Section 5. Risk Assessment

5.2 Coastal Erosion and Sea Level Rise

2014 Plan Update Changes

- Sea level rise was added to the Coastal Erosion section.
- The hazard profile has been significantly enhanced to include a detailed hazard description, location, extent, previous occurrences, probability of future occurrence, severity, warning time and secondary impacts.
- A summary of the 25 years of research on the New Jersey coastline is presented.
- Previous occurrences were updated with a section dedicated to Superstorm Sandy's effect on the shoreline.
- The Richard Stockton Coastal Research Center's coastal erosion susceptible area was used in the vulnerability assessment for Ocean County.
- Potential change in climate and its impacts on the flood hazard are discussed.
- The vulnerability assessment now directly follows the hazard profile.
- Estimated coastal erosion hazard areas were generated for the risk assessment.
- The exposure and vulnerability of the population, general building stock, State-owned and leased buildings, critical facilities and infrastructure are discussed.
- Environmental impacts is a new subsection.

For the 2014 Plan update the coastal erosion profile and vulnerability assessment were significantly enhanced to include updated information on the hazard and best-available data. Sea level rise is a new addition to this section. A summary of the 25 years of research on the New Jersey coastline conducted by the Richard Stockton College Coastal Research Center was incorporated. Detailed descriptions of past incidents were added to this profile with a section dedicated to Superstorm Sandy's effect on New Jersey's shoreline. The vulnerability assessment has been enhanced to include best available data on both coastal erosion and sea level rise. This information can be used by both the State agencies in developing mitigation strategies and the local jurisdictions as they develop their mitigation plans.

5.2.1 Profile

Hazard Description

Coastal Erosion

Erosion and flooding are the primary coastal hazards that lead to the loss of lives or damage to property and infrastructure in developed coastal areas. Coastal storms are an intricate combination of events that impact a coastal area. A coastal storm can occur any time of the year and at varying levels of severity. One of the greatest threats from a coastal storm is coastal flooding caused by storm surge. Coastal flooding is the inundation of land areas along the oceanic coast and estuarine shoreline by seawaters over and above normal tidal action.

Many natural factors affect erosion of the shoreline, including shore and nearshore morphology, shoreline orientation, and the response of these factors to storm frequency and sea level rise. Coastal shorelines change constantly in response to wind, waves, tides, sea-level fluctuation, seasonal and climatic variations, human alteration, and other factors that influence the movement of sand and material within a shoreline system.

Unsafe tidal conditions, as a result of high winds, heavy surf, erosion, and fog are ordinary coastal hazard phenomena. Some or all of these processes can occur during a coastal storm, resulting in an often detrimental impact on the surrounding coastline. Factors including: (1) storms such as Nor'Easters and hurricanes, (2) decreased sediment supplies, and (3) sea-level rise contribute to these coastal hazards.

Coastal erosion can result in significant economic loss through the destruction of buildings, roads, infrastructure, natural resources, and wildlife habitats. Damage often results from an episodic event with the combination of severe storm waves and dune or bluff erosion.

Historically, some of the methods used by municipalities and property owners to stop or slow down coastal erosion or shoreline change have actually exacerbated the problem. Attempting to halt the natural process of erosion with shore parallel or perpendicular structures such as seawalls (groins and jetties) and other hard structures typically worsens the erosion in front of the structure (i.e. walls), prevents or starves any sediment behind the structure (groins) from supplying down-drift properties with sediment, and subjects down-drift beaches to increased erosion. Since most sediment transport associated with erosion and longshore drift has been reduced, some of the State's greatest assets and attractions – beaches, dunes, barrier beaches, salt marshes, and estuaries – are threatened and will slowly disappear as the sediment sources that feed and sustain them are eliminated.

Sandy barrier/bluff coastlines are constantly changing as the result of wind, currents, storms, and sea-level rise. Because of this, developed sandy shorelines are often stabilized with hardened structures (seawalls, bulkheads, revetments, rip-rap, gabions, and groins) to protect coastal properties from erosion. While hardened structures typically prove to be beneficial in reducing property damage, the rate of coastal erosion typically increases near stabilization structures. This increased erosion impacts natural habitats, spawning grounds, recreational activity areas, and public access (Frizzera 2011). Table 5.2-1 summarizes the number and type of NJDEP shoreline structures off the coastline of New Jersey along the Atlantic Ocean and Inland Bays (current as of 1993).

Table 5.2-1. Number and Type of NJDEP Shoreline Structures

County	Breakwater	Groin	Jetty	Revetment	Seawall
Atlantic County	0	25	3	0	0
Cape May County	1	94	8	4	3
Cumberland County	0	1	1	0	0
Middlesex County	0	4	0	0	0
Monmouth County	0	172	9	1	11
Ocean County	0	72	3	0	0
Total	**1**	**368**	**24**	**5**	**14**

Source: NJDEP 1993

To counteract the negative impact of hard structures, alternative forms of shoreline stabilization that provide more natural forms of protection can be used. Along the New Jersey coast, beach nourishment and dune restoration are now the main forms of shoreline protection. In addition, existing groins have been notched to reestablish the flow of sediment to previously sand-starved areas of the beach. The sheltered coastlines in New Jersey consist of tidal marshlands and a few narrow, sandy beaches—all of which naturally migrate inland as the sea level rises. Experts have stated that marshes can keep pace with a 0.1 inch per year (inch/year) rate of sea level rise; however, the State's current rate is approximately 0.11 to 0.16 inch/year, a rate that is predicted to continue increasing (Frizzera 2011). Currently, bulkheads and revetments are the primary form of shore protection along these tidal areas. As sea level rises and coastal storms increase in intensity, coastal erosion and requests for additional shoreline stabilization measures are likely to increase (Frizzera 2011). Figure 5.2-1 shows beach nourishment activities in Sea Girt, New Jersey.

Figure 5.2-1. Beach Nourishment Activities in Sea Girt, New Jersey

Source: New Jersey HMP 2011

Sea Level Rise

The National Oceanic and Atmospheric Administration (NOAA) has identified four scenarios for global mean sea level rise in its 2012 report, "Global Sea Level Rise Scenarios for the United States National Climate Assessment". Based on these four scenarios, labeled "Lowest", "Intermediate -Low", "Intermediate-High" and "Highest", NOAA generally has estimated, factoring in future potential conditions, global sea level rise by the year 2050 at the following four levels, respectively: 0.3 feet; 0.7 feet; 1.3 feet; and 2.0 feet. In addition, NOAA has made available electronic tools for individual communities to assess risk on a local or regional basis, including its Sea Level Rise Tool for Sandy Recovery. The state is consistently applying these tools to inform the development of this plan. In addition, as part of the State's comprehensive effort to assess the potential long term efficacy and fiscal sustainability of specific risk reduction measures and improvements using CDBG funding, the State intends to utilize the federal government's available tools to consider the impact of potential sea level rise and consider whether project designs should be enhanced to address potential sea level rise scenarios where such enhancements are cost effective and reasonably practical given the inherent uncertainty in sea level rise modeling.

There is currently no coordinated, interagency effort to identify agreed upon estimates for future sea level rise. The United States National Climate Assessment Development and Advisory Committee, a federal committee writing the next National Climate Assessment, outlines sea level rise scenarios in the National Oceanic and Atmospheric Administration's Office of Oceanic and Atmospheric Research, Climate Program Office, Technical Report OAR CPO-1 entitled 'Global Sea Level Rise Scenarios for the United States National Climate Assessment'. NOAA has identified four scenarios for global mean sea level rise in its 2012 report, "Global Sea Level Rise Scenarios for the United States National Climate Assessment". FEMA's best available special flood hazard area (SFHA), or the 1-percent annual chance flood, has been integrated with these four scenarios of sea level rise labeled "Lowest", "Intermediate -Low", "Intermediate-High" and "Highest". Based on these scenarios, NOAA generally has estimated, factoring in future potential conditions, global sea level rise by the year 2050 at the following four levels, respectively: 0.3 feet; 0.7 feet; 1.3 feet; and 2.0 feet. . Please note these scenarios do not predict future changes but describe estimated potential future conditions. This report notes that the greatest uncertainty surrounding estimates is the rate and magnitude of ice sheet loss, primarily from Greenland and West Antarctica. Global sea level rise scenarios for New Jersey and New York State are provided in Table 5.2-2. These four scenarios reflect different degrees of ocean warming and ice sheet loss.

Table 5.2-2. NOAA Sea Level Rise Scenarios for New Jersey

Scenario	2050 (feet of rise)
Lowest	SFHA + 0.3 feet
Intermediate - Low	SFHA + 0.7 feet
Intermediate - High	SFHA + 1.3 feet
Highest	SFHA + 2.0 feet

Source: NOAA 2012
SFHA Special Flood Hazard Area

Rutgers University has developed a dataset based on NOAA's data which accounts for local variables. This is further discussed in Climate Change Impacts presented later in this section.

Regulatory Programs

Section 3 (Coordination of Local Planning) of the 2014 Plan update discusses the regulatory programs in place that protect the New Jersey coast. The two main programs are summarized below.

New Jersey Shore Protection Program

The New Jersey Shore Protection Program was created to provide for the protection of life and property along the coastline, to preserve vital coastal resources, and to maintain safe and navigable waterways throughout New Jersey. The Bureau of Coastal Engineering, which operates under the Office of Engineering and Construction within the New Jersey Department of Environmental Protection's (NJDEP) Natural and Historic Resources Group, is responsible for administering beach nourishment, shore protection, and coastal dredging throughout the State. The Bureau also maintains the State's aid to navigation; provides 24-hour operation of the Raritan Bayshore Floodgate; and conducts storm surveys, damage assessments, and emergency repairs for coastal storms that impact New Jersey (NJDEP 2012a).

New Jersey Coastal Management Program

The New Jersey Coastal Management Program (CMP), an extension of the NJDEP, is the lead for issues related to coastal erosion across the State. The CMP's mission is to ensure that coastal resources and ecosystems are maintained and to enhance the sustainability of coastal communities in the State. The CMP's central component is the Coastal Management Office. The Coastal Management Office is part of the Commissioner's Office of Policy and administers the planning and enhancement measures of the CMP. The Office is responsible for developing long-term projects related to coastal sustainability. The Office also advises the CMP on related policies and works with municipal, state, and federal partners on coastal erosion projects and grant funding opportunities (NJDEP 2012b).

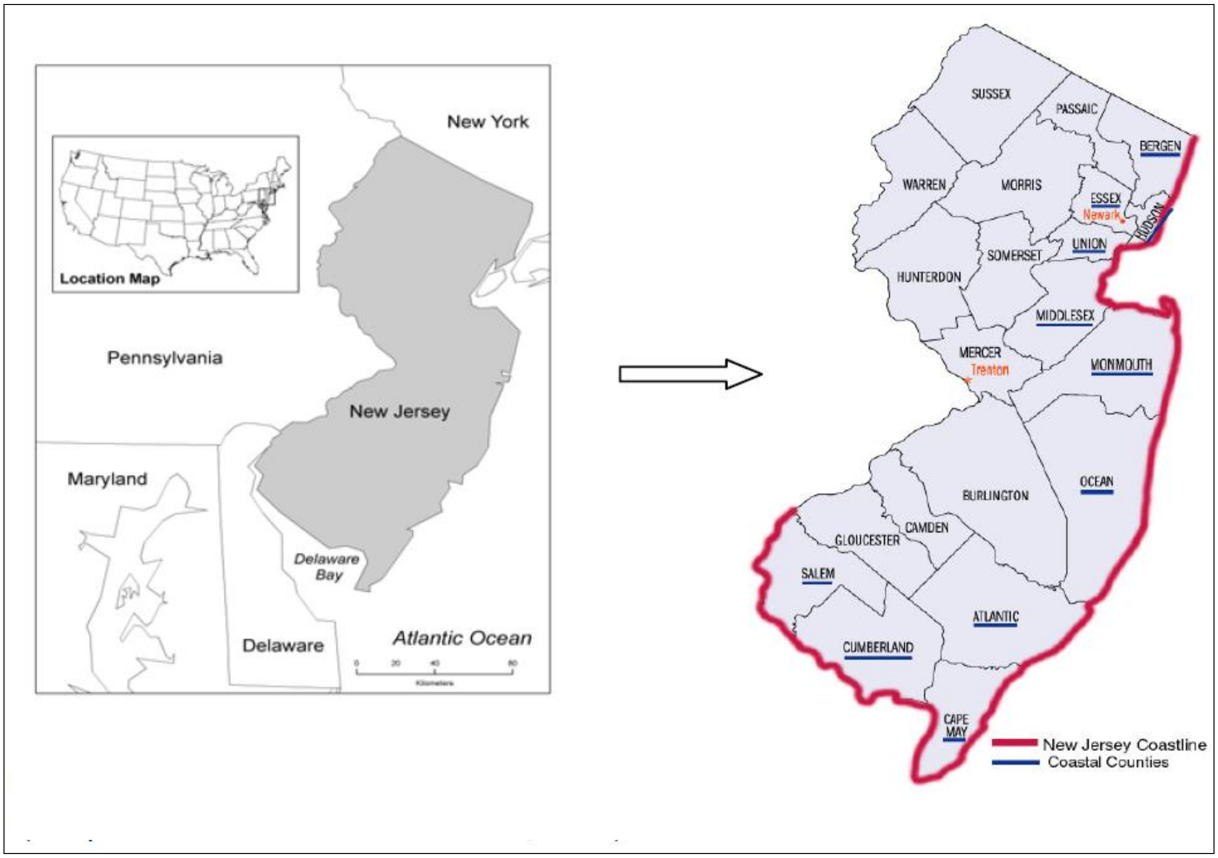
In addition to the activities of the CMP, the NJDEP's Bureau of Coastal Engineering also plays a role in the prevention of and response to coastal erosion. The Bureau of Engineering, in cooperation with the United States Army Corps of Engineers (USACE) provides beach nourishment and re-nourishment projects along the New Jersey Coastline. Beach nourishment involves replacing sand that has been eroded from natural sediment movement or as a result of a storm (NJDEP 2012b).

In order to ensure the prompt and coordinated acquisition of easements or other interests in real property necessary to facilitate the timely completion of a comprehensive system of Flood Hazard Risk Reduction Measures, as directed by the Governor under Executive Order (EO) 140, the NJDEP Commissioner established the Office of Flood Hazard Risk Reduction Measures ("the Office"). The Office is headed by a director, appointed by the NJDEP Commissioner. The Office is a single State entity responsible for the rapid acquisition of property vital to the post-Sandy reconstruction efforts. The Office will lead and coordinate the efforts of the NJDEP to acquire the necessary interests in real property to undertake Flood Hazard Risk Reduction Measures and shall perform such other duties as the NJDEP Commissioner may from time-to-time prescribe. No municipality, county or other agency or political subdivision shall enact or enforce any order, rule, regulation, ordinance, or resolution which will or might in any way conflict with any of the provisions of EO 140.

Location

New Jersey and its coastal communities are vulnerable to the damaging impacts of major storms along its 127 miles of coastline. New Jersey's coastal zone includes portions of eight counties and 126 municipalities. The coastal boundary of New Jersey encompasses the Coastal Area Facility Review Act (CAFRA) area and the New Jersey Meadowlands District. The coastal area includes coastal waters to the limit of tidal influence including: the Atlantic Ocean (to the limit of New Jersey's seaward jurisdiction); Upper New York Bay, Newark Bay, Raritan Bay and the Arthur Kill; the Hudson, Raritan, Passaic, and Hackensack Rivers, and the tidal portions of the tributaries to these bays and rivers. The Delaware River and Bay and other tidal streams of the Coastal Plain are also in the coastal area, as is a narrow band of adjacent uplands in the Waterfront Development area beyond the CAFRA area. Figure 5.2-2 shows the coastline of New Jersey with the coastal counties noted.

Figure 5.2-2. State of New Jersey Coastline



Source: Cooper et al. 2005

Over 300,000 acres of tidal wetlands provide breeding and nursery habitats for finfish and shellfish and act as a natural flood and pollution control system along the coastline of the State. More than 50 species of fish and shellfish are commercially and recreationally harvested in New Jersey. Bays, rivers, and 127 miles of ocean coastline provide recreational opportunities for residents and visitors of the State (NJDEP 2002).

In addition to the shore communities in New Jersey, a number of counties have shoreline that may be vulnerable to coastal erosion. New Jersey is bordered on three sides by water, including the Delaware River along the western border. Other counties that may be affected by shoreline change include the riverine counties of Gloucester, Camden, Burlington, Mercer, Hunterdon, Warren, and Sussex.

The Richard Stockton College Coastal Research Center (CRC)

In 1986, the Richard Stockton College CRC established the New Jersey Beach Profile Network (NJPBN) for the purpose of monitoring shoreline conditions along the coastline of New Jersey. NJBPN is made up of 105 beach profile sites along the State's entire shoreline, including the Raritan and Delaware Bays. The sites are located in Monmouth, Ocean, Atlantic, and Cape May Counties. The profile sites are spaced approximately one mile apart, with at least one site located in each oceanfront municipality. The dune, beach, and near-shore areas are surveyed at each profile site twice a year, in the fall and spring, and are analyzed for seasonal and multi-year changes in shoreline position and sand volume. Reports on each beach profile are published annually (Richard Stockton College CRC 2012a).

The NJBPN shoreline monitoring sites in Monmouth County extend from three sites along the eastern beaches of the Raritan Bay, to the oceanfront shoreline of Sandy Hook, then south to Manasquan Inlet. Monmouth County has the greatest number of beach profile sites because of the complexity of its shoreline. Monmouth County contains 36 profile stations, making it the most densely surveyed county in New Jersey (Richard Stockton College CRC 2012a).

As noted, although the majority of the counties in New Jersey have a shoreline, the primary coast line falls within four counties: Atlantic, Cape May, Monmouth, and Ocean. Information regarding each of these counties is discussed below.

Atlantic County

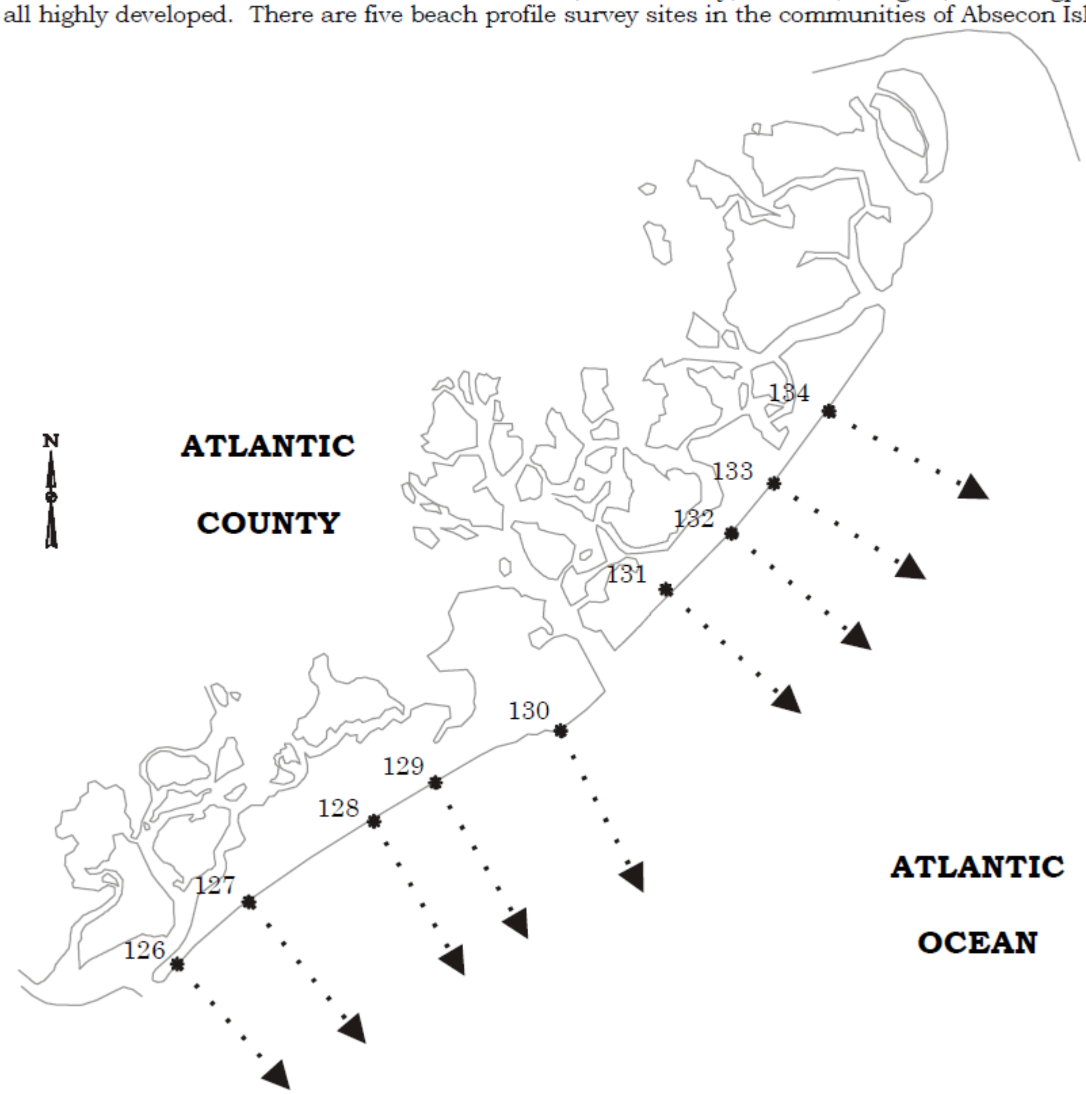
Atlantic County features a series of barrier island communities. The Atlantic County coastline consists of three barrier islands. The island of Little Beach belongs to the Forsythe National Wildlife Refuge and is located between Little Egg Inlet and Brigantine Inlet. Brigantine Island is divided into a northern third that is undeveloped and managed by New Jersey Green Acres Program. The City of Brigantine and its development occupies the remainder of the island. Absecon Island is home to Atlantic City, Ventnor City, Margate City, and the Borough of Longport, which are all highly developed (Richard Stockton College CRC 2012b). Figure 5.2-3 illustrates the beach profile locations in Atlantic County.

