Comprehensive Back Bay Adaptive Management Plan

Ocean City
Cape May County, New Jersey

Comprehensive Back Bay Adaptive Management Plan

For

The City of Ocean City Cape May County, New Jersey

Prepared By:

ACT ENGINEERS

ANCHOR QEA

August 28, 2020

Versions:

Final: August 28, 2020

Final Draft Delivered to the City: July 15, 2020

Revision 2: February 2019

Revision 1: February 2018

Initial Plan Drafted: August 2017

Authors:

City of Ocean City, NJ

The Honorable Jay A. Gillian and City Council

861 Asbury Avenue

Ocean City, NJ 08226

ACT Engineers, Inc

1 Washington Boulevard, Suite 3

Robbinsville, NJ 08691

320 S. Shore Road, Suite D

Marmora, NJ 08223

Anchor QEA

755 Business Center Drive, Suite 220

Horsham, PA 19044

TABLE OF CONTENTS

Executive Summary

The network of tidal waterways and wetlands surrounding Ocean City is an essential component of the local economy, commercial and recreational lifestyle, and environment. The need to keep Ocean City's waters navigable, provide flood resiliency and protect the unique and valuable natural resources requires a comprehensive and adaptable management plan for the back bay ecosystem. A multi-faceted approach, with numerous and varied management activities and implemented projects, is required, and must comply with all applicable regulatory requirements, in consultation with Federal and State Agencies.

While significant attention and partnerships have been developed to protect and enhance the oceanfront beach and dune systems, no unified effort has previously been developed for the bayside. Instead, bayside and waterway management has been an assortment of smaller, area-specific projects funded and typically executed individually by City, State, and Federal entities. The Barrier island of Ocean City is unique in that it is one of a few barrier islands where a single municipality is the steward over the entirety of the island. This Comprehensive Back Bay Management Plan is the latest effort to recognize the need to identify the importance of the back bay system and provide a framework for active stewardship of this vital resource to preserve the wealth of benefits it provides communities, natural and man-made, who live here year round and season after season.

Since 2015, Ocean City has initiated the planning and implementation of a comprehensive, bay-wide program for maintaining waterways, promoting flood resiliency, managing stormwater, and protecting the environment. This Comprehensive Back Bay Adaptive Management Plan is the synthesis of the planning and implementation to date and sets the stage for the 2020-2050 time period. Implementation of the Plan since 2015 has included:

- Under a waterway-area-specific dredging permit, and subsequently under the February 2018 City-wide permit, significant dredging programs have been conducted that resulted in the removal of approximately 280,000 cubic yards of material from City and private waterways;

- Development of partnership with the NJDOT Office of Maritime Resources to dredge State designated waterways saving city residents $6 million for dredging;

- Identification and permitting of alternative dredged disposal sites, for the beneficial re-use of the material. Ocean City dredge material has been beneficially reused at multiple locations for landscape and agricultural soil enhancement, capping of landfills, and, site construction;

- Construction of a permanent haul road from Roosevelt Boulevard to the Confined Disposal Facility 83, for initial emptying of 220,000 cubic yards and then subsequent additional emptying of dredged material and future long-term dredged material management, saving millions of dollars in transportation costs;

- An analysis of flooding impacts and preparation of a Comprehensive Flood Mitigation and Drainage Management Plan;

- Construction of a 2,700 linear foot living shoreline rock sill and 1,700 linear feet of invertebrate habitat castles' breakwater, to restore the historic footprint of Shooting Island, protect tidal wetlands, and provide improved flood protection to the City;

- Design and permitting of additional restoration projects and sediment control features with the potential to improve the cost-efficiency of the City's dredged material management needs;
- Award and implementation of the National Fish and Wildlife Foundation, Hurricane Sandy Coastal Resiliency Competition, $2 million Grant, to Ocean City for coastal resiliency projects;

- Implemented private dredge program allowing more than 300 residential properties to be dredged under the City-wide permit.

- Well-established working relationships with State and Federal regulators and Ocean City is considered by these agencies to be the model for creative solutions, innovative permitting, science based ecological evaluation, and productive collaboration of government; and,

- Hosted many public meetings and stakeholder meetings regarding planning and implementation of Management Plan projects.

This Comprehensive Back Bay Adaptive Management Plan, prepared by ACT Engineers, Inc. and Anchor, QEA (the ACT-Anchor Team), was commissioned by the elected officials of the City of Ocean City, Cape May County, New Jersey to provide the framework for managing the function, value and health of its back bay ecosystem and to strengthen the City's resiliency to coastal threats. Originally envisioned as a plan to anticipate and manage long range dredging needs, the scope of the plan has been modified to address comprehensive back bay management which includes the function and health of the back bay including: navigability and recreational value of all waterways; ecological health and habitat value of the ecosystem; and, storm resiliency provided by the back bay systems.

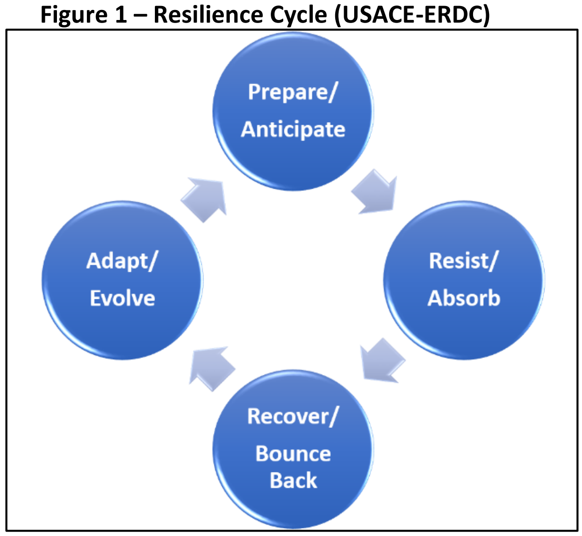
The Plan anticipates that adaptive management will be a central component of the long range management strategy for Ocean City's back bay ecosystem. Adaptive management is a decision-making process in which a system is managed variably over time, based on defined goals and objectives, with the flexibility to adjust operations due to contributing factors such as improved design methodology; environmental and resource conditions; monitoring results; redefined goals and needs; construction methodologies; and, regulatory oversight. In the face of economic, environmental, and climatic uncertainties, adaptive management improves the effectiveness of management strategies by using rigorous monitoring and evaluation methods in a continual learning process. As such, the benefit of the past five years of this holistic and collaborative approach are incorporated in the planning and strategies identified in this Comprehensive Back Bay Adaptive Management Plan.

I. Introduction & Background

A. Purpose

This Comprehensive Back Bay Adaptive Management Plan was commissioned by the elected officials of the City of Ocean City, Cape May County, New Jersey to provide the framework for managing the function, value and health of its back bay ecosystem and to strengthen the City's resiliency to coastal threats.

Figure 1 – Resilience Cycle (USACE-ERDC)



Coastal resiliency is defined by the U.S. Army Engineer Research and Development Center (ERDC) as the capacity to be prepared, withstand, or absorb damages, rapidly recover, and adapt to long-term changes (USACE, 2018). Resiliency is a critical component for systems (natural, nature-based, built infrastructure and community) that are susceptible to coastal hazards such as sea level rise, anticipated increases in the frequency and severity of storm surge, coastal flooding, and erosion. A healthy and functional back bay ecosystem has the capacity to reduce and mitigate these impacts. This Plan is intended as a long-term guidance tool for understanding how individual projects can, and should, combine to improve the function and health of the back bay system. For the purposes of this document, **function and health include navigability of all waterways; recreational value; ecological health and habitat value; and, storm resiliency provided by the back bay systems**.

This Plan is also expected to be a living document, aided from the site-specific experiences learned with each project as well as through routine maintenance dredging completed within Ocean City's back bay. It is expected this Management Plan may be amended, updated, or modified as new methodologies and techniques become available; the project goals and needs of the City evolve; and, adaptive management techniques ultimately result in the need for smaller scale projects with less adverse environmental impact.

B. Risks and Vulnerabilities

Coastal systems are increasingly vulnerable to flooding due to the combined influence of coastal storms, development and population growth, geomorphic change, and sea level rise (Woodruff et al., 2013). The New Jersey coastal zone is comprised of multiple shoreline types that sustain habitat and wildlife, support viable maritime and tourism industries, and harbor a way of life for many residents and visitors. Much of this coastal landscape is threatened by the impacts of episodic and chronic erosion, subsidence, shallow coastal flooding, nor'easters, tropical storms, and hurricanes. Coastal resiliency is fundamentally about mitigating the vulnerability for communities (impacts to humans), infrastructure and natural resources. Local vulnerability may include flooding from storms, king tides, land subsidence, and stormwater flooding and associated adverse impacts to water quality. Climate change threatens to exacerbate the impacts of coastal hazards by increasing the frequency and intensity of coastal storms, accelerating rates of sea level rise, increasing coastal erosion, and inundating low-lying portions of the shore (NJDEP-OCM, 2011). As a result, more people, development, and natural resources will be vulnerable to the impacts of coastal hazards than in the past.

Ocean City, Cape May County, NJ
(Google Earth)

Increasing Sea Levels have altered the natural processes of the New Jersey shore. As a result, coastal communities will likely experience more regular shallow coastal flooding events, greater rates of salinity intrusion into freshwater resources, changes in and loss of critical habitat, and more intense and frequent coastal storms. Additionally, the life expectancy of coastal engineering projects will decrease, the cost of shoreline stabilization will increase, making coastal resource protection harder to achieve. While storm surge and coastal flooding will pose increasing threats to the coastline, the inland environment and patterns of development mean that watershed storm water impacts will also constitute a significant portion of the future threat for flooding in the region.

Measures to promote storm flood resiliency and protection are a vital part of the economical sustainability of Ocean City. Even small amounts of sea level rise make rare floods more common by adding to tides and storm surge and restricting storm water discharges from the City. A recent study, New Jersey's Rising Seas and Changing Coastal

Storms: Report of the 2019 Science and Technical Advisory Panel (released by Rutgers University in November 2019) has established a benchmark for flood mitigation planning. This report cites that sea level has risen 17.6 inches (1.5 feet) along the NJ coast since 1911, compared to a 7.6-inch (0.6 feet) total change in the global mean sea-level. In just the past forty years data shows that sea level along the NJ coastline rose 8.2 inches (0.7 feet), and further projects that sea level will likely continue to rise in the range of 0.2 to 0.5 inches/year over the next 30 years. Higher sea-levels will increase the baseline for flooding from high tides and coastal storms.

Figure 1 (following page) illustrates a comparison of coastal New Jersey, New York, and global mean sea-level rise over a period from 1910 to 2020; and a comparison of coastal rate of change with individual lines representing the rate of sea-level change over 20-year periods based on the linear trends. As seen in **Figure 1**, New Jersey has experienced a greater level of sea-level rise when compared with New York and globally.

Projections of future sea-level rise and higher baselines of flooding have the potential to significantly impact the City. **Figure 2** (page 5) illustrates the potential impacts of rising sea levels under three scenarios.

Figure 3 (page 6) presents a comparison of potential impacts resulting from Sea, Lake and Overland Surges from Hurricanes (SLOSH) under three storm categories.

Figure 1 – Historical Sea-Level Rise (1910-2020)
(Source: New Jersey's Rising Seas and Changing Coastal Storms: Report of the 2019 Science and Technical Advisory Panel. Rutgers, The State University of New Jersey)

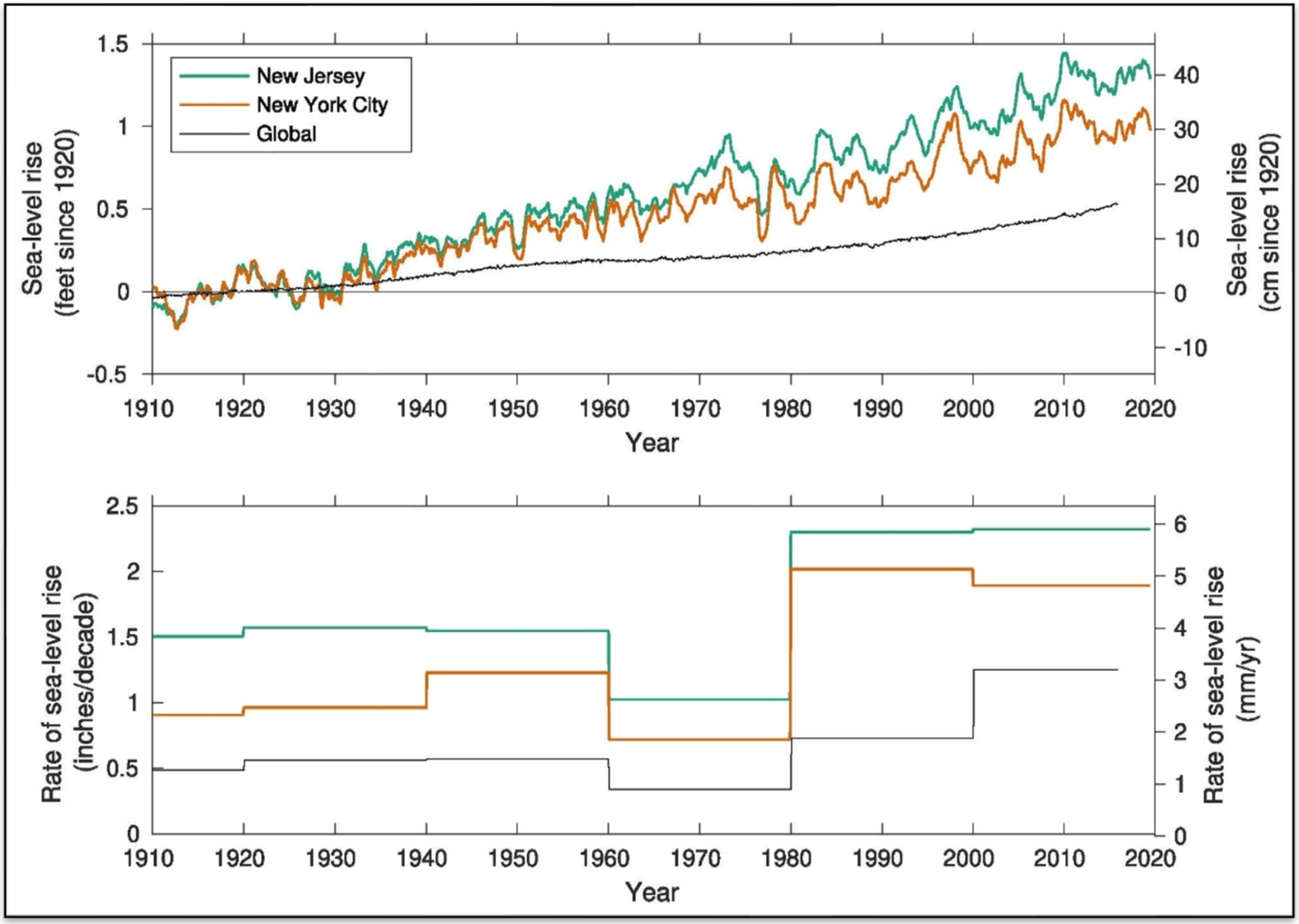
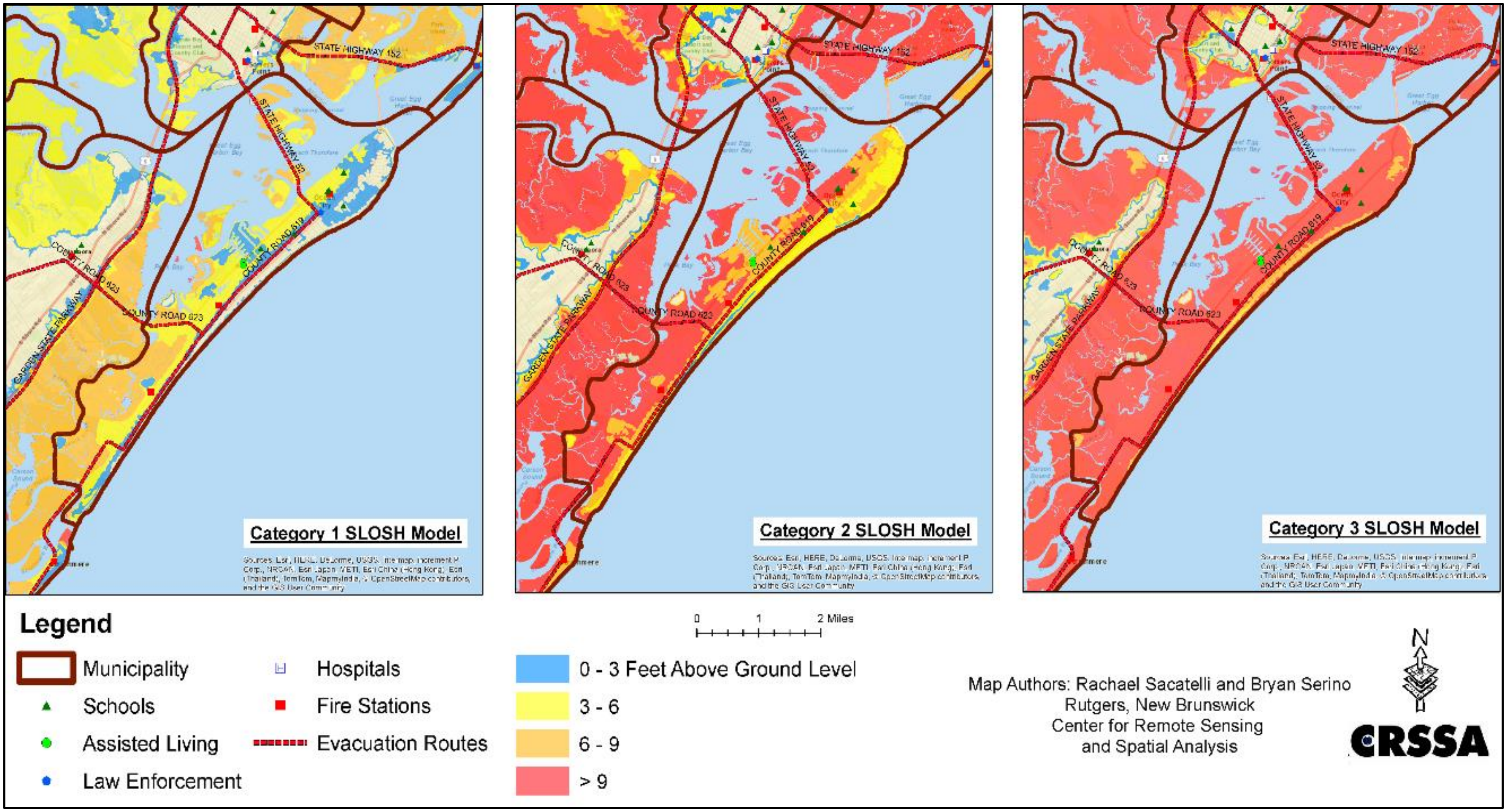


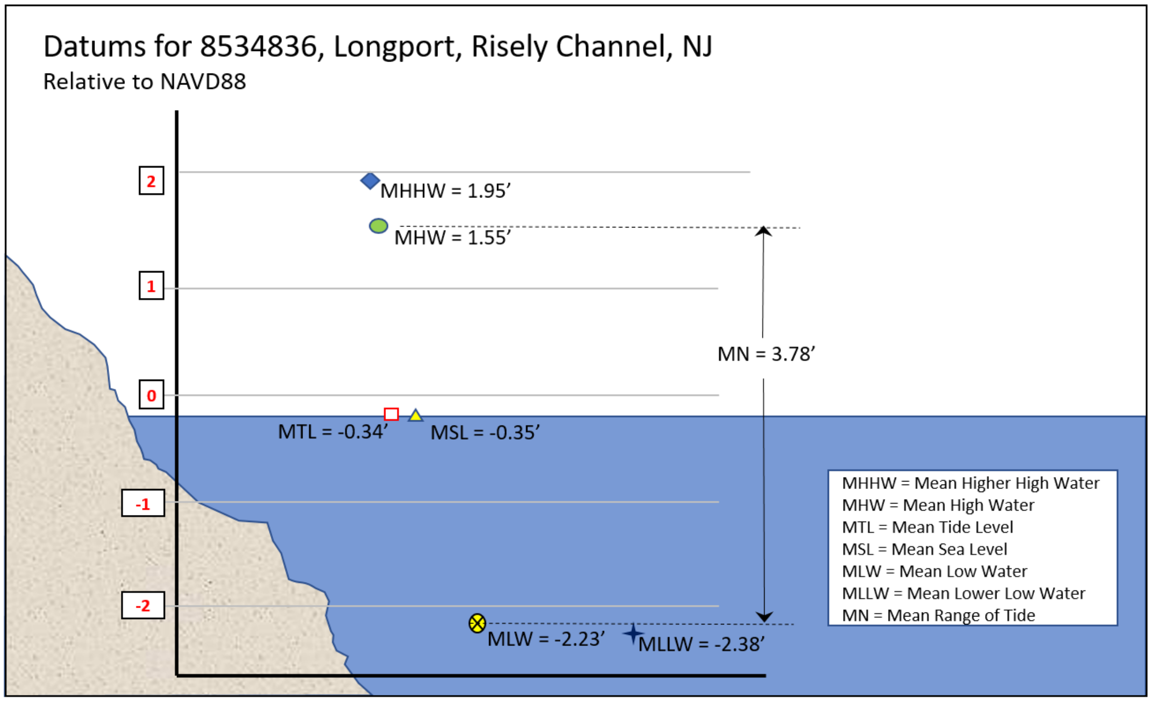
Figure 2 – Comparison of Sea-Level Rise Scenario **(Source: Rutgers CRSSA)**

Figure 3 – Comparison of SLOSH Models during different hurricane categories (Source: Rutgers CRSSA)



Long-term tide gauge records measure sea level relative to local land elevations through repeat leveling surveys from tide gauge reference points to local terrestrial benchmarks. The most widely accepted and utilized topographic survey benchmark datum in New Jersey is the North American Vertical Datum of 1988 (NAVD88). **Figure 4** below shows the relationship of the various tidal events in the back bays of Ocean City based upon the NAVD88 datum.

