eroded, large amounts of sand were deposited in parking lots and roads, and buildings within the historic district were damaged (IMT 2012i).

The Silver Gull Beach Club Historic District is in its original location on the Atlantic Ocean and retains a high degree of integrity in terms of setting, design, materials, workmanship, feeling, and association.

The Silver Gull Beach Club Historic District is in its original location on the Atlantic Ocean and retains a high degree of integrity in terms of setting, design, materials, workmanship, feeling, and association. Only one major alteration—the removal of a set of second-floor cabanas from the clubhouse building—has occurred. "The club continues to serve its original function and it conveys a strong sense of feeling and association as a mid-twentieth-century oceanfront recreational resource" (NPS n.d.c, 5).

The Silver Gull Beach Club is significant at the local level in the areas of entertainment/recreation, social history, community planning and development, and architecture. Its "period of significance is 1962–1963, the years the club was designed, constructed, and opened by its original owner the Atlantic Improvement Corporation" (NPS n.d.c, 8).

Breezy Point Surf Club

The Breezy Point Surf Club is an approximately 60-acre cabana complex in a coastal setting of relatively flat land facing the ocean on the Rockaway Peninsula. The historic district contains 69 contributing buildings, 11 contributing structures, and 1 contributing site; most of these were constructed between 1937 and 1962. The complex has two distinct sections of cabana courts known as the Original Courts and the Ocean Courts, along with several pools and athletic courts. The district reflects a primarily recreational landscape that evolved from 1937 to 1963 in response to increased demand for memberships in the club (NPS n.d.d; IMT 2012i).

The historic district retains a high degree of integrity in terms of its location (original), setting, design, materials, workmanship, feeling, and association. Although routine maintenance has occurred throughout the years, the majority of the original materials are intact and the workmanship of the buildings is still evident. The district retains a strong sense of its feeling and association as a large, recreational oceanfront resort built in the early to mid-19th century (NPS n.d.d). Damage to the Breezy Point Surf Club from Hurricane Sandy in 2012 was not extensive (Ehrler, pers. comm. 2013).

The Breezy Point Surf Club Historic District is eligible for listing in the National Register at the local level in the areas of entertainment/recreation, social history, and architecture. "The period of significance ranges from 1937, when the Club was established, and ends in 1963 when the layout of the cabana complex as it exists today was completed" (NPS n.d.d, 11).

Far Rockaway Coast Guard Station Historic District

The Far Rockaway Coast Guard Station Historic District is located just east of the Fort Tilden wharf area (Fort Tilden Historic District). The Coast Guard facility is considered historically and architecturally significant for its association with the "history of lifesaving services and as a distinctive example of Colonial Revival institutional architecture (NPS 2004e, 3). During the 19th and early 20th centuries, Far Rockaway was the site of numerous marine accidents and shipwrecks. An earlier lifesaving station—established by the New York Life Saving Benevolent Association—operated with volunteers at Far Rockaway as early as 1849 (NPS 2004e). The current station's construction began in 1938 with WPA funds and continued through 1944. The facility was designed with a boat basin, piers, breakwaters, marine railways, and radio communications. Through the years some support facilities have been removed (e.g., boat shop), but the complex is believed to retain substantial integrity of its original construction period (NPS 2004e). In 2012, Hurricane Sandy resulted in moderate damage to the main building, boathouse, garages, and power house (NPS n.d.g).

The Coast Guard facility is considered historically and architecturally significant for its association with the "history of lifesaving services and as a distinctive example of Colonial Revival institutional architecture.

Historic Structures

Historic structures include buildings, bridges, roads, temples, and other manufactured objects that extend the limits of human capability. Structures allow humans to live in harsh climates and in areas far removed from where they work and live (NPS 1998a). Gateway maintains a List of Classified Structures (LCS), a required list identifying historic structures that meet the criteria of the National Register or are elements of resources that do (NPS 1998a). The LCS includes information on the significance of and recommended treatment levels (preservation, restoration, etc.) for each structure. It provides data on all historic structures and their National Register status.

The LCS includes resources that are broadly defined as structures. In addition to buildings, other structures such as dams, mounds, forts, earthworks, etc. are included in this list. For instance, at Gateway, the LCS contains such structures as the Jacob Riis Park boardwalk and promenade, Mont Sec Avenue in Fort Wadsworth, the flagpole at Floyd Bennett Field, and the Elm Tree Light at Miller Field (NPS n.d.e).