Figure 5.2-3. Atlantic County Profile Site Locations

New Jersey Beach Profile Network
Atlantic County Profile Site Locations

Figure 6

There are nine NJBPN survey sites on the Atlantic County shoreline. The beach profile sites are located in the City of Brigantine, Atlantic City, the City of Ventnor, the City of Margate, and the Borough of Longport. The Atlantic County coastline consists of three barrier islands. Little Beach is bordered by Little Egg Inlet to the north and by Brigantine Inlet to the south. Little Beach is part of the Forsythe National Wildlife Refuge and is therefore not surveyed. South of Brigantine Inlet lay Brigantine Island, the northern third of which remains undeveloped as part of the New Jersey Green Acres program. There is one survey site along the undeveloped portion of the Brigantine shoreline and three additional sites on the developed portion. Absecon Inlet separates Brigantine Island from Absecon Island. The Absecon Island communities, Atlantic City, Ventnor, Margate, and Longport, are all highly developed. There are five beach profile survey sites in the communities of Absecon Island.



Source: NJBPN 2003

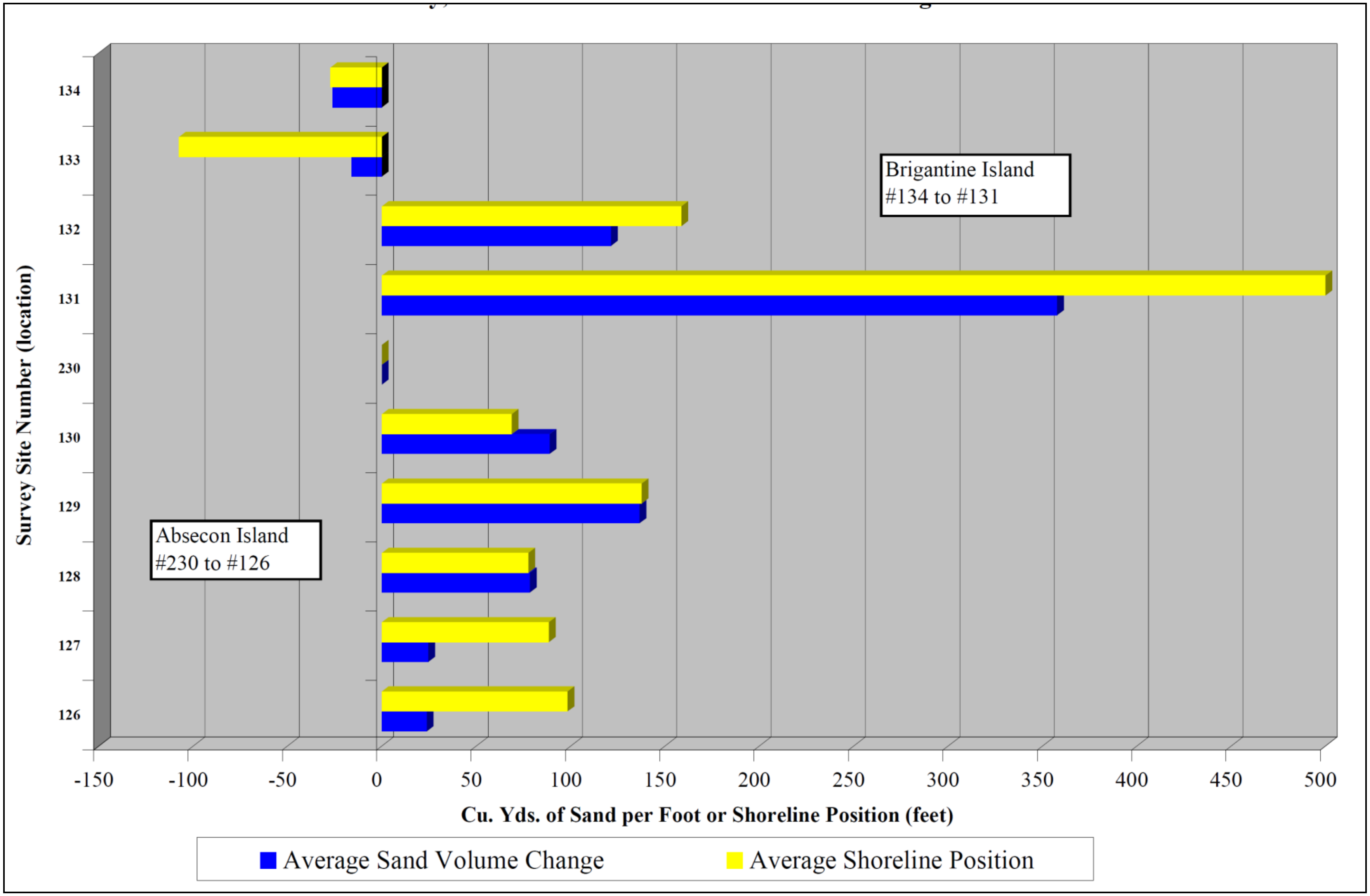
Perhaps the most well-known community in Atlantic County is Atlantic City. Atlantic City is located on Absecon Island and is approximately 60 miles east of Philadelphia. The proximity to Philadelphia makes Atlantic City a popular entertainment destination. Atlantic City became a major resort city after the legalization of gambling in 1976. The City features a four mile boardwalk that begins at the Absecon Inlet and extends to the City limits. Beyond the City limits the boardwalk extends south into Ventnor City. Atlantic City is bordered to the north by Brigantine and to the south by Longport. Both of these surrounding communities are much smaller than Atlantic City and are primarily residential beach communities (Richard Stockton College CRC 2012b).

There are 10 NJBPN survey sites along the Atlantic County shoreline. Atlantic County communities have been the direct or indirect beneficiaries of federally sponsored beach nourishment projects, as well as having been the sites of multiple state and locally sponsored projects in past years. Sand has been systematically harvested from Brigantine Inlet or Absecon Inlet to substantially add to the beach's width and sand volume, and has enhanced the dune protection for landward properties. The federal Absecon Island project was completed between fall 2003 and spring 2004 with sand derived from Absecon Inlet. The refusal of Margate City and Longport to participate in the project has resulted in a significant loss of sand from the southern third of Ventnor City beaches through end-effect erosion. Sand is transported south to the areas not initially replenished causing the fill to deteriorate on the southern portion of Ventnor beach. The NJBPN surveys have shown substantial increases in sand volume at Benson Avenue in Margate and a minor increase all the way south at 17th Street in Longport. The Ventnor City profile is located in the middle of the municipal shoreline and has remained stable because it is well north of the project's termination at the border with Margate City. End-effect erosion from fill projects is a significant reason to have continuity of projects across an entire barrier island or between inlets (Richard Stockton College CRC 2012b).

The northern beaches in Atlantic City deteriorated between 2009 and 2010, and Hurricane Irene further exacerbated issues in 2011. The USACE proceeded with an emergency fill project at the Atlantic City Beach in 2011. The Brigantine project was similarly evaluated and as a result, USACE supplemented the beach with 96,000 cubic yards of emergency fill using quarry sand trucked to the north end of the development on the island. Funding is in place to initiate the placement of maintenance fill using Brigantine Inlet ebb-tidal shoals (Richard Stockton College CRC 2012b).

Figure 5.2-4 shows the beach volume and shoreline change over the last 25 years for each of the profile stations in Atlantic County. The pattern change on Brigantine Island is one of strong shifts in material from the north end of the island to the south impounded by the north jetty to Absecon Inlet. The federal project on Absecon Island has produced positive changes over the past eight to nine years (Richard Stockton College CRC 2012b).

Figure 5.2-4. Beach Volume and Shoreline Position Changes Over 25 Years, Atlantic County

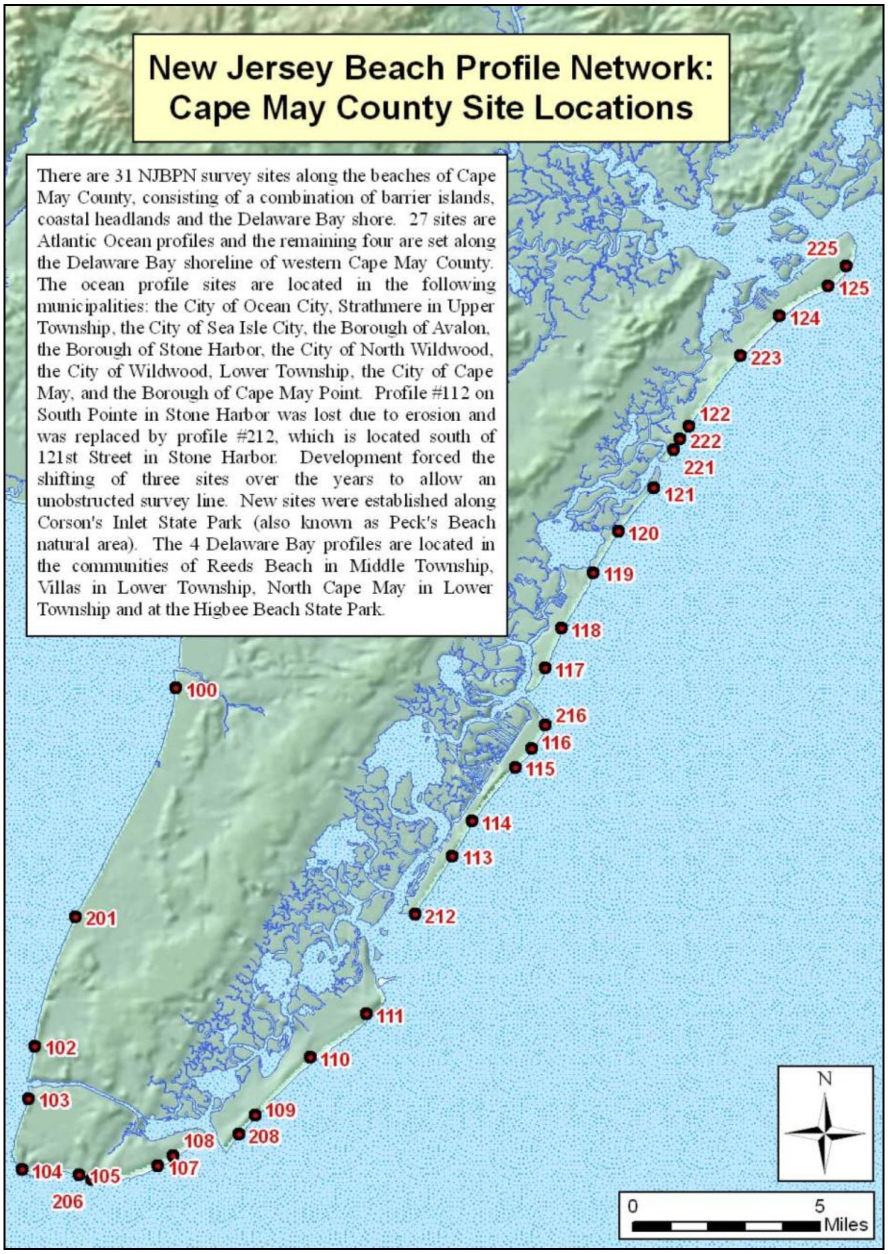


Source: Richard Stockton College CRC 2012b

Cape May County

From north to south, Cape May County begins with Ocean City, which features a 2.5-mile boardwalk and eight miles of beaches. A popular destination in Cape May County is the Wildwoods, which is a collection of four communities including North Wildwood, West Wildwood, Wildwood City, and Wildwood Crest. The southern border of Cape May County is the southernmost tip of the New Jersey shore, where the Atlantic Ocean meets the Delaware Bay. The City of Cape May is designated as a historic landmark city. Cape May is also a terminal for the Cape-May Lewes Ferry, which transports passengers and vehicles across the Delaware Bay from Cape May to Lewes, Delaware (Richard Stockton College CRC 2012c). Figure 5.2-5 shows the profile locations in Cape May County.

Figure 5.2-5. Cape May County Beach Profile Locations



Source: Richard Stockton College CRC 2012c

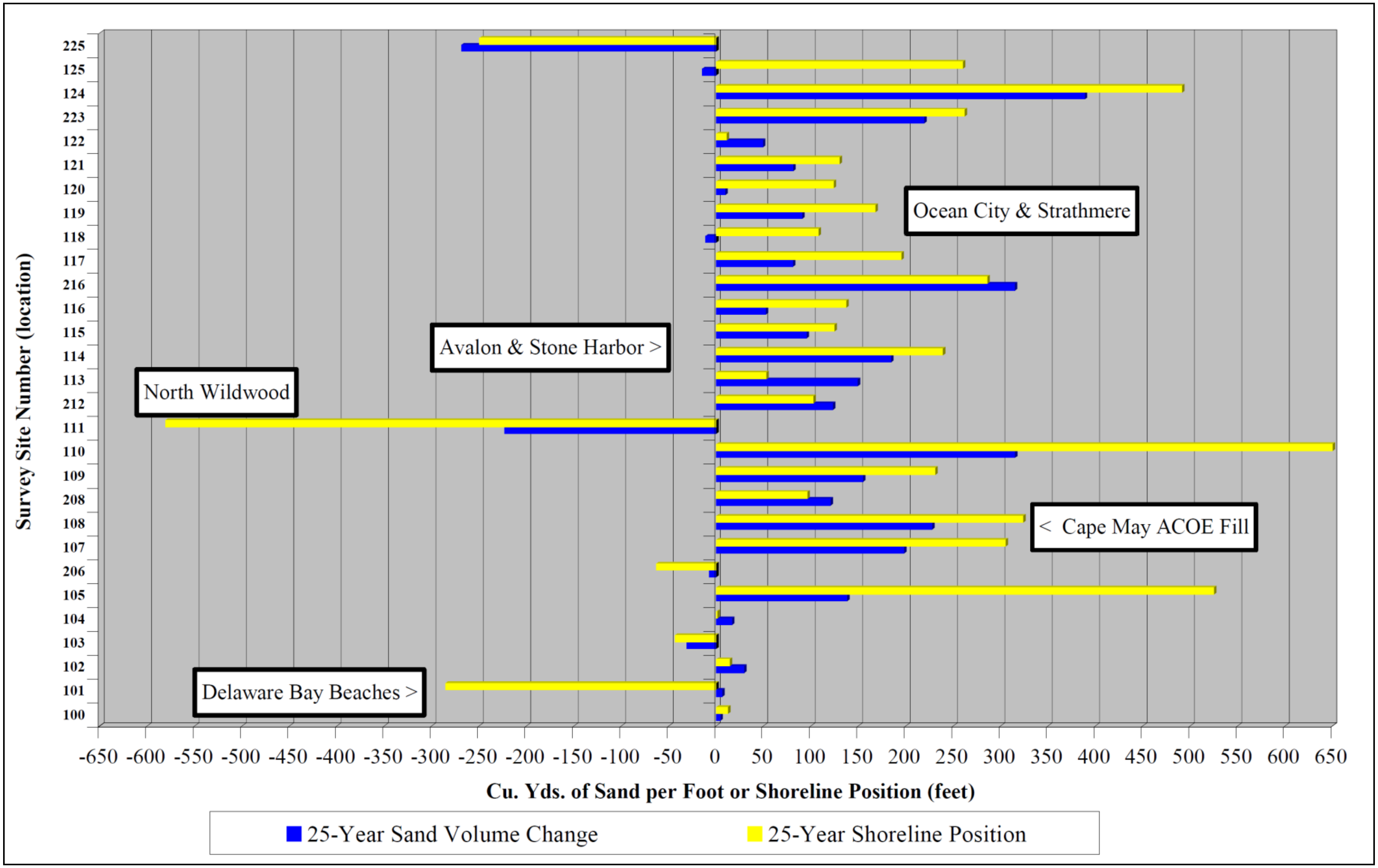
Cape May County contains 31 NJBPN survey sites along the beaches, consisting of barrier islands, coastal headlands, and the Delaware Bay shoreline. Of those 31 sites, 27 survey sites are Atlantic Ocean profiles and four sites are set along the Delaware Bay shoreline of western Cape May County. The 25-year assessment for Cape May County has shown that the multiple episodes and variety of beach restoration projects significantly improved the quality, shore-protection value, and recreational use of the beaches throughout the County. The commercial boardwalk segment of Ocean City underwent a major economic renaissance since 1992 with improvements to its shore protection extending to 56th Street. The survey site at 20th Street in Ocean City has seen the high tide-line shift from landward of the boardwalk in 1991 to over 600 feet seaward over the past 21 years. In 2009, a state and local project reinforced Whale Beach, an extremely narrow and vulnerable shoreline section in Strathmere, with a wider beach and dune system that saved this area from serious structural loss. Sea Isle City received sand from Corson's Inlet in 2009 and in 2011 as part of a restoration effort (Richard Stockton College CRC 2012c).

The Borough of Avalon continues a 25-year history of beach management, employing multiple innovative concepts since the 1993 installation of a beach-saver reef system and inlet geo-textile-submerged breakwaters. A federal project restored the shoreline in Cape May City to greater economic stability and prosperity. The Baltimore Avenue beach consisted of water at the seawall at low tide with no usable beach at all. Today, there is a 350-foot wide beach and dune system the length of the City oceanfront. North Wildwood applied for and received state assistance to restore approximately half the sand lost to the communities to the south and into Hereford Inlet. Recent studies of this Inlet indicated that significant changes to the main tidal channels cutting through the ebb-tidal delta system could have great impacts on the adjacent island shoreline associated with inlet processes. The traditional main ebb channel has competition from a new channel that exists between Stone Harbor's South Point and a highly variable sand island locally known as Champaign Island. If the new channel becomes dominant, the North Wildwood inlet shoreline and northern oceanfront beach will experience major sand accumulation (Richard Stockton College CRC 2012c).

The Borough of Cape May Point's experimental reef project continued to have a positive impact on the shorelines of those cells where the concrete structures were placed between groins defining the two cells. This work has verified the sand retention properties of these structures in that type of installation. Sand also migrated westward to the two groin cells not involved in either breakwater installation or direct sand placement. This has been very beneficial for the Borough (Richard Stockton College CRC 2012c).

Figure 5.2-6 shows the beach volume and shoreline change over the last 25 years for each of the profile stations in Cape May County. The sites located on the north end of each barrier island have an erosional tendency, especially in North Wildwood (#111). Multiple beach nourishment projects have given Cape May County a strong, positive change value in both sand volume and shoreline position. The five Delaware Bay cross sections have much smaller magnitude change rates (Richard Stockton College CRC 2012c).

Figure 5.2-6. Beach Volume and Shoreline Position Changes Over 25 Years, Cape May County

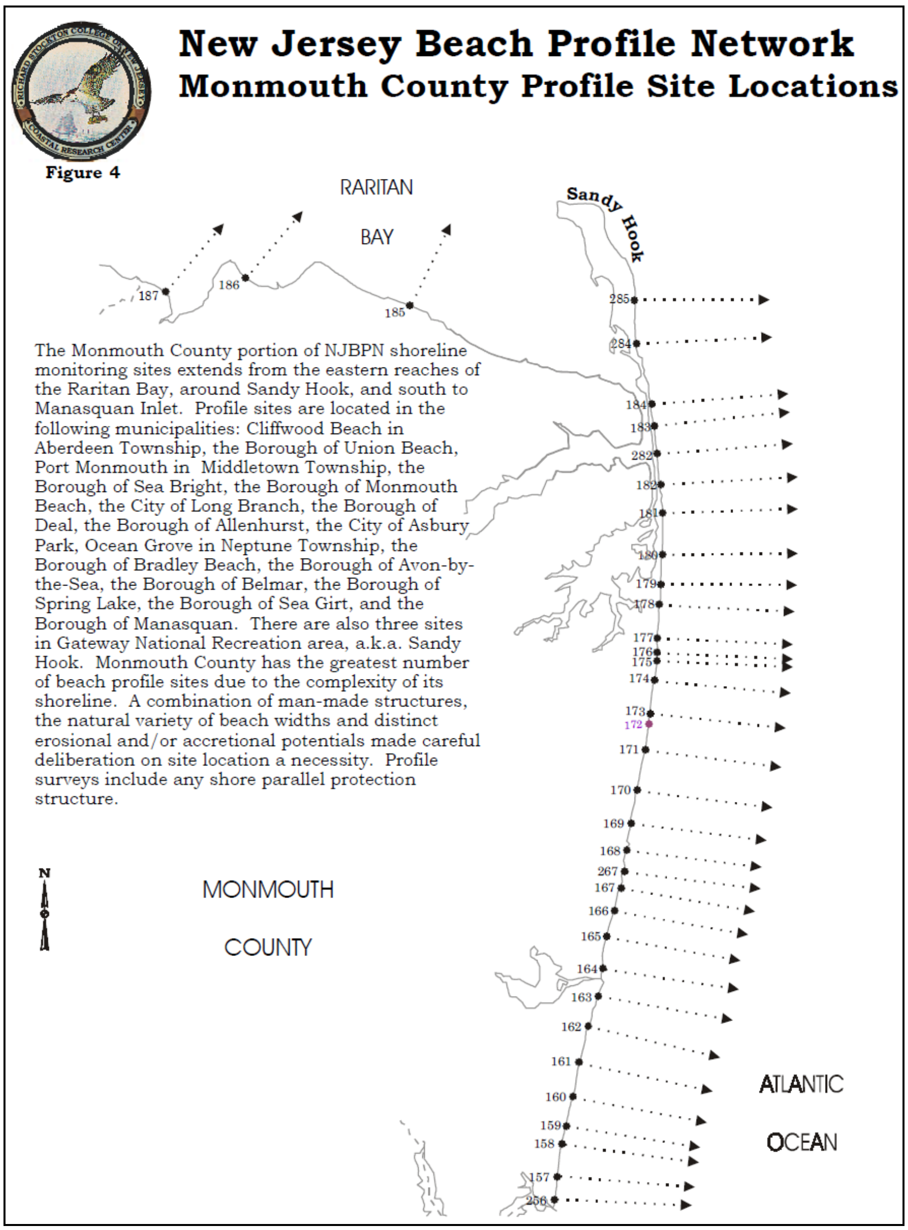


Source: Richard Stockton College CRC 2012c

Monmouth County

New Jersey's shoreline starts in Monmouth County at the Sandy Hook barrier islands located at the mouth of the Lower Bay directly adjacent to Brooklyn, New York. Sandy Hook is owned and maintained by the National Park Service. This area consists of several public beaches including North Beach, Gunnison Beach, and South Beach. South of Sandy Hook is Asbury Park, an area steeped in a rich musical tradition, which recently underwent somewhat of a renaissance in the past decade to become a popular tourist spot along the coast. Further south is Ocean Grove, which is a historic area, denoted on the National Registration of Historic Places. Also located in Monmouth County is Belmar, which is a popular vacation destination that features natural and cultural resources (Richard Stockton College CRC 2012d). Figure 5.2-7 shows the profile locations in Monmouth County.