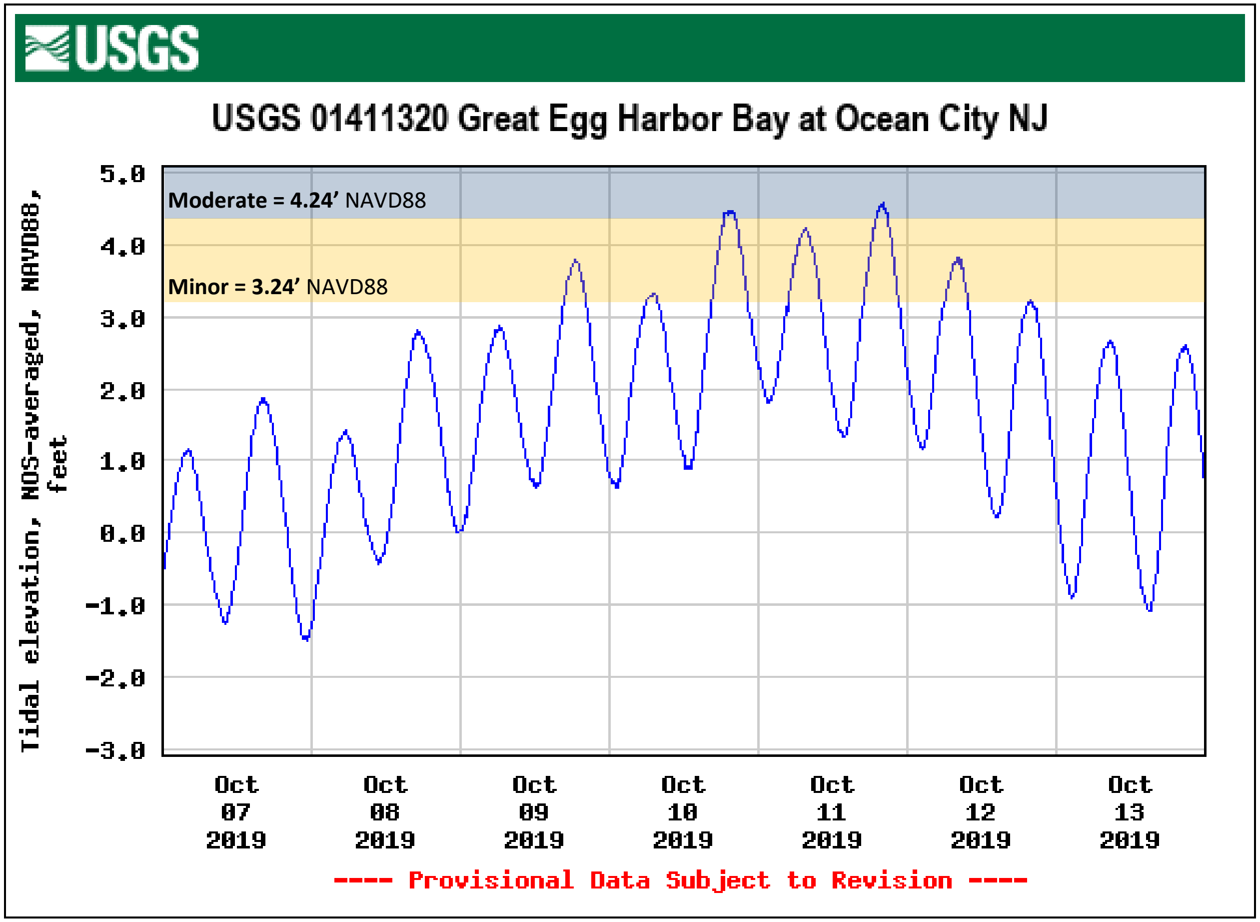
Figure 4 – Tidal Datum for Ocean City, NJ (Source: NOAA Tides & Currents)



As confirmed with digital elevation model (DEM) mapping, the City of Ocean City has elevations ranging from more than 30-feet at the crest of the oceanfront dunes to areas within the adjacent marshes below mean low water. The average elevation of the City (even accounting for the dunes) is 5.4-feet NAVD88. Many low lying areas of the City that experience flooding during storm and high tide events have elevations of less than 3ft NAVD88.

The United States Geological Survey (USGS) tide gauge used to measure tides within the back bays of Ocean City is located at Great Harbor Bay (**Figure 5**). This tide gauge is located north of Ocean City. There is an Ocean City tide gauge further south than the Great Egg Harbor Bay gauge. However, this southern gauge currently has less than twenty (20) years of data and thus, cannot be utilized for modeling and permit applications.

Figure 5– Tidal Gauge (Source: U.S. Geologic Service tide gauge)



Source: USGS National Water Information System

This USGS chart illustrates a flood event recorded between October 7, 2019 and October 13, 2019.

A distant but stalled coastal storm generated a week of strong north/northeast winds but no rain. High tides flooded streets over the course of four days.

Tidal elevations fluctuate daily from gravitation attraction of the sun and moon and the rotation of earth. The height and time fluctuations depend to varying degrees on the location of the sun and moon, and to the details of the shape and depth of back bays, coastlines, coastline depth and prevailing ocean currents. The shape of bays and estuaries can also magnify the intensity of tides. Narrow inlets and shallows tend to dissipate incoming tides. Local wind and weather patterns can also affect tides. Strong offshore winds can move water away from coastlines, exaggerating low tide exposures. Onshore winds may act to push water into back bays, greatly eliminating low tide exposures. High – pressure systems can depress sea levels, leading to clear sunny days with exceptionally low tides. Conversely, low-pressure systems that contribute to cloudy, rainy conditions typically are associated with tides that are much higher than predicted.

Some common influences on sea level measurements include tidal variations, local hydrodynamic variability, changes in regional and coastal oceanographic processes, climate-related global sea level variations and local and regional vertical land movement (VLM). Sea level is rising faster at the New Jersey shore than the global average because of land subsidence (Miller et al., 2017).

The New Jersey coastline is sinking due to compaction and isostatic adjustment, which will add another 9 to 18 cm (or approximately 3.5 inches to 7 inches) of sea surface elevation by 2100.

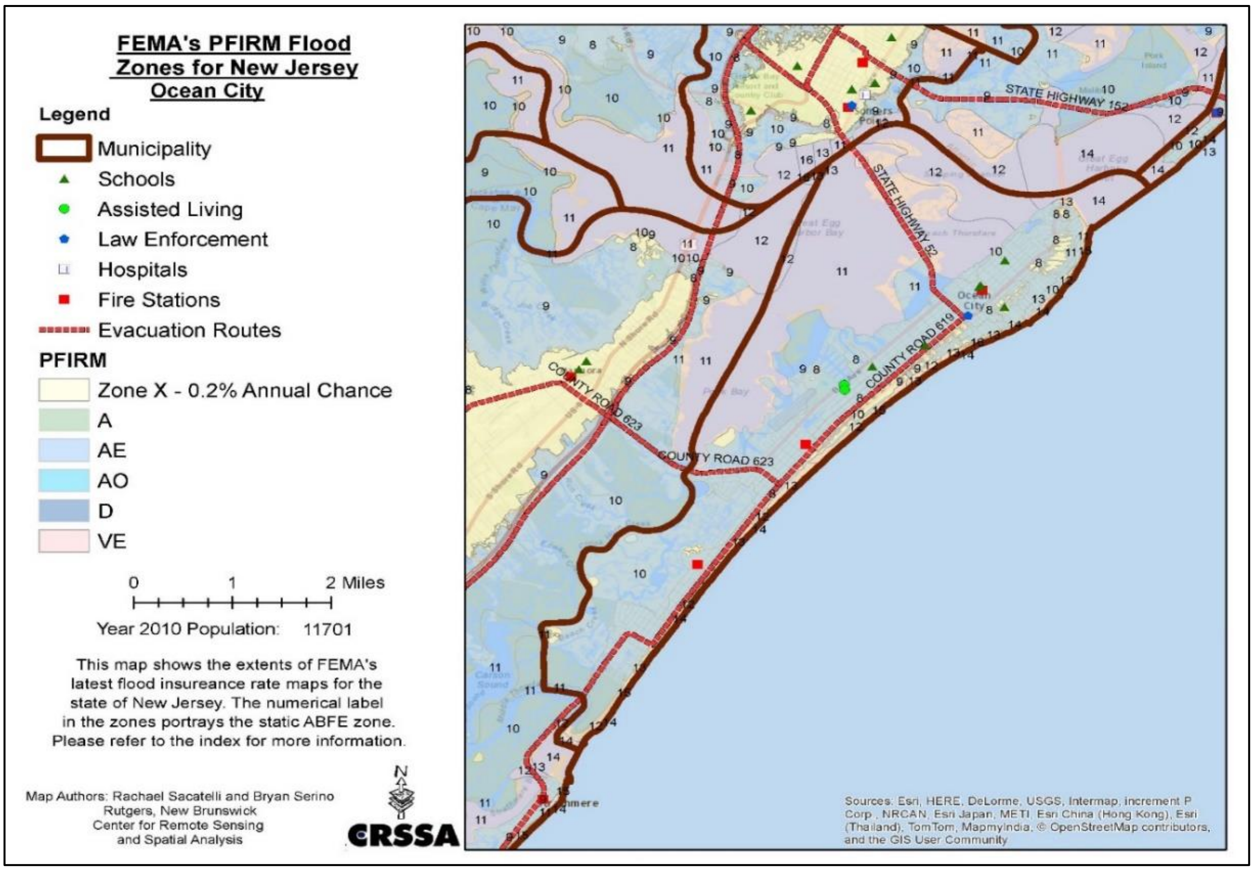
(Kennish, 2014)

Groundwater withdrawal is a more prominent factor affecting relative sea-level rise in the mid-Atlantic region in the 20th century. Measured among inland terrestrial bedrock locations (Bayonne, Trenton, and Camden), sea level rose by 12 inches. Along coastal New Jersey (from Sandy Hook to Cape May), relative sea-level rose an additional 4 inches due to compaction of sediments caused by natural effects and groundwater withdrawal (Miller et al., 2017). Feedback from year-round residents and commercial and recreational fishers, collected from public outreach and social media efforts over the past five (5) years describe ongoing island edge erosion and more frequent marsh inundation during normal tidal cycles.

C. Needs, Opportunities & Constraints

Ocean City entered the National Flood Insurance Program in 1970 and has been recertified each year since 1991. The entire island has been determined to be in the Special Flood Hazard Area for the 100-year storm as determined in 1984 by the National Flood Insurance Program (NFIP) (see **Figure 6** below) with an A-zone Base Flood Elevation (BFE) of either 7.75' or 8.75' NAVD88 and a V-zone BFE of 9.75-12.75' on the beach front.

Figure 6 – FEMA Flood Zone Map (Source: Rutgers CRSSA)

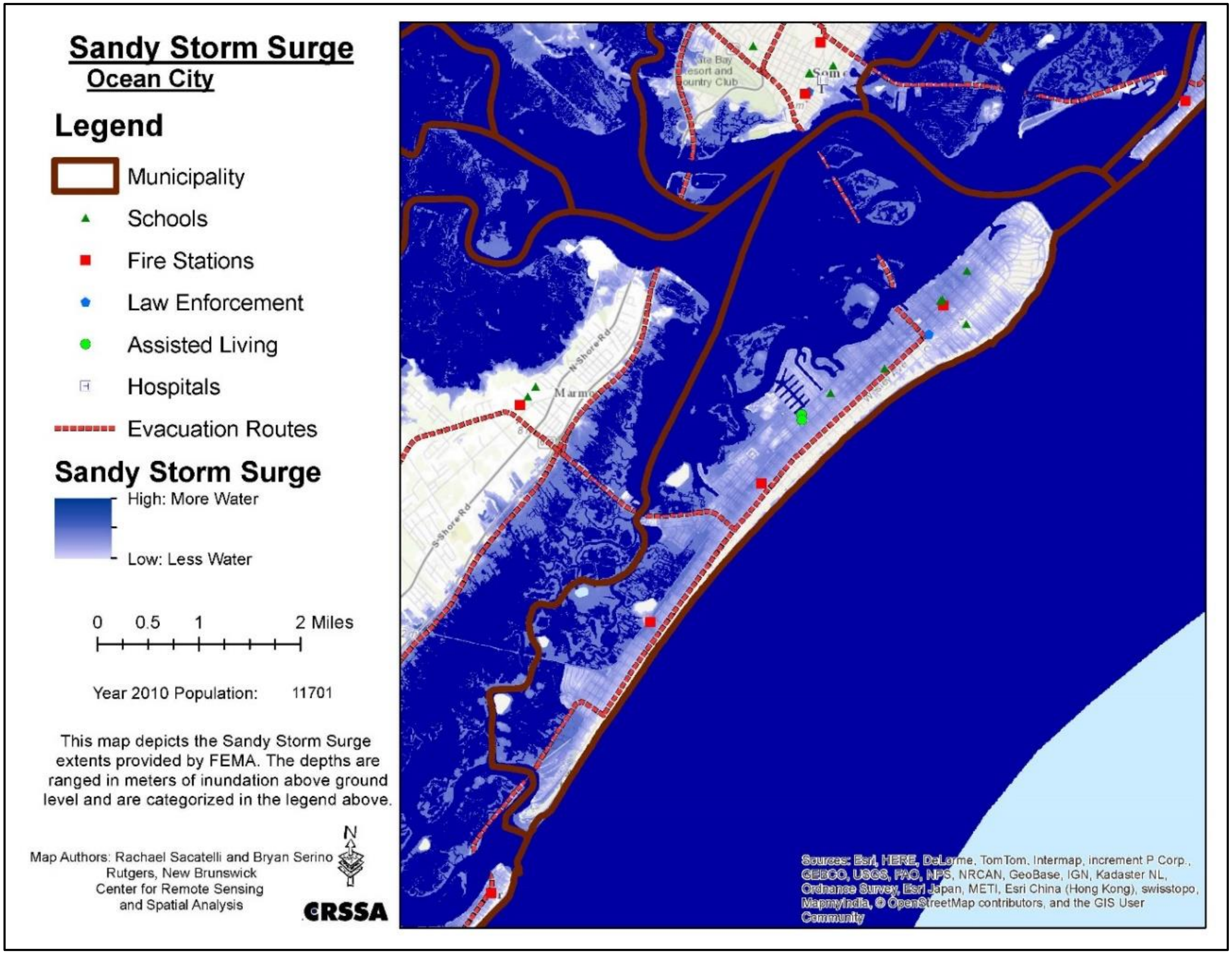


The history of flooding within Ocean City indicates that major flooding can occur during any season of the year. Flooding occurs from tropical storms, extratropical cyclones (nor'easters), and severe thunderstorm activity. High tides and strong waves attributed with these events can result in severe damage to coastal areas.

10th and Bay Avenues, before Superstorm Sandy made landfall.
Photo credit: Helen Berry.

Figure 7 (following page) illustrates the severity of inundation during Hurricane Sandy between 5th Street and 26th Street associated with flood waters at elevation 7' (NAVD88). Floodwaters from Superstorm Sandy reached a maximum elevation of 7.25' (NAVD88).

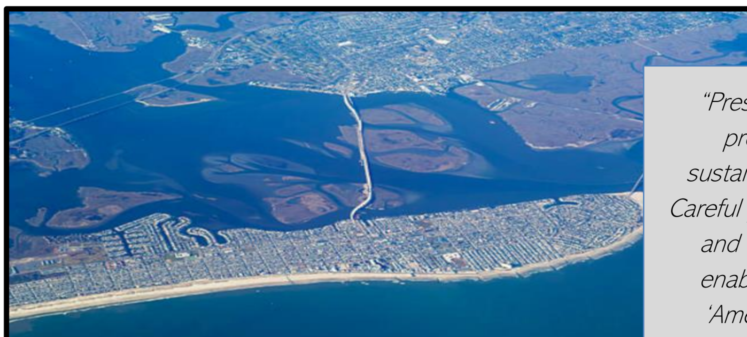
Figure 7 – Storm Surge from Superstorm Sandy (2012) **(Source: Rutgers CRSSA)**



1. Needs

Ocean City strives to strike a balance between protection and preservation of its unique and irreplaceable natural resources and meeting its goals and needs to protect the City, residents and visitors. The back bays and coastal wetlands are vital to the City's economy. Without navigable waterways, healthy water quality, and fish and wildlife habitat, the City's entire tourism and ecotourism economy is in jeopardy.

The ability of coastal communities to stand against, and recover from, coastal hazards is rooted in understanding their potential and specific exposure and vulnerabilities. Ocean City aims to develop a cost effective, comprehensive, adaptive framework for management of the back bay ecosystem and identify partnerships with responsible public and private entities, who are committed to the health of the back bay system.



"Preservation of Ocean City's rich history and proactive management promoting future sustainability are core values of the community. Careful planning, coordination with allies, agencies, and adaptation to unanticipated changes will enable Ocean City to maintain its heritage as 'America's Greatest Family Resort' for future generations."

-Ocean City Community Resiliency Plan

Photo: Aerial view of Ocean City, NJ

2. Opportunities

Managing the navigability, health and ecosystems of Ocean City's back bays provides opportunities to improve the City's resiliency and capacity to prepare, withstand, or absorb damages, rapidly recover, and adapt to long-term changes, such as future storm events.

Specific identified opportunities include:

- Promoting the public's awareness of their potential flood risks and mitigation strategies to protect themselves and their community;
- Adopting ordinances and design standards that will better enable homes and businesses to anticipate, plan, recover and adapt from the effects of coastal storms;

- Focusing public agencies on community vulnerabilities to hazards such as flooding;
- Encouraging regional solutions to flood- and storm-related impacts;
- Ensuring that future capital projects are designed and constructed to incorporate features that are resilient to storm- and flood-related impacts;
- Integrating hazard mitigation into Master Plan elements and also, into the overall bay management program;
- Focusing on resiliency when rebuilding damaged facilities and City infrastructure;
- Fostering greater awareness of environmental protection and stewardship of our natural resources, to provide for a more sustainable future;
- Continuing to maintain effective emergency services with specific training for emergency events;
- Maintaining and improving the City's infrastructure (roads, sidewalks, and stormwater system), to maximize recovery during and after major storm events;
- Proactively identifying areas that are particularly vulnerable; and,
- Continuing to monitor for changes and developing and implementing adaptation plans.

3. Constraints

Key constraints involved with management of the City's back bay include:

- Funding
- Public perception
- Stakeholder participation, and
- Regulatory/Permitting requirements

Funding, public perception and stakeholder participation is, of course, vital to the success of any project and are recognized as a critical element that should always be considered. Regulatory / permitting requirements is likely the most cumbersome constraint to implementing and adopting projects and mitigative strategies necessary to anticipate, plan, mitigate, recover, and adapt to coastal hazards. Regulatory oversight occurs at the State level (New Jersey Department of Environmental Protection (NJDEP); NJ Department of Transportation (NJDOT); NJDEP Office of Dredging and Sediment Technology; State Historic Preservation Office, etc.) and also, at the Federal level with the U.S. Army Corps of Engineers, usually as the lead agency, with reviews from numerous other Federal agencies, including, but not limited to, U.S. Fish and Wildlife; National Oceanic and Atmospheric Administration – National Marine Fisheries; etc.. Because the back bay ecosystem is such a valuable natural resource, permit applications are scrutinized for potential adverse impacts.

It is acknowledged regulatory agencies prefer to issue approvals for single and complete projects. However, for many reasons, a single and complete project cannot always be proposed or permitted due to:

- Conditions at each project area (location, flora, and fauna inventory, etc.) and project components (berms, marsh restoration, dredge holes, etc.) are unique and require in-depth analyses, including physical and chemical testing, and design;

- The proposed areas to be dredged and the volume of material to be excavated vary depending on factors such as sedimentation resulting from normal and severe storm events; tidal cycles; geography, and, navigational requirements. Dredged material management options are dependent upon its analytical and physical properties;

- Analytical test results remain 'valid' only for a period of time, after which the NJDEP requires re-testing;

- The method of dredging; transport, temporary storage, and de-watering of the material; and, the re-use of the material is defined by constraints such as the end re-use availability, location, material composition, and regulatory oversight;

- Permit approvals are typically valid for 5- or 10-years and must be renewed with current data;

- Physical field conditions vary and change over time;
- Regulatory requirements, timing restrictions, testing requirements, etc. change over time; and,
- Finally, any and all components of the dredging and dredged material management program must be cost effective and sustainable for the City.

II. City of Ocean City Physical Setting and Bay Features

A. Overview

The City of Ocean City is a resort community located on the northernmost barrier island in Cape May County, between the Great Egg Harbor Bay and Atlantic Ocean. The City occupies the entire coastal barrier island including Corson's Inlet State Park at the southern-most end. To the west, the municipality includes a large portion of the Great Egg Harbor Bay and Intracoastal Waterway, bay islands and coastal salt marsh wetlands and the tidal waterways through them. Ocean City is bounded on the north by Atlantic County and the Great Egg Harbor Bay, on the east by the Atlantic Ocean, on the south-southwest by the Township of Upper and the City of Sea Isle City and the west by the Township of Upper.

According to the 2010 United States Census Bureau data, the municipal boundary of Ocean City encompasses a total of 10,797 square miles, which includes 6.333 square miles of land and 4.464 square miles of water.

B. Back Bay Management Area Features

Barrier islands are especially fragile environments. Natural features of back bay systems act as a line of first defense absorbing the energy of the sea and protecting the land behind. These natural features include salt marshes, wetlands and island resources that are components of a complex, dynamic system constantly interacting with, and impacted by, wind and water. The back bay provides important habitat for many species of plants, marine life, and faunae. Salt marshes and wetlands also act as natural buffer zones, providing added protection from waves and increased stabilization. **Figures 8 and 9** (below and page 19), illustrate the Back Bay Management Area extent and features. The following sections detail Ocean City's back bay features.