Historic structures included in this plan are primarily located within the boundaries of National Register historic districts in the park. These districts include Fort Wadsworth, Fort Tilden, Fort Hancock and Sandy Hook Proving Ground, Floyd Bennett Field, Jacob Riis Park, Miller Field, Silver Gull Beach Club, and Breezy Point Surf Club (see discussions about each of these resources in this section).

The LCS contains 355 structures from these historic districts, with the exception of Silver Gull Beach Club and Breezy Point Surf Club. These two districts have recently been determined eligible for the National Register and the park will likely be adding their contributing structures to the LCS in the near future. Within the park, there are buildings that may be more than 50 years of age which have not been evaluated for NRHP eligibility (Ehrler 2013).

Historic structures encompassed in LCS represent the following historic districts, with examples of building types included:

- Fort Tilden Historic District—Nike Missile installations, Taft-era batteries, post structures

- Jacob Riis Park Historic District—park structures, boardwalk, promenade, parking lot

- Fort Wadsworth Historic District—fort housing, third system and Endicott-era batteries, warehouse, Mont Sec Avenue, torpedo-storage building, seaplane hangar

- Floyd Bennett Field Historic District—hangars, garage/maintenance shop, light beacon, fire pump house, seaplane ramp, runways/taxiways

- Fort Hancock and Sandy Hook Proving Ground National Historic Landmark District—fort housing, bakery, chapel, commissary, mess halls, Sandy Hook Lighthouse and Keeper's Quarters, Spermaceti Cove Life Saving Station, power plant, Endicott/Taft-era batteries, Nike Missile installations

- Miller Army Airfield Historic District—Hangar No. 38, hangar apron, Elm Tree Light

The LCS identifies each structure by name, number, and location. Individual structure summaries include specific data on physical description, historical significance, construction materials, and function and use. Please refer to the Gateway LCS (NPS n.d.e) for additional detail on historic structures identified for the districts above.

The National Register nomination form for Breezy Point Surf Club lists 79 contributing structures, including those related to transportation (roads/parking areas) and recreation (e.g., cabanas, boardwalks and walkways, pools, cabins, showers) (NPS n.d.d). Fifteen contributing structures are listed in the National Register nomination form for the Silver Gull Beach Club, including those related to transportation (roads/parking) and recreation (e.g., clubhouse, pools, cabanas) (NPS n.d.c). (Please refer to the "Historic District" discussions for information on the context of the Gateway historic structures and to the Gateway LCS [NPS n.d.e] for specifics on each structure.)

Archeological Resources

Archeological resources in the park date primarily to later pre-contact (Woodland period) and historical periods (see "Cultural Resource Context for Gateway National Recreation Area"). Cultural manifestations include both surface and subsurface materials. Many of the archeological resources identified in earlier studies can no longer be located (NPS 2009a, 2011a, 2011b, 2011c). This is related to a variety of factors, including inaccuracy of the original recordation, the influence of natural processes (e.g., erosion), and the significant effect of landfilling operations that have occurred throughout the region in the late 19th and 20th centuries.

Pre-Contact Archeological Sites

Most of the recorded pre-contact sites in the park are described as lithic scatters, lithic/ceramic scatters, campsites, or shell middens. Most of these remain undated or are believed to date to the Woodland period. A variety of isolated finds, including a fluted projectile point believed to date to the Paleo-Indian period (NPS 2011a), have also been recovered from park lands. Occasionally, a site will reflect the use of an area during both pre-contact and historical periods (e.g., the VanDeventer-Mouquin site at Fort Wadsworth) (Louis Berger Associates, Inc. 1990; NPS 2011b). The potential for encountering pre-contact archeological resources in the future is dependent on the original sensitivity and later historical use of the area. For greater detail on pre-contact archeological resources and the potential for future discoveries throughout the park, please refer to NPS 2009a, 2011a, 2011b, and 2011c.

Historical Archeological Sites

Certain historical activities tend to leave more substantial structural remains than others (e.g., houses, sheds, foundations, fortifications). Isolated artifacts and light scatters of historical materials may receive less attention. All are considered important clues to historical use of an area and should be used to guide future investigations in the park.