Figure 5.2-7. Monmouth County Profile Site Locations



Source: NJBPN 2003

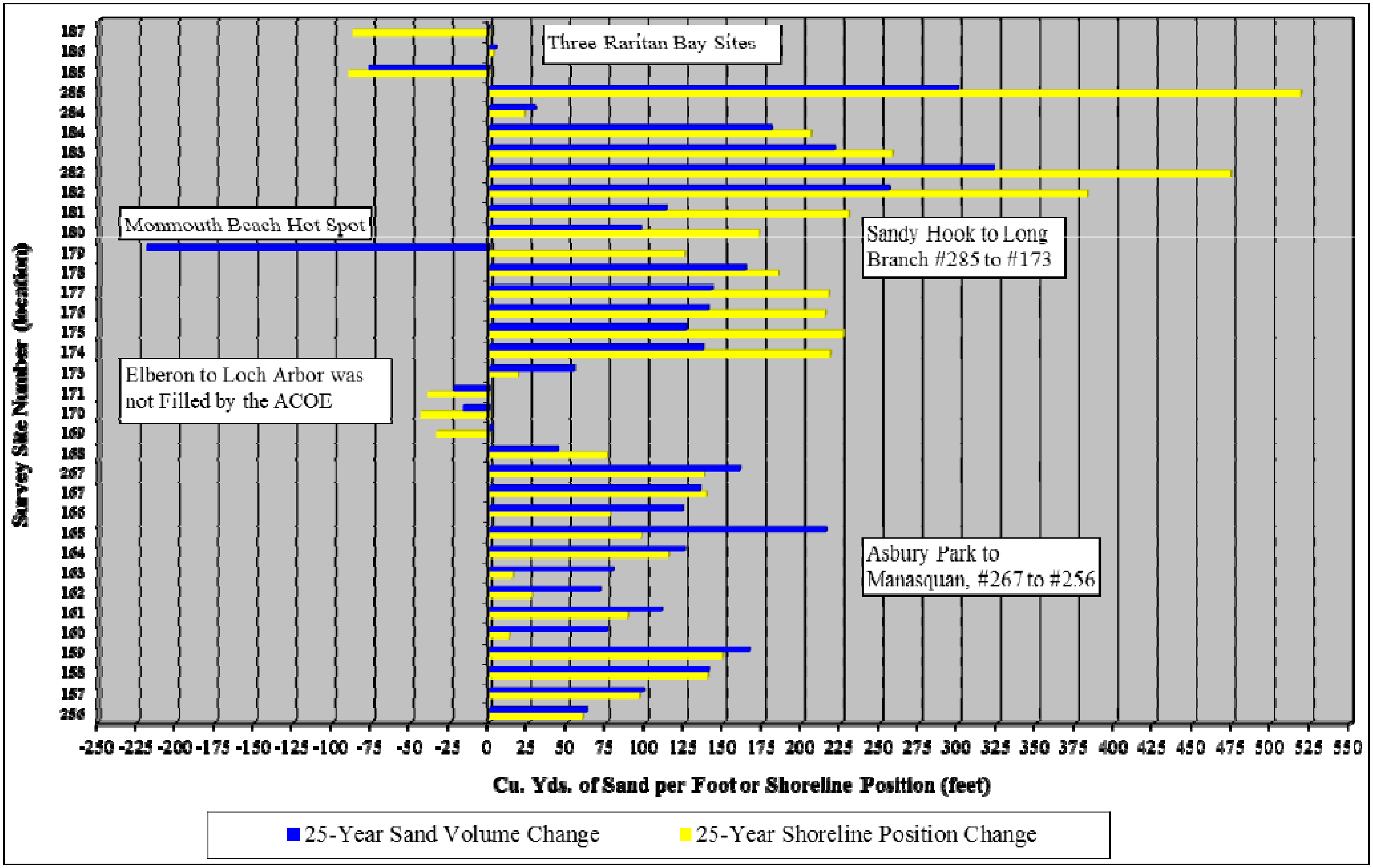
Monmouth County contains 36 profile stations, making it the most densely surveyed county. Figure 5.2-7 shows the beach volume and shoreline change over the last 25 years for each of the profile stations in the County. Many of the sites show the influence of the federal beach nourishment project and subsequent maintenance fill that was added to several locations in response to a storm in 1997. The sites experienced a substantial loss of sand caused by El Niño in 2009 and 2010; however, Monmouth County is considered to be in good shape for volume and shoreline position when compared to the 1986 conditions. Beach nourishment is credited for the positive state of Monmouth County beaches, with only a few locations suffering from erosion. Those areas affected by erosion were either not included in the federal project or are located adjacent to a coastal structure that blocks the littoral flow of sand (Richard Stockton College CRC 2012d).

As seen in Figure 5.2-8, Site 179 (Cottage Road in Monmouth Beach) has experienced persistent, rapid loss of sand deposits. A massive stone groin protects the Monmouth Beach Club property and is positioned approximately 500 feet south of this survey point. Because of this, the dominant littoral currents are directed north; as sand moves north away from the groin at the Cottage Road site, it is not being replaced by significant material traveling north around the groin. The groin did not allow sediment to pass further south and the profile site beach accumulated sand following the 2009-2010 winter storm season. If this is the case, the Cottage Road site will be a perpetual “hot spot” for erosion. This site has the worst erosion history of any site in Monmouth County. The net sand volume change was a loss of 8.82 cubic yards per foot (yd^3/ft) and a 13-foot shoreline retreat between 2010 and 2011 (Richard Stockton College CRC 2012d).

Site 167 in Asbury Park gained sand volume in five of 11 years (2002, 2005, 2007, 2009, and 2011) since the 1999 beach nourishment, which allowed the beach to maintain its appearance and storm resistance without need for maintenance. At Site 160 (Salem Avenue) in Spring Lake, sand volume increased for more than 10 years following the initial sand placement in 1997. The site also experienced three years of loss that brought the total volume below the amount placed during the federal project. However, the site continues to maintain a healthy profile 13 years after the project was completed (Richard Stockton College CRC 2012d).

During the 2009-2010 winter storm season, Monmouth County had substantial loss of sediment from its beaches; however, the County has retained over 13 million cubic yards of sand above the amount recorded in 1993. Between Hurricane Irene in September 2011 and the October 2011 Nor’Easter, the sand volume of beaches increased by 174,000 cubic yards. The CRC computed a loss rate for the 21 miles of USACE-managed beaches, and without any further addition of sand volume, the emplaced fill will be completely gone by 2068 (Richard Stockton College CRC 2012d).

Figure 5.2-8. Beach Volume and Shoreline Position Changes Over 25 Years, Monmouth County

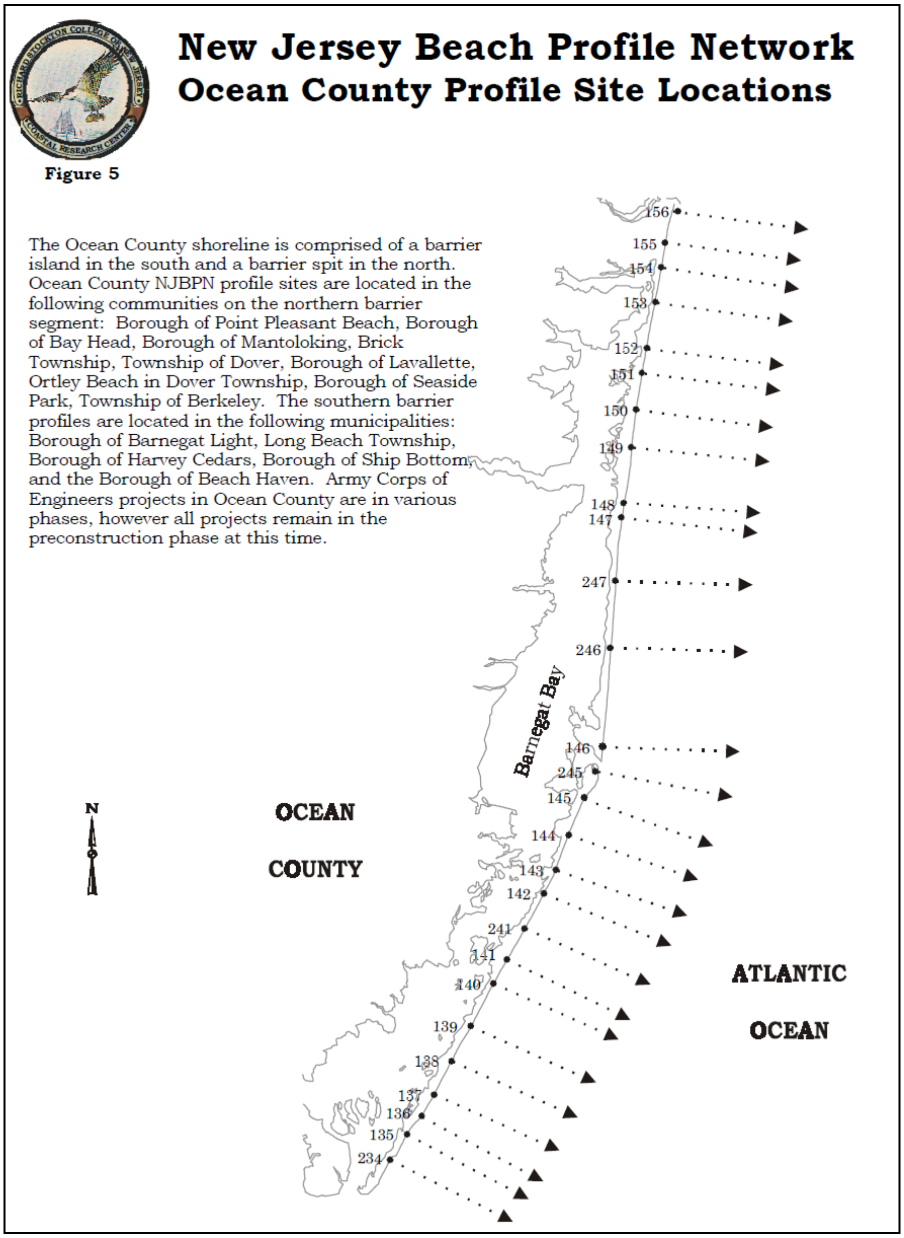


Source: Richard Stockton College CRC 2012d

Ocean County

Ocean County is located south of Monmouth County. Ocean County has the longest oceanfront shoreline of the four coastal counties (45.2 miles); the northern section comprises 23.6 miles, and Long Beach Island makes up 21.6 miles. A total of 13.4 miles of undeveloped shoreline covers two large parcels: Island Beach State Park (10.0 miles) and Holgate (3.4 miles). Ocean County includes one inlet—Barnegat Inlet—dividing the northern section from Long Beach Island between Manasquan Inlet to the north and Little Egg Inlet on the south. The northern section is unique along the New Jersey coastline in that it lies within a zone where sand transport parallel to the shoreline is essentially zero over long periods of time (Richard Stockton College CRC 2012e). Figure 5.2-9 shows the beach profile locations in Ocean County.

Figure 5.2-9. Ocean County Profile Site Locations



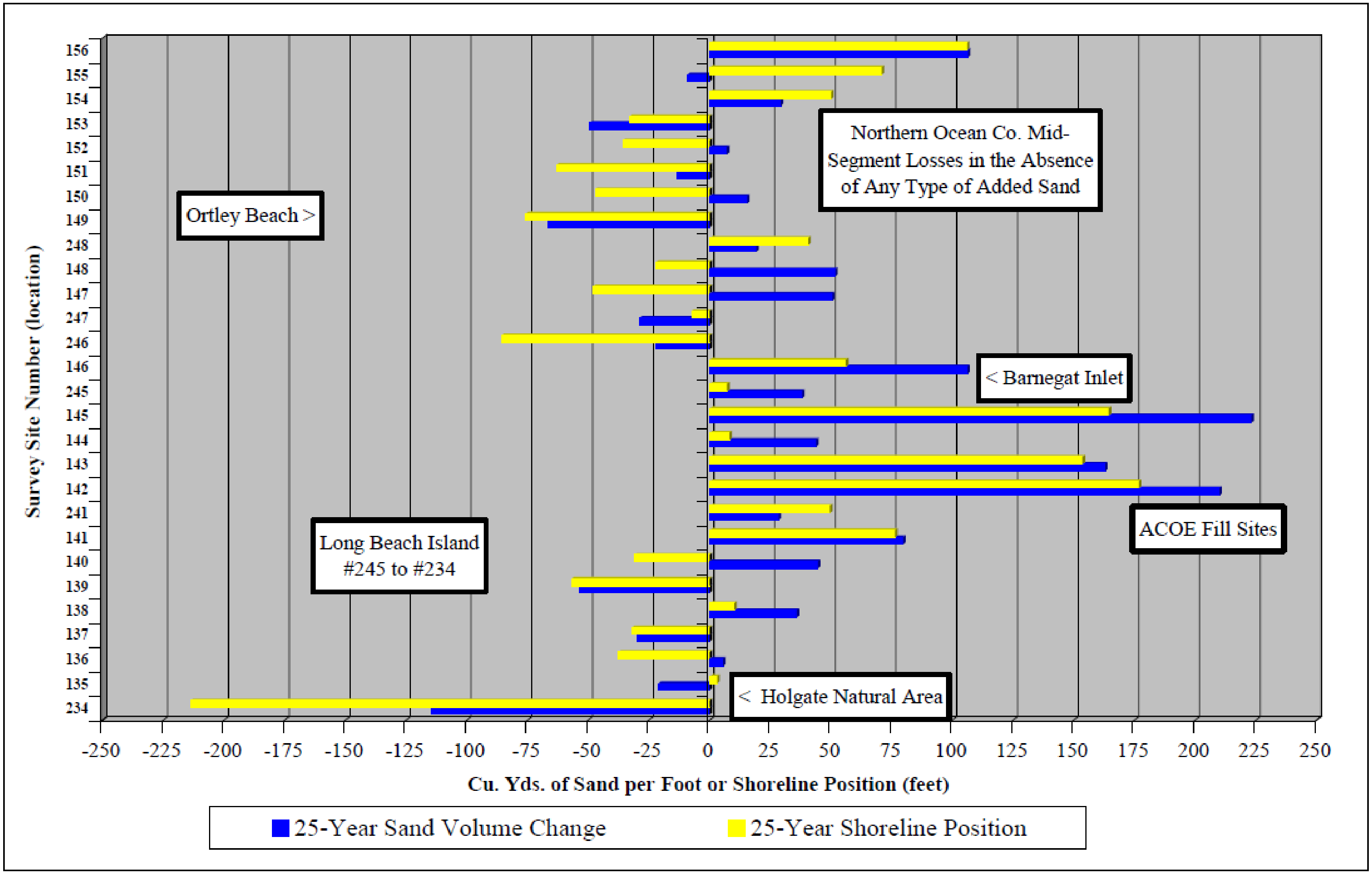
Source: NJBPN 2003

Ocean County features many beach communities and, unlike Monmouth County, features a series of barrier islands that are separate from the mainland. During Superstorm Sandy in 2012, Ocean County sustained the most significant damages. Directly south of Monmouth County is Point Pleasant Beach. Point Pleasant begins at the Manasquan inlet to the north, which also marks the end of the intracoastal waterway on the east coast. Moving further south is Seaside Heights, which is a relatively small town featuring two large piers and numerous amusement and entertainment facilities. Seaside Heights is bordered to the west by Barnegat Bay and to the east by the Atlantic Ocean. As a popular attraction, the population of Seaside can expand beyond 40,000 on summer weekends. Long Beach Island (LBI), a collection of several shore communities, is approximately 18 miles in length. LBI is located approximately four to six miles off of the mainland. Aside from the communities of LBI, the island also features a 3-mile long nature reserve (Richard Stockton College CRC 2012e).

In northern Ocean County, no federal, state or locally funded beach nourishment projects have been initiated over the past 25 years. Following the March 1962 Nor'Easter, sand was pumped on the County's shoreline. The sand was derived from dredging deep borrow zones within Barnegat Bay. These 30-foot-deep areas are still present and represent biological dead zones caused by the lack of oxygen circulation in the deep water column. Following this dredging project, dunes were built and the shoreline slowly recovered (Richard Stockton College CRC 2012e).

Figure 5.2-10 shows the beach volume and shoreline change over the last 25 years for each of the profile stations in the County. The amount of sand added or lost is indicated in blue and the change in shoreline position landward or seaward is shown in yellow. Beach nourishment activity did not occur in northern Ocean County, and the middle sites (Surf City, Harvey Cedars, and Ship Bottom) were recipients of USACE projects since 2006. The huge loss in the Holgate Natural area is caused by the lack of sand bypassing the terminal rock groin in Beach Haven (Richard Stockton College CRC 2012e).

Figure 5.2-10. Beach Volume and Shoreline Position Changes Over 25 Years, Ocean County



Source: Richard Stockton College CRC 2012e

Extent

Coastal Erosion

Coastal erosion is measured as the rate of change in the position or horizontal displacement of a shoreline over a period of time (FEMA 1996). A number of factors determine whether a community experiences and/or is vulnerable to greater long-term erosion or accretion:

- Exposure to high-energy storm waves;
- Sediment size and composition of eroding coastal landforms feeding adjacent beaches;
- Near-shore bathymetric variations which direct wave approach;
- Alongshore variations in wave energy and sediment transport rates;
- Relative sea level rise;
- Frequency and severity of storm events; and
- Human interference with sediment supply (e.g. revetments, seawalls, jetties) (Woods Hole Sea Grant 2003).

Such erosion may be intensified by activities such as boat wakes, shoreline hardening, or dredging.

Sea Level Rise

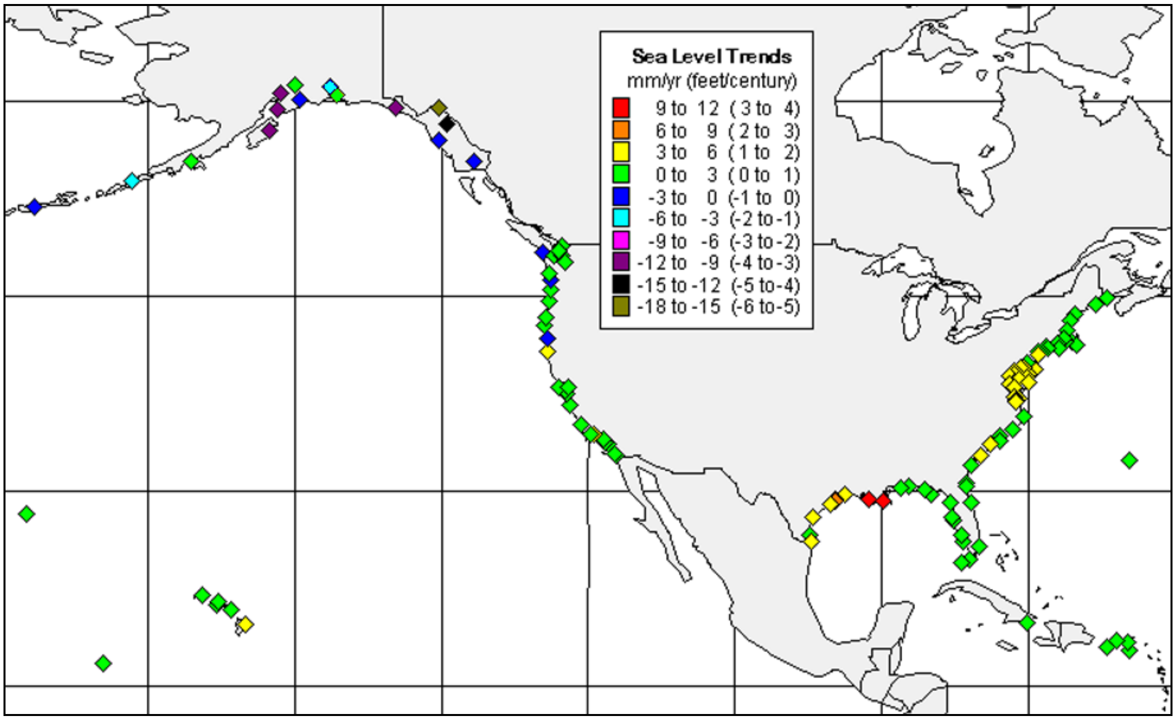
According to the USGS, the coastal vulnerability index (CVI) provides a preliminary overview, at a National scale, of the relative susceptibility of the Nation's coast to sea-level rise. This initial classification is based upon variables including geomorphology, regional coastal slope, tide range, wave height, relative sea-level rise, and shoreline erosion and accretion rates. The combination of these variables and the association of these variables to each other furnish a broad overview of coastal regions where physical changes are likely to occur due to sea-level rise.