Figure 8 –City of Ocean City, NJ Back Bay Management Area (Source: ArcGIS)

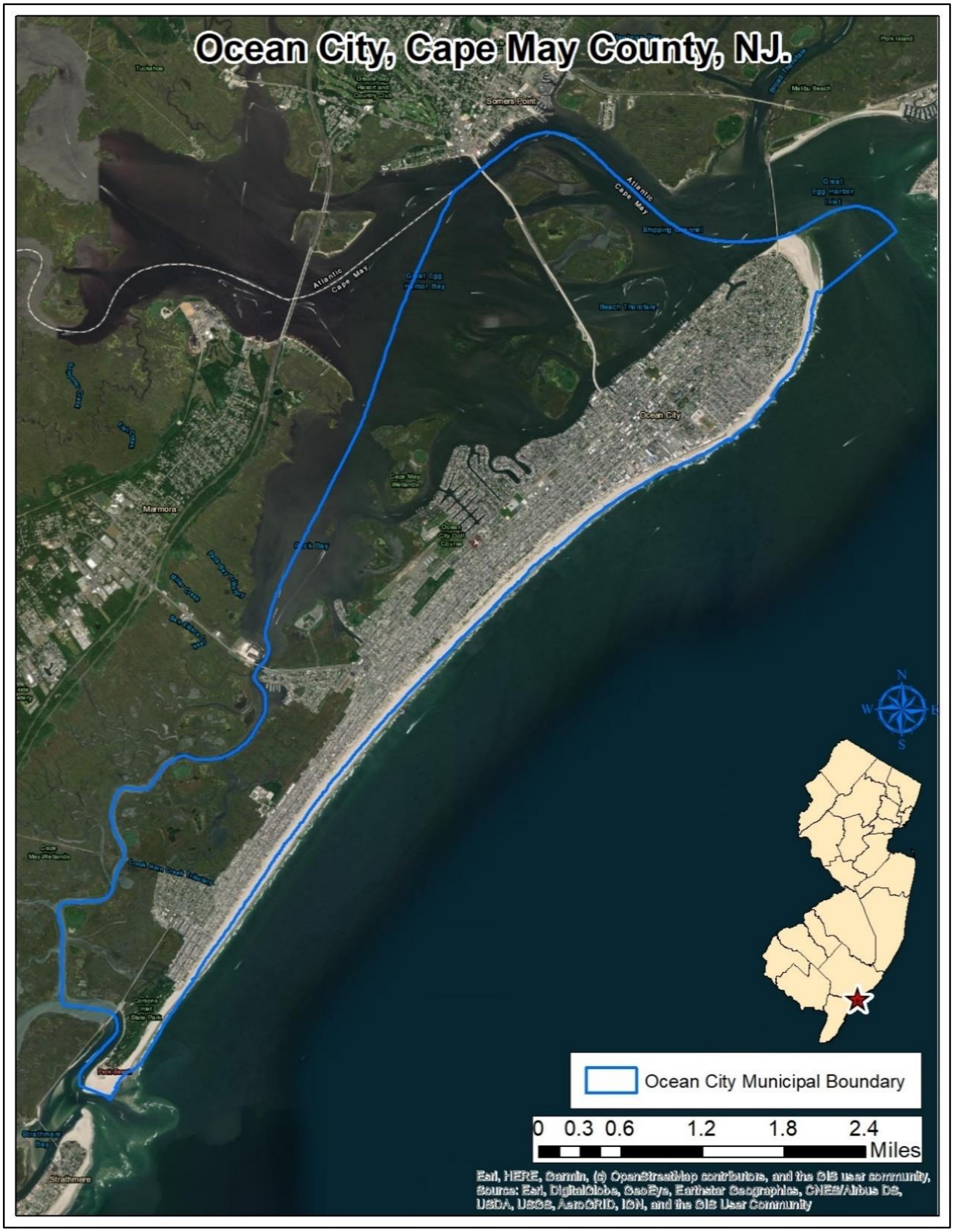
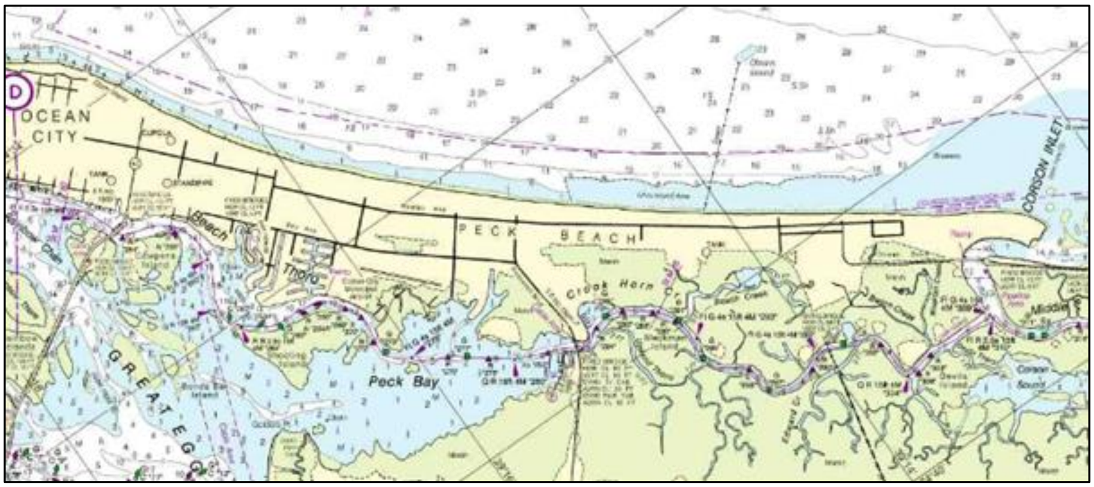


Figure 9 –City of Ocean City, NJ Back Bay Features (Source: Google Maps)

1. Waterways

The navigable waters of the City include public and privately owned boat slips, human-made lagoons and canals, back bay open water areas, and the Intracoastal Waterway (**Figure 10**). The maintenance of these waterways is the combined responsibility of the private property owners, City, State and Federal Government.

Figure 10 – INTRACOASTAL WATERWAY LITTLE EGG HARBOR
(Source: www.nauticalchartsonline.com)



The waterways must be navigable for commercial and recreational use. A navigable depth of 5 ft. (plus 1 ft. over dredge allowance) is typically proposed in the private slips, City and State-designated channels, and 7 ft. (plus 1 ft. over dredge allowance) in the Intracoastal Waterway. **Figure 11** shows the State-designated, City and private waterways / dredging areas.

Figure 11 – State-designated, City & Private Waterways
(Source: ACT Engineers / Anchor QEA, 2016)

2. Islands / Marshes / Wetlands

Significant features of back bays include bay and mainland shorelines, coastal marshes (wetlands), channels and islands. The wetlands and marshes in Ocean City's back bays contain a significantly high number of plant and animal species compared to other landforms, and provide a variety of important ecological services including:

- Coastal resiliency (flood protection and buffering storm and wave energy)
- Recharging groundwater aquifers
- Natural filters for removing pollution from runoff, and
- Habitat and spawning areas for fish and wildlife.

Tidal wetlands are areas of high nutrient and biological productivity which improve water quality by trapping sediments and nutrients, reducing turbidity, restricting the passage of toxins and heavy metals, and decreasing biological oxygen demand.

Photo of Howard Stainton Wildlife Refuge, freshwater wetlands

Freshwater wetland areas are less common on the barrier island with the most obvious exception of the 16-acre City-owned Howard Stainton Wildlife Refuge, a wetlands mitigation site between 26th Street and 30th Street, originally preserved in association with a planned residential development. This property was a part of a 1960s residential development planned for filled lots that was stopped from further development by the Freshwater Wetlands Regulations in the late 1980s.

Figure 12 (page 23) presents the current mapping of tidal marshes and wetlands in Ocean City. **Table 1** and **Figures 13a through 13d** present a comparison of the net land mass gains/losses of the identified back bay islands since 1931. The land mass (in acres) was compared between 1931-1978 and 1978-2015 and indicates a net loss of back bay land mass totaling 414.71 acres between 1931-2015.

Figure 12 –City of Ocean City, Map of Tidal Marshes/Wetlands (Source: ArcGIS)

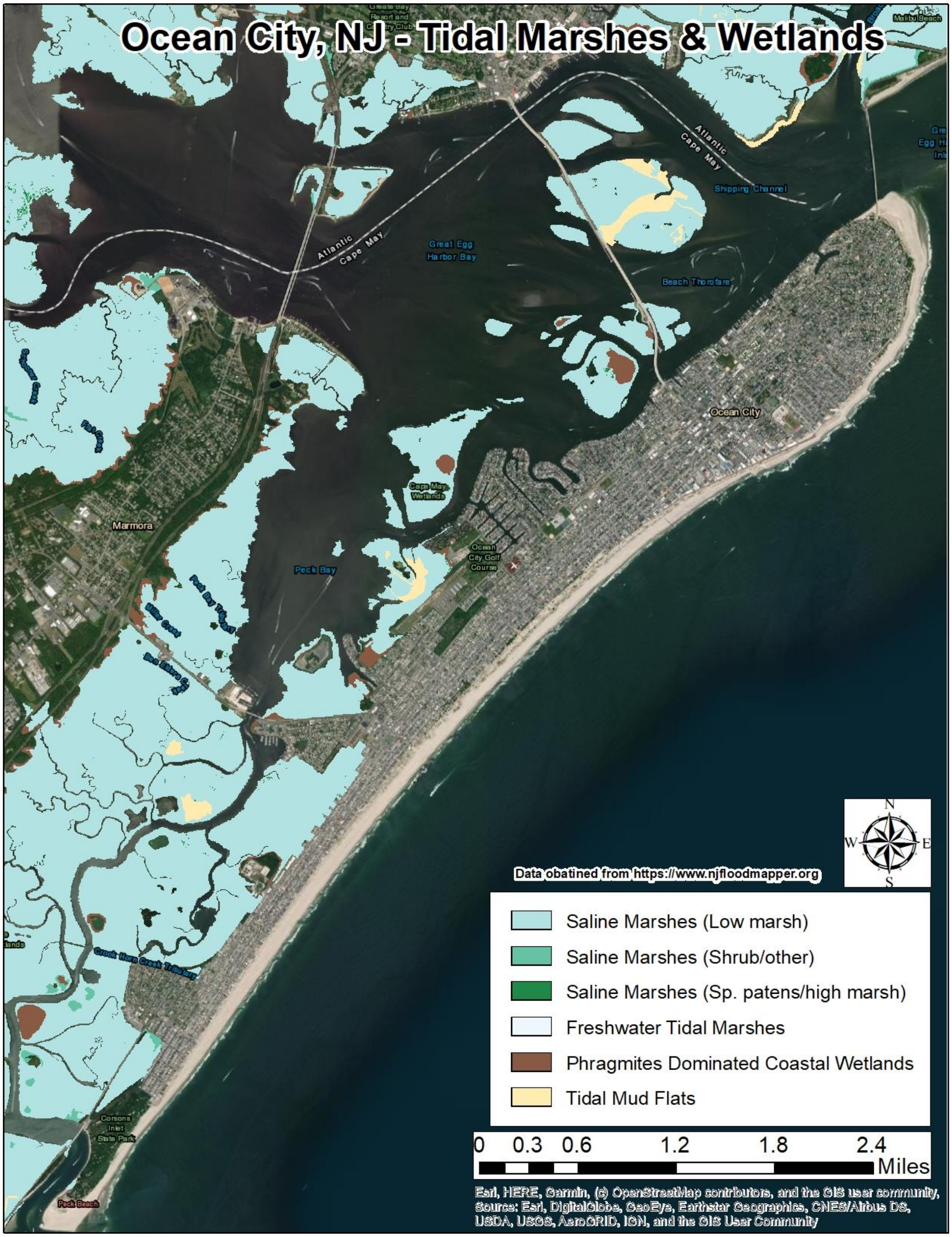


Table 1 – Back Bay Island Mass Net Gain/Loss Evaluation (1930 – 2015)

ID	AREA (FT^2)					Acres Lost/Gain		Net loss/gain (acres)
	1930	AREA LOST/GAIN	1978	AREA LOST/GAIN	2015	1930-1978	1978-2015	
1	2,308,239.66	-2,308,239.66	0.00	1,466,114.00	1,466,114.00	-52.990	33.657	-19.333
2	2,249,709.02	-923,246.66	1,326,462.36	721,575.99	2,048,038.35	-21.195	16.565	-4.630
3*	5,645,432.41	-1,874,597.68	3,770,834.73			-43.035		
4*	4,102,601.00	-1,710,071.44	2,392,529.56	3,099,205.60	9,318,845.81	-39.258	71.148	-91.360
5*	3,550,335.09	-3,494,059.16	56,275.92			-80.213		
6	1,044,117.98	-1,044,117.98	0.00	433,487.06	433,487.06	-23.970	9.951	-14.018
7	336,966.24	-336,966.24	0.00	37,797.76	37,797.76	-7.736	0.868	-6.868
8	324,771.31	-143,282.75	181,488.55	22,413.04	203,901.59	-3.289	0.515	-2.775
9	909,915.05	-888,018.24	21,896.81	113,163.45	135,060.25	-20.386	2.598	-17.788
10	817,718.57	-759,144.94	58,573.63	519,642.23	578,215.86	-17.428	11.929	-5.498
11	2,731,571.59	-1,993,343.14	738,228.46	2,087,902.31	2,826,130.77	-45.761	47.932	2.171
12	4,250,051.28	1,832,719.43	6,082,770.71	-2,610,924.66	3,471,846.05	42.073	-59.939	-17.865
13	0.00	0.00	0.00	328,900.77	328,900.77	0.000	7.551	7.551
14	785,565.00	-729,248.11	56,316.89	7,689.14	64,006.03	-16.741	0.177	-16.565
15	1,999,316.56	-1,999,316.56	0.00	28,882.78	28,882.78	-45.898	0.663	-45.235
16	6,898,650.01	-1,386,852.80	5,511,797.20	-107,948.86	5,403,848.34	-31.838	-2.478	-34.316
17	171,266.98	-171,266.98	0.00	3,183.98	3,183.98	-3.932	0.073	-3.859
18	254,693.96	-133,723.58	120,970.38	-25,383.11	95,587.27	-3.070	-0.583	-3.653
19	1,358,449.55	-843,400.31	515,049.24	-128,066.33	386,982.91	-19.362	-2.940	-22.302
20	2,774,033.20	-1,539,311.71	1,234,721.49	386,643.84	1,621,365.32	-35.338	8.876	-26.462
21	876,398.72	-757,961.12	118,437.60	-15,988.52	102,449.08	-17.400	-0.367	-17.767
CDF	6,232,642.67	-1,108,049.49	5,124,593.17	309,440.92	5,434,034.09	-25.437	7.104	-18.334
AIRPORT	4,675,337.80	-1,154,210.59	3,521,127.22	-227,067.18	3,294,060.04	-26.497	-5.213	-31.710
22	2,579,751.93	57,316.75	2,637,068.68	-306,234.25	2,330,834.44	1.316	-7.030	-5.714
23	722,214.46	59,846.58	782,061.04	-322,370.58	459,690.46	1.374	-7.401	-6.027
24	1,633,116.04	-517,230.22	1,115,885.83	100,188.30	1,216,074.12	-11.874	2.300	-9.574
CDF/AIRPORT Lagoon	1,263,374.86	204,696.28	1,468,071.14	-325,880.26	1,142,190.88	4.699	-7.481	-2.782

**Islands 3, 4 & 5 combined between 1978 and 2015.*

Total Net Loss (acres) -414.71

Figure 13a – Historical Wetland Gains and Losses 1930, 1978 and 2015)

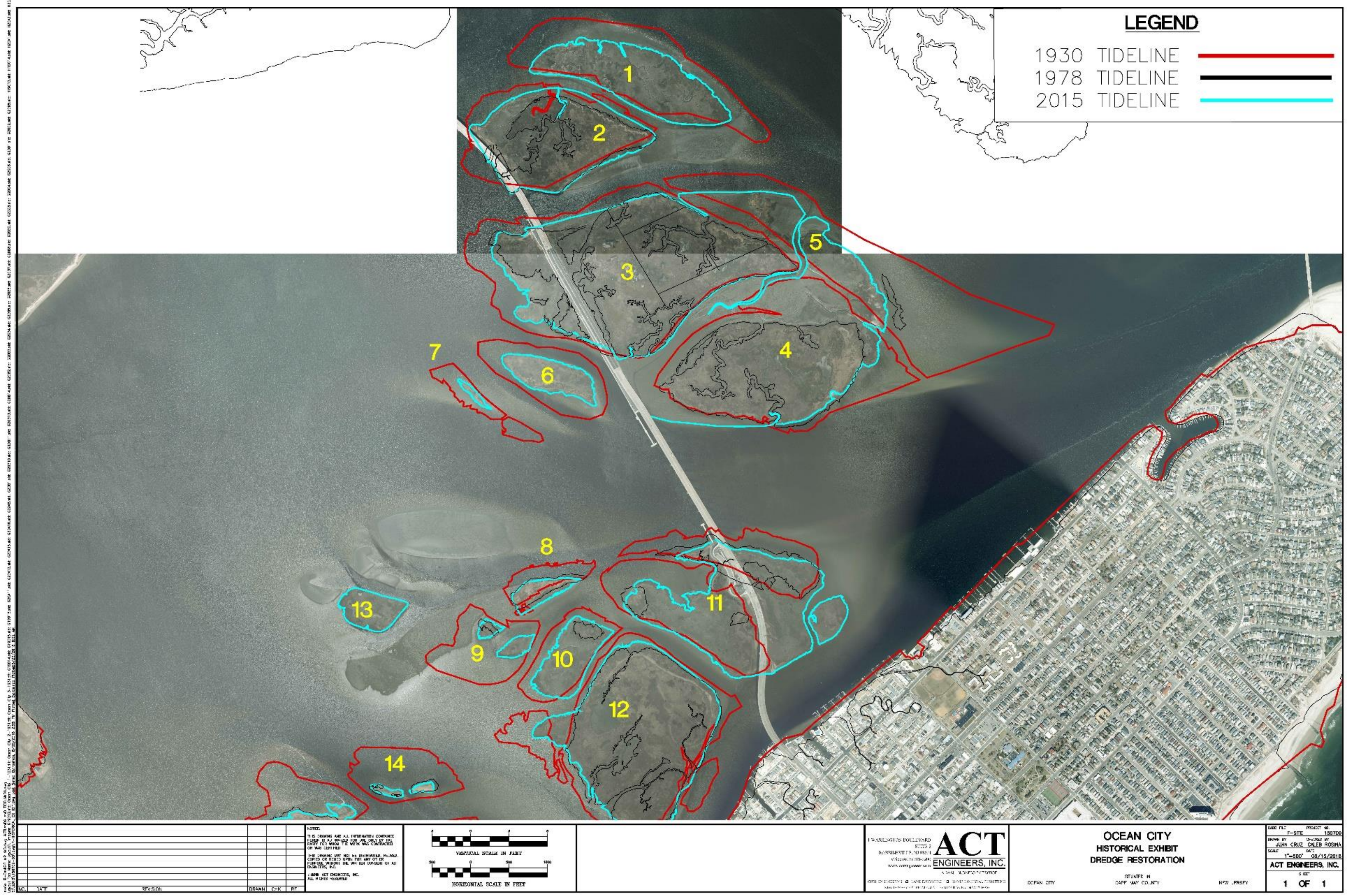


Figure 13b – Historical Wetland Gains and Losses 1930, 1978 and 2015)

Figure 13c – Historical Wetland Gains and Losses 1930, 1978 and 2015)

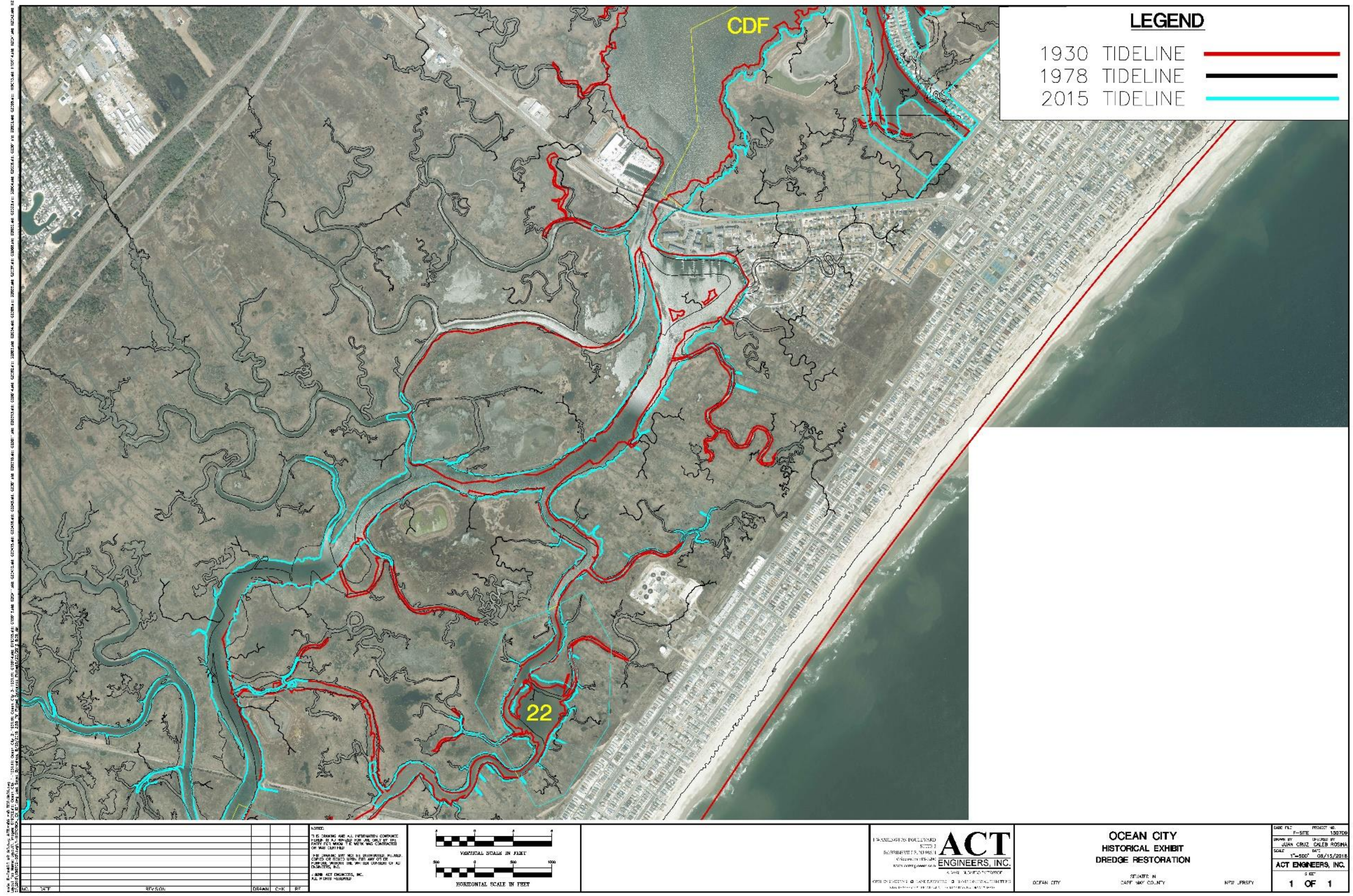


Figure 13d – Historical Wetland Gains and Losses 1930, 1978 and 2015)

Ocean City's back bay wetlands are the foundation of the commercial fisheries industry, recreational fishing, and ecotourism. Two thirds of the value of the commercial fisheries industries on the East Coast of the United States comes from species that live at least part of their life cycle in the tidal marshes (Bollman, 1977).

Ocean City's back bay wetlands are slowly eroding and drowning due to the combined forces resulting from increased sea levels in the bay, storm surges and boater activity. Preliminary survey data from Garretts and Shooting Island as well as main island edges along the western airport boundary and the north side of Roosevelt Boulevard indicate that elevations of the marsh surface range from -0.05 to 3.0. This elevation correlates to the upper range of the tidal cycle, marking the high tide line at 2.9 feet. Models predict under a moderate-emissions scenario, roughly consistent with current global policies, coastal areas of New Jersey are likely (at least a 66% chance) to see sea level rise of 1.4 to 3.1 ft between 2000 and 2070 (STAP, 2019). With just one foot of sea level rise, New Jersey could lose as much as 10,000 acres of the State's Bayshore area (Kennish, 2014).