Historical archeological sites recorded in the park include remnants of structures related to residential housing, military activities (forts, etc.), homesteads, and commercial activities; middens/refuse deposits; and transportation rights-of-way. While many are still evident, a considerable number have been destroyed or can no longer be located; in some cases, the area has been filled, covering the site (NPS 2011c). For greater detail on historical archeological resources and the potential for future discoveries throughout the park, please refer to NPS 2009a, NPS 2011a, 2011b, and 2011c.

Investigators speculate that additional archeological resources may be discovered associated with both domestic and military occupations of park lands. For instance, limited archeological materials may remain from 18th and 19th century occupations within the Fort Wadsworth Historic District boundaries. It is believed possible that remnants of shoreline batteries, signaling beacons, and homesteads may exist within specific areas of the district, although their integrity may be compromised (NPS n.d.b). There is also a potential for several significant historical archeological sites within the boundaries of the Miller Army Air Field

Historical archeological sites recorded in the park include remnants of structures related to residential housing, military activities (forts, etc.), homesteads, and commercial activities; middens/refuse deposits; and transportation rights-of-way.

Historic District. For instance, a Dutch settlement—Nielve Dorp, ca. 1600—was located near the present site of the airfield. A country estate on land located within the district boundaries was built in 1843 by William Vanderbilt. In 1936–1937, the Vanderbilt Mansion, water tower, and barns were razed to allow for expansion of the landing field to the west (NPS 1979c).

The potential for the discovery of additional in situ archeological resources in Gateway is influenced by a variety of natural and human factors. These include ancient and historical sea-level fluctuations, erosion and sediment transport due to tidal/wave action, and land filling/land-modification activities in the 19th and 20th centuries. All these factors affect the potential for the discovery of buried archeological resources, and their influence varies by geographic location. Although many natural coastal park areas have been buried beneath deep fill deposits, there are also areas where intact soils and archeological deposits have been recorded. For these reasons, the potential for the identification of intact archeological deposits in the park is strongly dependent on the types and effects of past and ongoing natural and human processes. The potential for discovery of archeological resources in each specific area of the park should be evaluated based on each area's unique set of circumstances.

The potential for submerged cultural resources in the study area includes both pre-contact and historic sites and historical shipwrecks.

Recent and comprehensive archeological assessments that considered the issue of the potential for archeological resources in Gateway included area-specific analyses of the sensitivity for such resources (NPS 2009a, 2011a, 2011b, 2011c). These studies have included consideration of both natural and human impacts on specific park areas, and they have speculated on where the areas of highest potential for archeological resources may be. For instance, in Fort Wadsworth (Staten Island Unit), high-potential areas include pre-contact sites on bluffs within 1,000 feet of the shoreline, 18th century structures, late 19th century batteries, pre-contact sites on bluffs and terraces in the southern and western portions of Fort Wadsworth, and others (NPS 2011b).

The sensitivity for archeological resources located within portions of Breezy Point Tip in the Jamaica Bay Unit stands in contrast to the high-sensitivity areas at Fort Wadsworth. In this second case, the recent formation of the landform and the lack of long-term historical occupation have created a situation in which the potential for archeological resources of any period is very low. The ability to predict to a limited extent the sensitivity of an area for the presence of archeological resources is an outcome of the patterned nature of human behavior. Such predictions have many uses, one of which is their use in project planning.

Submerged Archeological Resources

The potential for submerged cultural resources in the study area includes both pre-contact and historic sites and historical shipwrecks. The identification of the former categories is difficult, at best, and is related to a variety of issues such as the ever-changing beach morphology caused by sediment transport that redeposits and disturbs in situ cultural materials along the coastlines. Changes in sea level through the millennia are also believed to have made larger terrestrial areas available for pre-contact human occupation in the area, much of which is now submerged (Panamerican Consultants 2001). In addition,

significant storm-related coastline alterations (e.g., those caused by Hurricane Sandy) and numerous historical dredging activities in the larger harbor area have disturbed or obliterated resources. That said, the potential for submerged archeological deposits is noted by researchers who report the presence of over 200 artifacts, tentatively identified as ranging from the Early Archaic to Late Woodland periods, recovered along a stretch of beach in Monmouth County, New Jersey. The beach area had been recently renourished by sands dredged from an offshore area east of Sandy Hook and redeposited on the New Jersey beach (Panamerican Consultants 2001, 6).