The Center for Operational Oceanographic Products and Services has been measuring sea level for over 150 years, with tide stations of the National Water Level Observation Network operating on all coastlines of the United States. Changes in mean sea level (MSL), either a sea level rise or sea level fall has been computed at128 long-term water level stations using a minimum span of 30 years of observations at each location. The measurements have been averaged by month to remove the effect of higher frequency phenomena (storm surge) in order to compute an accurate linear sea level trend (NOAA 2013).

Figure 5.2-11 is a map of regional MSL in the United States. This map provides an overview of variations in the rates of relative local MSL at long-term tide stations. The variations in sea level trends primarily reflect differences in rates and sources of vertical land motion. Areas that experienced little-to-no change in MSL are shown in green, including stations consistent with average global sea level rise rate of 1.7 to 1.8 mm/year. These stations do not experience significant vertical land motion. Stations that experienced positive sea level trends (yellow to red) experience both global sea level rise and lowering or sinking of the local land, causing an apparent exaggerated rate of relative sea level rise. Stations that are blue to brown have experienced global sea level rise and a greater vertical rise in local land, causing an apparent decrease in relative sea level. The rates of relative sea level rise reflect actual observations and must be accounted for in any coastal planning or engineering applications (NOAA 2013). Table 5.2-3 shows these changes for Atlantic City, Sandy Hook, and Cape May.

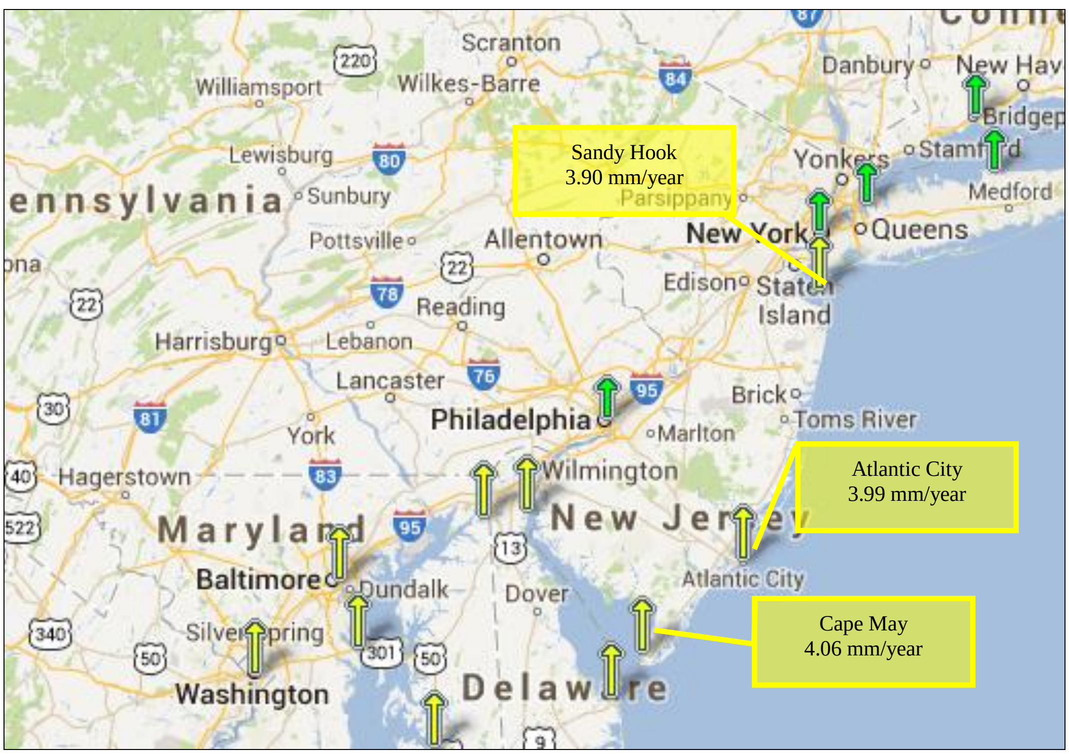
The global sea level trend has been recorded by satellite altimeters since 1992 and the latest calculation can be obtained from NOAA's Laboratory for Satellite Altimetry. The University of Colorado's Sea Level Research Group compares global sea level rates calculated by different research organizations and provides detailed explanations about the issues involved (NOAA 2013).

Figure 5.2-11. Relative Sea Level Variations of the United States



Source: NOAA 2013

Figure 5.2-12. Sea Level Trends in New Jersey



Source: NOAA 2013

Table 5.2-3. Linear MSL Trends and 95% Confidence Intervals

Station Name	First Year	Year Range	For all data to 2006		Previously Published Trends	
			MSL Trend (mm/year)	+/- 95% Confidence Interval	MSL Trend (mm/year)	+/- 95% Confidence Interval
Atlantic City	1911	96	3.99	0.18	3.98	0.21
Cape May	1965	42	4.06	0.74	3.88	1.04
Sandy Hook	1932	75	3.90	0.25	3.88	0.29

Source: NOAA 2013
mm/year millimeter per year
MSL Mean Sea Level

Figure 5.2-12 presents the most recent NOAA relative sea level variations along the Mid-Atlantic coast. Three NOAA tide gauge stations are located on the New Jersey coastline, where tide gauge measurements are made with respect to a local fixed reference level on land. Table 5.2-3 presents the history and MSL trends at the three New Jersey stations, which show the result of a combination of the global sea level rate and the local vertical land motion.

As more information is collected at water level stations, the linear MSL trends can be recalculated each year. Table 5.2-4 below shows the MSL trends calculated from the beginning of the station record to recent years (2006 to 2012). The values do not indicate the trend in each year, but the trend of the entire data period up to that year.

Table 5.2-4. Update Mean Sea Level Trends

Station Name	2006	2007	2008	2009	2010	2011	2012
Atlantic City	3.99 mm/yr	3.98 mm/yr	3.98 mm/yr	4.01 mm/yr	4.04 mm/yr	4.07 mm/yr	4.10 mm/yr
Cape May	3.90 mm/yr	3.87 mm/yr	3.88 mm/yr	3.93 mm/yr	4.00 mm/yr	4.05 mm/yr	4.06 mm/yr
Sandy Hook	4.06 mm/yr	3.99 mm/yr	4.00 mm/yr	4.22 mm/yr	4.45 mm/yr	4.53 mm/yr	4.64 mm/yr

Source: NOAA 2013
mm/yr millimeter per year

Previous Occurrences and Losses

As mentioned previously, coastal erosion can occur gradually as a result of natural processes or from episodic events such as hurricanes, Nor'Easters, and tropical storms. Coastal erosion also results from sea-level rise, which occurs due to a combination of factors which may differ by location. Based on all sources researched, known events that have caused coastal erosion in the State of New Jersey and its counties are identified in Table 5.2-5. The events listed in Table 5.2-5 and following the table include those discussed previously in the 2011 State Plan, with the addition of events that occurred between January 1, 2010 and December 31, 2012.

For those events that resulted in a FEMA disaster declaration, see Table 5.2-6. Detailed information regarding those events is presented in Appendix D.

Table 5.2-5. Coastal Erosion Incidents in New Jersey, 1936 to 2012

Date(s) of Event	Event Type	Counties Affected	Description
1936	Hurricane	Ocean	A Category 2 hurricane hit parallel to the New Jersey coastline. Strong waves flooded much of Long Beach Island and caused severe beach erosion along the coast. Approximately 200 feet of sand near the Barnegat Lighthouse were lost, threatening the foundation of the lighthouse.
1944	Tropical Storm	Cape May	A tropical storm hit Cape May County after passing through the Delmarva Peninsula, causing severe beach erosion and high tides.
March 6-8, 1962	Nor'Easter	Coastal New Jersey	The most damaging Nor'Easter since the 1888 Blizzard. The damage from this storm was primarily caused by its prolonged duration, resulting in damaging overwash and flooding through five successive high tides. It struck the New Jersey coast for three days and generated a 3.5-foot storm surge over three successive high tides, with each tide peaking at 8.8 feet above mean lower low water (MLLW). Massive waves of up to 40 feet high generated by sustained winds of 45 knots blew over 1,000 miles of open ocean and came crashing towards the coastline. This coastal storm took nine lives, damaged 16,407 structures, and flooded 21,533 structures to various degrees. The storm caused approximately $120 million in damages. See Appendix D (FEMA Disasters) for additional information regarding this event.
October 28 – November 4, 1991	Halloween Nor'Easter	Coastal New Jersey	The 1991 Halloween Nor'Easter, also known as the Perfect Storm, caused strong waves of up to 30 feet in height. High tides along the shore were the second highest on record—only surpassed by the 1944 hurricane—while significant bay flooding occurred. Strong waves and persistent intense winds caused extreme beach erosion, amounting to 13.5 million cubic feet of sand lost in one location. In all, damage amounted to $90 million, though no deaths occurred in the State.
September 22-26, 1992	Tropical Storm Danielle	Coastal New Jersey	Tropical Storm Danielle made landfall in the Delmarva Peninsula and caused significant beach erosion across the mid-Atlantic region, including New Jersey. Despite avoiding a direct hit, the State still suffered erosion.
December 10-17, 1992	Coastal Storm	Ocean, Monmouth, Cape May, Cumberland, Bergen, Salem, Middlesex, Atlantic, Union, Essex and Hudson	A peak storm surge of 4.3 feet was measured on December 11, 1992, as the water reached an elevation of 9.14 feet MLLW. The water did not recede until December 14th. Waves of up to 44 feet were measured 25 miles offshore of Long Branch during the storm. This coastal storm took two lives, damaged 3,200 homes, and caused approximately $750 million in damages. See Appendix D (FEMA Disasters) for additional information regarding this event.
August 8-25, 1994	Hurricane Felix	Coastal New Jersey	Although the strong winds and heavy rains did not directly affect the United States, large swells generated by Felix produced dangerous surf conditions including some coastal flooding and rip currents from northeastern Florida to New England. Isolated areas of severe beach erosion occurred along the New Jersey coast.
December 22-26, 1994	Storm	Coastal New Jersey	This storm caused $17 million in damages and tides were 2.5 feet above normal, which led to significant coastal erosion and flooding.
January 7-8, 1996	Blizzard	Atlantic, Burlington, Mercer, Monmouth, and Ocean	A record-breaking snowfall hit most of New Jersey, causing municipalities to exceed their annual snow budget, several buildings to collapse, and over 57,000 homes to lose power. The storm produced moderate flooding with moderate-to-severe beach erosion from Manasquan south along the Jersey Shore. A total of

Table 5.2-5. Coastal Erosion Incidents in New Jersey, 1936 to 2012

Date(s) of Event	Event Type	Counties Affected	Description
			28 deaths and numerous injuries were reported, as well as over $50 million in damages.
July 13, 1996	Tropical Storm Bertha	Atlantic, Cape May, Cumberland, and Monmouth	Wind gusts ranged from 43 mph in Atlantic City to 60 mph in Seaside Park. Approximately 40,000 customers were without power. Tidal departures were about two feet or less from normal levels. Monmouth Beach suffered severe beach erosion. Approximately 60 feet of 120-foot-wide beach at the south of the Borough was gone.
February 4-9, 1998	Nor'Easter	Atlantic, Cape May, Cumberland, Monmouth and Ocean	The strongest Nor'Easter of the winter hit coastal New Jersey, from Ocean County southward, bringing damaging winds, moderate-to-severe coastal flooding, extensive beach erosion, several dune breaches, and heavy rain. A State of Emergency was declared for all coastal counties, and Atlantic and Cape May Counties were declared federal disaster areas. Beach erosion was the largest problem in Monmouth and Ocean Counties. In Avalon, beach erosion left 10-foot cliffs. Severe beach erosion was reported at Cape May Point. In Brigantine, substantial flooding and beach erosion was experienced, especially at the north end of the island. About 75% of its sand was carried away. In Longport, the ocean met the bay from 11th through 24th Streets and erosion caused vertical cliffs of four to five feet. Longport streets had to be cleared of debris. Ocean County had $9 million in damages, mainly from beach erosion. Beaches at Point Pleasant to Island Beach State Park suffered moderate to severe erosion. In Bay Head, remnants of its old boardwalk were uncovered and the Borough lost 10 feet of dunes and 125 feet of beach at its south end. Ortley Beach's dune line was flattened. In Harvey Cedars, erosion was worse at the south end of the town where the surf exposed the gravel base. Brant Beach suffered the worst erosion in the County as the ocean broke through at two places. In Monmouth County, moderate-to-severe beach erosion was experienced. Total damage in New Jersey was estimated at $17 million. See Appendix D (FEMA Disasters) for additional information regarding this event.
April 16, 2007	Nor'Easter	Statewide	In the wake of the departing Nor'Easter, the combination of strong winds, snow on tree limbs and heavy rain loosening the ground caused many tree limbs, trees and wires to be knocked down on April 16. The strong winds caused about 120,000 homes and businesses in the state to lose power. See Appendix D (FEMA Disasters) for additional information regarding this event.
November 11-15, 2009	Remnants of Tropical Storm Ida (Nor'Easter)	Atlantic, Cape May, and Ocean	Remnants of Hurricane Ida brought 30- to 40-mph winds and 8- to 15-foot swells. Maximum-sustained winds were near 45 mph, with higher gusts at times. This three-day Nor'Easter was considered one of the worst to impact the State in recent years and caused significant erosion along the New Jersey shoreline. Atlantic and Cape May Counties experienced widespread tidal flooding. The north end of Avalon in Cape May County experienced substantial beach erosion as a result of the storm. Beaches on the north end lost 125,700 cubic yards of sand and the dunes in the north end lost 34,000 cubic yards of sand. The large volume of sand loss was evident, as the sea wall under the dune crest was completely exposed. Long Beach Island in Ocean County sustained significant damage from this storm. Harvey Cedars and Holgate suffered the most severe erosion of their beaches and dunes. Large sections of dune were lost throughout Long Beach Island. Several beach-front properties were completely undercut by wave action in Beach Haven while other properties had the dune completely removed seaward of their house.

Table 5.2-5. Coastal Erosion Incidents in New Jersey, 1936 to 2012

Date(s) of Event	Event Type	Counties Affected	Description
August 27 – September 5, 2011	Hurricane Irene	Coastal New Jersey	Hurricane Irene made landfall near the Little Egg Inlet along southern New Jersey on August 28. This was the first hurricane to make landfall in the State since 1902. The storm created 15- to 18-foot drop offs on some beaches. The NJDEP reported beach erosion of two to four feet in height and 50 to 100 feet wide was common along most of the shoreline. At Seven Presidents Oceanfront Park in Long Branch, their access steps and 300 feet of beach were lost and had sporadic cuts in the dune. Beaches that lost up to 150 feet of sand included Ocean Grove, Bradley Beach, Loveladies, Long Beach Township, Wildwood, and Wildwood Crest. Beaches that experienced 200-foot-wide areas of erosion included Harvey Cedars, Surf City, Ship Bottom, Beach Haven, and the Holgate section of Long Beach Township. Other areas of erosion included Seaside Heights (140 feet of erosion), Seaside Park (120 feet), Avon-by-the-Sea (between 50 and 120 feet), and Belmar (between 80 and 100 feet). Bay Head suffered cuts to its dune system throughout the Town, ranging from three to eight feet high and five to 15 feet wide. Mantoloking and Lavalette had similar cuts to their dune systems.
October 29, 2011	Nor'Easter	Coastal New Jersey	Northeast New Jersey experienced snow from this storm, while coastal New Jersey experienced flooding and strong winds. Peak wind gusts averaged 50 mph along the coast. Cliffwood Beach in Monmouth County lost some beach elevation and experienced shoreline retreat (loss of 7.07 yds3/ft with a 17-foot shoreline retreat. In Port Monmouth at Spy House in Monmouth County, the sand volume decreased by 10.81 yd^3/ft because of a 0.24-foot decrease in bay bottom elevations across 1,000 feet and the shoreline retreated three feet. See Appendix D (FEMA Disasters) for additional information regarding this event.
October 26 – November 8, 2012	Superstorm Sandy	Statewide	Superstorm Sandy was the costliest natural disaster by far in the State of New Jersey. Record-breaking high tides and wave action combined with sustained winds as high as 60 to 70 mph with wind gusts as high as 80 to 90 mph to batter the State. Statewide, Sandy caused an estimated $29.4 billion in damage, destroyed or significantly damaged 30,000 homes and businesses, affected 42,000 additional structures, and was responsible directly or indirectly for 38 deaths. A new temporary inlet formed in Mantaloking (Ocean County) where some homes were swept away. About 2.4 million households in the State lost power. It would take two weeks for power to be fully restored to homes and businesses that were inhabitable. Also devastated by the storm was New Jersey's shellfish hatcheries including approximately $1 million of losses to buildings and equipment, and product losses in excess of $10,000 at one location alone. Overall, average rainfall totals were 2.78 inches with a maximum rainfall of 10.29 inches at the Cape May (Cape May County) station. Another source indicated a maximum rainfall total of 12.71 inches in Stone Harbor (Cape May County). A maximum wind gust of 78 mph was reported in Robbins Reef. A maximum storm surge of 8.57 feet was reported in Sandy Hook. Hurricane Sandy caused approximately $30 billion in damages in New Jersey and caused 12 deaths in the State. See Appendix D (FEMA Disasters) for additional information regarding this event.

MLLW *Mean Lower Low Water*
Mph *miles per hour*
NJDEP *New Jersey Department of Environmental Protection*
yd^3/ft *Cubic Yards per Feet*

FEMA Disaster Declarations

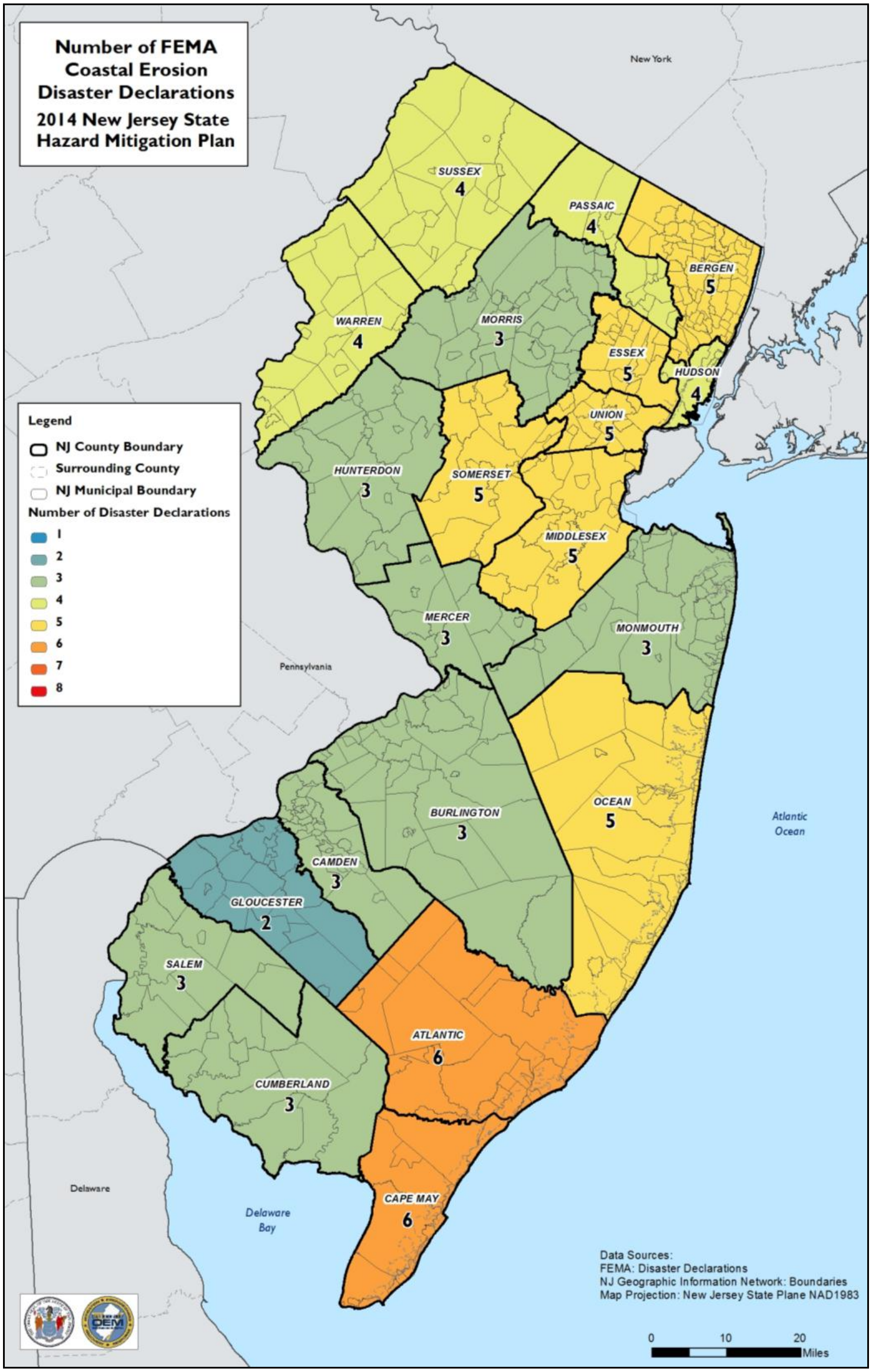
Between 1954 and 2012, FEMA declared that the State of New Jersey experienced eight erosion-related disasters (DR) or emergencies (EM) classified as one or a combination of the following disaster types: severe storms, coastal storms, heavy rain, tropical storm, hurricane, high winds, and high tide. Generally, these disasters cover a wide region of the State and have impacted many counties, though not all with coastal erosion effects (FEMA 2013).