"Salt marsh vegetation also had a significant positive effect on shoreline stabilization as measured by accretion, lateral erosion reduction, and marsh surface elevation change. Salt marsh characteristics that were positively correlated to both wave attenuation and shoreline stabilization were vegetation density, biomass production, and marsh size.

-Department of Ocean Sciences, University of California, Santa Cruz, California, United States of America

Aerial view of Ocean City's Shooting Island

3. Mosquito Ditches

Historically, the most significant problems within the State have been in coastal locations where salt marshes provide large areas of mosquito larval habitat. Prior to the implementation of mosquito control measures, many of the State's most important recreational and tourist destinations were considered nearly uninhabitable due to the nuisance and potential for disease transmission associated with the large mosquito populations in these areas. In the 1960's and 70's (as a means of reducing mosquito problems as well as restore severely disturbed salt marsh habitat), several organizations within the State developed and refined techniques for Open Marsh Water Management (OMWM). OMWM is a land management practice that restores salt marsh habitat that has been disturbed by human intervention through practices such as parallel grid ditching and salt hay farming to more natural environs while increasing tidal exchange on the marsh. The practice results in increased habitat for a variety of fauna, while facilitating effective mosquito control by introducing natural fish predators to feed on larvae (OMCC, undated).

Photo of Cape May County Mosquito Control ditching equipment

Photo of mosquito ditches north of 34th Street in Ocean City

4. Bayfront Development/Private Boat Slips

Waterfront Development in Ocean City

The bay front, including a number of human-made lagoons and canals in private, City or State ownership, is almost entirely bulkheaded from the north end of the island to 36th Street. The elevations of the bulkheads vary, allowing storm tide water to overtop or circumvent around, entering the City and producing flooding. The current Ocean City land use ordinance requires that the top of any non-oceanfront bulkhead be at elevation 5.75' NAVD88 in order to prevent flooding in storms less than the 100-year storm and to prepare for rising sea level. All City-owned municipal street-end bulkheads have been, or will be, reconstructed to this minimum design elevation.

5. Stormwater Infrastructure

All runoff from the City's roofs, sidewalks, parking lots and streets eventually discharges to the ocean or the bay through a municipal stormwater collection system. Most of the system discharges stormwater to the bay, but along the beachfront from the north end to 29th Street, large stormwater outfall pipes discharge water from the underground collection system across the beach and into the ocean. A survey of the City's stormwater management infrastructure was conducted in the early 1990s, in accordance with the Sewage Infrastructure Improvement Act. A total of 221 outfalls to the ocean, bay and wetlands were identified during the survey. The City routinely inspects and replaces and upgrades the oceanfront stormwater outfall pipes. **Figure 14** illustrates a City-wide view of the stormwater system (pipes, outlets, etc.) overlain on digital elevation model (DEM) (elevation mapping). **Figure 15** depicts the Merion Park neighborhood, as an example of focused mapping.

Figure 14 –City of Ocean City, Stormwater Map (Source: ArcGIS)

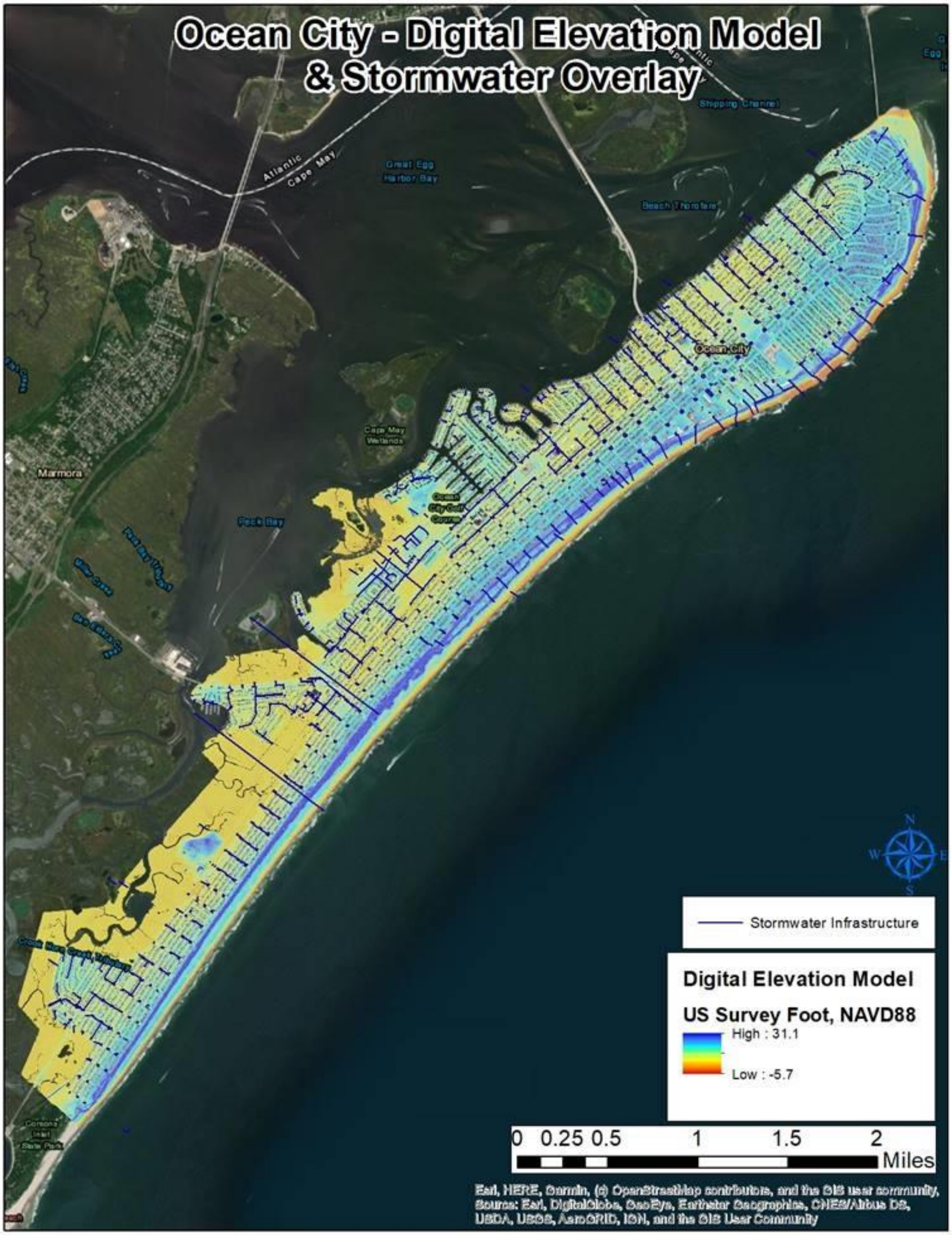
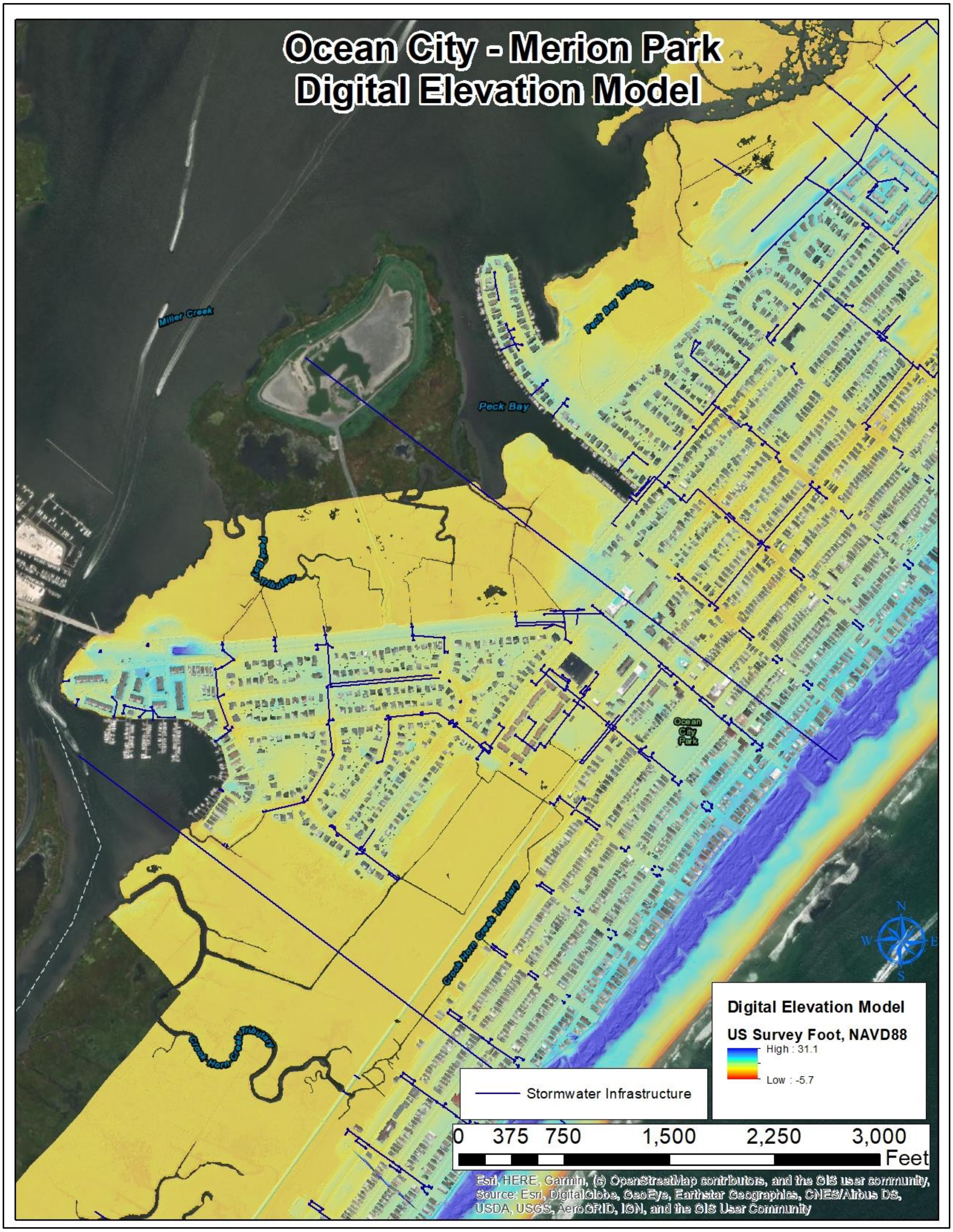
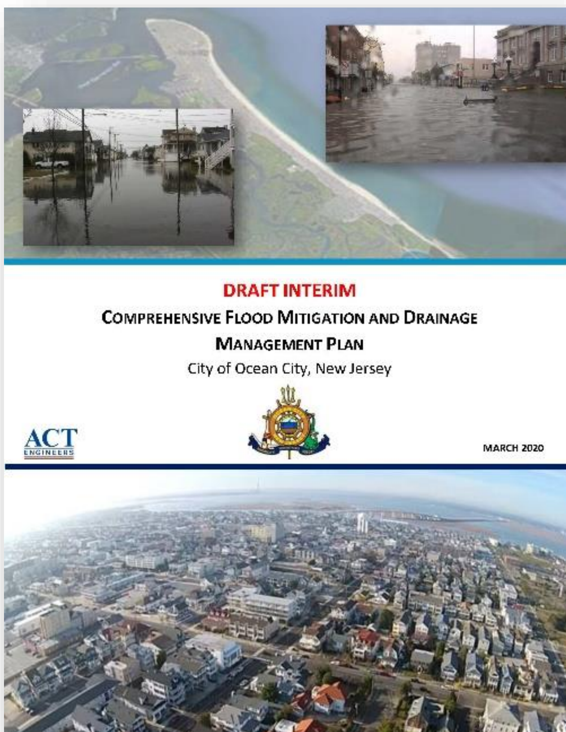


Figure 15 –Marion Park, Ocean City, Stormwater Map (Source: ArcGIS)



The City's stormwater drainage systems are designed to channel excess rainwater from the streets and discharge it into the bay or ocean. But with rising sea levels and higher tides, seawater can backflow into these pipes and spill out into the streets. This causes flooding even on days without rain, and as a result, the City has implemented the use of check valves in an effort to reduce the effect of this issue.

An additional stressor on the City's stormwater drainage infrastructure results from percolation of stormwater into the soil and along utility conduits beneath the City, during tidal and storm events. The City is evaluating the significance, measurement, and locations where subsurface water contributes to flooding.



Additionally, a Flood Mitigation & Drainage Management Plan was commissioned by the City to provide a basis for near-term and long-term planning and management of flood mitigation (ACT Engineers 2020). It is meant as an adaptive plan that documents the current information and predictions pertaining to sea level rise, and provides a basis from which to plan, implement and evaluate the City's ability to anticipate, plan, and implement adaptations to address future conditions.

6. Former Railroad Berm

A pre-existing (and out of commission) railroad berm/embankment (**Adjoining photo**) with remnants of the former Pennsylvania Reading Seashore Line (PRSL) that once serviced Ocean City, is located approximately 120 feet west of West Avenue from 36th to 52nd Street within the marsh of the bayfront. At 52nd Street, the railroad berm turns westward toward the mainland. North of 36th Street the embankment meets the alignment of Haven Avenue. The top of the embankment elevation is 5 +/- feet (NAVD88).

Several breaches in the embankment allow tidal waters to flow from the bay side of the embankment unimpeded to the island side and storm water drainage from the island to the bay. Repairing the breaches and controlling storm water runoff and uncontrolled bay water backflow between the railroad berm and island is being evaluated as a potential flood mitigation measure.

Photo of railroad berm

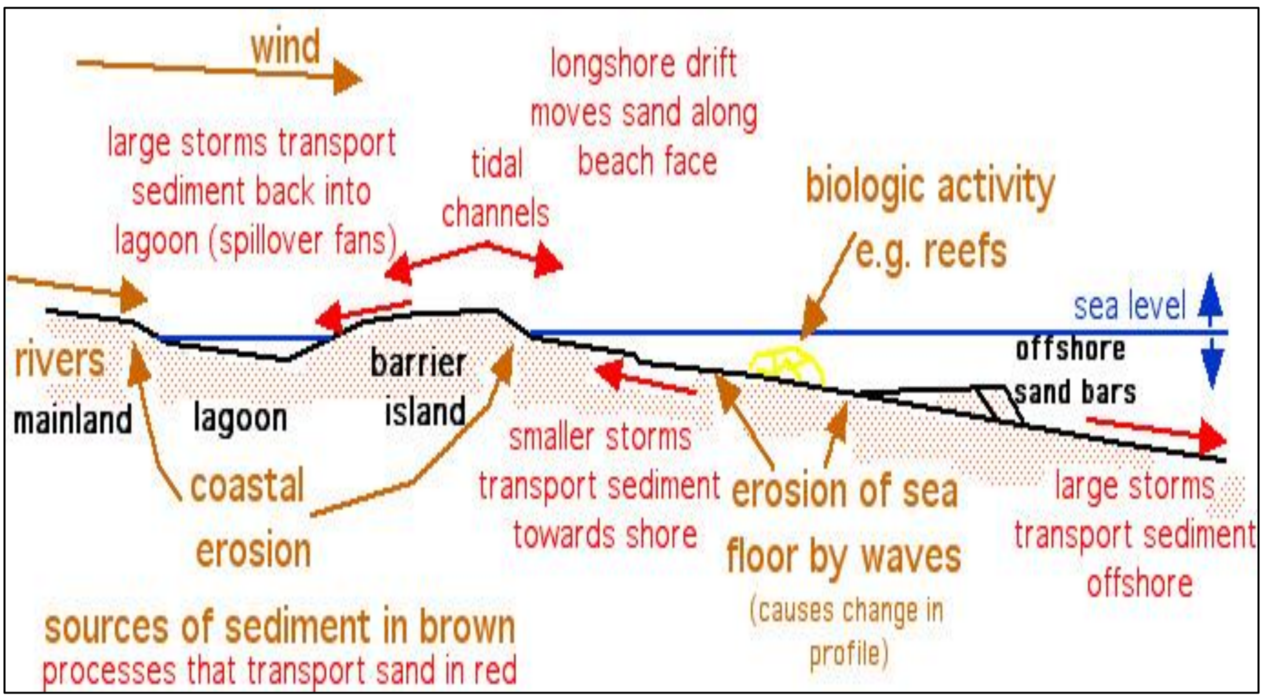
Figure 16 – Aerial view of former railroad berm (looking north) (Source: ACT Engineers aerial drone footage)

C. Back Bay Sediment System

1. Sources of Sediment

Barrier islands are inherently dynamic systems, in constant motion, often moving and changing shape in response to storms, tides, winds, and human impacts. Barrier islands are interconnected by littoral (longshore) water currents, wind, and other features. These connections can be easily disrupted as activity on one island can adversely affect other islands along the coast. Long term trends have shown, in the absence of beach nourishment, NJ's Barrier Islands migrate inland as beaches erode on the seaward side and form on the landward side. Ocean waters constantly affect the shape of barrier islands, namely through current and wave energy. When waves strike the shore at an angle, they generate a "longshore current" that travels parallel to the shore. Longshore currents move sediment along the shore in a process known as "littoral drift" or "longshore sediment

Figure 17 – Sediment Cycle (Source: http://maps.unomaha.edu)



transport." Sediment erosion and deposition can also occur in a shore perpendicular direction, termed "cross-shore" transport, which is responsible for the continuous profile movement between onshore and offshore regions. Given the history of beach profile changes, wave/storm climate, historical sea level changes and beach nourishment practices, it is evident that the Ocean City beaches are maintained on a recurring basis through active human intervention (construction of breakwaters and beach nourishments projects).

Primary sediment sources in the back bay waters of Ocean City are transported during storm events, as well as sediment loads from tributaries to the Great Egg Harbor Bay (**Figure 18**). Agricultural and land use along the upper reaches and nearby lands/banks cause sediment erosion and run off in streams and rivers over time. Gradually these sediments are carried as bedload and transported into the delta and bays. Subsequently, during storms and other high energy events, the deposited sediments get redistributed in the bays and end up in low velocity zones such as marinas, channels, and boat slips.

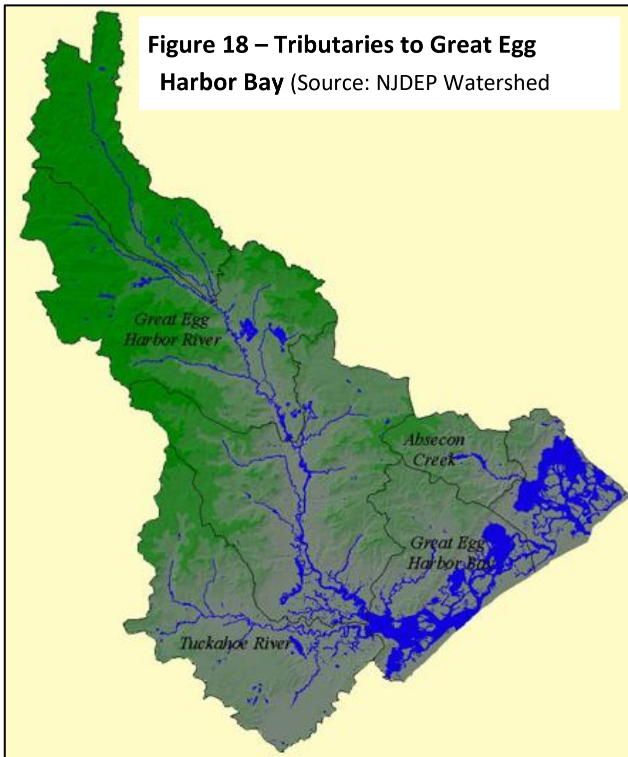


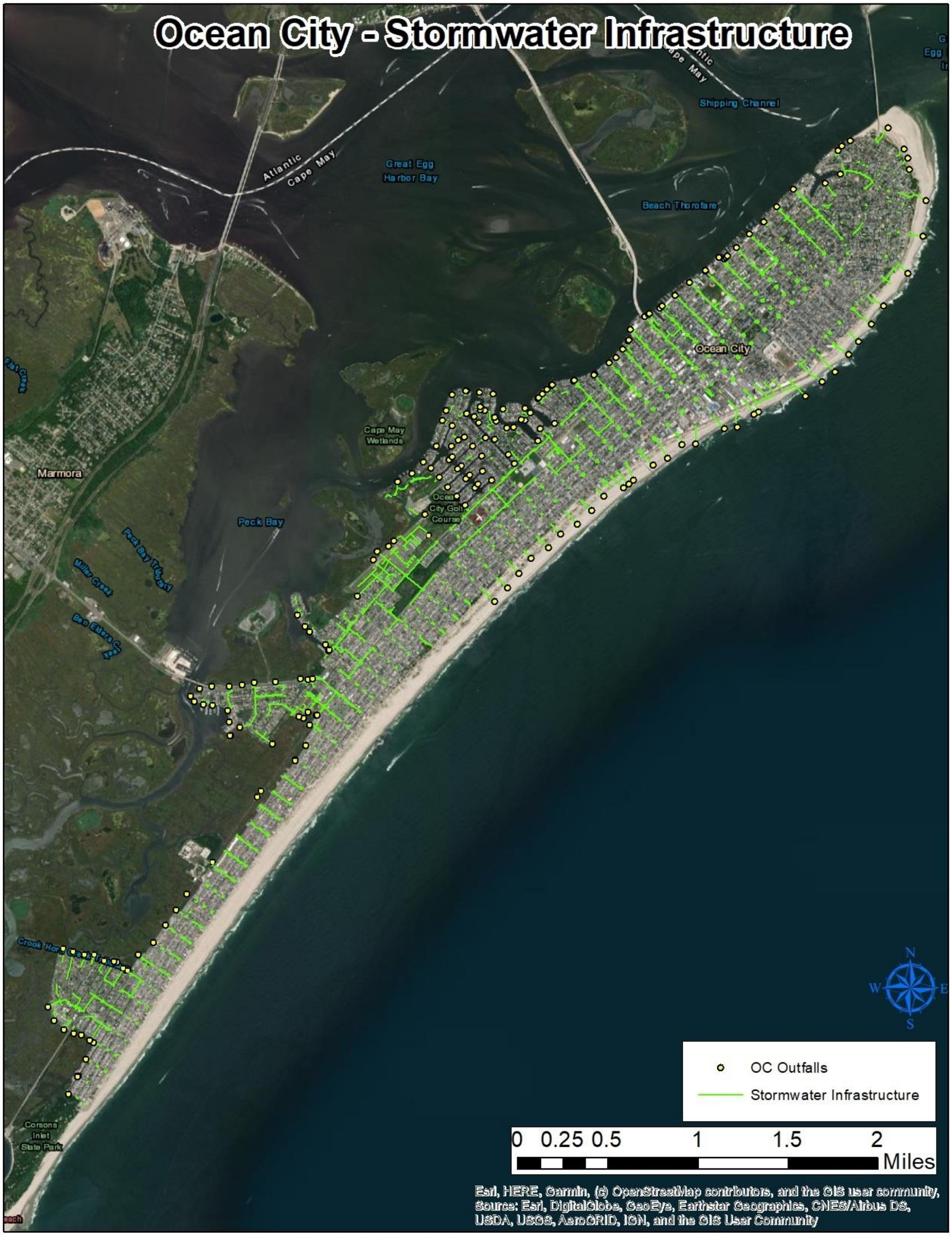
Figure 18 – Tributaries to Great Egg Harbor Bay (Source: NJDEP Watershed

2. Outfalls

Bayside stormwater outfalls at 3rd Street (ACT Engineers photo)

A survey of the City's stormwater management infrastructure was conducted in the early 1990s, in accordance with the Sewage Infrastructure Improvement Act. A total of 221 outfalls to the ocean, bay and wetlands were identified during the survey. Sediment is eroded and transported in stormwater runoff. Stormwater outfalls are sources of sediment discharge to the bay and oceanfront. **Figure 19** below maps the stormwater infrastructure system, including bayside and oceanfront outfalls in the City.