Prior research indicates that shipwrecks dating to the Colonial period and later are known to occur in the general harbor region, with the potential to exist in waters managed by Gateway (Panamerican Consultants 2001) (see also “Maritime History” under “Historic Context”). For instance, several recent remote-sensing surveys associated with proposed projects around the Sandy Hook Unit and the Fort Wadsworth area have revealed magnetic anomalies indicating the potential for cultural materials of unknown historical significance (NPS 2004a; Panamerican Consultants 2001). A recent survey (PBS&J 2009) within the waters of Jamaica Bay, including waters under the jurisdiction of Gateway, found no significant magnetic anomalies or sonar targets that might indicate the presence of buried/submerged cultural resources. However, the authors provided information on several shipwrecks that are known to be present in waters adjacent to lands managed by the NPS. These include the *Mistletoe*, the *Black Warrior,* the *Ajace*, and the *Cornelia Soule,* all of which sank, burned, or were grounded between 1859 and 1924 (PBS&J 2009, 18). New York State also maintains a list of shipwrecks in Jamaica Bay. These submerged historic resources are also subject to disturbance from weather, development (construction of undersea utility lines, structures, etc.), and dredging activities.

Museum Collections

Gateway manages a variety of museum objects and archival materials that have been collected in the park, as well as some acquired through donations, purchases, and transfers. Museum holdings include significant cultural collections associated with local military, aviation, and maritime history; pre-contact artifacts dating back to the Woodland period; archive and manuscript collections (NPS management records, rare books); and natural history collections (NPS 2011d).

Museum collections at Gateway are currently managed under the Final Collection Management Plan (Collection Management Plan) (NPS 2009b). The Collection Management Plan was drafted prior to the impacts on museum collections resulting from Hurricane Sandy in 2012. Storm damage at Fort Hancock required that collections housed there be salvaged and transferred (ongoing) to storage areas at Fort Wadsworth. Storm-related impacts and concerns mentioned by the Incident Management Team (IMT) after the storm included the continued threats to museum collections posed by lack of climate control and potential flood-related contamination of collections (IMT 2012a). It is assumed that as the impacts of the storm become better defined, further revisions to the Collection Management Plan may be necessary. Despite the considerable effect of consolidating collections into one facility at Fort Wadsworth, in many other regards the Collection Management Plan represents the most current information on existing conditions related to Gateway's museum collection planning and management. The majority of the following information is gathered from the Collection Management Plan.

In addition, the Scope of Collection Statement guides the management of museum collections at Gateway by defining the scope of "present and future museum collection holdings … that contribute directly to the understanding and interpretation of the park's purpose, themes, and resources" (NPS 2011d, 4). The Scope of Collection Statement is used extensively to assist the park in efforts such as historical military structure restoration and the interpretation of park resources for the public (NPS 2011d). Most of the park's museum collection objects have been acquired through donations, field collections, transfers, and purchases. As of 2012, the park had 1,953 accessions and an estimated 661,786 objects in the museum collection. Of these, 195,760 objects are cataloged.

As of 2012, the park had 1,953 accessions and an estimated 661,786 objects in the museum collection. Of these, 195,760 objects are cataloged.

The Gateway museum collections represent the history and significance of important cultural resources in the park. The park manages collections associated with the following significant resources: Fort Hancock and Sandy Hook Proving Ground (Sandy Hook Lighthouse, Spermaceti Cove Life Saving Station), Fort Wadsworth, Miller Field, Great Kills Park, Jacob Riis Park, Fort Tilden, Floyd Bennett Field, Jamaica Bay Wildlife Refuge, the Breezy Point Tip, and other areas of the park (NPS 1981a, 2011d). Such collections include site-associated objects (e.g., ordnance, furnishings, weapons, coins), uniforms, aircraft, and large weapons. Significant archival collections include, among other things, materials donated by veterans who served at the various park sites, both civilian and military. Significant archeological collections include objects related to Fort Hancock and Sandy Hook Proving Ground (e.g., munitions, ordnance), Fort Wadsworth (objects related to past military/community life at the fort), and Miller Field.