Based on all sources researched, known erosion-related events that have affected New Jersey and were declared a FEMA disaster are identified in Table 5.2-6. Figure 5.2-13 illustrates the number of FEMA-declared disasters by County.

Table 5.2-6. FEMA Coastal Erosion-Related Disaster Declarations, 1954 to 2012

Disaster #	Disaster Type	Declaration Date	Incident Period	Atlantic	Bergen	Burlington	Camden	Cape May	Cumberland	Essex	Gloucester	Hudson	Hunterdon	Mercer	Middlesex	Monmouth	Morris	Ocean	Passaic	Salem	Somerset	Sussex	Union	Warren	# Counties Impacted
DR-124	Severe Storm, High Tides, Flooding	3/9/1962	3/9/1962	Not Available																					
DR-973	Coastal Storm, High Tides, Heavy Rain, Flooding	12/18/1992	12/10/1992 – 12/17/1992	X	X			X	X	X		X			X	X		X		X	X		X		12
DR-1206	Coastal Storm	3/8/1998	2/4/1998 – 2/8/1998	X				X										X							
DR-1694	Severe Storms, and Inland and Coastal Flooding	4/26/2007	4/14/2007 – 4/20/2007	X	X	X	X			X		X		X	X		X		X		X	X	X	X	14
DR-1867	Severe Storms, and Flooding Associated with Tropical Depression Ida and a Nor'Easter	12/22/2009	11/11/2009 – 11/15/2009	X				X										X							3
DR-4021	Hurricane Irene	8/31/2011	8/27/2011 – 9/5/2011	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	21
DR-4048	Severe Storm	11/30/2011	10/29/2011		X			X		X			X		X				X		X	X	X	X	10
DR-4086	Hurricane Sandy	10/30/2012	10/26/2012 – 11/8/2012	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	21

Figure 5.2-13. FEMA-Declared Coastal Erosion Declarations by County



Source: FEMA 2013

Recent Beach Nourishment Activities

To counteract the effects of natural erosion as well as to prevent storms from devastating the beachfront communities, the Bureau of Coastal Engineering (NJDEP) works with the federal government and has undertaken numerous beach nourishment and re-nourishment projects in the beach counties of New Jersey (NJDEP 2012b).

The Bureau also constructs and maintains shore protection structures including jetties, groins, seawalls, breakwaters, and bulkheads, which maintain the coastline as well as navigation channels across the State. These various stabilization methods help to slow the gradual erosion of sediment from New Jersey beaches. State protection projects are funded through a Shore Protection Fund, which supports federal, state, and local cost-sharing processes depending on the size and scope of the project (NJDEP 2012b).

Atlantic County

The Atlantic County communities have been the direct or indirect beneficiaries of federally sponsored beach nourishment projects, as well as having been the sites of multiple State and locally sponsored projects in past years. Sand has been systematically harvested from Brigantine Inlet or Absecon Inlet to substantially add to the beach width and the sand volume on the beach, and have enhanced the dune protection for landward properties. The federal Absecon Island project was completed between fall 2003 and spring 2004 with sand derived from Absecon Inlet. The refusal of Margate City and Longport to participate in the project has resulted in a significant loss of sand from the southern third of Ventnor City beaches through end-effect erosion (Richard Stockton College CRC 2012a).

Cape May County

Beach nourishment derived from inlet shoals, truck-haul from quarries or offshore borrow sites has resulted in Cape May County having the most highly modified coastline along the New Jersey coast. There are five coastal projects involving federal cooperation with the State of New Jersey and the local municipality. These are Ocean City (northern two-thirds of the island), Avalon, Stone Harbor, Cape May City, and Cape May Meadows/Cape May Point. The Peck’s Beach balancing project (Ocean City) is a State/local project. The State also concluded beach nourishments in the City of North Wildwood, Upper Township, and Sea Isle City in 2009. Reeds Beach on Delaware Bay was a State project creating beach restoration as a side benefit from a navigation improvement at Bidwell Creek. The federal Cape May western shoreline project was proposed to primarily benefit migratory shorebirds and promote horseshoe crab egg-laying with a one-time beach restoration. The project consists of ecosystem restoration at Villas (Lower Township) and the vicinity of an 80-foot wide berm over a length of 29,000 feet. This project is waiting for sufficient funding (Richard Stockton College CRC 2012c).

Storm damage inflicted on the Cape May County shoreline between October 2009 and March 2010 were addressed with restoration projects in North Wildwood, Avalon, Sea Isle City, and Upper Township (community of Strathmere). Hurricane Irene impacts were remedied with two novel efforts at back-passing surplus sand from zones where accretion dominates the processes in the Borough of Avalon and the City of North Wildwood. Avalon acquired permits to move 63,000 cubic yards of sand from two segments of the island between 70th and 31st Streets, with a substantial exclusion zone between two sites where permits allowed excavation. The exclusion zone was required by the United States Fish and Wildlife service to preclude any impact on nesting or foraging by piping plovers, a State and federal endangered species. The City of North Wildwood cooperated with the Borough of Wildwood Crest (by agreement with the City of Wildwood) to excavate up to 96,000 cubic yards of sand from the berm along the Borough oceanfront and truck this surplus north through Wildwood and deposit it within a footprint where Hurricane Irene-generated erosion had produced that quantity of documented loss. A total of 93,000 cubic yards of sand was moved by mid-May 2012 and graded into a dune toe deposit and a wider recreational beach between 3rd and 7th Avenues. The North Wildwood project required permits from USACE, plus modifications to State permits held by the two municipalities allowing beach nourishment and surplus sand removal to the dunes. The permit modifications revolved around an alternative sand source and means of placement (trucks) in North Wildwood and an alternative disposal site in the case of Wildwood Crest (moving it to North Wildwood instead of into the dune system in Wildwood Crest) (Richard Stockton College CRC 2012c).

Other notable municipal projects include the efforts by the Borough of Avalon to complete a 650,000-cubic yard restoration of the beach between 10th and 28th Streets using Townsend's Inlet sand. Sand was pumped onto the Ocean City beaches in 2009. Cape May County is the most varied and diverse in the State in terms of beach restoration and maintenance. Most of the sediment supply comes from four of the five tidal inlets in Cape May County, with the offshore supplying Cape May City and Cape May Point. USACE returned to Cape May County twice during 2010 and provided maintenance beach sand on the shorelines (Richard Stockton College CRC 2012c).

Monmouth County

Monmouth County received the benefit of the largest, most expensive, and most comprehensive beach nourishment project ever granted in the United States beginning in 1994. Completed by the New York District USACE for $210 million, this project continued in three phases until 2000. In all, 21 miles of County shoreline were restored with a 100-foot-wide berm and a dune system built in all locations where practical (a total of 6.1 million cubic yards of sand) (Richard Stockton College CRC 2012d).

Maintenance fills have been completed following two strong storms in 1998, hot-spot erosion in Monmouth Beach that occurred in 1997 and 2002 and in southern Long Branch in March 2009. The southern Long Branch project extended south of West End Avenue and north toward Broadway Avenue. Funds in the amount of $2,961,000, $3,305,000 and $1,316,000 were appropriated for fiscal years 2006, 2007, and 2008, respectively. This funding was used to design and construct approximately 2,400 linear feet of beach re-nourishment in South Long Branch (Richard Stockton College CRC 2012d).

Ocean County

No beach nourishment projects have been federally, state, or locally funded in northern Ocean County in the past 25 years (prior to Superstorm Sandy). Sand was pumped onto the county shoreline following the March 1962 northeast storm derived from dredging deep borrow zones within Barnegat Bay. These 30-foot-deep areas are still present and represent biological dead zones caused by the lack of oxygen circulation in the deep water column. Dunes were built and the shoreline slowly recovered. In 1992, storm damage revealed the presence of vintage cars that were used to block wave action until the dune was re-built. The Borough of Mantoloking recovered vehicles and discovered they had significant value to those interested in the parts for restoration projects (Richard Stockton College CRC 2012e).

Post Superstorm Sandy Beach Nourishment Activities

For detailed information regarding the impacts Superstorm Sandy had on New Jersey, please see Appendix D. This section will only describe the beach nourishment activities that took place after the Storm.

Following Superstorm Sandy, the USACE Philadelphia District has been working to restore previously constructed coastal storm risk management projects in New Jersey and Delaware. Work has been ongoing through the months since the storm. The USACE projects in New Jersey include:

- Long Beach Island - dredging and pumping operations are completed at Harvey Cedars, Surf City and Brant Beach (34-57th Streets)

- Absecon Island - dredging and pumping operations are ongoing at Atlantic City. Work will then proceed to Ventnor and is expected to be completed in October and November.
- Brigantine - work completed
- North Ocean City - work completed
- Avalon & Stone Harbor - work completed
- Cape May City - work to begin in late September
- Lower Cape May Meadows - periodic nourishment work completed

As of August 2013, approximately 17 million cubic yards of sand was slated to be placed throughout New Jersey through the near-term coastal restoration work, including two projects managed by the USACE New York District (Keansburg and Sea Bright to Manasquan). The Keansburg project included the placement of approximately 875,000 cubic yards of sand along 2.5 miles of shoreline along Raritan Bay. Repairs to eroded levees, repairs to the damaged wingwall adjacent to the tide gate, and debris removal along the levees will also be part of this project (USACE 2013a).

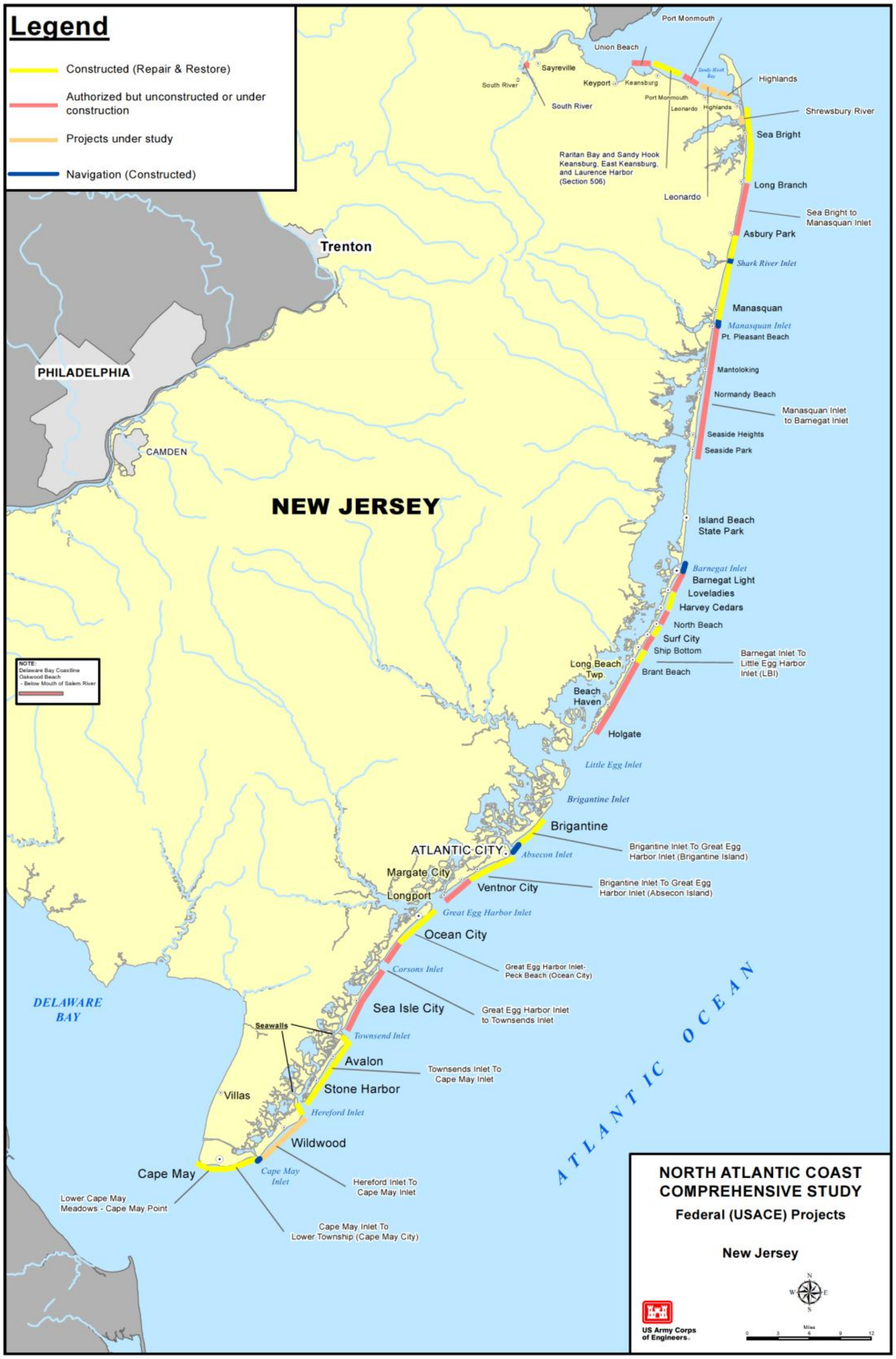
The Sea Bright to Manasquan project included the placement of approximately eight million cubic yards of sand along 18 miles of the coastline from Manasquan to Sea Bright. It included replacement of sand in areas eroded during Sandy as well as sand to restore the project area to its original design profile (USACE 2013b).

As discussed earlier in subsection 5.2.1 (Hazard Description), the State under EO 140 created the Office of Flood Hazard Risk Reduction Measures. On October 17, 2013, the Christie Administration and the USACE announced a list of projects for critical USACE beach and dune construction projects that reduce risk to lives, properties, and infrastructure by rebuilding 44 miles of the New Jersey coastline and providing the State with the most comprehensive and continuous coastal protection system it has ever had. The projects in these areas were previously designed and authorized; however, not constructed due to a need to secure funding easements. Congress appropriated $1 billion for these and additional flood protection projects in New Jersey as part of the Hurricane Sandy Disaster Relief Appropriations Act of 2013 (Drewniak and Reed 2013). The projects are as follows:

- Port Monmouth portion of Raritan Bay and Sandy Hook Bay project area
- Southern Ocean City, Upper Township, and Sea Isle City portions of the Great Egg Harbor Inlet to Townsends Inlet project area
- Longport and Margate portions of Absecon Island within the Brigantine Inlet to Cape May Inlet project area
- Beach Haven, Long Beach Township and Ship Bottom on the Long Beach Island portion of the Little Egg Inlet project area
- Bay Head, Berkeley, Brick, Lavallette, Mantoloking, Point Pleasant Beach, Toms River, Seaside Heights and Seaside Park within the Manasquan Inlet to Barnegat Inlet project area
- Allenhurst, Deal, Loch Arbour and the Elberon section of Long Branch within the Sandy Hook to Barnegat Inlet Section I project area
- The Union Beach section of the Raritan Bay and Sandy Hook Bay project area

Figure 5.2-14 illustrates the USACE beach replenishment projects along the New Jersey coastline.

Figure 5.2-14. USACE Beach Replenishment Projects



Source: USACE 2013

Probability of Future Occurrences

Coastal Erosion

Coastal erosion is measured as the rate of change in the position or horizontal displacement of a shoreline over a specific period of time, measured in units of feet or meters per year. Erosion rates vary as a function of shoreline type and are influenced primarily by episodic events. Monitoring of shoreline change based on a relatively short period of record does not always reflect actual conditions and can misrepresent long-term erosion rates due to storm frequency.

A number of factors determine whether a community exhibits greater risk of long-term erosion or accretion:

- Exposure to high-energy storm waves;
- Sediment size and composition of eroding coastal landforms feeding adjacent beaches;
- Near-shore bathymetric variations that direct wave approach;
- Alongshore variations in wave energy and sediment transport rates;
- Relative sea-level rise; and
- Human interference with sediment supply (such as revetments, seawalls, and jetties) (Woods Hole Sea Grant 2003).

The long-term patterns of coastal erosion are difficult to detect because of substantial and rapid changes in coastlines in the short-term (that is, over days or weeks from storms and natural tidal processes). It is usually severe short-term erosion events, occurring either singly or cumulatively over a few years, that cause concern and lead to attempts to influence the natural processes. Analysis of both long- and short-term shoreline changes are required to determine which is more reflective of the potential future shoreline configuration (FEMA 1996).

The return period of an episodic erosion event is directly related to the return period of a coastal storm, hurricane or tropical storm. The one-percent annual chance erosion event can be determined using a predictive model that establishes the one-percent annual chance tide and water surface level, or surge elevation and the resulting wave heights. Storm wave heights, periods and directions have specific impacts on the dunes, currents, and other erosion processes. Analyses of coastal erosion impacts from the one-percent annual chance flood event are included in high-hazard zone determinations shown on NFIP maps. The impacts may vary for each reach of coastline.

A more significant measure of coastal erosion is the average annual erosion rate. Erosion rates can be used in land-use and hazard management to define areas in which development should be limited or where special construction measures should be used. The average annual erosion rate is based on analysis of historical shorelines derived from maps, charts, surveys, and aerial photography obtained over a period of record.

From Sandy Hook south to Little Egg Inlet, the maximum long-term erosion rate is -8.6 meters per year and the maximum short-term erosion rate is -6.1 meters per year. From Little Egg Inlet south to Cape May Inlet, the maximum long-term erosion rate is -4.3 meters per year and the maximum short-term rate is -19.3 meters per year. These rates show that shorelines are eroding (USGS 2011).

In New Jersey, coastal erosion will continue to be an on-going problem along many areas of coastline. It is difficult to assign a probability to the near constant small on-going erosion that may occur over a continuous period of time. However, a probability can be assigned to larger storm events such as Nor'Easters and hurricanes, which can result in significant, rapid coastal erosion. The period of time suggest the probability of coastal erosion will be about the same in the future, with year-to-year variations (Gutierrez et al. 2007).

Sea Level Rise

The CVI, as described in the Extent section of this profile, uses physical characteristics of the coastal system to classify the potential effects of sea-level rise on open coasts. This approach combines the coastal system's susceptibility to change with its natural ability to adapt to changing environmental conditions, yielding a quantitative measure of the shoreline's natural vulnerability to the effects of sea-level rise (Gutierrez et al. 2007).

Severity

Coastal Erosion

Coastal erosion is measured as the rate of change in the position or horizontal displacement of a shoreline over a period of time. It is generally caused by storm surges, hurricanes, windstorms, and flooding. Coastal erosion may be exacerbated by human activities, such as boat wakes, shoreline hardening, and dredging (FEMA 1996).

Natural recovery after erosion events can take months or years. If a dune or beach does not recover quickly enough via natural processes, coastal and upland property may be exposed to further damage in subsequent events. Coastal erosion can cause the destruction of buildings and infrastructure (FEMA 1996).

Sea Level Rise

Extreme weather events will continue to be the primary driver of increasing water levels. However, a consensus has not yet been reached on how the frequency and magnitude of storms may change in coastal regions of the United States (NOAA 2012).

Warning Time

Meteorologists can often predict the likelihood of weather events that can impact shoreline communities in the short term and ultimately the shoreline. NOAA's National Weather Service monitors potential events, and provides forecasts and information, sometimes several days in advance of a storm, to help prepare for an incident. With the number of structures increasing along the coast, the shoreline becomes increasingly modified. Impact from weather incidents will continue to influence the State's coastal areas, intensifying and exacerbating the coastal erosion situation.

Secondary Hazards

Windstorm events can blow beach and dune sand overland into adjacent low-lying marshes, upland habitats, inland bays, and communities. Flooding from extreme rainfall events can scour and erode dunes as inland floodwaters return through the dunes and beach face into the ocean (FEMA 1996).

Shore protection structures such as seawalls and revetments often are built to attempt to stabilize the upland property. However, typically they eliminate natural wave run-up and sand deposition processes and can increase reflected wave action and currents at the waterline. Increased wave action can cause localized scour in front of structures and prevent settlement of suspended sediment (FEMA 1996).

According to NOAA, sea level rise can amplify factors that currently contribute to coastal flooding: high tides, storm surge, high waves, and high runoff from rivers and creeks. All of these factors change during extreme weather and climate events (NOAA 2012). Other secondary hazards that could occur along the mid-Atlantic coast in response to sea-level rise:

- Bluff and upland erosion – shorelines composed of older geologic units that form headland regions of the coast will retreat landward with rising sea level. As sea level rises, the uplands are eroded and sandy materials are incorporated into the beach and dune systems along the shore and adjacent compartments (Gutierrez et al. 2007).