Figure 19 – Stormwater Infrastructure with bayside and oceanfront outfalls (Source: ArcGIS)

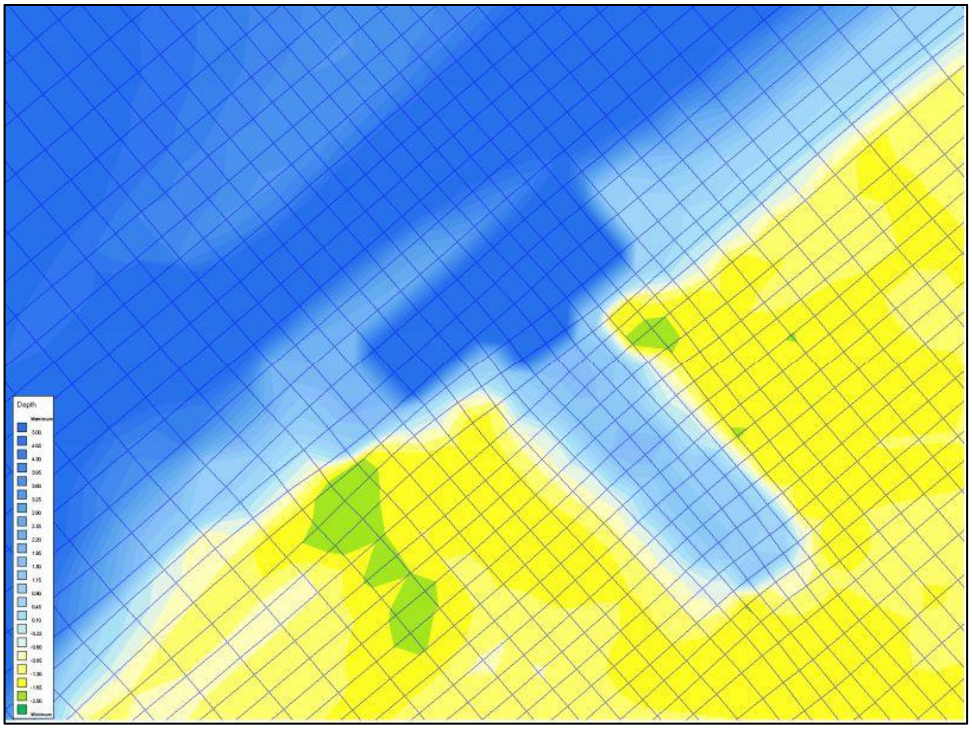


3. Hydrodynamic Modeling

A comprehensive hydrodynamic model of Great Egg Bay was developed by Anchor QEA in 2017 to evaluate circulation and sedimentation patterns in Great Egg Harbor Bay (the Bay). The model is capable of simulating a range of conditions to aid in the decision-making process regarding ways to optimize sediment management, flood control, and improving coastal resiliency. The initial modeling was used to simulate existing conditions and historical storm events to analyze the efficiency of potential engineering controls to reduce sedimentation in the channels and lagoons. The utility of the model was subsequently extended to evaluate sea level rise and coastal resiliency, as well as overall back bay circulation patterns – including assessing the effects of various environmental restoration projects including thin layer placement in wetlands as well as island restoration alternatives within the Bay. The model is updated regularly to reflect the progress made by local dredging and resiliency projects.

The hydrodynamic report included identification of several sedimentation reduction and management strategies including deflector walls, bubble curtains, sediment traps, thin layer placement, wetland restoration, island creation and marsh edge restoration. See **Figure 20** below for example simulation results for a sediment trap to minimize sedimentation in Snug Harbor. A sediment trap is a strategically located deeper area of intended deposition, where sediment is captured rather than continuing to flow and eventually building up in more shallow, navigated areas. Several island creation alternatives were also evaluated using the model.

Figure 20 – Model Simulated Optimal Location of Sediment Trap (Source: Anchor QEA)



4. Sediment Budget

Bottom sediments in the Bay range from fine-grained sediments (e.g., silts, silty clay) to coarse material (e.g., sands and shell fragments). Bottom sediments exhibit a grain size gradient that has coarser material near the inlet and finer material further into the Bay. According to the 2006 Regional Sediment Budget (USACE 2006), approximately 537,000 cubic yards of sediment is transported to the Great Egg Inlet per year. Based on this annual contribution of primarily sandy sediment from the ocean side, and the concentration of coarser material near the east side of the Bay, it can be concluded the inlet and flood shoals serve as the primary source of sand to the estuary. This is supported by the increasing occurrence of fines toward the western portions of the Bay. Although outside of the scope of this evaluation, sediment loading from stormwater outfalls may also contribute to the presence of fines throughout the back-bay (Anchor, 2016).

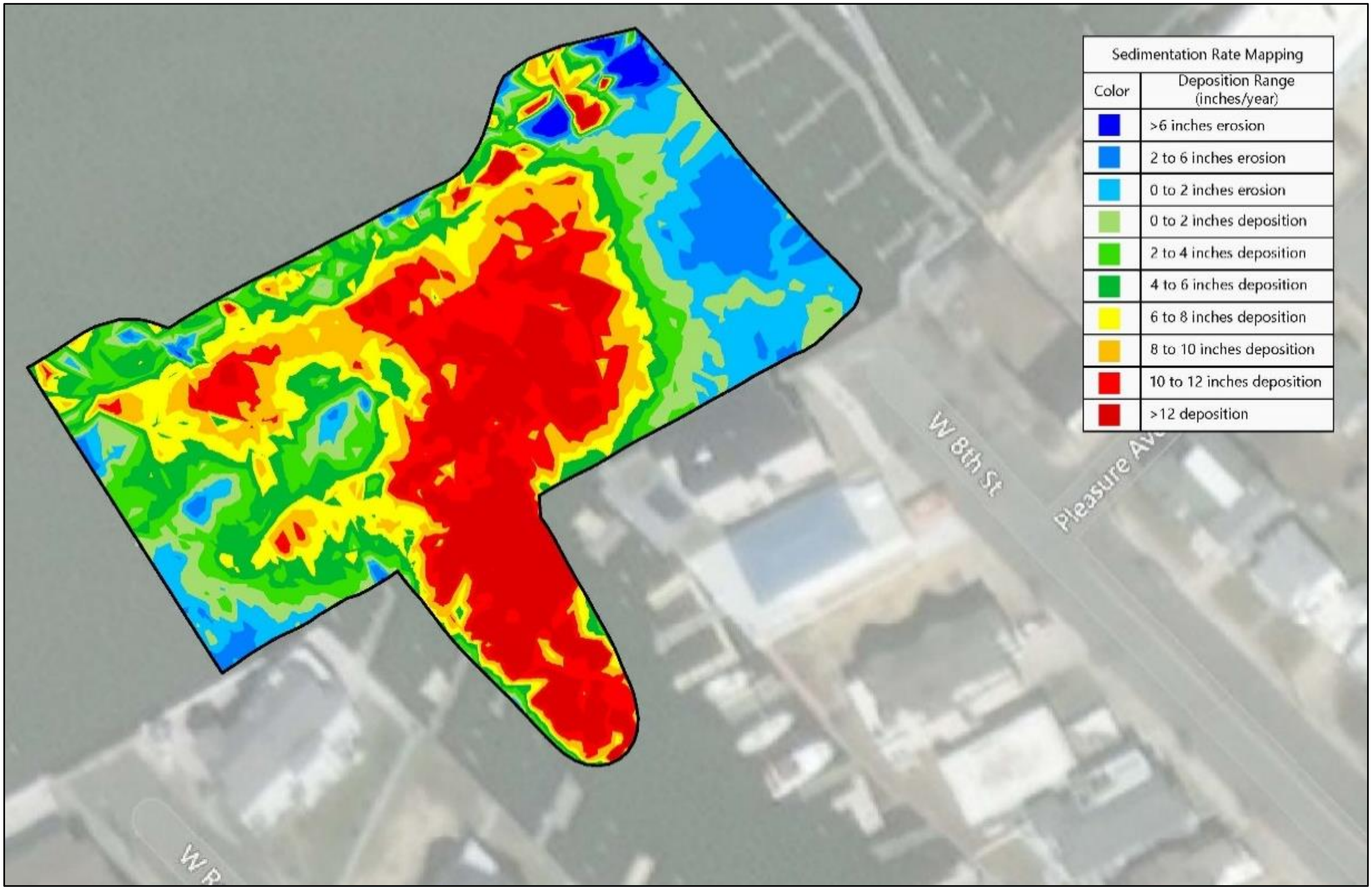
The ACT-Anchor team used past bathymetric survey data of various back bay lagoons to calculate annual sedimentation rates. The surveys used were conducted between 2015 and 2020 to support the back bay dredging and dredge material management programs. A total deposition in cubic yards (cy) was calculated for the study area as well as a total surface area (in square feet). By evaluating the deposition over the duration between the two survey events, an annual deposition rate could be derived. **Table 2** below presents the deposition evaluation study areas, bathymetric surveys utilized for the evaluation, dates of those surveys, and the calculated average deposition rate for each location (inches per year) (Anchor, 2020).

As of November 2016, an estimated 621,862 cubic yards of material was identified as targeted for removal from the area's waterways, to achieve desired navigational depths. A City-wide dredging permit was issued in February 2018 and, to date (July 2020), an estimated 280,000 cubic yards of sediment has been dredged from private, City, State and Federal waterways. Looking forward, with projected sedimentation rates, an estimated volume of 60,000 cubic yards of material in waterways, boat slips, etc. will need to be dredged annually as routine maintenance dredging, to maintain targeted navigational depths. **Figure 21** (page 40) shows an example deposition rate map for Snug Harbor.

Table 2. Deposition Rates by Area

Location	Survey A		Survey B		Average Deposition Rate (inches/year)
	Description	Date	Description	Date	
Snug Harbor	2017 Back Bay	5/10/2017	2018 Pre-Dredge	9/5/2018	6.1
Glen Cove	2018 Back Bay	2/26/2018	2019 Pre-Dredge	9/13/2019	8.6
Carnival Bayou	2018 Post-Dredge	10/24/2018	2019 Pre-Dredge	2/26/2020	3.3
Venetian Bayou	2017 Back Bay	5/10/2017	2018 Pre-Dredge	10/4/2018	1.2
South Harbor	2016 Post-Dredge	10/28/2016	2019 Pre-Dredge	9/11/2019	4.7
Clubhouse/Bluefish	2015 Back Bay	10/7/2015	2018 Back Bay	2/26/2018	2.4
Waterview	2015 Back Bay	10/13/2015	2018 Back Bay	2/26/2018	2.7

Figure 21 – 2020 Snug Harbor Depositional Rate Map
(Source: Anchor QEA)



III. Back Bay Adaptive Management

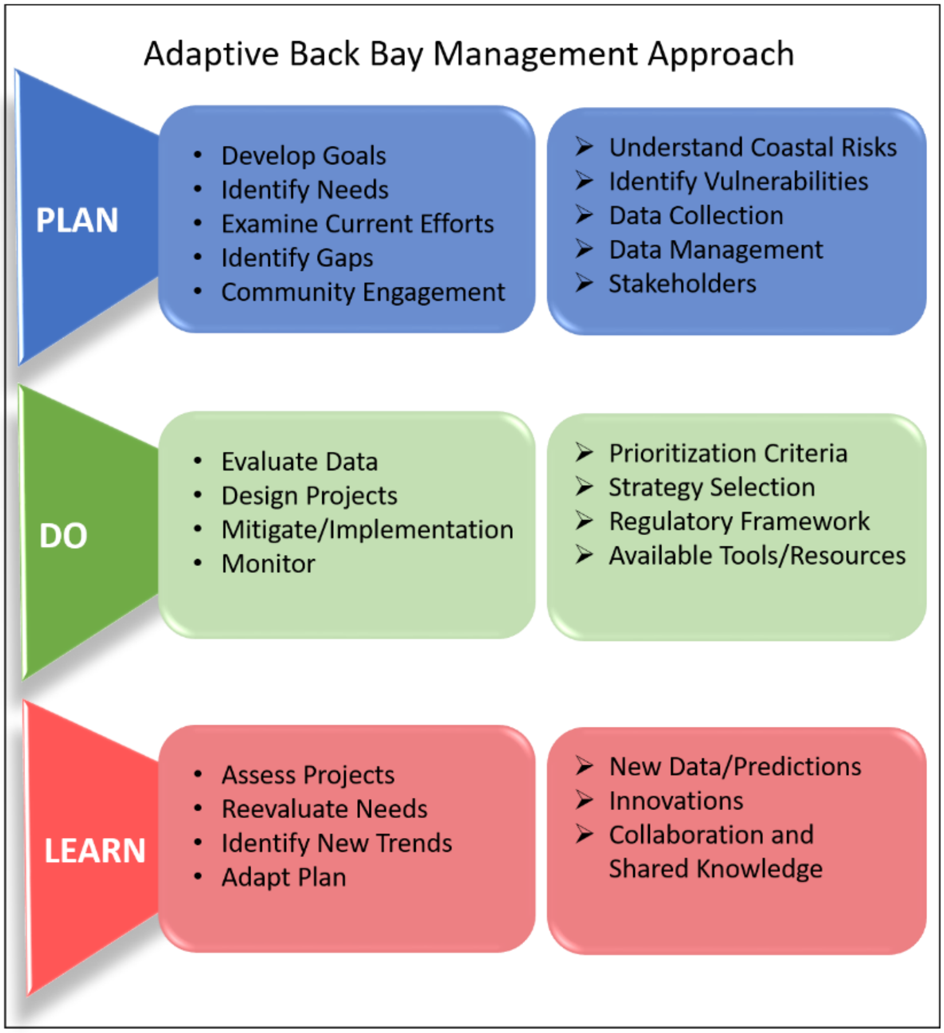
The network of waterways surrounding Ocean City is an essential component of the local economy, commercial and recreational lifestyle, and environment. The need to keep Ocean City's waters navigable, provide flood resiliency and protect the unique and valuable natural resources requires a comprehensive management plan for the back bay ecosystem. A multi-faceted approach, with numerous and varied management activities is required; conducted in accordance with all applicable regulatory requirements and in consultation with Federal and State Agencies.

Aerial drone view of Ocean City bayside waterfront (Source: ACT Engineers aerial drone footage)

A. A. Back Bay Adaptive Management Approach

Adaptive management is an iterative decision-making process in which a system is managed variably over time, based on defined goals and objectives, with the flexibility to adjust operations due to environment and resource conditions. In the face of economic, environmental, and climatic uncertainties, adaptive management (**Figure 22**) can improve the effectiveness of management strategies by using rigorous monitoring and evaluation methods in a continual learning process.

Figure 22 – Adaptive Back Bay Management Approach



1. Planning and Considerations

a. Goals and Needs

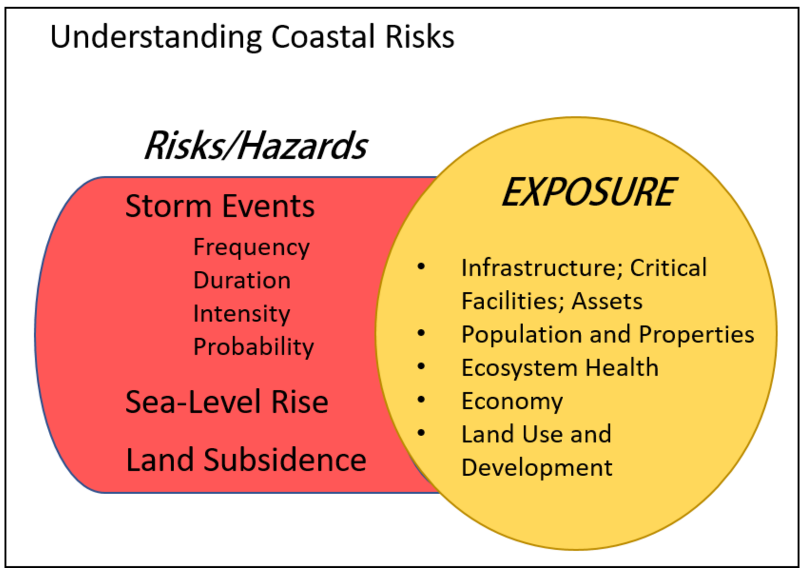
The identification of the City's short-term and long-term goals are based on the need to ensure that social, economic, and environmental back bay resources are protected, maintained, and enhanced.

Needs will be assessed for identified problems, exploring the root causes, and determining appropriate strategies to implement solutions. The assessment of needs includes consideration of future impacts based on data trends, and will lead to well-defined goals and projects, both in the short and long term timeframes.

b. Coastal Risks and Vulnerability

Identifying vulnerable natural resources is the initial step to understand the threat of coastal hazards and sea level rise. Flood protection and coastal community resiliency can be accomplished by reducing or mitigating tidal wave run-up, fetch, sedimentation, and associated flooding impacts. **Figure 23** illustrates the three aspects of coastal risks and resulting exposure that Cities like Ocean City can be subject to.

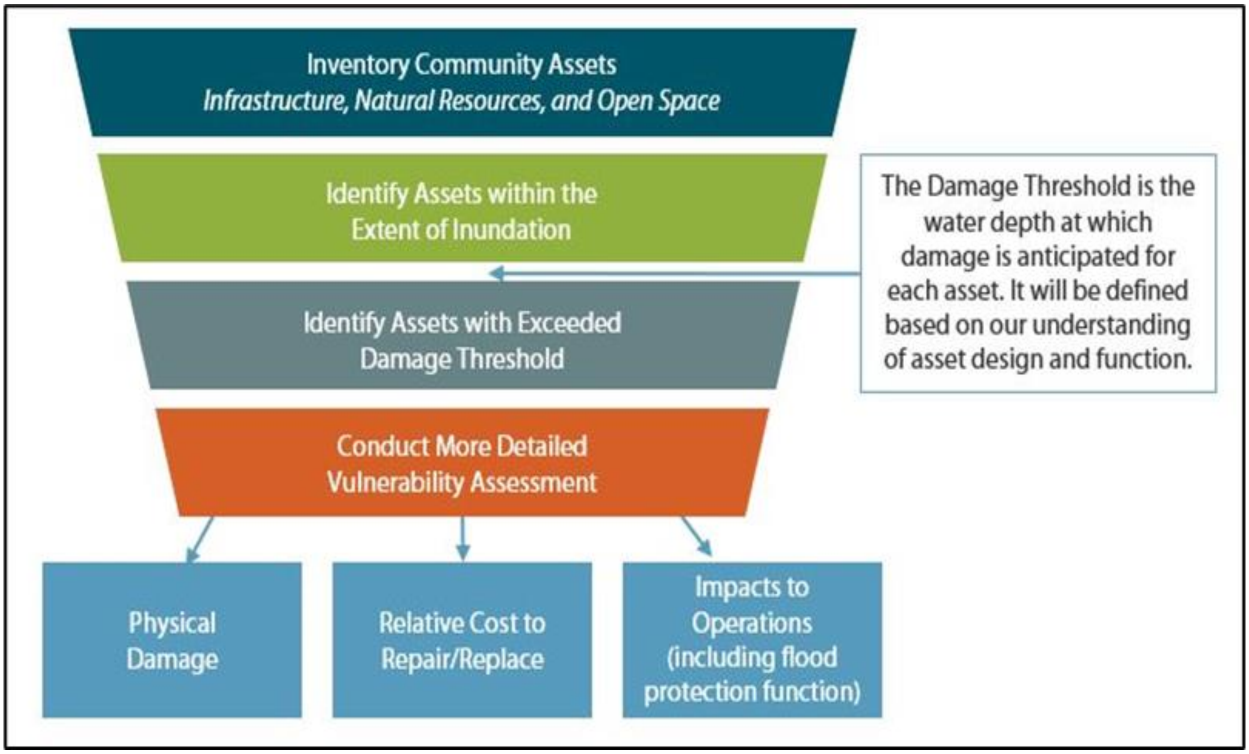
Figure 23 – Coastal Hazards and potential exposures



Vulnerability can be assessed using different methods. **Figure 24** shows a schematic of one of the methods which starts with an inventory of assets of interest to the Owner, including infrastructure, natural resources (parks, wetlands, etc.), and open spaces. Then, using a design water level (derived out of considerations such as storm intensity, sea level rise scenario, estimated subsidence, etc.), the extent of inundation and potential damages can be assessed. The economic impacts of such damages can then be categorized using monetary assumptions regarding the value of the asset, cost to repair or replace, or, in extreme cases, even retreat.

This tool gives the City Resource manager options to consider when future budget reserves are to be set, for sea level rise adaptation planning, in the long term.