The natural resource collection is divided into three disciplines: biology, geology, and paleontology. The purpose of the collection is "to support scientific research, resource management, and education; provide baseline data of park natural resources; document changes these resources are undergoing because of internal park conditions and external effects; provide a database for researchers concerned with resource use by the park's pre-contact occupants; preserve important or locally significant species collected in response to specific research or interpretive needs; to guarantee the protection of specimens whose in-situ preservation cannot be assured" (NPS 2011d, 10).

Gateway's museum collection began in 1968 at Fort Hancock (Fort Hancock and Sandy Hook Proving Ground) and became the focus of the Sandy Hook Unit collection when the U.S. Army transferred the fort to the NPS in 1972. Fort Hancock remained the main storage location for the park's collection of objects, archives, archeological collections, and other items. In 1995, the NPS gained possession of Fort Wadsworth (Staten Island), where additional collections were then housed. Prior to being stored at Fort Wadsworth, collections were also stored at Floyd Bennett Field. Before Hurricane Sandy hit the area in 2012, collections at Fort Hancock were curated in three storage locations (Buildings 32, 47, 125), whereas Fort Wadsworth used two locations (Building 210 basement and Building

210 first-floor storage). None of these storage locations was considered large enough to accommodate the current museum collection and its potential growth, and none was used solely for the storage of museum objects (NPS 2009b, 86).

When Hurricane Sandy hit the New Jersey/New York coastline in the fall of 2012, its impact (storm surge, wind, etc.) seriously jeopardized the collections at Fort Hancock. The Sandy Hook Unit of the park sustained considerable storm damage and the most sensitive collection materials were salvaged from Fort Hancock and taken to Fort Wadsworth to ensure their preservation. Collections at both Fort Wadsworth and Floyd Bennett Field were not seriously impacted by the storm. It is tentatively planned for rest of the Fort Hancock collections to be moved to Fort Wadsworth permanently (Mahan, pers. comm. 2013a). New challenges for appropriate storage space exist today with the recent consolidation of these materials.

The Gateway museum collections are purposefully "evaluated for their contributing value to the park's resources based on the park's enabling legislation, the park's mission statement, the sites' National Register documentation, and established themes developed in park planning documents such as the Long-range Interpretive Plan."

The Gateway museum collections are purposefully "evaluated for their contributing value to the park's resources based on the park's enabling legislation, the park's mission statement, the sites' National Register documentation, and established themes developed in park planning documents such as the Long-range Interpretive Plan" (NPS 2009b, 14; 2004b). The primary themes identified in the Long-range Interpretive Plan and included in the Collection Management Plan (NPS 2009b) include the following:

- The Wonders, Dynamics, and Challenges of an Urban Estuary
- Fighters, Falcons, Monarchs, and Missiles: A Heritage of Flight
- From Colonial Outpost to World Power: The Changing Nature of National Defense
- Immigrants to Presidents: Symbols and Stories of the American Odyssey
- Shaping the Modern World: Innovations in Health, Recreation, and Transportation

In the Collection Management Plan, the park staff has examined a variety of issues important to the adequate preservation of museum collections. Summaries of existing conditions related to specific issues and upon which recommendations are presented in the Collection Management Plan, are summarized below. Please see NPS 2009b for detailed recommendations addressing each issue.

Scope of Collection Statement. Use new Scope of Collection Statement guidelines and periods of significance as filters for accepting new collections; deaccession collections that fall outside of the Scope of Collection Statement or that were accessioned in error; and work with the Resource Management Division to establish and maintain collections related to each unit of the park.

Museum Records. Among other things, address staff training, standardization of cataloging protocols, and resolution of existing problems related to artifact cataloging and descriptions.

Use of and Access to Collection. Research and registration forms are being successfully used to access collection storage areas. Expand use of all NPS researcher registration forms and establish a dedicated research space for museum collections. Improve accessibility of resource management records for researchers. Accessioning and processing of archival collections currently in curatorial custody should be accomplished under the guidance of a professional archivist.

Archives and Manuscript Collections. Establish a clear direction for management of park archives and manuscript collections. Archival materials not cataloged into the museum collection are constantly at risk. Use cataloging methods that will clarify contextual information, how items are associated, why they are significant for the park, and why/how they came to be curated by the park. The addition of a professional archivist would aid in conducting an overdue appraisal with the National Archives and Records Administration to ensure that NPS and other agency records can be examined holistically by provenance.