- Overwash, inlet processes, shoreline retreat, and barrier island narrowing – as sea-level rise occurs, storm overwash will become more likely. Tidal inlet formation and migration will become important components of future shoreline changes. Barrier islands are subject to inlet formation by storms. If the storm surge produces channels that extend below sea level, an inlet may persist after the storm. The combination of rising sea level and stronger storms can create the potential to accelerate shoreline retreat in many locations. Assessments of shoreline change on barrier islands have shown that barrier island narrowing has been observed on some islands over the last 100 years (Gutierrez et al. 2007).
- Threshold behavior – changes in sea level rise can lead to conditions where a barrier system becomes less stable and crosses a geomorphic threshold; making the potential for rapid barrier-island migration or segmentation/disintegration high. Unstable barriers may be defined by rapid landward recession of the ocean shoreline, decrease in barrier width and height, increased overwashing during storms, increased barrier breaching and inlet formation, or chronic loss of beach and dune sand volume. With the rates of sea-level rise and climate change, it is very likely that these conditions will worsen (Gutierrez et al. 2007).
- Loss of critical habitat – natural ecosystems may be impacted by warmer temperatures and associated changes in the water cycle. The changes could lead to loss of critical habitat and further stresses on some threatened and endangered species (Rutgers 2013).
- Threatened coastline – New Jersey is vulnerable to significant impacts due to geologic subsidence, topography of its coastline, current coastal erosion, and a high density of coastal development. According to median projections of current sea level rise, it would threaten the majority of the State's coastal areas (Rutgers 2013).

Climate Change Impacts

Providing projections of future climate change for a specific region is challenging. Shorter term projections are more closely tied to existing trends making longer term projections even more challenging. The further out a prediction reaches the more subject to changing dynamics it becomes.

The New Jersey Climate Adaptation Alliance is a network of policymakers, public and private-sector practitioners, academics, non-governmental organizations (NGO), and business leaders aligned to build climate change preparedness in the state of New Jersey. The Alliance is facilitated by Rutgers University, which provides science and technical support, facilitates the Alliance's operations and advances its recommendations. A document titled *Change in New Jersey: Trends and Projections* was developed to identify recommendations for state and local public policy that will be designed to enhance climate change preparedness and resilience in New Jersey (Rutgers 2013).

Temperatures in the Northeast United States have increased 1.5 degrees Fahrenheit (°F) on average since 1900. Most of this warming has occurred since 1970. The State of New Jersey, for example, has observed an increase in average annual temperatures of 1.2°F between the period of 1971-2000 and the most recent decade of 2001-2010 (ONJSC, 2011). Winter temperatures across the Northeast have seen an increase in average temperature of 4°F since 1970 (Northeast Climate Impacts Assessment [NECIA] 2007). By the 2020s, the average annual temperature in New Jersey is projected to increase by 1.5°F to 3°F above the statewide baseline (1971 to 2000), which was 52.7°F. By 2050, the temperature is projected to increase 3°F to 5°F (Sustainable Jersey Climate Change Adaptation Task Force 2013).

Both northern and southern New Jersey have become wetter over the past century. Northern New Jersey's 1971-2000 precipitation average was over five inches (12%) greater than the average from 1895-1970. Southern New Jersey was two inches (five-percent) wetter late in the 20th century (Office of New Jersey State

Climatologist). Average annual precipitation is projected to increase in the region by five-percent by the 2020s and up to 10% by the 2050s. Most of the additional precipitation is expected to come during the winter months (New York City Panel on Climate Change [NYCPCC] 2009). In addition, heavy precipitation events have increased in the past 20 years.

Coastal Erosion

Coastal areas may be impacted by climate change in different ways. Coastal areas are sensitive to sea-level rise, changes in the frequency and intensity of storms, increase in precipitation, and warmer ocean temperatures. According to NASA, warmer temperatures may lead to an increase in frequency of storms, thus leading to more weather events that cause coastal erosion.

Sea Level Rise

Changes in global temperatures, hydrologic cycles, coverage of glaciers and ice sheets, and storm frequency and intensity are captured in long-term sea level records. Sea levels provide a key to understanding the impact of climate change (NOAA 2013).

Sea level rise increases the risks coastal communities face from coastal hazards (floods, storm surges, and chronic erosion). It may also lead to the loss of important coastal habitats. The historical rate of sea level rise along the New Jersey coast over the past 50 years was 0.12 to 0.16 inches per year. Future rates are predicted to increase to 0.5 inches/year (Miller and Kopp 2013). By 2050, the sea level is expected to rise 16 inches from the current mean (Rutgers 2013).

5.2.2 Vulnerability Assessment

The following discusses New Jersey's vulnerability to the coastal erosion and sea level rise hazards. To understand risk, the assets exposed to the hazard areas are identified. For the coastal erosion and sea level rise hazards, the entire coastline of New Jersey is exposed. However, certain areas are at greater risk than others.

Coastal erosion and sea-level rise are of concern to the State because of the large number of communities and cultural resources located along the coast. Beaches serve as a buffer and protect the built environment and other natural resources on the mainland from coastal storm events such as hurricanes, tropical storms, and Nor'Easters, which can cause shoreline erosion or accretion.

The New Jersey Administrative Code (N.J.A.C.) Coastal Zone Management Rules defines erosion hazard areas as, "shoreline areas that are eroding and/or have a history of erosion causing them to be highly susceptible to further erosion, and damage from storms. Erosion hazard areas may be identified by any one of the following characteristics:

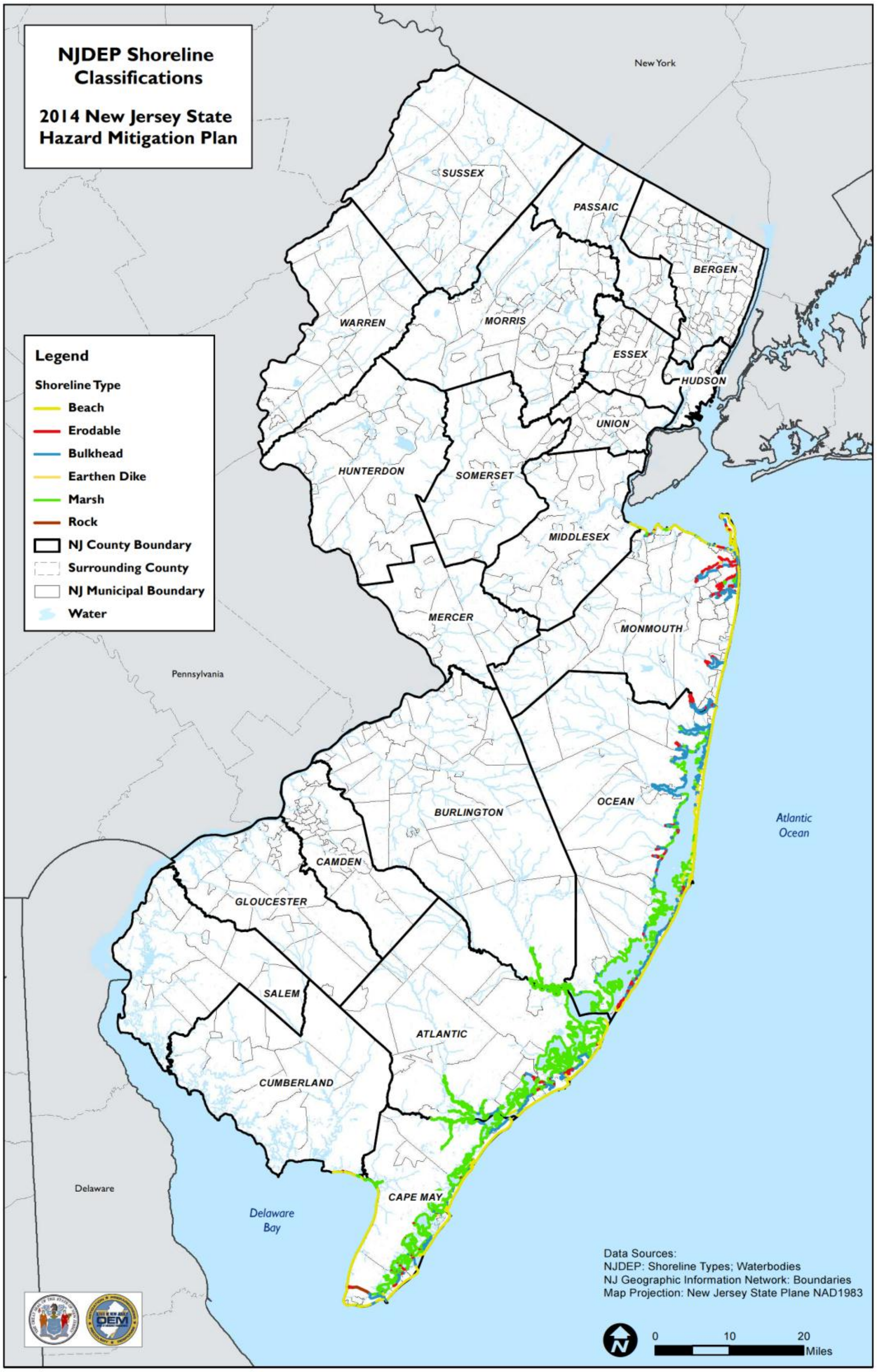
- Lack of beaches
- Lack of beaches at high tide
- Narrow beaches
- High beach mobility
- Foreshore extended under boardwalk
- Low dunes or no dunes
- Escarped foredune
- Steep beach slopes
- Cliffed bluffs as adjacent to beach
- Exposed, damaged, or breached jetties, groins, bulkheads, or seawalls
- High long-term erosion rates
- Pronounced downdrift effects of groins (jetties)" (N.J.A.C. 2013)

Further, erosion hazard areas are defined as extending inland from the edge of a stabilized upland area to the limit of the area likely to be eroded in 30 years for one- to four-unit dwelling structures, and 60 years for all other structures, including developed and undeveloped areas (N.J.A.C. 2013). The extent of an erosion hazard area is calculated by multiplying the projected annual erosion rate at a site by 30 for the development of one- to four-unit dwelling structures, and by 60 for all other developments.

A USGS report for the National Assessment of Shoreline Change entitled *Historical Shoreline Change along the New England and Mid-Atlantic Coasts* was released in 2011. The New England and Mid-Atlantic shores were subdivided into a total of 10 analysis regions for the purpose of reporting regional trends in shoreline change rates. The average rate of long-term shoreline change for the New England and Mid-Atlantic coasts was -0.5 meters per year. The average net long-term rate of shoreline change for the New Jersey 'North' region (located from Sandy Hook to south to Little Egg Inlet) was -0.6 meters per year. Meanwhile, the long-term net shoreline change rate in the New Jersey 'South' region (located from Little Egg Inlet south to Cape May Point) is strongly accretional (0.8 meters per year) (USGS 2011).

To estimate exposure to long-term coastal erosion for purposes of this risk assessment, the following shoreline types as defined by NJDEP were used: (1) "beach," which includes waterfront areas composed of 100 percent sand; and (2) "erodable," which includes any soft shoreline other than beach, such as rock, marsh, sea wall or earthen dike. Figure 5.2-15 illustrates the NJDEP shoreline classifications. To generate the extent of the estimated coastal erosion hazard area, an erosion rate of 0.6 meters per year was multiplied by 60 to include all structure types and developed/undeveloped areas (annual erosion rate of 0.6 meters x 60 years = 36 meters or approximately 120 feet). Although the 'South' region indicated an average accretion rate, to estimate potential vulnerability and losses, the average rate of erosion of the 'North' region was used. Therefore, population, buildings, and infrastructure within 120 feet of the identified beach or erodable shoreline types are identified as vulnerable to long-term coastal erosion. Please note this methodology assumes that once lost to erosion, an area of land is not subsequently restored. This methodology is consistent with that used to evaluate coastal erosion in the Atlantic and Monmouth County hazard mitigation plans.

Figure 5.2-15. NJDEP Shoreline Classifications



Source: NJDEP 1993

The Richard Stockton College CRC conducted an analysis to identify and rank the areas with greatest susceptibility to coastal erosion in Ocean County as a result of a 100-year storm event. These locations are listed in Table 5.2-7 below and illustrated in Figure 5.2-16. This coastal erosion susceptible area was also used to estimate exposure to the hazard in Ocean County and is discussed further below.

Table 5.2-7. Coastal Erosion Areas Susceptible to a 100-Year Storm Event in Ocean County

Location in Ocean County	Susceptibility Rank
Lavallette Borough (northernmost)	High
Dover (Toms River) Beaches North (central, Chadwick beach area)	High
Lavallette Borough (central and southern) and Dover (Toms River) Beaches South (northern third)	High
Bay Head (northern half) and Point Pleasant Beach Borough (southernmost tip)	Medium
Brick Township (southern third) and Dover (Toms River) Beaches North (northernmost)	Low
Mantoloking Borough (north-central, central, and southern)	Low
Seaside Park Borough	Low

Source: Richard Stockton College CRC 2013

In addition to coastal erosion, this section also assesses New Jersey's vulnerability to sea level rise using a 2050 planning horizon and the global mean scenarios outlined in the NOAA's Office of Oceanic and Atmospheric Research, Climate Program Office, Technical Report OAR CPO-1 entitled 'Global Sea Level Rise Scenarios for the United States National Climate Assessment'. As previously noted these four scenarios are:

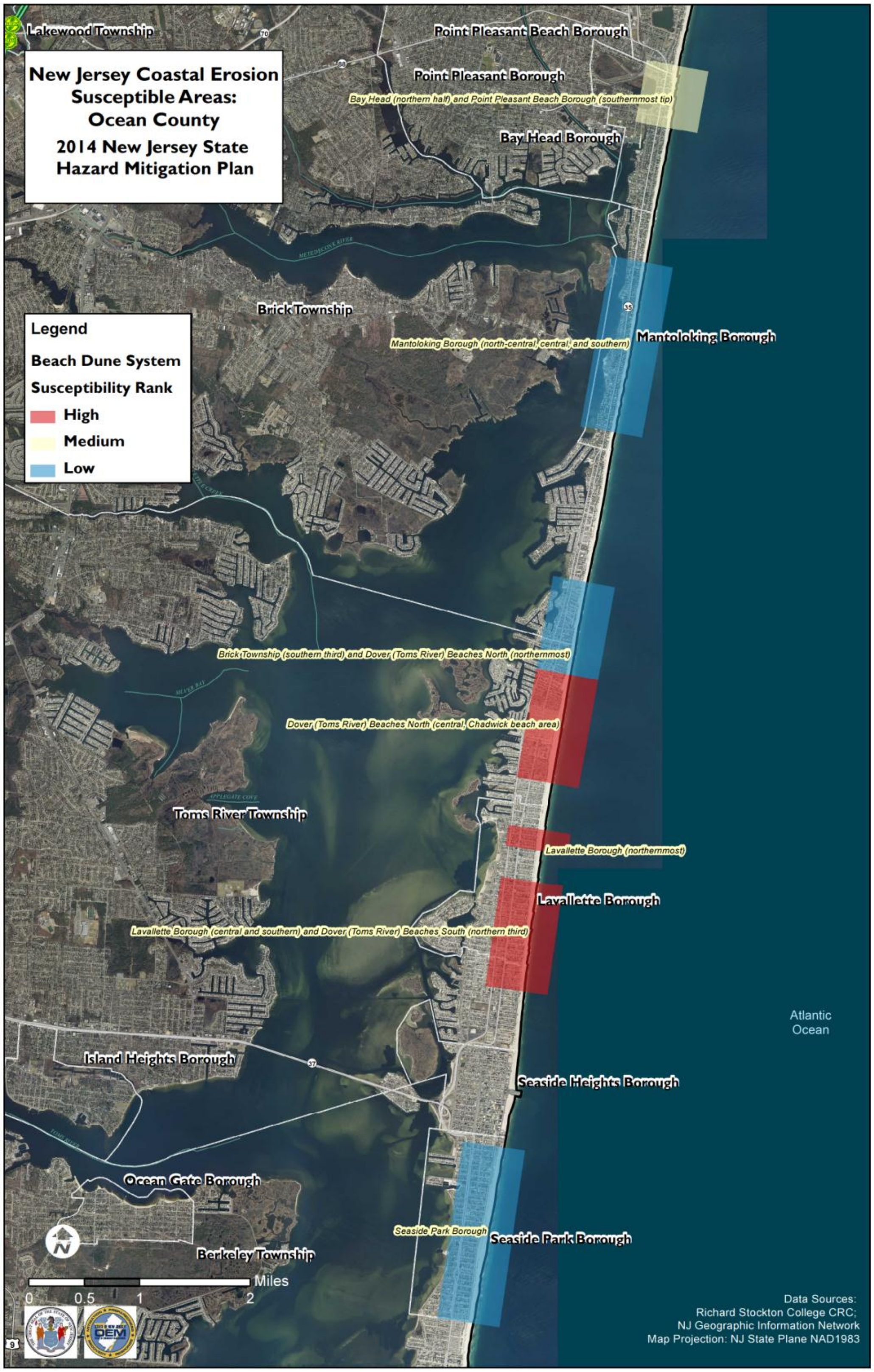
- Lowest [Best Available Special Flood Hazard Area (SFHA) + 0.3 feet]
- Intermediate-Low (Best Available SFHA + 0.7 feet)
- Intermediate-High (Best Available SFHA + 1.3 feet)
- Highest (Best Available SFHA + 2.0 feet)

NOAA has made available electronic tools for individual communities to assess risk on a local or regional basis, including its Sea Level Rise Tool for Sandy Recovery. The State is consistently applying these tools to inform this plan. In addition, as part of the state's comprehensive effort to assess the potential long term efficacy and fiscal sustainability of specific risk reduction measurements and improvements using CDBG-DR funding, the state intends to utilize the federal government's available tools to consider the impact of potential sea level rise and consider whether project designs should be enhanced to assess potential sea level rise scenarios, where such enhancements are cost effective and reasonably practical given the inherent uncertainty in sea level rise modeling.

As mentioned earlier, these sea level rise scenarios do not predict future changes but are being used as potential future estimates and projections for the purpose of hazard mitigation planning. There are limitations of this data and analyses discussed above; however, these scenarios provide trajectories for use in assessing sea level rise vulnerability in New Jersey.

The following sections address assessing vulnerability and estimating potential losses by jurisdiction and to State facilities. Refer to Section 5.8 (Hurricane) which discusses the State's exposure to storm surge using the FEMA Region IV Coastal Flood Loss Atlas team's storm surge inundation grids from the National Hurricane Center's Sea, Lake and Overland Surge from Hurricanes (SLOSH) model. Storm surge mapping may also be used to identify facilities that may be potentially at risk to coastal erosion.

Figure 5.2-16. Coastal Erosion Areas Susceptible to a 100-Year Storm Event in Ocean County



Source: Richard Stockton College CRC 2013

Assessing Vulnerability by Jurisdiction

A review of historic shoreline data dating back to 1863 provided by NJDEP indicates the coastline of the State has significantly changed (moving landward and seaward) because of the effects of erosion, accretion, beach nourishment, and structural shoreline protection measures. Shoreline change, whether erosion or accretion, is dependent upon several factors including location (e.g., open-ocean facing shore) and exposure to high-energy storm waves. The coastal high hazard area (or V zone where "V" stands for velocity wave action) is the most hazardous part of the coastal floodplain, because of its exposure to wave effects. Section 5.6 (Flood) discusses the assets exposed and vulnerable in the V zone.

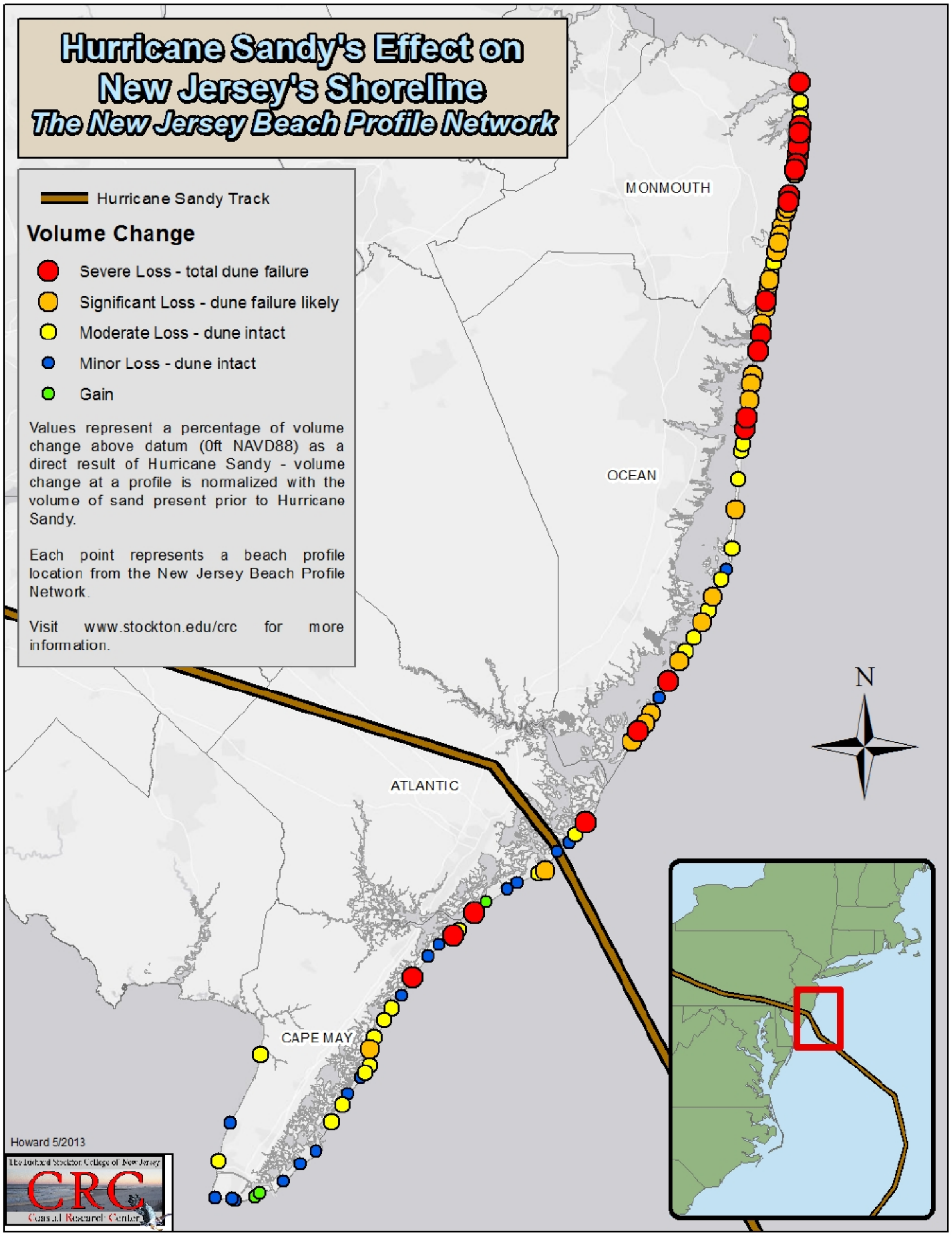
Further, storm surge inundation can exceed the regulatory floodplain boundaries (V and A zones), which can also contribute to coastal erosion. Section 5.8 (Hurricane) discusses the storm surge areas generated by FEMA's Coastal Flood Loss Atlas team as a result of Category One through Four hurricanes in the following 15 NJ Counties: Atlantic, Bergen, Burlington, Cape May, Cumberland, Essex, Gloucester, Hudson, Mercer, Middlesex, Monmouth, Ocean, Passaic, Salem, and Union Counties.