Figure 24 – A Process for Assessing Coastal Vulnerability of Assets



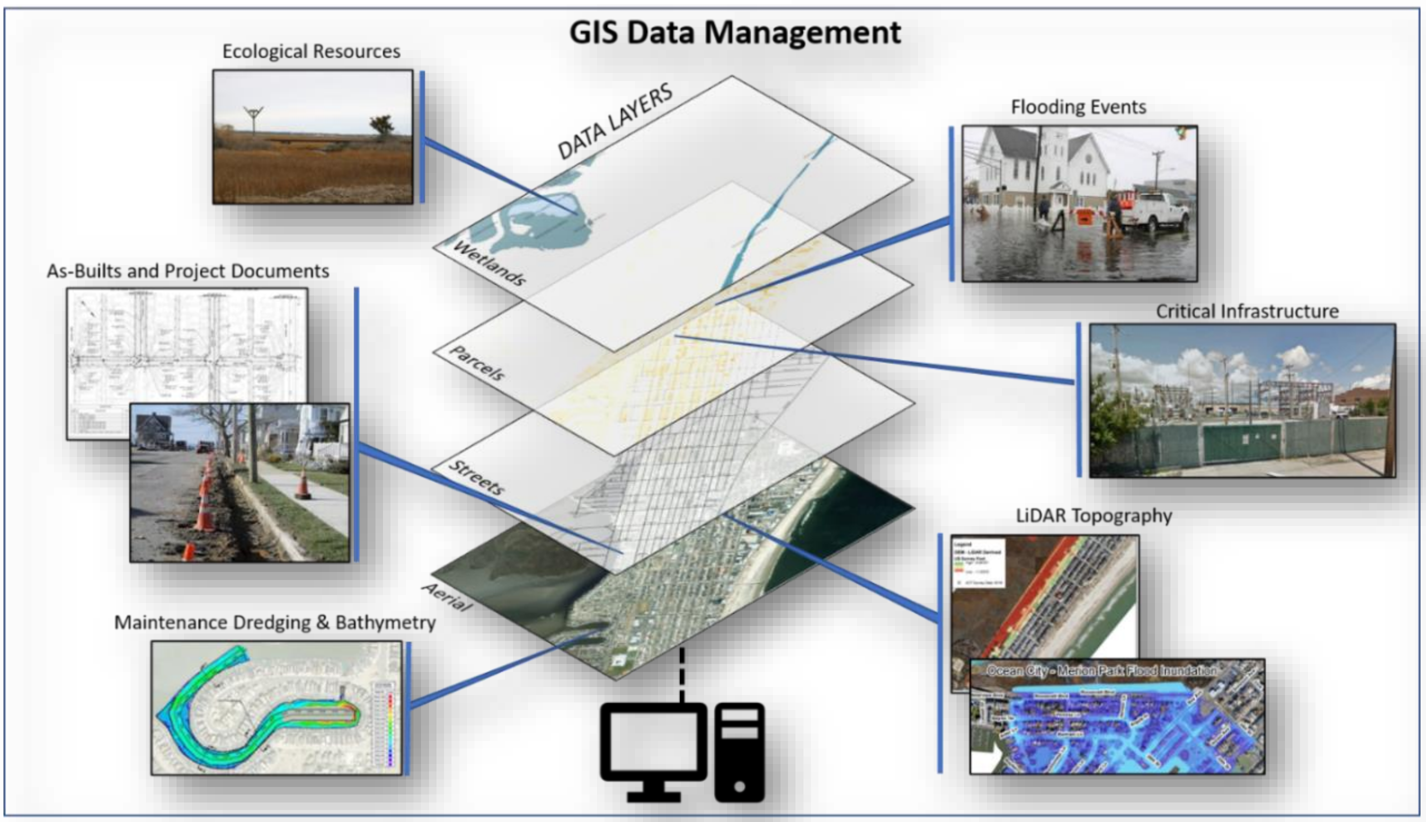
The back bay islands have the capacity to reduce the intensity of back bay flooding impacts. This capacity of the natural ecosystem to provide protection is important in many locations: where nature provides other critical services, for food, recreation and wildlife habitat; where engineered defenses are too costly or impractical; or where adjacent lands are of low value and considered not worth extensive investment. The ability of ecosystems to perform these functions is highly variable and so it is critical to understand when and where ecosystems can help to protect coastlines.

By identifying historic changes in the surface elevation of the wetlands; the areal footprint; plant communities, diversity, abundance, and biomass; and, soil and water chemistry, a better understanding of the current health of wetlands can be determined. Based on this, the functional value of the wetlands, and ongoing influence of human and other anthropogenic effects can be assessed to prioritize areas needing significant restoration.

c. Data Collection and Management

Compilation of existing data ('As-Built' drawings, construction plans, utility plans and surveys) is a critical component to the planning process and identifying data gaps. Efficient data management streamlines the planning process. Integration of hardcopies, digital scans, AutoCAD files and project documents (photos, design packages, etc.) can be managed in a Geographical Information System (GIS) format, which can be tailored to individual uses, and eventually become the main information repository for the City. Opportunities also exist for implementing a real-time public interface to disseminate information, as well as solicit feedback from residents. **Figure 25** illustrates how various data can be compiled into a GIS management system, that can facilitate the adaptive management approach.

Figure 25 – GIS Data Management



2. Do – Project Selection & Implementation

a. Evaluate Data and Identify Data Gaps

Following the collection of data, evaluation will identify areas of priority, gaps in information, and potential strategies for mitigation. Social and economic factors will be part of the evaluation process for considering potential adaptation measures, as strategies are tailored to specific issues or areas of the City.

b. Agency Roles, Responsibilities and Authorities

This Adaptive Back Bay Management Plan approach focuses on an understanding of the regulatory agencies, resources, and tools available. Implementation of projects may require applicable approval and permitting at the State and Federal levels. In addition, several entities may provide assistance or partnership with the funding, design and implementation of certain restorative projects that will enhance the back bay ecosystems. **Figure 26** presents potential stakeholders in the development and implementation of projects.

Figure 26 – Stakeholders

City of Ocean City, NJ

The City serves as the lead in project development and has been assisted by the ACT-Anchor Team. Relevant planning documents, as identified in **Figure 27**, are cited within this Management Plan, and serve as resources in the planning of projects in the back bay management area.

Figure 27 – Relevant Planning Documents

Relevant City of Ocean City, NJ Planning Documents

Ocean City Master Plan (February 1988)
Ocean City Master Plan Reexamination Report (November 1, 2000)
Ocean City Master Plan Land Use Element (December 2001)
Ocean City Redevelopment Plan – Blocks 1001 and 1101 (June 2005)
Ocean City Stormwater Management Plan (July 13, 2005)
Ocean City Master Plan Reexamination Report (November 15, 2006)
Ocean City Housing Element and Fair Share Plan (December 3, 2008)
Ocean City Master Plan Conservation Plan Element (June 10, 2009)
Ocean City Beach Maintenance Plan (December 2009)
Cape May County Hazard Mitigation Plan (October 2010)
Ocean City Master Plan Reexamination Report (October 17, 2012)
Ocean City Community Resilience Plan (Draft)
Ocean City Floodplain Management Plan Committee Report (April 2, 2014)
Ocean City Floodplain Management Plan (2015)
Ocean City Strategic Recovery Planning Report (2015)
Ocean City Capital Improvement Plan (March 2015)
Ocean City Flood Damage Prevention Ordinance (Chapter 31)
Ocean City Zoning and Land Use Code (Chapter 225)
NFIP Community Rating System

United States Army Corps of Engineers (USACE), Philadelphia District

The USACE, Regulatory Branch, is the Federal agency responsible for regulating navigable waters and jurisdictional wetlands, under Section 10 of the Rivers and Harbors Act and Section 404 of the Clean Water Act, respectively. The USACE regulates all structures, filling and dredging in the City's waterways.

All USACE Individual Permits are published for public comment and also, for review by other Federal agencies, such as the U.S. Fish & Wildlife Service (USFWS). The USFWS provides comments on permit applications relative to the protection of wildlife resources through the effective enforcement of Federal laws, and assisting with efforts to recover endangered species, conserve migratory birds, preserve wildlife habitat, safeguard fisheries, and combat invasive species.

The USACE has studied the back bay ecosystems of the New Jersey coastline and provided data and recommendations in their interim report entitled 'New Jersey Back Bays Coastal Storm Risk Management Study. Additional details of this Interim Report are presented later in this section.

New Jersey Department of Environmental Protection (NJDEP)

NJDEP, Division of Land Use Regulation / Office of Sediment Technology is the State agency responsible for the evaluation and permitting of all activities conducted in, and adjacent to, waters of the State of NJ. As part of the review of dredging permit application, the NJDEP evaluates the proposed dredged material management options. Existing management options include disposal, and/or various beneficial uses of the dredged material (as outlined in this Plan).

Various NJDEP departments applicable to certain projects may include: Division of Land Use Regulation, Office of Sediment Technology; Bureau of Tidelands, State Historic Preservation Office, Bureau of Shellfisheries and, Division of Fish and Wildlife.

New Jersey Department of Transportation – Office of Maritime Resources (NJDOT- OMR)

NJDOT/OMR engages with municipalities and counties to implement environmental restoration and resiliency projects that provide both ecosystem and coastal community benefits. NJDOT/OMR is the lead State agency for maintaining over 200 nautical miles of engineered waterways and additional 150 nautical miles of Federal waterways in New Jersey. OMR oversees the implementation of the NJ State Channel Dredging Program providing safe navigation channels for the NJ Marine Transportation System and enabling access to shore based infrastructure. NJDOT/OMR works closely with municipalities in providing dredging guidance and assistance for dredged material placement and agreements.

c. Available Resources

Key publicly reference and guidance documents evaluated during development of the Plan and available to the City to support planning for coastal hazard mitigation and resiliency improvements include the following:

GUIDANCE

- US Army Corps of Engineers New Jersey Back Bay (NJBB) Coastal Storm Risk Management Interim Feasibility Study and Environmental Scoping Document
- US Army Corps of Engineers Use of Natural and Nature-Based Features (NNBF) for Coastal Resilience
- New Jersey's Coastal Community Vulnerability Assessment and Mapping Protocol
- New Jersey's Rising Seas and Changing Coastal Storms: Report of the 2019 Science and Technical Advisory Panel
- Manual for Coastal Hazard Mitigation (New Jersey Sea Grant College Program)
- NOAA's Office of Ocean and Coastal Resource Management published the manual "Adapting to Climate Change: A Planning Guide for State Coastal Managers.
- The Nature Conservancy – Natural Solutions Toolkit
- The American Shore and Beach Preservation Association (ASBPA)
- Stevens Institute of Technology

WEBSITES & TOOLS

- Climate and Flood Resilience Program - https://www.nj.gov/dep/cfr/
- NJ Floodmapper - https://www.njfloodmapper.org/
- Climate Central - https://sealevel.climatecentral.org/maps/
- Coastal Resilience Resource Library - http://www.conservationgateway.org/
- FEMA Flood Insurance mapping - https://www.fema.gov/
- NJ Resiliency Network web site - http://www.njresiliency.com/
- NOAA Sea Level Rise Viewer - https://coast.noaa.gov/slr/#

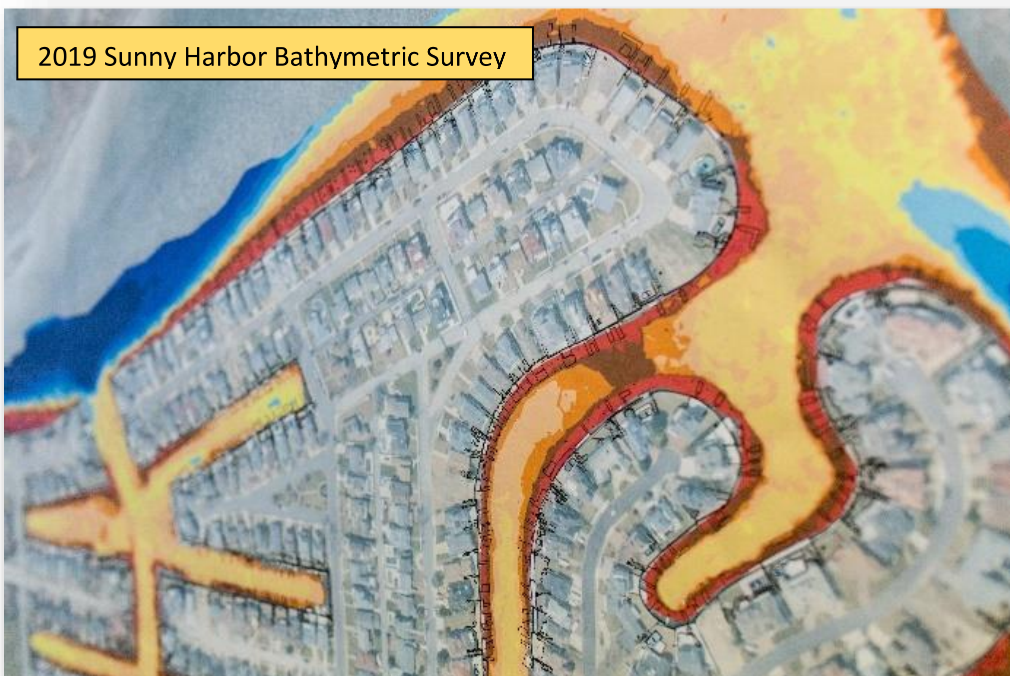
The listed resources are provided as examples and do not reflect an all-inclusive representation of the available documents.

d. Monitoring and Adaptive Management

A comprehensive monitoring program incorporates multiple tools and considers a variety of systems and processes that can provide input to the vulnerability assessment and adaptation strategy.

(1) Bathymetric Surveying

A City-wide bathymetric survey was initially completed by ACT Engineers in 2015 and has been updated annually. These surveys were used to secure the City-wide dredging permit and then, subsequently, to prioritize dredging areas of the City, as presented during public meetings. The following photograph is an example of the bathymetric survey maps that depict ranges of existing water depths by color.



(2) Aerial Mapping / Light Detection and Ranging (LiDAR)

Aerial High Definition Light Detection and Ranging (HD LiDAR) topographic surveying and mapping have been completed for the City and orthomosaic (a series of individual photos which are programmatically matched up so that they form a new composite image, consisting of all the smaller ones) mapping, including a base map for future design, and a Digital Elevation Mode (DEM) were created.

(3) Material Management

(a) Dredge Material Containment Facilities (DMCF)

Dredged material is removed from the waterway and traditionally, has been stored and de-watered in a Confined Disposal Facility (CDF). There are four (4) CDF sites in Ocean City:

- Two CDFs are located in the southern end of the City south of 34th Street and are owned and operated by the State of New Jersey
- Site 83 CDF located near 34th Street
- Route 52 CDF located under the Route 52 Causeway

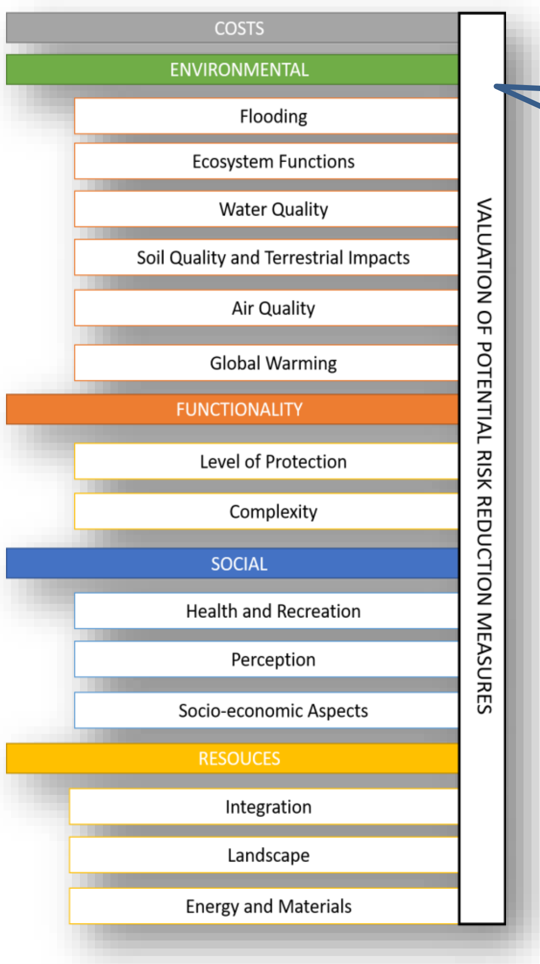
The Site 83 and Route 52 CDFs are operated and maintained by the City, for use when performing maintenance dredging. Historically, the City's dredging and dredged material management program was largely reactionary. A City-wide dredging permit was obtained in 2018, in an effort to permit and plan a dredging master plan. Dredge material has been removed from CDF 83 and the Route 52 CDF to accommodate short term dredging needs. Due to the primarily silt composition of the dredge material within Ocean City's waterways, the current process of material dewatering, (active or passive) re-excavation, transport and beneficial reuse at an approved upland location is costly and time consuming. Creative and cost-effective solutions to dredged material management are being evaluated. To that end, dredging contractors have been successful with direct loading of mechanically dredged material into sealed dump trucks and transported to a site for beneficial re-use. This method reduces the handling of the material and provides a more cost effective approach for managing material.

(b) Alternative Use Determination (AUD)

Beneficial reuses of dredged material involve the use of dredged material for some productive purpose. As stated in NJ's Coastal Zone Management rules (2015), the beneficial reuse of dredged material is encouraged whenever feasible, as it will only increase safe navigation within the State while enhancing, restoring, and improving the environment for New Jersey and its residents.

One of the most common beneficial reuses of dredged material is as substrate for habitat development (e.g., wetland restoration or creation, fishery enhancement). Other beneficial uses of dredged material include development of parks and recreational facilities (e.g., walking and bicycle trails, wildlife viewing areas); agricultural, forestry, and horticultural uses; strip-mine reclamation/solid waste management (e.g., fill for strip mines, landfill capping); shoreline construction (e.g., levee and dike construction); construction/industrial development (e.g., bank stabilization, brownfields reclamation); and beach nourishment (e.g., restoration of eroding beaches). Wherever sediment is needed, dredged material could be the source.

e. Decision Matrices



The project implementation process broadly consists of the following basic steps:

1. Preliminary design concept
2. Gather data
3. Refine concept drawing/design
4. Develop final design
5. Do value engineering / construction review?
6. Develop bid documents
7. Bid project and start construction
8. Manage / monitor construction
9. Monitoring for success

Potential projects to anticipate, plan, recover and adapt from the effects of coastal storms plan measures to reduce risks and need to be evaluated for their potential/perceived benefits related to potential risk reduction measures identified for the back bay.

The cost/benefit ratio and available funding will be considered for the implementation of the proposed strategy. Environmental considerations include potential benefits of flood mitigation and protection against sea level rise; ecosystem health; and, protection, enhancement, and restoration of natural resources. Functionality of potential strategies will be assessed for their capability to provide protection and complexity of the overall design. Social considerations will determine how the proposed strategy will benefit the health and recreational conditions, as well is public feedback/perception and social and economic impact to the community. The level of resources required and how the proposed strategy integrates with the City's overall plan will also be significant considerations.

After valuation, proposed projects will be prioritized for implementation. An example of a prioritization matrix is presented as **Figure 28**.

Figure 28 – Project Prioritization Matrix

Criteria		Score = 3 points	Score = 2 points	Score = 1 point	Points
Viability	Effort	Can be implemented with minimal additional effort/coordination, OR already planned for	Requires some additional effort (design, evaluation, coordination).	Very early stage; long-term consideration; requires extensive evaluation, design.	
	Funding	Funding budgeted, OR available	Additional funding sources required; OR funding needs to be incorporated into future budget planning.	No Funding; potential sources need to be sought and evaluated.	
	Regulatory/Legal	All requirements, permits/agreements in place OR not needed	Partially completed; In-Progress; OR not deemed an impediment.	All requirements need to be identified; potential issues addressed and resolved.	
	Partnerships (Financial/Educational)	Collaboration/Partnerships in place, OR not needed	Partner stakeholders identified, OR desired; coordination in progress.	No Collaborators identified but required.	
	Community Engagement	Community outreach conducted; OR not needed	Community outreach in progress; OR additional engagement required.	Community outreach required; Effort needs to be developed.	
	Community Support	Widespread community support	Mixed public support	Negative public support	
Strategic Urgency	Flooding Issues	Requires immediate attention to alleviate known issue	Should be in consideration to alleviate vulnerabilities identified.	Part of a long-term strategy	
	Benefits	Will provide immediate benefit	Will provide some benefit; part of a larger strategy that will maximize benefits.	No immediate benefits	
	Resiliency	No action will result in continued damage	No action may contribute to issues; further evaluation and study required.	Immediate action not required; Future action in response to sea level rise	
	Restorative	Will directly contribute to restoration of natural environment/habitats	May indirectly benefit natural environment/habitats	Will negatively impact natural environment	
Cost	Value	Good value	Fair value	Low value	
	Cost Effectiveness	Cost effective – will alleviate future costs associated with damage/response/…	Costs will alleviate some issues; longer range benefits may apply.	Costs exceed benefits	
	Additive Benefits	Will provide additive benefits	Moderate additive benefits; requires evaluation after completion	Action will only address a specific problem	

Total Score = ______

(1) Triggers for Action

(a) Navigation

Routine bathymetry surveys confirm areas of shoaling that adversely impact navigation of both recreational and commercial vessels. Lack of navigational depths certainly triggers the need for dredging and dredged material management. Also, projects such as sediment traps and other measures to reduce or mitigate sedimentation transport may be warranted. The following image is an example of a 2019 pre-dredge bathymetric mapping with color-coding of ranges of water depths. Areas colored blue have sufficient water depths for navigation and areas of orange tending towards red has less water and are generally areas targeted for dredging, to maintain navigational depths of water.

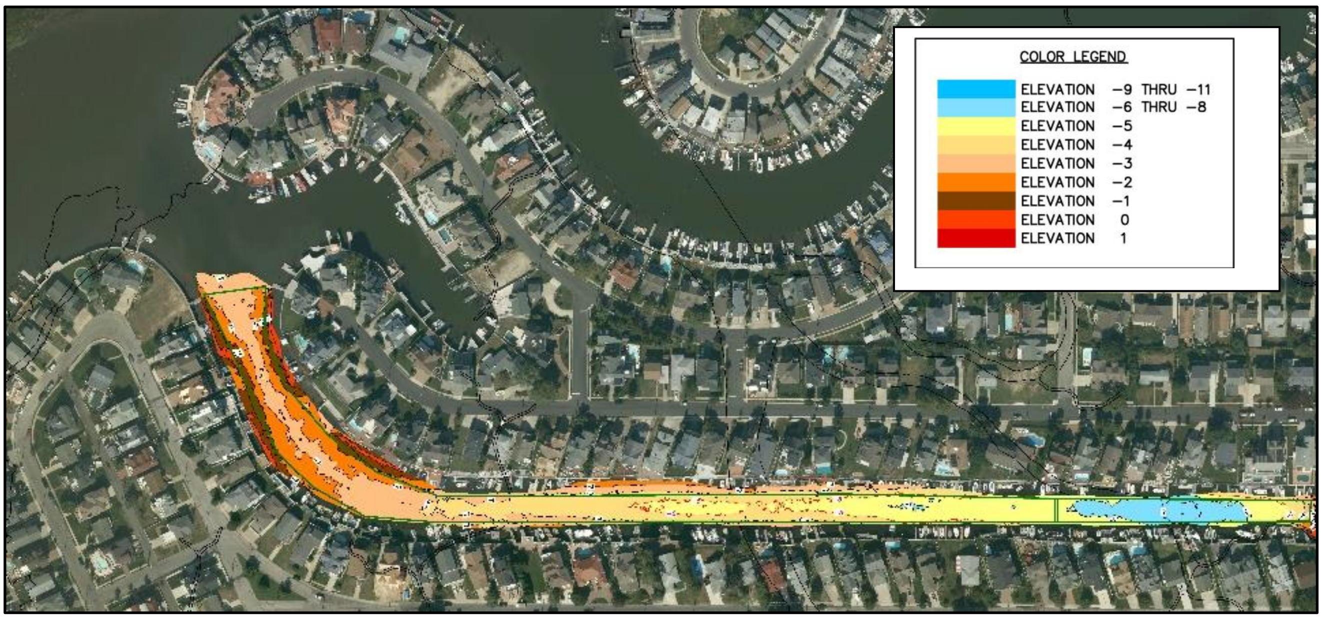


Figure 29 - Dredge prism of Sunny Harbor (Source: ACT Engineers, Inc.)