Archeology Collections. Duplication of archeological records has occurred in some instances but the overall effort to accession and document these materials has improved. The collections can continue to enhance the quality of museum exhibits and educational and interpretive programs. A complete survey of these materials is greatly needed to identify museum-quality objects. Attaching photographs to their electronic catalog records will make these materials more accessible to staff and researchers. Additional cataloging and rehousing of the collection is necessary to improve the current storage conditions and at the same time, a survey can be completed.

Collection Storage. The NPS Service-wide Storage Plan (2006c) recommends upgrading the existing facilities at Fort Wadsworth to improve climate control and to consider as an option for infrequently used collections from other area parks. Portions of the summary of this issue as presented in the Service-wide Storage Plan and the Collection Management Plan are outdated because the description of the Fort Hancock storage areas has changed so dramatically. The damage to Fort Hancock caused by Hurricane Sandy required some sensitive collections housed there to be moved (ongoing) to Fort Wadsworth on Staten Island, and the park currently plans to house all collections there for the foreseeable future (Mahan, pers. comm. 2013a). It is also expected that the recommendations for collection storage at Fort Wadsworth will be revised due to the transfer of collections from Fort Hancock. Both plans ultimately suggest the need to work within the ongoing general management plan effort to identify and evaluate feasible long-term alternatives that address the need to consolidate the Gateway collections.

Exhibits. The preservation focus is on the exhibition of textiles and paper-based objects; the substitution of high-quality color photographs for paper-based objects, when appropriate; the rotation of textile items on exhibit for more than six months; the monitoring of objects; and the maintenance of a list of all exhibit items on a biannual basis.

Curatorial Staff. Several positions need to be created in the Resource Management Division to improve the curatorial program and records management. In addition, there is a need for training designed to improve the quality of the program. Park management should provide overall guidance and ensure that funding and resources are prioritized appropriately.

Funding and Programming. NPS-wide programs maintain a five-year funding cycle; it is important that Gateway projects be submitted and programmed to these multi-year lists. The park should improve the updating and revising of the Annual Checklist Program to reflect existing conditions for museum collections. Additional staffing is a critical need.

Visitor Use and Experience

Spanning three New York City boroughs and the northernmost portion of the New Jersey shore, Gateway's park lands stand in sharp contrast to the nearby metropolitan area and offer abundant opportunities for residents and visitors to recreate and experience nature and historic settings. Natural areas; water, beaches, and coastal views; historic coastal defense and maritime structures; diverse recreation opportunities; and educational and interpretive programming combine to create rich and varied visitor experiences at Gateway.

The Gateway lands and waters serve many millions of visitors a year, making Gateway an important urban park environment on the East Coast and in the New York and New Jersey Metropolitan area.

Visitor Use and Characteristics

To inform the general management planning effort for Gateway, in 2009 the NPS commissioned Pennsylvania State University's Department of Recreation, Park, and Tourism Management to synthesize findings from past visitor studies and analyze areawide demographics characteristics and projected trends (Mowen, Graefe, and Graefe 2009). Relevant visitor characteristics from the Pennsylvania State University synthesis are summarized in this section (see the "Visitation Patterns" section in this chapter) along with park visitation statistics reported on the NPS Integrated Resource Management Applications portal (NPS 2013c, 2013d).

The Gateway lands and waters serve many millions of visitors a year, making Gateway an important urban park environment on the East Coast and in the New York and New Jersey Metropolitan area. Encompassing 27,025 acres of land and water in New York City and New Jersey, the three units of Gateway form an expansive public green space for both the local urban population and tourists to enjoy.

In 1974, the first year that the park reported visitation, Gateway had over 3.8 million visitors. Substantial increases and a few intermittent decreases have occurred since then, but annual visitation has remained around 9 million total visitors over the last 10 years (NPS 2013c) (figure 3-14 on next page).

Gateway recreation visitation typically ranks it within the top five parks in the national park system (NPS 2013c). Many of the sites in Gateway are in the "backyard" of New York City and New Jersey residents, who use the park lands for recreation and exercise. At most park sites, people from the local area account for the majority of visitors. A review over the last five years indicates that visitor use levels peak in the summer months, decrease in the fall, and are lowest in the winter and spring.