Twelve of the 21 New Jersey counties included erosion (either coastal and/or riverine erosion) as a hazard of concern in their hazard mitigation plans. Table 5.1-2 in Section 5.1 (State Risk Assessment Overview) summarizes these hazard-of-concern identifications. In addition to the coastal counties on the Atlantic Ocean or along inland bays, inland counties indicated they experience minor erosion along their river shorelines. Camden County's hazard mitigation plan indicates that they experience minor erosion along the Delaware River, which runs along the western edge of the County. Passaic County's hazard mitigation plan identifies erosion as a hazard because of the presence of the Passaic River. Essex County indicates in their hazard mitigation plan that they have a low vulnerability to coastal erosion.

Based on the historic record, review of the local hazard mitigation plans, and the updated State risk assessment results that continue to be presented in this section, the counties most threatened by coastal erosion are Atlantic, Cape May, Monmouth, and Ocean. More specifically in these counties, engineering in channels has created offsets leaving the northeast corners of the barrier islands to the south highly vulnerable to wave action and thus coastal erosion.

As discussed earlier in this hazard section, the Richard Stockton College Coastal Research Center (CRC) researchers monitor shoreline change at 105 beach sites in four counties (Atlantic, Cape May, Monmouth, and Ocean). A 25-year shoreline change analysis of each of the 105 monitoring sites was conducted to present the overall trend for each county. Richard Stockton College CRC also conducts post-storm survey and assessment of the New Jersey shoreline in response to severe beach erosion resulting from the impact of storm events. Nearly all of the 105 NJBPN sites were surveyed immediately after Superstorm Sandy to provide accurate assessments of sand volume losses to New Jersey's beaches. Figure 5.2-17 illustrates the percent volume change above datum (0 feet NAVD88) as a direct result of Superstorm Sandy at each beach profile site. The volume change at each site is normalized with the volume of sand present prior to Superstorm Sandy. As this figure depicts, nearly all of these sites in Atlantic, Cape May, Monmouth, and Ocean Counties showed evidence of sand volume losses as a result of Superstorm Sandy in 2012 (Richard Stockton College CRC 2013).

Figure 5.2-17. Superstorm Sandy's Effect on New Jersey's Shoreline



Source: Richard Stockton College CRC 2013

To estimate population and buildings exposed to this hazard, a spatial analysis was conducted using the 2010 U.S. Census blocks, the default general building stock inventory available in HAZUS-MH at the Census-block level and the two hazard areas described above: 1) Richard Stockton College (RSC) CRC susceptible areas in Ocean County and 2) long-term coastal erosion (within 120 feet of the identified beach or erodible shoreline). Where the Census block centroid was located within the defined hazard area the population and building replacement cost values were totaled. Tables 5.2-8 and 5.2-9 summarize these results by county. Please note there are limitations to this analysis and the results should only be used as an estimate. Further, the information in these tables does not account for the increase in population (of both residents and tourists) during the summer months, or the changes in occupancy of homes seasonally or post-Superstorm Sandy. As improved statewide building footprint data becomes available, these estimates will be updated.

Using the RSC CRC coastal erosion susceptible area, the spatial analysis indicates that an estimated 3,090 people (or less than one-percent of the total population) and $1.8 billion in building replacement cost value are located in the coastal erosion susceptible area in Ocean County.

Using the long-term coastal erosion hazard area, the spatial analysis indicates that six of the 21 counties are exposed: Atlantic, Cape May, Cumberland, Middlesex, Monmouth and Ocean Counties. In summary, an estimated 31,995 people (or less than one-percent of the total population) and an estimated $10 billion in building replacement cost value are potentially vulnerable.

Table 5.2-8. Population Exposed to Coastal Erosion

County	Total Population (2010)	Population in RSC Coastal Erosion Susceptible Area	% of Total	Population in the Approximate Coastal Erosion Hazard Area (Long-Term)	% of Total
Atlantic	274,549	-	-	3,339	1.2
Bergen	905,116	-	-	0	0
Burlington	448,734	-	-	0	0
Camden	513,657	-	-	0	0
Cape May	97,265	-	-	4,995	5.1
Cumberland	156,898	-	-	145	0.1
Essex	783,969	-	-	0	0
Gloucester	288,288	-	-	0	0
Hudson	634,266	-	-	0	0
Hunterdon	128,349	-	-	0	0
Mercer	366,513	-	-	0	0
Middlesex	809,858	-	-	444	0.1
Monmouth	630,380	-	-	16,111	2.6
Morris	492,276	-	-	0	0
Ocean	576,567	3,090	<1	6,952	1.2
Passaic	501,226	-	-	0	0
Salem	66,083	-	-	0	0
Somerset	323,444	-	-	0	0
Sussex	149,265	-	-	0	0

Table 5.2-8. Population Exposed to Coastal Erosion

County	Total Population (2010)	Population in RSC Coastal Erosion Susceptible Area	% of Total	Population in the Approximate Coastal Erosion Hazard Area (Long-Term)	% of Total
Union	536,499	-	-	0	0
Warren	108,692	-	-	0	0
Total	**8,791,894**	**3,090**	**<1**	**31,995**	**<1**

Source: United States Census 2010; Richard Stockton College CRC 2013; NJDEP 1993
Notes: RSC Richard Stockton College

Table 5.2-9. Building Replacement Cost Value Exposed to Coastal Erosion by County

County	Total Building RCV	RCV in RSCs Coastal Erosion Susceptible Area	% of Total	RCV in the Approximate Coastal Erosion Hazard Area (Long Term)	% of Total
Atlantic	$38,043,171,000	-	-	$1,579,101,000	4.2
Bergen	$154,077,482,000	-	-	$0	0.0
Burlington	$62,700,794,000	-	-	$0	0.0
Camden	$70,467,051,000		-	$0	0.0
Cape May	$24,665,528,000	-	-	$2,106,325,000	8.5
Cumberland	$18,128,613,000	-	-	$10,769,000	0.1
Essex	$113,124,687,000	-	-	$0	0.0
Gloucester	$33,534,660,000	-	-	$0	0.0
Hudson	$82,290,184,000	-	-	$0	0.0
Hunterdon	$21,720,513,000	-	-	$0	0.0
Mercer	$56,194,660,000	-	-	$0	0.0
Middlesex	$119,947,782,000	-	-	$71,805,000	0.1
Monmouth	$96,235,266,000	-	-	$4,062,291,000	4.2
Morris	$86,634,810,000	-	-	$0	0.0
Ocean	$73,559,915,000	$1,835,414,000	2.5	$2,545,377,000	3.5
Passaic	$66,705,864,000	-	-	$0	0.0
Salem	$8,092,037,000	-	-	$0	0.0
Somerset	$52,513,253,000	-	-	$0	0.0
Sussex	$20,979,595,000	-	-	$0	0.0
Union	$79,329,736,000	-	-	$0	0.0
Warren	$14,442,755,000	-	-	$0	0.0
Total	**$1,293,388,356,000**	**$1,835,414,000**	**<1**	**$10,375,668,000**	**<1**

Source: HAZUS-MH 2.1; Richard Stockton College CRC 2013; NJDEP 1993
Note: The total building replacement cost values (RCV) are for all occupancy types (residential, commercial, industrial, religious, government and education) and represent both structure and contents. RSC = Richard Stockton College.

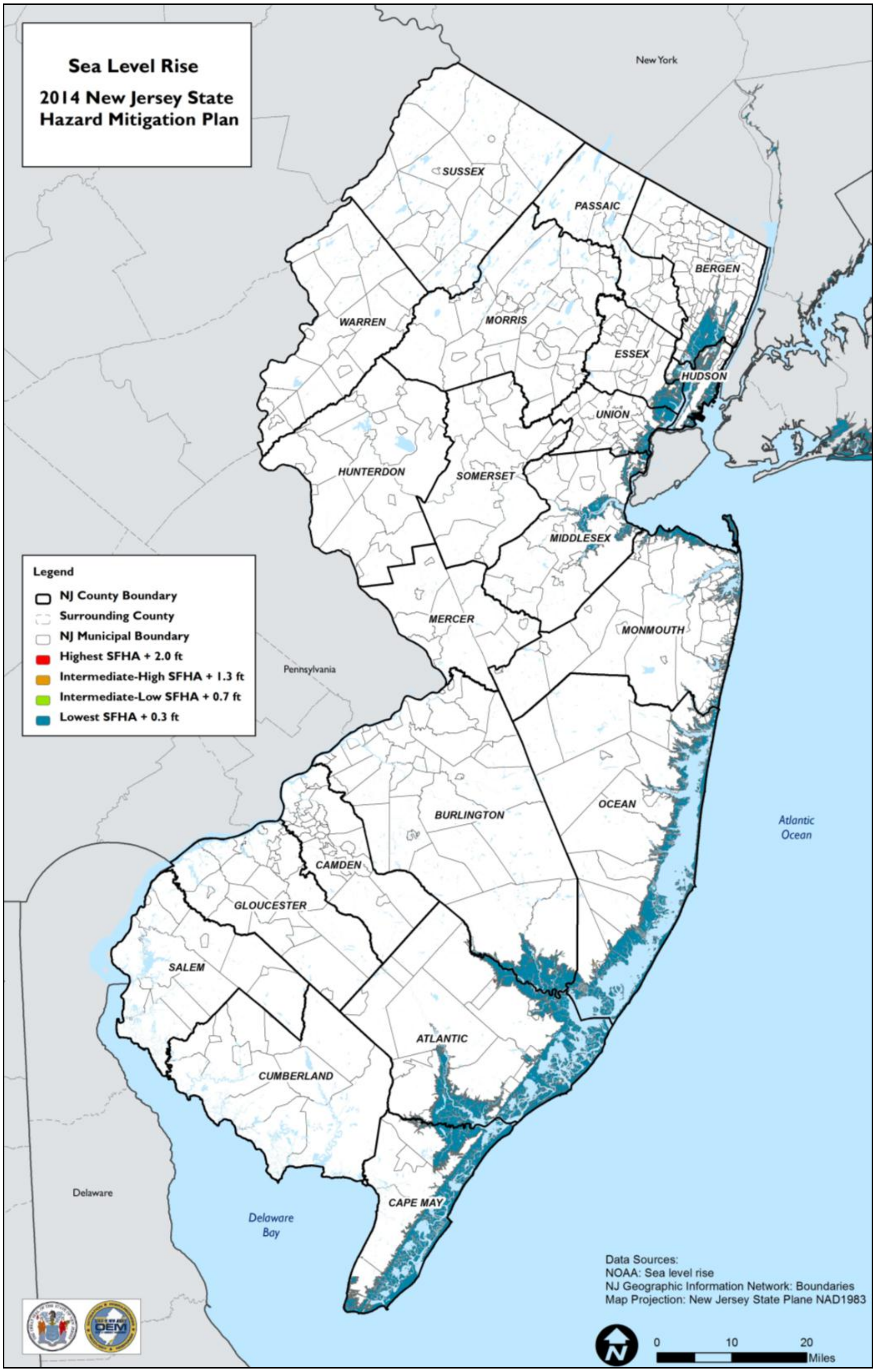
Preliminary results of a Richard Stockton College CRC study of Cape May County indicate that overall, with the exception of isolated areas on the barrier islands, Cape May County is less susceptible to erosion when compared to Atlantic, Monmouth, and Ocean Counties because of the offshore topography.

To assess the Counties exposed to sea level rise, the NOAA spatial layers of the four sea level rise scenarios were overlaid on the State in GIS. Figure 5.2-18 illustrates the four sea level rise scenarios and their estimated area of impact in the following Counties: Atlantic, Burlington, Bergen, Cape May, Essex, Hudson, Middlesex, Monmouth, Ocean, and Union. As mentioned earlier, Cumberland and Salem Counties located along the Delaware Bay as well as Gloucester, Camden and Burlington Counties located along the tidally influenced portion of the Delaware River are excluded from this analysis.

Future changes in growth and development may impact vulnerability. Figure 4-22 in Section 4 indicates an increase in the number of housing units authorized by building permits from 2010 to 2012 for many of the coastal counties exposed to coastal erosion and sea level rise: Bergen, Essex, Hudson, Middlesex, Monmouth, Ocean, and Union. If the proposed new development is located within the hazard areas, there is a potential increase in risk to life, property and the environment. However, the State has controls through CAFRA which regulates development in defined CAFRA boundaries. In addition, new construction will be required to meet current standards which are designed to provide increased protection compared to existing development in the area.

Coastal areas impacted by Superstorm Sandy are in the redevelopment phase. Similar to new construction, redevelopment will be required to meet current standards which may provide increased protection compared to their pre-event conditions. Dune replenishment projects will continue and their role in mitigating vulnerabilities considered. The U. S. Army Corps of Engineers dune replenishment projects as described in earlier in this section and illustrated on Figure 5.2-13 will serve to help mitigate the impacts of coastal erosion. Any identified vulnerabilities will be considered as the State continues to rebuild and redevelop in the aftermath of Superstorm Sandy and beyond.

Figure 5.2-18. Global Mean Sea Level Rise Scenarios for New Jersey



Source: NOAA 2012
Note: Due to the scale of the map, it is difficult to see the highest, intermediate-high and intermediate-low scenarios.

Assessing Vulnerability of State Facilities

To assess the vulnerability of the State-owned and leased facilities provided by New Jersey's Office of Management and Budget, a spatial analysis was conducted using the coastal erosion hazard areas. Using geographic information system (GIS) software, these hazard areas were overlaid with the State facility data outlined in Section 5.1 to determine the number of State facilities potentially at risk to coastal erosion. Table 5.2-10 summarizes the State-owned and leased facilities vulnerable to coastal erosion by county, and Table 5.2-11 summarizes the facilities by State agency. The analysis indicates there are two State buildings, both located in Ocean County, vulnerable to coastal erosion. These State buildings are owned by the Department of Children and Families and the NJDEP.

Table 5.2-10. Number of State-Owned and Leased Buildings in the Coastal Erosion Hazard Area by County

County	Total Number of Buildings	Number of State Buildings in RSC's Coastal Erosion Susceptible Area			Number of State Buildings in the Approximate Coastal Erosion Hazard Area (Long Term)		
		Owned	Leased	Total	Owned	Leased	Total
Atlantic	87	-	-	-	0	0	0
Bergen	46	-	-	-	0	0	0
Burlington	345	-	-	-	0	0	0
Camden	70	-	-	-	0	0	0
Cape May	114	-	-	-	0	0	0
Cumberland	367	-	-	-	0	0	0
Essex	74	-	-	-	0	0	0
Gloucester	46	-	-	-	0	0	0
Hudson	22	-	-	-	0	0	0
Hunterdon	333	-	-	-	0	0	0
Mercer	390	-	-	-	0	0	0
Middlesex	264	-	-	-	0	0	0
Monmouth	163	-	-	-	0	0	0
Morris	103	-	-	-	0	0	0
Ocean	103	1	0	1	1	0	1
Passaic	71	-	-	-	0	0	0
Salem	56	-	-	-	0	0	0
Somerset	38	-	-	-	0	0	0
Sussex	63	-	-	-	0	0	0
Union	35	-	-	-	0	0	0
Warren	120	-	-	-	0	0	0
Total	**2,910**	**1**	**0**	**1**	**1**	**0**	**1**

Source: OMB 2013; Richard Stockton College CRC 2013; NJDEP 1993
Notes: RSC Richard Stockton College

Table 5.2-11. Number of State-Owned and Leased Buildings in the Coastal Erosion Hazard Area by Agency

State Agency	Total Number of Buildings	Number of State Buildings in RSC's Coastal Erosion Susceptible Area			Number of State Buildings in the Approximate Coastal Erosion Hazard Area (Long Term)		
		Owned	Leased	Total	Owned	Leased	Total
Agriculture	1	0	0	0	0	0	0
Banking and Insurance	1	0	0	0	0	0	0
Chief Executive	1	0	0	0	0	0	0
Children and Families	90	1	0	1	0	0	0
Community Affairs	9	0	0	0	0	0	0
Corrections	696	0	0	0	0	0	0
Education	64	0	0	0	0	0	0
Environmental Protection	330	0	0	0	1	0	1
Health	3	0	0	0	0	0	0
Human Services	463	0	0	0	0	0	0
Judiciary	4	0	0	0	0	0	0
Juvenile Justice Commission	181	0	0	0	0	0	0
Labor and Work Force Dev.	6	0	0	0	0	0	0
Law and Public Safety	11	0	0	0	0	0	0
Legislature	4	0	0	0	0	0	0
Military and Veterans Affairs	262	0	0	0	0	0	0
Miscellaneous Commissions	1	0	0	0	0	0	0
Motor Vehicles Commission	69	0	0	0	0	0	0
Personnel	1	0	0	0	0	0	0
State	9	0	0	0	0	0	0
State Police	122	0	0	0	0	0	0
Transportation	565	0	0	0	0	0	0
Treasury	17	0	0	0	0	0	0
Total	**2,910**	**1**	**0**	**1**	**1**	**0**	**1**

Source: OMB 2013; Richard Stockton College CRC 2013; NJDEP 1993
Notes: RSC Richard Stockton College

To assess the vulnerability of critical facilities, a spatial analysis was conducted with the defined coastal erosion hazard areas and the critical facilities and infrastructure defined in Section 5.1. There are 14 critical facilities (police, fire, and EMS buildings) in Ocean County vulnerable to coastal erosion as a result of a 100-year event. Table 5.2-12 summarizes these results in Ocean County by susceptibility ranking. There are no critical facilities located within 120 feet of the identified beach and erodible shoreline types.

Table 5.2-12. Number of Critical Facilities in Ocean County Susceptible to Coastal Erosion from a 100-year Event

Critical Facility Type	Susceptibility Rank		
	High	Medium	Low
Emergency Medical Services	1	1	3
Fire	1	1	2
Police	1	1	2
School	1	0	0
Total	**4**	**3**	**7**

Source: Richard Stockton College CRC 2013; NJGIN 2013; OHSP 2013

Coastal erosion and sea level rise can also severely impact roads and infrastructure. As coastline evolution continues, evacuation and emergency routes need to be considered. As discussed in the New Jersey Hurricane Evacuation Study Transportation Analysis, Cape May, Atlantic, Ocean, and Monmouth Counties are principal origination points for evacuation movements in the State during a hurricane evacuation event. These counties include significant westbound and northbound evacuation routes. Using the hurricane evacuation routes in the New Jersey spatial dataset, routes used to direct traffic inland in case of a hurricane threat are located in the coastal erosion hazard area. These include portions of Atlantic City Expressway; United States Route 40; State Highways 35, 36, 37, 72, and 152; and County Roads 12A, 520, 607, 619, 621, and 625.

To assess the vulnerability of State buildings and critical facilities to sea level rise, a spatial analysis was conducted using the NOAA sea level rise scenario polygon data. In summary, it is estimated that between 133 and 153 State-owned and leased buildings may potentially be vulnerable to sea level rise by the year 2050. Tables 5.2-13 and 5.2-14 summarize these results. As stated, these tables do not include potential inundation in Burlington (along the Delaware River), Cumberland, Camden, Gloucester and Salem counties.

Any identified vulnerabilities to State facilities will be considered as the State continues to rebuild and redevelop in the aftermath of Superstorm Sandy and beyond. Dune replenishment projects will continue and their role in mitigating vulnerabilities considered.