(b) Recreation

Recreation and tourism are vital to, if not the cornerstone of, Ocean City's financial stability. Clogged waterways prevent recreational and commercial boating and prohibit mooring of boats at residential docks. Additionally, nuisance flooding is a safety concern, prohibits pedestrian and vehicular access and can result in adverse environmental impacts.

The photos above are of Snug Harbor lagoon before and after maintenance dredging which restored marine access to the properties.

(c) Ecological / Fish & Wildlife

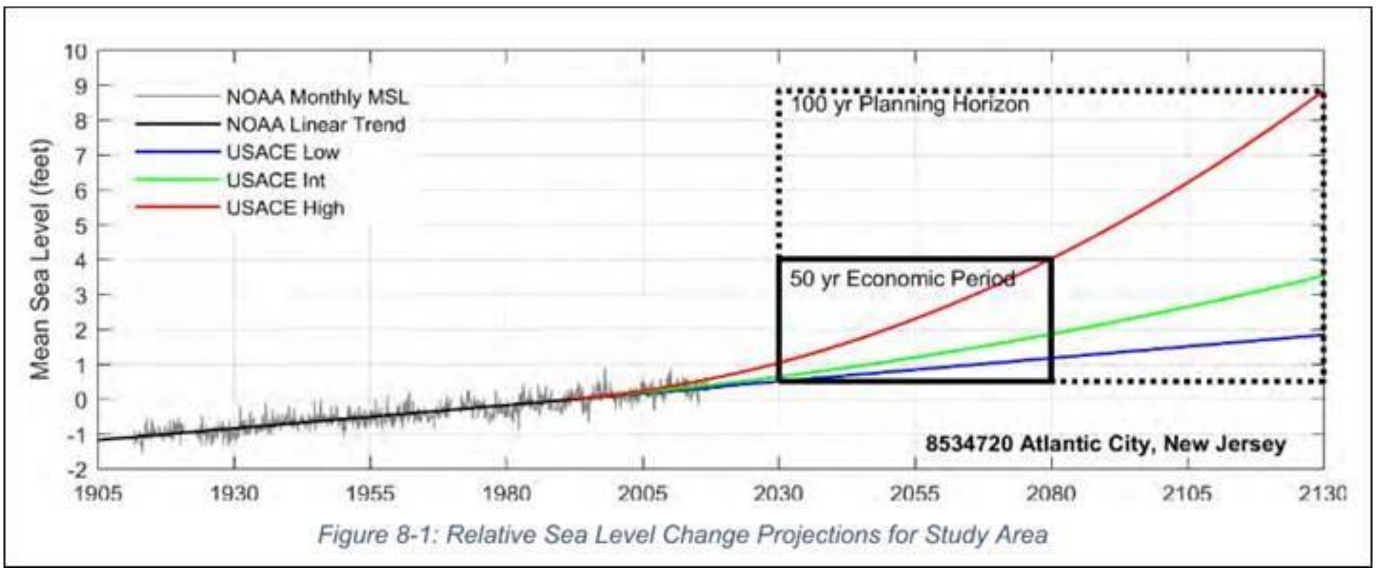
The Great Egg Harbor River and Bay estuary is an extremely productive ecosystem that supports diverse aquatic and terrestrial habitats and species. Of great importance is the presence of estuarine and anadromous (fish that ascend up into fresh waters from the sea for breeding) fisheries populations for both recreational and commercial value. There are shellfish lease areas for production and harvest of clams and oysters and these invertebrates are also critical to the food chain. With numerous bay islands, expanses of tidal wetlands, and freshwater wetlands, the abundance of herbaceous and obligate vegetation, with upland nesting habitat provide vital nesting and wintering habitat for raptors, colonial nesting waterbirds, and, migrating and wintering waterfowl. It is estimated there are almost 150 species of special emphasis in the Great Egg Harbor River estuary and include federally and state-listed threatened and endangered species and species of special concern (a precursor to being ranked as threatened) (USFWS, 1997).

There are 7,662 hectares (18,932 acres) of tidal marsh in the estuary, predominantly high marsh dominated by salt-meadow cordgrass (Spartina patens) interspersed by numerous intertidal creeks and ditches with smooth cordgrass (Spartina alternifora). The protection of the back bay ecosystem is vital.

(d)Flooding

Climate change factors have caused an uptick in flooding experienced by coastal communities. Land development, historical land subsidence and rising sea levels all contribute to increased flood frequency and associated property damages. **Figure 30** shows a Sea Level Rise prediction chart for Atlantic City, from USACE (2019). The three predictions depict low, intermediate, and high sea level rise scenarios, and associated impacts for planning and design purposes. Many local towns have installed local tide gages to adequately capture these trends on a local basis, recognizing that data on the order of decades are often required to have confidence in the reliability of collected data

Figure 30 – Sea Level Change Projections (Source: USACE, 2019)



f. Mitigation / Implementation Goals

Ocean City intends to implement varied and multiple management techniques to cost effectively:

- Manage and maintain Ocean City's navigable waters,
- Preserve, enhance, and restore ecological habitat, and
- Provide improved flood protection and resiliency.

These goals are the foundation of the economic viability of the City. Ultimately, the intent of this Adaptive Management Plan is to reduce the annual dredging needs of the City and provide natural resiliency protection and preserve economic sustainability.

NON-STRUCTURAL STRATEGIES
- Acquisition
- Enhanced Flood Warning and Evacuation System
- Land Use Management
- Zoning
- Flood Insurance

STRUCTURAL STRATEGIES
- Building Retrofit
- Closure Structures
- Floodwalls and Levees
- Seawalls
- Revetments
- Bulkheads
- Storm Surge Barriers
- Sediment Traps

NATURAL AND NATURE BASED FEATURES
- Living Shorelines
- Island Restoration
- Sediment Management
- Wetland/Edge Stabilization
- Thin Layer Wetland Restoration

Ensuring high water quality in New Jersey's coastal waters is critical to the functioning of our coastal ecosystems, which support valuable biodiversity and local communities. Projects with a goal to maintain or improve water quality are designed to either facilitate reductions in, or reduce the rate of input of, concentrations of nutrients, contaminants and/or suspended solids that can inhibit ecosystem functions. Most defensive measures are meant to help minimize wave action, reduce erosion, and protect against storm surge. Many communities along the East and Gulf Coasts have employed armoring or "grey" infrastructure measures, such as seawalls, tide gates, and levees. Some have used ecosystem-based, or "green," infrastructure measures, such as beach nourishment, saltmarsh restoration, and the creation of new offshore reefs (EPA 2009).

(1) Non-Structural Strategies

Zoning – Zoning regulations are an effective method to regulate parcel use, density of development, building dimensions, setbacks, type of construction, shore protection structures, landscaping, etc. Land Use Ordinances can also be used to regulate where development can and cannot take place, making it an invaluable tool in efforts to protect natural resources and environmentally sensitive areas and guide development away from hazard-prone areas. Examples of effective zoning include maximum impervious coverage limitations to promote infiltration of stormwater and minimum bulkhead heights to minimize flooding.

Redevelopment Restrictions – Combining restrictions with acquisition / demolition / relocation programs provides safer options to property owners in the wake of the loss of or damage to their homes or businesses.

Conservation Easements – A conservation easement is a legal agreement between a landowner and a land trust or government agency that can be used to restrict development in sensitive and hazard-prone areas.

Compact Community Design – The high density development suggested by compact community design can allow for more opportunities to guide development away from sensitive and hazard-prone areas.

Acquisition, Demolition, and Relocation – The most effective way to reduce losses is to acquire hazard-prone properties, both land and structures, demolish or relocate structures, and restrict all future development on the land.

Setbacks – Setbacks can protect structures from hazards by keeping the structures away from a property's most vulnerable areas.

Building Codes – Building codes that regulate design, construction, and landscaping of new structures can improve the ability of structures in hazard-prone areas to withstand hazard events.

Education is also a key component of institutional controls. Communicating the importance of Ocean City's efforts to protect its natural resources, as well as create a resilient community for the future, is an important path moving forward. Education and transfer of knowledge can be disseminated through community events and meetings, information repositories (such as Ocean City's website), and public promotion/advertising.

Ocean City participates in the NFIP Community Rating System (CRS) and continues to work to improve their CRS rating through various activities.

The City maintains their stormwater systems regularly according to their established Storm Water Management Plan (SWMP, SPPP). The City recently purchased a Jet-Vac truck to enhance its stormwater maintenance program.

(2) Structural Strategies

Numerous structural strategies are available to provide flood protection to the City's back bay and increase the City's resiliency to future sea-level rise.

Infrastructure protection and building retrofitting are strategies to protect existing infrastructure in place and entails adapting measures to elevate above floodwaters, fortify against floodwaters, or block floodwaters. Structures such as revetments, storm surge barriers and bulkheads are commonly utilized to protect the land behind them from flooding, prevent erosion and/or maintain development. Bulkheads are common throughout the back bay and are primarily intended to retain or prevent movement of the land, although by maintaining elevations across the bayside do provide protection from flooding and sea level rise.

Levees are man-made structures, usually an earthen embankment, designed to contain, control, or divert the flow of water so as to reduce risk from temporary flooding.

Relocating utility infrastructure, such as treatment plants and pump stations, to higher elevations, can also reduce risks from coastal flooding and exposure as a result of coastal erosion or wetland loss.

Stormwater Management is also an effective strategy as drainage systems may be ill-equipped to handle the amount of stormwater runoff that will accompany the more intense rainfall events expected in the future, and those in low-lying areas will be further challenged by losses in elevation attributed to rising sea levels.

(3) Natural and Nature-based Strategies – (NNB)

Restoration, enhancement, and creation of wetlands in the back-bay area is a critical component of the comprehensive dredging and dredged material management plan. Sediment physical properties testing results from back bay sediment sampling indicate that the sediment within Ocean City's navigable waterways is predominately fine grained material (average of 96% fines / silts) which is well-suited for wetland restoration applications. Dredging combined with a well-planned wetland restoration and marsh enhancement program could result in a beneficial reuse of dredged material generated from ongoing maintenance dredging operations. Engineered and constructed wetlands act in the same manner as natural wetlands, though design features may be included to enhance risk reduction or provide for adaptive management of bay wetlands considering future sea level conditions.

Since Superstorm Sandy, there has been increased interest in using NNBF solutions to provide protection of the bay ecosystem from coastal storms and sea level rise. The USACE Engineering Research and Development Center (ERDC) is currently developing national guidelines for NNBF projects, and NJDOT continues to support and advance such initiatives, as well. These innovative coastal resilience techniques, which include features such as living shorelines and tidal wetland restoration, provide promising new approaches to shoreline protection and enhancement (Yepson et al., 2016).

The best solutions to the challenges facing Ocean City may depend more on rethinking the value of existing or restored natural resources.

The Nature Conservancy
New Jersey

"Natural Solutions Toolkit" explores nature-based solutions by:

- Developing hybrid approaches that link natural and built defense structures.
- Managing freshwater resources in innovative ways to benefit nature, economy, and society.
- Accounting for multiple ocean benefits provided by various ecosystems.
- Reducing water treatment costs while protecting biodiversity, storing carbon, and improving human health and well-being.
- Using water markets to incentivize water conservation and reallocate saved water back to freshwater and estuary ecosystems.

Living Shorelines

Living shorelines are a nature-based solution to shoreline erosion and, when appropriately designed, to nuisance tidal flooding. They are defined by the State of New Jersey as a shoreline management practice that addresses the loss of vegetated shorelines and beaches by providing for the protection, restoration, or enhancement of these habitats. This is accomplished through the strategic placement of plants, stone, sand or other living and non-living materials (NJ RCI, 016).

Figure 31 – Shooting Island Rock Sill constructed as part of a multi-phased restoration and flood resiliency project (Source: ACT Engineers, 2020)

Living shorelines use stabilization techniques that rely on vegetative plantings, organic materials, and sand fill or a hybrid approach combining vegetative plantings with low rock sills or living breakwaters to keep sediment in place or reduce wave energy.

Living shoreline techniques include:

- Beach Restoration
- Marsh Sill Construction
- Installation of Living Reef Breakwaters / Habitat castles
- Breakwater
- Ecologically-Enhanced Revetment

Other economic and social benefits of healthy, resilient coastlines include:

- Improved water quality from rainwater run-off from pavements being filtered through marshes and living shorelines;

- Healthy, critical nursery habitat for important commercial and recreational fisheries, which provides a positive impact on local employment and ecotourism; and

- Increase ecotourism revenue to local businesses from birders, recreational fishers, kayakers, wildlife photographers, etc.

Sediment Management

Sediment derived from dredging that cannot be retained within the ecosystem can (and should be) beneficially re-used for a multitude of both upland and wetland projects. Ocean City has successfully modified the City-wide dredging permit to send dredged material for use at sod farms, landfills, landscaping facilities, construction projects, etc., re-using this renewable resource.

Sediments that can be retained within the system can be utilized either by diverting into sediment traps or used for marsh plain elevation enhancement and/or or bay island restoration.

Wetland/Island Restoration

Wetland creation, enhancement and shoreline creation and stabilization are ideal for beneficial re-use of dredged material. Material dredged from the Back-Bay area originated in the wetlands and shorelines and by using it for engineering with nature projects, it retains the sediment in the same ecosystem. Wetland restoration and enhancement methods can include:

- Reintroducing or correcting tidal flow by breaching dykes, changing channel morphology, plugging, or filling ditches, and other methods
- Recreating marsh area that had been lost due to excavation or erosion
- Changing the elevation of the marsh so that it receives optimal tidal flow by excavating fill or adding sediment to drowning marshes, and
- Managing flora and fauna; for example, to remove nuisance or invasive species and re-establish native wetland species.

Ocean City has a considerable amount of area of back bay islands and tidal wetlands. In 1977/78, the State of New Jersey mapped these coastal wetlands and promulgated the boundaries under the Coastal Wetlands Act of 1970

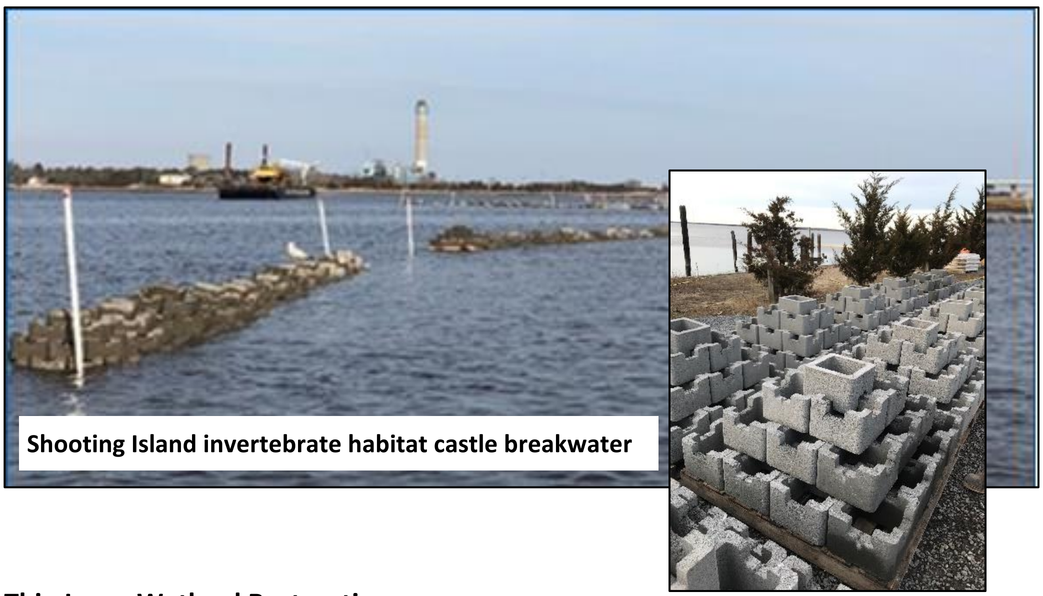
(N.J.A.C. 7:7 et seq.). Since mapping, the wetlands and their shorelines have eroded creating scarp edges. Suitable dredged material can be beneficially re-used as material to restore and enhance the eroded wetlands and shorelines. Integrating nature-based / living shoreline techniques for marsh edge protection, combined with thin layer placement (for marsh enhancement), these subsiding and eroding wetlands can be converted back to productive natural habitats. Likewise, islands can be transformed back to valuable habitats through targeted dredged material placement for restoration and enhancement purposes. Finally, rings or berms can be constructed around eroding islands or wetlands, and dredged material placed behind them to arrest long-term edge sloughing and associated land loss.

Any dredge material planned for placement in this manner must undergo screening or other testing to be approved for such use. Using dredge material from nearby locations better increases the odds of the material being similar to one another and meeting State usage criteria.

For Ocean City, restoring appropriate stabilized marsh slope and planting with indigenous tidal wetland species is a critical component to long term back bay health and island resiliency. The existing marsh edges have eroded due to the combined factors of rising relative sea levels and land subsidence. It is estimated that approximately 4,000 acres of tidal wetlands / shorelines could be restored in this manner to develop a resilient Ocean City back-bay system. It also provides a means to use dredged material from the City's channels and lagoons in a beneficial capacity while improving storm impact resiliency. A good example of this approach is the Shooting Island restoration that the ACT-Anchor Team designed and constructed in 2019. As envisioned, 2,700 linear feet of living shoreline structure made of rip rap and another 1,700 feet of an invertebrate habitat castles' breakwater were placed in the intertidal zone to provide protection during storm surges and facilitate continued sediment buildup along the marsh edges. This living shoreline is already providing shore protection and arresting the islands marsh edge erosion, while providing long term conditions that are beneficial to the establishment of coastal wetlands.

Wetland/Island Edge Stabilization

Ocean City's tidal wetlands and islands have been eroding at an alarming rate due to accelerated storms and associated damages. Restoration and enhancement techniques focused specifically to arrest such edge losses are therefore appropriate for consideration at several areas along the back-bay. Techniques are often varied; however, include natural and rip-rap structures, as well as use of dredged material. Often times, a barrier or ring is placed outside of the eroding marsh or island edge, which is then backfilled with dredged material to create a connected marsh to the existing one. Depending on the timing of placement of dredged material (following sill construction), fish windows or other openings to ensure circulation behind the placed structures may be necessary.



Shooting Island invertebrate habitat castle breakwater

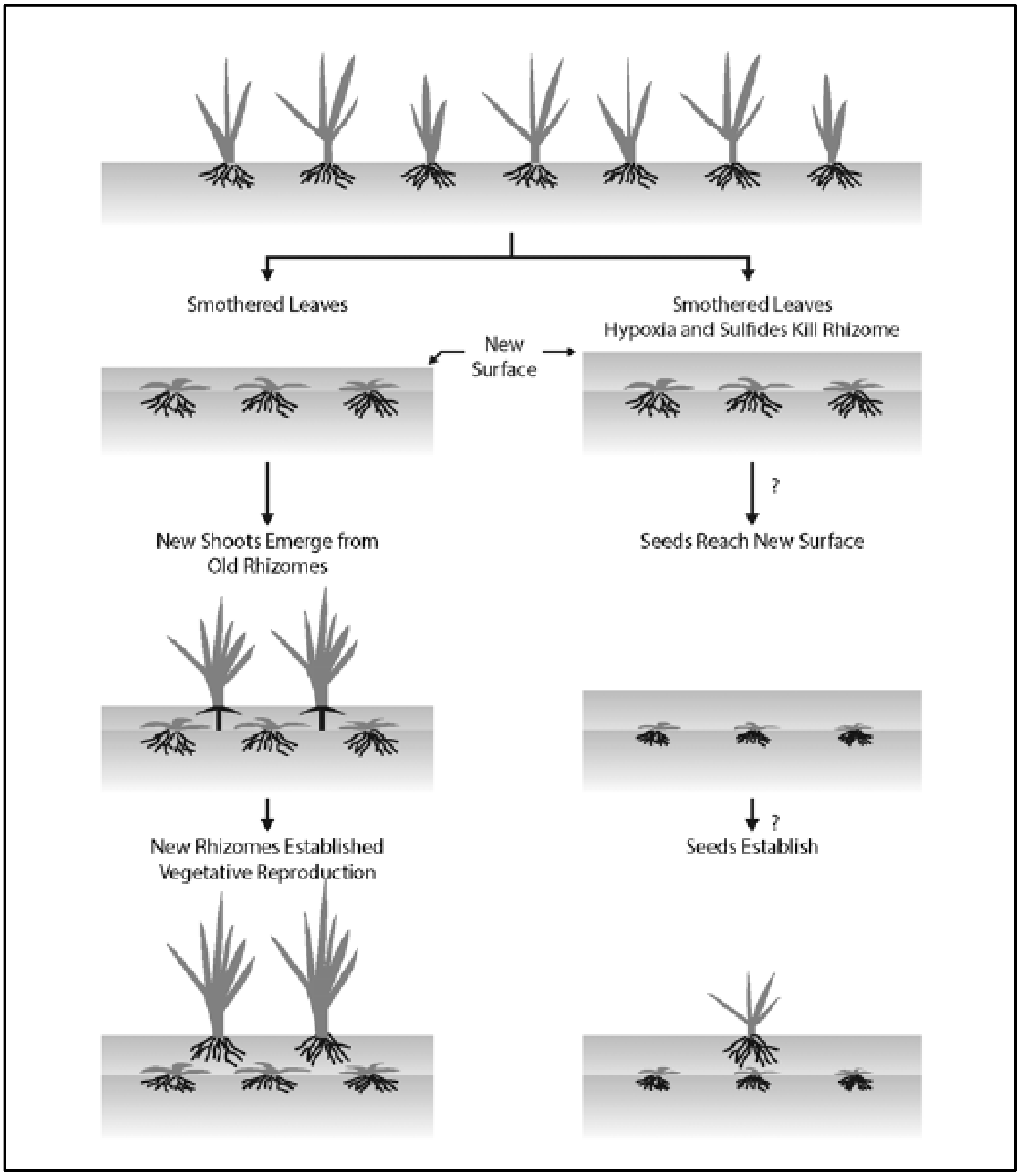
Thin Layer Wetland Restoration

The Back-Bay wetlands provide wildlife habitat, flood storage capacity, wave retention and other functions. The lower end of the tidal wetlands is dominated by Spartina alterniflora, requiring twice daily tidal inundation. Therefore, the wetlands elevation must be such that the marsh surface is flooded at high tide and fully drain at low tide. The stability of coastal wetlands is largely a function of the balance between sediment accretion, marsh subsidence, and sea-level rise. One method of potentially slowing wetland loss is to artificially supply sediments to

Spray placement of dredged material

subsiding marshes by a method of depositing thin layers of sediment, usually by spraying a sediment slurry under high pressure over the marsh surface (Ray, 2007, Mohan et al, 2017). Past studies show that as long as dredged material is applied to existing marshes in lift thickness less than 12 inches, natural recovery of the marsh vegetation should occur within a timeframe of 2-4 years.