Table 5.2-13. Number of State-Owned and Leased Buildings Vulnerable to Sea Level Rise by County

County	Total Number of Buildings	SFHA + 0.3 feet			SFHA + 0.7 feet			SFHA + 1.3 feet			SFHA + 2.0 feet		
		Owned	Leased	Total	Owned	Leased	Total	Owned	Leased	Total	Owned	Leased	Total
Atlantic	87	10	6	16	12	6	18	12	6	18	13	6	19
Bergen	46	1	0	1	1	1	2	1	1	2	1	1	2
Burlington	345	0	0	0	0	0	0	0	0	0	1	0	1
Camden	70	0	0	0	0	0	0	0	0	0	0	0	0
Cape May	114	6	1	7	6	1	7	7	1	8	9	1	10
Cumberland	367	0	0	0	0	0	0	0	0	0	0	0	0
Essex	74	30	2	32	30	2	32	30	2	32	31	2	33
Gloucester	46	0	0	0	0	0	0	0	0	0	0	0	0
Hudson	22	10	1	11	10	1	11	10	1	11	13	1	14
Hunterdon	333	0	0	0	0	0	0	0	0	0	0	0	0
Mercer	390	0	0	0	0	0	0	0	0	0	0	0	0
Middlesex	264	0	0	0	0	0	0	0	0	0	1	0	1
Monmouth	163	33	1	34	33	1	34	36	1	37	40	1	41
Morris	103	0	0	0	0	0	0	0	0	0	0	0	0
Ocean	103	31	1	32	31	1	32	31	1	32	31	1	32
Passaic	71	0	0	0	0	0	0	0	0	0	0	0	0
Salem	56	0	0	0	0	0	0	0	0	0	0	0	0
Somerset	38	0	0	0	0	0	0	0	0	0	0	0	0
Sussex	63	0	0	0	0	0	0	0	0	0	0	0	0
Union	35	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.2-13. Number of State-Owned and Leased Buildings Vulnerable to Sea Level Rise by County

County	Total Number of Buildings	SFHA + 0.3 feet			SFHA + 0.7 feet			SFHA + 1.3 feet			SFHA + 2.0 feet		
		Owned	Leased	Total	Owned	Leased	Total	Owned	Leased	Total	Owned	Leased	Total
Warren	120	0	0	0	0	0	0	0	0	0	0	0	0
Total	**2,910**	**121**	**12**	**133**	**123**	**13**	**136**	**127**	**13**	**140**	**140**	**13**	**153**

Source: OMB 2013; NOAA 2013
Note: Please note the data provided by NOAA excludes potential inundation in Burlington (along the Delaware River), Cumberland, Camden, Gloucester and Salem Counties.

Table 5.2-14. Number of State-Owned and Leased Buildings Vulnerable to Sea Level Rise by Agency

Agency	Total Number of Buildings	SFHA + 0.3 feet			SFHA + 0.7 feet			SFHA + 1.3 feet			SFHA + 2.0 feet		
		Owned	Leased	Total	Owned	Leased	Total	Owned	Leased	Total	Owned	Leased	Total
Agriculture	1	0	0	0	0	0	0	0	0	0	0	0	0
Banking and Insurance	1	0	0	0	0	0	0	0	0	0	0	0	0
Chief Executive	1	0	0	0	0	0	0	0	0	0	0	0	0
Children and Families	90	2	3	5	2	3	5	2	4	6	2	4	6
Community Affairs	9	0	0	0	0	0	0	0	0	0	0	0	0
Corrections	696	29	1	30	29	1	30	29	1	30	30	1	31
Education	64	0	0	0	0	0	0	0	0	0	1	0	1
Environmental Protection	330	38	0	38	40	0	40	40	0	40	45	0	45
Health	3	0	0	0	0	0	0	0	0	0	0	0	0
Human Services	463	0	0	0	0	0	0	0	0	0	0	0	0
Judiciary	4	0	0	0	0	0	0	0	0	0	0	0	0
Juvenile Justice Commission	181	0	0	0	0	0	0	0	0	0	0	0	0
Labor and Work Force Dev.	6	0	1	1	0	1	1	0	1	1	0	1	1
Law and Public Safety	11	0	1	1	0	1	1	0	1	1	0	1	1
Legislature	4	0	0	0	0	0	0	0	0	0	0	0	0
Military and Veterans Affairs	262	40	0	40	40	0	40	44	0	44	47	0	47
Miscellaneous Commissions	1	0	0	0	0	0	0	0	0	0	0	0	0

Table 5.2-14. Number of State-Owned and Leased Buildings Vulnerable to Sea Level Rise by Agency

Agency	Total Number of Buildings	SFHA + 0.3 feet			SFHA + 0.7 feet			SFHA + 1.3 feet			SFHA + 2.0 feet		
		Owned	Leased	Total	Owned	Leased	Total	Owned	Leased	Total	Owned	Leased	Total
Motor Vehicles Commission	69	1	0	1	1	0	1	1	0	1	1	0	1
Personnel	1	0	0	0	0	0	0	0	0	0	0	0	0
State	9	0	0	0	0	0	0	0	0	0	0	0	0
State Police	122	6	5	11	6	5	11	6	5	11	6	5	11
Transportation	565	5	0	5	5	0	5	5	0	5	8	0	8
Treasury	17	0	1	1	0	1	1	0	1	1	0	1	1
Total	**2,910**	**121**	**12**	**133**	**123**	**12**	**135**	**127**	**13**	**140**	**140**	**13**	**153**

Source: OMB, 2013; NOAA, 2013

Note: Please note the data provided by NOAA excludes potential inundation in Burlington (along the Delaware River), Cumberland, Camden, Gloucester and Salem Counties.

Table 5.2-15. Number of Critical Facilities Vulnerable to Sea-Level Rise SFHA + 0.3 feet

County	Total Count	Airport	Special Needs	Communication	Correctional Institutions	Dam	Electric Power	EMS	Ferry	Fire	Highway Bridge	Highway Tunnel	Light Rail Facility	Medical	Military	Natural Gas	Oil	Police	Port	Potable Water	Rail Facility	School	Shelter	Wastewater
Atlantic	388	0	1	0	0	14	1	13	0	13	0	0	0	1	0	0	0	6	0	1	0	19	7	1
Bergen	1,148	1	1	0	1	5	1	9	1	8	0	0	0	0	0	0	0	4	0	0	2	9	5	4
Burlington	747	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Camden	701	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cape May	229	1	2	0	0	7	0	14	0	18	0	0	0	0	1	0	0	8	1	0	0	15	12	4
Cumberland	251	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Essex	784	1	0	0	2	0	0	0	0	2	1	0	0	0	0	0	0	3	3	0	1	1	1	1
Gloucester	346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hudson	493	0	2	1	1	0	2	6	3	11	1	1	12	4	0	1	0	2	2	1	6	29	11	5
Hunterdon	328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mercer	538	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Middlesex	816	0	0	0	0	9	0	0	0	1	0	0	0	0	0	0	1	0	0	2	0	1	0	0
Monmouth	905	0	3	0	0	11	0	15	2	14	0	0	0	2	1	0	0	6	1	0	0	17	0	6
Morris	913	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocean	621	0	1	0	0	5	0	24	0	18	0	0	0	0	0	0	0	12	0	0	1	7	1	0
Passaic	648	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salem	201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Somerset	539	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sussex	542	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Union	607	0	0	0	0	8	1	1	0	1	1	0	0	0	0	0	0	2	5	0	0	1	2	2
Warren	351	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**12,096**	**3**	**10**	**1**	**4**	**63**	**5**	**82**	**6**	**86**	**3**	**1**	**12**	**7**	**2**	**1**	**1**	**43**	**12**	**4**	**10**	**99**	**39**	**23**

Note: Please note the data provided by NOAA excludes potential inundation in Burlington (along the Delaware River), Cumberland, Camden, Gloucester and Salem Counties.

Table 5.2-16. Number of Critical Facilities Vulnerable to Sea-Level Rise SFHA + 0.7 feet

County	Total Count	Airport	Special Needs	Communication	Correctional Institutions	Dam	Electric Power	EMS	Ferry	Fire	Highway Bridge	Highway Tunnel	Light Rail Facility	Medical	Military	Natural Gas	Oil	Police	Port	Potable Water	Rail Facility	School	Shelter	Wastewater
Atlantic	388	0	1	0	0	14	2	14	0	14	0	0	0	2	0	0	0	6	0	1	0	20	7	1
Bergen	1,148	1	1	0	1	6	2	9	1	9	0	0	0	0	0	0	0	4	0	0	4	9	5	4
Burlington	747	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Camden	701	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cape May	229	1	2	0	0	7	0	15	0	18	0	0	0	0	1	0	0	8	1	0	0	15	12	4
Cumberland	251	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Essex	784	1	0	0	2	0	0	0	0	2	1	0	0	0	0	0	0	3	3	0	1	2	2	1
Gloucester	346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hudson	493	0	2	1	1	0	2	6	3	11	1	1	12	5	0	1	0	2	3	1	6	29	12	5
Hunterdon	328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mercer	538	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Middlesex	816	0	0	0	0	9	0	0	0	2	0	0	0	0	0	0	1	0	0	2	0	1	0	0
Monmouth	905	0	3	0	0	12	0	16	2	15	0	0	0	2	1	0	0	7	1	0	0	18	1	6
Morris	913	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocean	621	0	1	0	0	5	0	24	0	18	0	0	0	0	0	0	0	12	0	0	1	7	1	0
Passaic	648	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salem	201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Somerset	539	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sussex	542	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Union	607	0	0	0	0	8	1	1	0	1	1	0	0	0	0	0	0	3	5	0	0	1	3	2
Warren	351	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**12,096**	**3**	**10**	**1**	**4**	**65**	**7**	**85**	**6**	**90**	**3**	**1**	**12**	**9**	**2**	**1**	**1**	**45**	**13**	**4**	**12**	**102**	**43**	**23**

Note: Please note the data provided by NOAA excludes potential inundation in Burlington (along the Delaware River), Cumberland, Camden, Gloucester and Salem Counties.

Table 5.2-17. Number of Critical Facilities Vulnerable to Sea-Level Rise SFHA + 1.3 feet

County	Total Count	Airport	Special Needs	Communication	Correctional Institutions	Dam	Electric Power	EMS	Ferry	Fire	Highway Bridge	Highway Tunnel	Light Rail Facility	Medical	Military	Natural Gas	Oil	Police	Port	Potable Water	Rail Facility	School	Shelter	Wastewater
Atlantic	388	0	1	0	0	14	2	14	0	14	0	0	0	3	0	0	0	6	0	1	0	20	7	2
Bergen	1,148	1	1	0	1	6	2	9	1	9	0	0	0	0	0	0	0	4	0	0	4	10	6	4
Burlington	747	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Camden	701	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cape May	229	1	2	0	0	7	0	15	0	18	0	0	0	0	1	0	0	8	1	0	0	15	12	5
Cumberland	251	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Essex	784	1	0	0	2	0	0	0	0	2	1	0	0	0	0	0	0	3	3	0	1	4	2	1
Gloucester	346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hudson	493	0	2	1	1	0	2	6	3	11	1	1	13	5	0	1	0	2	3	1	6	31	12	5
Hunterdon	328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mercer	538	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Middlesex	816	0	0	0	0	9	0	0	0	2	0	0	0	0	0	0	1	0	0	2	0	1	1	0
Monmouth	905	0	3	0	0	13	0	17	2	17	0	0	0	2	1	0	0	7	1	0	0	18	1	6
Morris	913	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocean	621	0	1	0	0	6	0	24	0	18	0	0	0	0	0	0	0	13	0	0	1	8	1	0
Passaic	648	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salem	201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Somerset	539	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sussex	542	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Union	607	0	0	0	0	8	1	2	0	3	1	0	0	0	0	0	0	3	5	0	0	3	4	2
Warren	351	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**12,096**	**3**	**10**	**1**	**4**	**67**	**7**	**87**	**6**	**94**	**3**	**1**	**13**	**10**	**2**	**1**	**1**	**46**	**13**	**4**	**12**	**110**	**47**	**25**

Note: Please note the data provided by NOAA excludes potential inundation in Burlington (along the Delaware River), Cumberland, Camden, Gloucester and Salem Counties.

Table 5.2-18. Number of Critical Facilities Vulnerable to Sea-Level Rise SFHA + 2.0 feet

County	Total Count	Airport	Special Needs	Communication	Correctional Institutions	Dam	Electric Power	EMS	Ferry	Fire	Highway Bridge	Highway Tunnel	Light Rail Facility	Medical	Military	Natural Gas	Oil	Police	Port	Potable Water	Rail Facility	School	Shelter	Wastewater
Atlantic	388	0	1	0	0	14	2	15	0	15	0	0	0	3	0	0	0	7	0	1	0	20	7	2
Bergen	1,148	1	1	0	1	6	2	10	1	9	0	0	0	0	0	0	0	6	0	0	4	11	8	4
Burlington	747	0	0	0	0	3	0	1	0	1	0	0	0	0	0	0	0	0	0	0	0	0	1	0
Camden	701	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Cape May	229	1	2	0	0	7	0	16	0	19	0	0	0	0	1	0	0	8	1	0	0	15	12	5
Cumberland	251	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Essex	784	1	0	0	2	0	0	1	0	3	1	0	0	0	0	0	0	3	3	0	2	5	2	1
Gloucester	346	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hudson	493	0	2	1	1	0	2	6	3	11	1	1	14	5	0	1	0	2	3	2	6	32	12	5
Hunterdon	328	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mercer	538	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Middlesex	816	0	0	0	0	9	0	1	0	3	0	0	0	0	0	0	1	1	0	2	0	3	1	0
Monmouth	905	0	3	0	0	14	0	20	2	19	0	0	0	2	1	0	0	7	1	0	0	19	1	6
Morris	913	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ocean	621	0	1	0	0	7	0	25	0	19	0	0	0	0	0	0	0	13	0	0	1	10	1	0
Passaic	648	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Salem	201	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Somerset	539	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sussex	542	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Union	607	0	0	0	0	8	1	2	0	3	1	0	0	0	0	0	0	3	5	0	0	4	5	2
Warren	351	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	**12,096**	**3**	**10**	**1**	**4**	**69**	**7**	**97**	**6**	**102**	**3**	**1**	**14**	**10**	**2**	**1**	**1**	**50**	**13**	**5**	**13**	**119**	**50**	**25**

Note: Please note the data provided by NOAA excludes potential inundation in Burlington (along the Delaware River), Cumberland, Camden, Gloucester and Salem Counties.

Estimating Potential Losses by Jurisdiction

Life, property and the environment located within the coastal erosion hazard areas defined earlier in this section are potentially at risk for loss from coastal erosion. As stated earlier, eight of the 21 counties are within the jurisdiction of the Coastal Area Facility Review Act (CAFRA), six of which are located in the defined long-term coastal erosion hazard areas: Atlantic, Cape May, Cumberland, Middlesex, Monmouth, and Ocean Counties. Further, the Richard Stockton College CRC identified areas with greatest susceptibility to coastal erosion in Ocean County as a result of a 100-year storm event. Building and infrastructure damage as a result of coastal erosion can impact a community's economy and tax base. The replacement cost value of buildings within the coastal erosion hazard areas are summarized in Table 5.2-9 above.

Current replacement cost data is not available at the structural level for the general building stock across the State. Table 5.2-9 identifies a total risk exposure using the default general building stock in HAZUS-MH at the Census-block level. As more current replacement cost data becomes available either at the aggregate or structure level, and probabilistic modeling is developed to estimate potential loss as a result of coastal erosion, this section of the Plan will be updated.

The State's coastal resources are an enormous driver to the local and statewide economy and losses can greatly impact the State's tax base and the local industries (e.g., tourism). In 2012, the New Jersey tourism economy supported 318,500 jobs, which were approximately 10% of the total employment of the State. The tourism sector generated $34.7 billion of state GDP in 2012, or approximately 7.0% of the entire state economy. In addition to the direct impact of the shore, tourism generated $4.5 billion in indirect and induced impacts on the State economy (NJ Tourism 2013).

Future changes in growth and development may affect vulnerability and potential losses in the future. As stated earlier, coastal areas impacted by Superstorm Sandy are in the redevelopment phase. Similar to new construction, redevelopment will be required to meet current standards which may provide increased protection compared to their pre-event conditions and result in a decrease in future potential losses.

Estimating Potential Losses of State Facilities

All State-owned and leased buildings and critical facilities located within the coastal erosion hazard areas presented earlier in this section are potentially at risk for loss from coastal erosion. There is a total risk exposure of $887,897 for State buildings vulnerable to coastal erosion in Ocean County as a result of a 100-year storm event. Further, there is a total risk exposure of $134,327 for the one NJDEP building located within 120 feet of the identified beach and erodible shoreline types. Refer to Tables 5.2-19 and 5.2-20 below.

Table 5.2-19. Total Replacement Cost Value of State-Owned and Leased Buildings in the Coastal Erosion Hazard Area by County

County	RCV of Buildings	RCV in RSC's Coastal Erosion Susceptible Area			RCV in the Approximate Coastal Erosion Hazard Area (Long-Term)		
		Owned	Leased	Total	Owned	Leased	Total
Atlantic	$358,024,830	-	-	-	$0	$0	$0
Bergen	$219,423,769	-	-	-	$0	$0	$0
Burlington	$892,775,538	-	-	-	$0	$0	$0
Camden	$640,350,857	-	-	-	$0	$0	$0
Cape May	$117,950,706	-	-	-	$0	$0	$0
Cumberland	$813,708,672	-	-	-	$0	$0	$0

Table 5.2-19. Total Replacement Cost Value of State-Owned and Leased Buildings in the Coastal Erosion Hazard Area by County

County	RCV of Buildings	RCV in RSC's Coastal Erosion Susceptible Area			RCV in the Approximate Coastal Erosion Hazard Area (Long-Term)		
		Owned	Leased	Total	Owned	Leased	Total
Essex	$674,467,788	-	-	-	$0	$0	$0
Gloucester	$76,531,777	-	-	-	$0	$0	$0
Hudson	$164,209,619	-	-	-	$0	$0	$0
Hunterdon	$411,264,979	-	-	-	$0	$0	$0
Mercer	$3,477,412,371	-	-	-	$0	$0	$0
Middlesex	$651,385,213	-	-	-	$0	$0	$0
Monmouth	$247,560,648	-	-	-	$0	$0	$0
Morris	$459,016,431	-	-	-	$0	$0	$0
Ocean	$172,110,712	$887,897	$0	$887,897	$134,327	$0	$134,327
Passaic	$292,868,078	-	-	-	$0	$0	$0
Salem	$57,046,533	-	-	-	$0	$0	$0
Somerset	$233,331,698	-	-	-	$0	$0	$0
Sussex	$49,168,422	-	-	-	$0	$0	$0
Union	$85,257,584	-	-	-	$0	$0	$0
Warren	$106,656,334	-	-	-	$0	$0	$0
Total	**$10,200,522,559**	**$887,897**	**$0**	**$887,897**	**$134,327**	**$0**	**$134,327**

Source: OMB 2013; Richard Stockton College CRC 2013; NJDEP 1993
Notes: RCV Replacement cost value.
RSC Richard Stockton College
- Data is not available for the Counties noted.

Table 5.2-20. Total Replacement Cost Value of State-Owned and Leased Buildings in the Coastal Erosion Hazard Area by Agency

State Agency	Total RCV	RCV in RSCs Coastal Erosion Susceptible Area			RCV in the Approximate Coastal Erosion Hazard Area (Long Term)		
		Owned	Leased	Total	Owned	Leased	Total
Agriculture	$2,876,615	-	-	-	$0	$0	$0
Banking and Insurance	$83,777,640	-	-	-	$0	$0	$0
Chief Executive	$12,653,376	-	-	-	$0	$0	$0
Children and Families	$855,320,877	$887,897	$0	$887,897	$0	$0	$0
Community Affairs	$142,133,954	-	-	-	$0	$0	$0
Corrections	$1,705,111,918	-	-	-	$0	$0	$0
Education	$313,825,668	-	-	-	$0	$0	$0
Environmental Protection	$466,946,331	-	-	-	$134,327	$0	$134,327
Health	$146,433,703	-	-	-	$0	$0	$0
Human Services	$1,689,928,602	-	-	-	$0	$0	$0
Judiciary	$114,021,053	-	-	-	$0	$0	$0
Juvenile Justice Commission	$258,880,851	-	-	-	$0	$0	$0
Labor and Work Force Development	$242,663,875	-	-	-	$0	$0	$0
Law and Public Safety	$498,665,653	-	-	-	$0	$0	$0
Legislature	$165,085,389	-	-	-	$0	$0	$0

Table 5.2-20. Total Replacement Cost Value of State-Owned and Leased Buildings in the Coastal Erosion Hazard Area by Agency

State Agency	Total RCV	RCV in RSCs Coastal Erosion Susceptible Area			RCV in the Approximate Coastal Erosion Hazard Area (Long Term)		
		Owned	Leased	Total	Owned	Leased	Total
Military and Veterans Affairs	$954,650,961	-	-	-	$0	$0	$0
Miscellaneous Commissions	$15,650,656	-	-	-	$0	$0	$0
Motor Vehicles Commission	$928,029,459	-	-	-	$0	$0	$0
Personnel	$8,513,417	-	-	-	$0	$0	$0
State	$208,816,705	-	-	-	$0	$0	$0
State Police	$473,621,856	-	-	-	$0	$0	$0
Transportation	$512,199,066	-	-	-	$0	$0	$0
Treasury	$400,714,935	-	-	-	$0	$0	$0
Total	**$10,200,522,559**	**$887,897**	**$0**	**$887,897**	**$134,327**	**$0**	**$134,327**

Source: OMB 2013; Richard Stockton College CRC 2013; NJDEP 1993
Notes: RCV Replacement cost value.
RSC Richard Stockton College

As discussed in Section 5.1 (Risk Assessment Overview), the replacement cost value for critical facilities was not available for the 2014 Plan update. As this data becomes available, the State will update this section of the Plan. Refer to the discussion in 'Assessing Vulnerability to State Facilities' presented earlier which summarizes the critical facility exposure analysis results.

Environmental Impacts

Coastal erosion can impact beaches, wetlands, marshes, and coastal habitats. The erosion that could be experienced on the barrier islands will decrease their ability to function as buffers against further estuarine, wetland, and land loss. If there is a reduction of these natural environments and the ecological and natural functions they provide, coastal communities may experience more frequent and destructive flooding, compromised water supplies, and smaller or fewer beaches (Center for Ocean Solutions 2013).