Figure 32 – Marsh vegetation recovery following material placement (from Wilber, 1992)



3. LEARN: Assessment & Adaptation

a. Assessment of Projects

Projects are each individually assessed to determine if the intended goals/objectives were achieved. For example, did the project:

- Mitigate coastal flooding by restoring or improving marsh hydrology and tidal dynamics.
- Improve water quality and reduce contaminant levels.
- Provide high quality habitat for salt marsh biota
- Decrease erosion and enhance marsh accretion and resilience to sea level rise
- Maintain and enhance shoreline integrity; preserve marsh area and distribution to support migration corridors, e.g., maintaining marsh and wetland habitat in flyways
- Dissipate wave energy from storm surges associated with coastal storms to protect fish and wildlife habitat and human communities
- Increase infiltration and decrease erosion by reducing impervious surface effects on resilience
- Use information and modeling to help articulate community risk reduction benefits of marshes and wetlands

Develop performance metrics are based on quantitative assessment *techniques, such as:*

Biotic

- Salt marsh plant community monitoring (e.g., species composition, percent cover, areal coverage of the high and low marsh community type)
- Nekton abundance, species richness
- Submerged aquatic vegetation (SAV) (e.g., seagrass), species, density, extent, health (disease/epiphytes)

Abiotic

- Marsh accretion and erosion
- Groundwater dynamics
- Water quality: salinity, conductivity, temperature, dissolved oxygen, pH
- Inundation extent, rates, and frequency

Structural/Engineering

- Marsh surface elevation change trend - long-term 3+ years and short term.

b. Lessons Learned, Trends and Predictions, Evaluation

The adaptive management process includes evaluations prior to, and throughout, the project to identify lessons learned, identify any trending patterns or predictions, and adjust, as necessary. Lessons learned may not be limited to the project but may be identified in similar projects. It is prudent to consider relevant research and studies that may aid in refining the project to meet the goals and needs. For example, marsh restoration pilot programs conducted by State, Federal or other conservation agencies may yield design and/or construction methodologies beneficial to a City project. Finally, sea level rise projections may change in the future and adaptive management adjustments warranted.

B. Historical Back Bay Management

Together with State of NJ and the Federal government, Ocean City has established a history of maintaining and managing the barrier island for the benefit of residents, tourism, fishery resources and environmental awareness. Dredging began in Ocean City as early as the 1920's with the creation of the current lagoons. At that time, there were essentially no rules or regulations for dredging, and the material dredged was used as fill to create the current uplands. Ocean City owned dredging equipment for maintaining back bays and lagoons and pumped the material onto the north end beaches until the 1970s. In accordance with regulations, Ocean City, the State of New Jersey, and the US Army Corps of Engineers (USACE) continued dredging operations, placing dredged material in several Confined Disposal Facilities (CDFs) within the open water, wetland, and upland areas along the western side of Ocean City. CDFs were historically constructed in the middle of back bays, proximate to the dredging locations. Long term emptying and management of the CDFs was not a consideration. In some situations, CDFs were constructed with a single use or finite use in mind; once filled, they were abandoned.

While significant attention and partnerships have been developed to protect and enhance the beachfront and dune systems, which comprise the leading edge of the island, no singular effort has been developed for the bayside. Instead, bayside and waterway management has historically been a patchwork of smaller, independent projects funded by individual, City, State and Federal entities. Since 2015, Ocean City has been striving to plan and implement a comprehensive, bay-wide program for maintaining waterways, promoting flood resiliency, managing stormwater, and protecting the environment.

In 2015, Ocean City was awarded a National Fish and Wildlife Foundation - Hurricane Sandy Coastal Resiliency Competition Grant that funded the construction of a 2,700 linear foot living shoreline to restore the island's historic footprint and 1,700 linear feet of invertebrate habitat breakwater, to restore result in further flood protection of the City. Subsequent proposed phases of the project in permitting review in 2020 include backfill behind the sill to restore shoreline and thin layer placement of dredged material for marsh restoration through elevation enhancement.

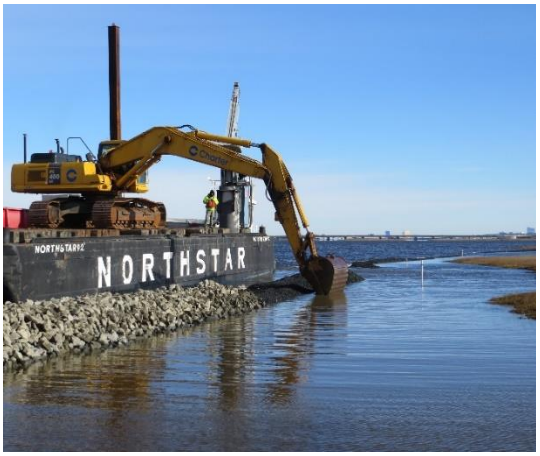
Ocean City's CDF83 was at capacity with prior dredging programs' material. With the implementation of a comprehensive master plan, the City emptied the CDF, for future dredging projects' material dewatering and storage. Structural improvements to this CDF and to the Route 52 CDF have been implemented in an effort to more efficiently and cost effectively manage dredged material.

In 2018, Ocean City obtained a City-wide dredging permit that, with subsequent modifications for dredging methods, material offloading and material disposal, has identified numerous and varied options for upland beneficial re-use of dredged material. In addition to larger scale dredging projects, Ocean City has also completed numerous projects to further the comprehensive management of its back bay waters. A permanent haul road was constructed from Roosevelt Boulevard to CDF83, for the purpose of facilitating dredged material management.

A sediment trap in the area of Snug Harbor (8th Street) was permitted in 2020 to mitigate sedimentation transport in the Bay and reduce the need for maintenance dredging. These projects, implemented and proposed, are intended to aid in reducing impacts from future storms, minimize the need for continued larger scale dredging projects and, ultimately, protection and enhance habitats for numerous fish and wildlife species.

Shooting Island Shoreline Restoration – Phase 1

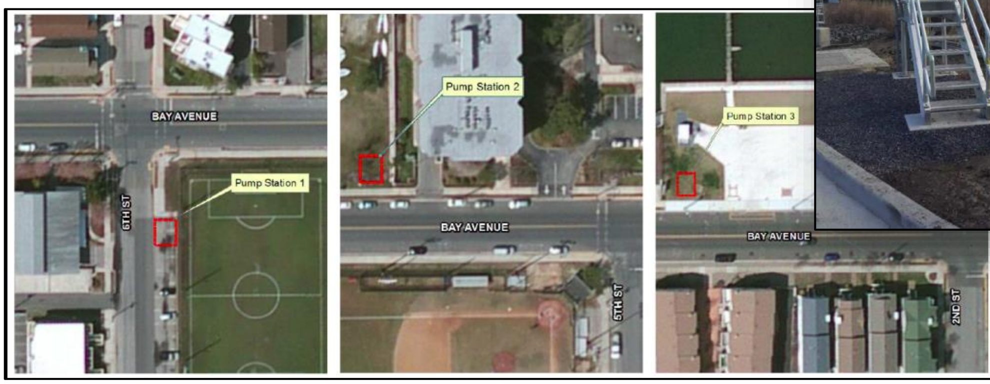
The Shooting Island Shoreline Restoration project involved the protection and restoration of 100+ acres of tidal wetlands on this bay island. Over the past forty years, the island has seen significant erosion due to wind and wave action, both naturally occurring and from vessel wake. To mitigate erosional forces, the Shoreline Restoration project included installation of a rock sill breakwater on the northern face of the island and invertebrate habitat block clusters on the western portion of the island.



C. Current Adaptive Management Efforts

Ocean City has embarked on a localized storm water management analysis and management plan, to reduce or mitigate flooding events in the most impacted areas. Studies and analyses include an inventory of the existing stormwater management system in the City with recommendations for infrastructure upgrades and replacements.

Ocean City has further evaluated drainage issues and recently completed the installation of three pump stations in the Merion Park section of the City to alleviate flooding impacts. Together, the pumps are capable of moving approximately 22,000 gallons per minute (GPM).



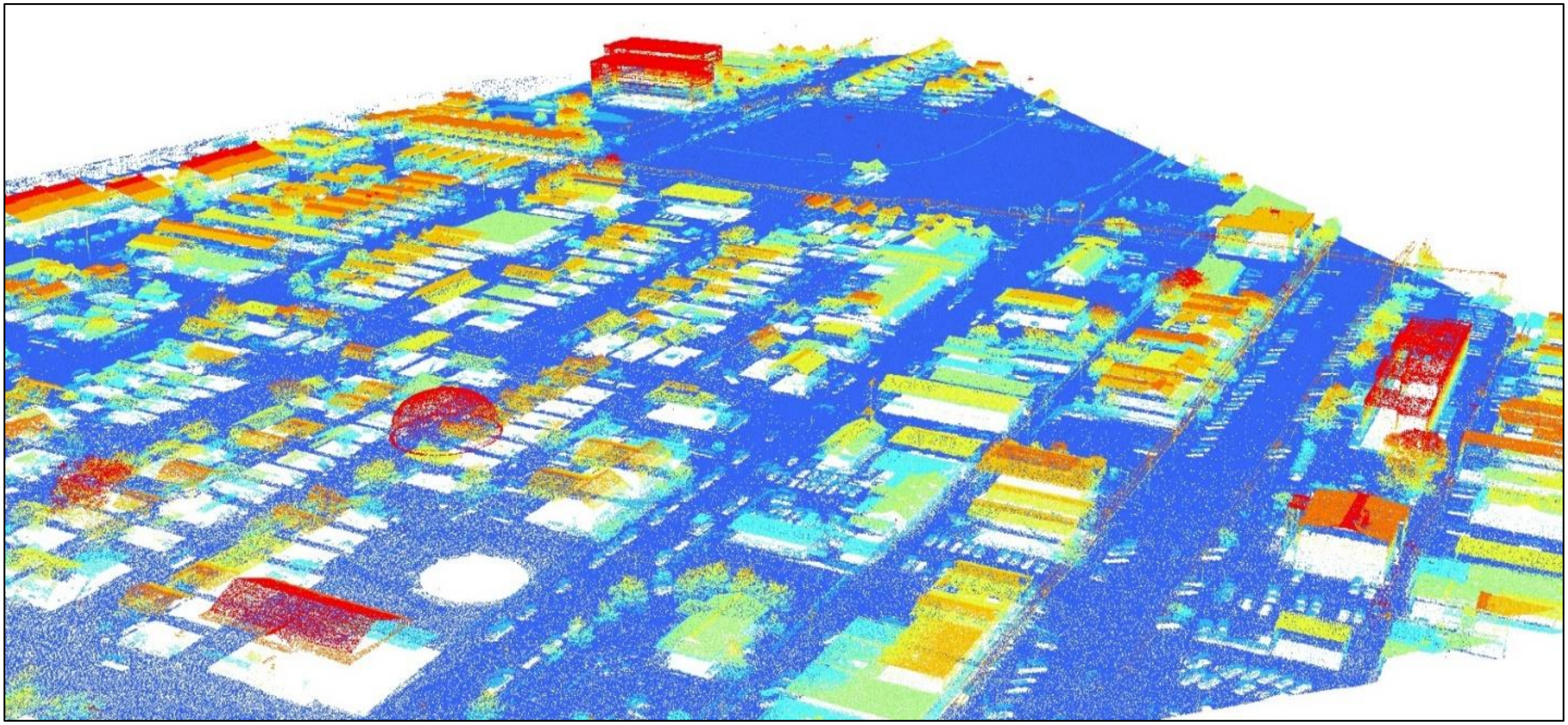
The City has been proactively addressing flood conditions and other infrastructure needs that impact the back bay ecosystem, through the completion of annual capital improvement projects (**Figure 33** page 73). Roadway elevations were raised where feasible to minimize flooding during minor flooding events. Additional storm inlets and piping were installed to collect stormwater and convey it underground to discharge points more efficiently.

The City recently invested in a project providing a City-wide topographic survey using Light Detection and Ranging (LiDAR). This type of advanced surveying method will provide accurate and comprehensive elevation data representing current conditions, which will benefit future studies and evaluations for flood mitigation. **Figure 34** (page 74) demonstrates a mapping of digital elevations for a portion of the City.

Figure 33 – Representative Capital Improvement Projects

2016 Road and Drainage Improvements
2017 Road Improvements
North End Drainage & Road Improvements
2018 Road Improvements
Downtown Streetscape Improvement Program
Salt Storage and Fuel Tank
ADA Boardwalk and Beach Ramps
4th Street Life Saving Station
2018 NJDOT Grant 12th Street Neighborhood Road Improvement Project
South End Improvements
Midtown Road Improvements
Civic Center Improvements
Bay Avenue CMCMUA Force Main Replacement
Stormwater outfalls and bulkheads
Atlantic Avenue Parking Lot Improvement
Pump Stations (completed and proposed)
2019 NJDOT West Avenue Project
2020 NJDOT Asbury Avenue Project
2021 NJDOT West Avenue – 18th – 26th Street
Bayside Center Improvements & Shellfish Upweller
City Hall Improvements
Grimes Field Improvements
Midtown Road
Music pier Improvements
Ocean City Fire Station #3 northern driveway

Figure 34 – Digital Elevation Mapping for Ocean City



IV. Future Back Bay Management (2020-2050)

A. Immediate / Short-Term Need Actions

- Target administrative (non-structural) policy to update/amend current planning and ordinances
- Continue compiling relevant and available physical, scientific, economic data
- Evaluate integration of all data into a Geographic Information System (GIS) platform
- Continued Identification of data shortfalls
- Continue evaluation of known or emerging challenges.

B. Routine or Interim Actions

- Continue annual bathymetry and dredging program
- Continue Shooting Island restoration; dredged material placement at sills and thin-layer placement
- Complete installation of sediment trap at Snug Harbor; monitor for success
- Finalize and adopt Flood Mitigation and Drainage Management Plan
- Capital Project Planning & Budgeting of initiatives which are consistent with the Back Bay Plan

C. Long-Term Actions

- Monitor sea level rise projections vs. measurements
- Identify long-range projects to address sea level rise/climate change
- Evaluate impact of subsidence
- Evaluate impact of groundwater contributing to tidal flooding
- Evaluate storm water infrastructure
- Accept a master plan methodology for storm water flood mitigation

D. Considerations and Goals

- Marsh health and edge protection
- Water quality
- Ecological health, including fisheries and shellfish populations
- Reduce the need for dredging
- Flood mitigation plan recommendations
- Dredged material beneficial re-use
- Maintain regulator and stakeholder relationships
- Cost efficiency awareness
- Managed ecosystem to allow for natural processes

V. Conclusions and Back Bay Management Plan Updates

Barrier islands are inherently dynamic systems, in constant motion, often moving and changing shape in response to storms, tides, winds, and human impacts. Barrier islands are interconnected by littoral (longshore) water currents, wind, and other features the location of the resultant barrier island is the balancing point of the forces acting upon it. These connections can be easily disrupted as activity on one island can adversely affect other islands along the coast. Long term trends have shown, in the absence of beach nourishment, NJ's Barrier Islands migrate inland as beaches erode on the seaward side and form on the landward side. Through human development, the natural balancing effect of this migration has been halted by human influence of the island of Ocean City over the past 100 years.

While significant attention and partnerships have been developed to protect and enhance the oceanfront beach and dune systems, no unified effort has been developed for the bayside. Instead, bayside and waterway management has been an assortment of smaller, area-specific projects funded and typically executed individually by City, State, and Federal entities. The Barrier island of Ocean City is unique in that it is one of a few barrier islands where a single municipality is steward over the entirety of the island. This Comprehensive Back Bay Management Plan is the latest effort to recognize the need to identify the importance of the back bay system and provide a framework for active stewardship of this vital resource to preserve the wealth of benefits it provides communities, natural and man-made, who live here year round and season after season.

Since 2015, Ocean City has initiated the planning and implementation of a comprehensive, bay-wide program for maintaining waterways, promoting flood resiliency, managing stormwater, and protecting the environment. This Comprehensive Back Bay Adaptive Management Plan is the synthesis of the planning and implementation to date and sets the stage for the 2020-2050 time period. Implementation of the Plan since 2015 has included:

- Under a waterway-area-specific dredging permit, and subsequently under the February 2018 City-wide permit, significant dredging programs have been conducted that resulted in the removal of approximately 280,000 cubic yards of material from City and private waterways;

- Development of partnership with the NJDOT Office of Maritime Resources to dredge State designated waterways saving city residents $6 million for dredging;

- Identification and permitting of alternative dredged disposal sites, for the beneficial re-use of the material. Ocean City dredge material has been beneficially reused at multiple locations for landscape and agricultural soil enhancement, capping of landfills, and, site construction;

- Construction of a permanent haul road from Roosevelt Boulevard to the Confined Disposal Facility 83, for initial emptying of 220,000 cubic yards and then subsequent additional emptying of dredged material and future long-term dredged material management, saving millions of dollars in transportation costs;

- An analysis of flooding impacts and preparation of a Comprehensive Flood Mitigation and Drainage Management Plan;

- Construction of a 2,700 linear foot living shoreline rock sill and 1,700 linear feet of invertebrate habitat castles' breakwater, to restore the historic footprint of Shooting Island, protect tidal wetlands, and provide improved flood protection to the City;

- Design and permitting of additional restoration projects and sediment control features with the potential to improve the cost-efficiency of the City's dredged material management needs;

- Award and implementation of the National Fish and Wildlife Foundation, Hurricane Sandy Coastal Resiliency Competition, $2 million Grant, to Ocean City for coastal resiliency projects;

- Implemented private dredge program allowing more than 300 residential properties to be dredged under the City-wide permit.

- Well-established working relationships with State and Federal regulators and Ocean City is considered by these agencies to be the model for creative solutions, innovative permitting, science based ecological evaluation, and productive collaboration of government; and,

- Hosted many public meetings and stakeholder meetings regarding planning and implementation of Management Plan projects.

Future implementation of this Plan includes a continuation of the City's efforts to provide for these communities through the:

1.) Systematic development of Near-Term projects to protect and preserve natural and man-made communities;

2.) Consistent implementation of Routine/Interim Actions to maintain the progress made to date;

3.) Careful monitoring of systems and evaluation when planning Long Term projects which restore back bay function and health; and,

4.) Thorough consideration of goals for Ocean City's Back Bay systems.

This Comprehensive Back Bay Adaptive Management Plan is intended as a living document that is updated and revised, as needed, to keep current of new project purposes and needs; updated trends, data, and projections; consider and utilize, as appropriate, innovations in design and construction methods; and, employ new and better design and construction implementation strategies. All City projects that may impact or consider the back bay ecosystem should be planned and implemented consistent with this Management Plan. If there are interests which are not consistent with the current version of this Plan, it is likely an indication that an update to the Plan is needed to continue holistic management of the back bay of Ocean City.

VI. References

ACT Engineers, Inc., and Anchor QEA. 2020. *Comprehensive Flood Mitigation and Drainage Management Plan, City of Ocean City, New Jersey (Draft Interim, for City Review).*

Anchor QEA. 2020. Internal Memo from Merritts, T., M. Henderson and R. Mahon to E. Rosina, ACT Engineers, Re: 2020 Deposition Analysis within Back Bay of Ocean City, NJ.

Anchor QEA. 2017. *Analysis of Island Restoration Options in Great Egg Harbor Bay, New Jersey, Using a State-of-the-Art Hydrodynamic Model.*

Anchor QEA. 2016. *Hydrodynamic Modeling and Sediment Management Evaluation of Ocean City, New Jersey*.

Bollman, Frank H. 1977. The Value of Estuarine Fisheries Habitats: Some Basic Considerations in their Preservation. Presented at the U.S. Environmental Protection Agency (USEPA), Office of Water Planning and Standards. Estuarine Pollution Control and Assessment, Proceedings of a Conference, Volume 1.

Bridges, T. S., Wagner, P. W., Burks-Copes, K. A., Bates, M. E., Collier, Z., Fischenich, C. J., Gailani, J. Z., Leuck, L. D., Piercy, C. D., Rosati, J. D., Russo, E. J., Shafer, D. J., Suedel, B. C., Vuxton, E. A., and Wamsley, T. V., (2014). *Use of natural and nature-based features (NNBF) for coastal resilience*. ERDC SR-15-1. Vicksburg, MS: U.S. Army Engineer Research and Development Center.

Cahoon, D.R., (2010). *Sea-Level Rise Impacts on Salt Marsh Processes in the Northeast Region*. US Geological Survey.

City of Ocean City, (2015). *Community Resilience Plan.*

City of Ocean City, (2016). *Floodplain Management Plan .*

City of Ocean City, (2005). *Stormwater Management Plan* .

Climate Central (2020). Sea Level Rise and Coastal Flood Risk: Summary for Ocean City, NJ. http://ssrf.climatecentral.org.s3websiteuseast1.amazonaws.com/Buffer2/states/NJ/downloads/pdf_reports/Town/NJ_Ocean_Cityreport.pdf.

Cooper M, Beevers M, Oppenheimer M. (November 2005). *Future Sea Level Rise and the New Jersey Coast. Assessing Potential Impacts and Opportunities*. Woodrow Wilson School of Public and International Affairs, Princeton University. Science Technology and Environmental Policy Program.

Dahl, T.E. and Stedman, S.M. (2013). *Status and trends of wetlands in the coastal watersheds of the Conterminous United States 2004 to 2009*. U.S. Department of the Interior, Fish and Wildlife Service and National Oceanic and Atmospheric Administration, National Marine Fisheries Service.

Department of the Interior (2015). *Recommendations for assessing the effects of the DOI Hurricane Sandy Mitigation and Resilience Program on ecological system and infrastructure resilience in the Northeast coastal region*.

Herrington, T. (2001). *New Jersey Sea Grant College Program Manual for Coastal Hazard Mitigation*.

Kennish, M. J., A. Spahn, and G. P. Sakowicz. (2014). *Sentinel site development of a major salt marsh system in the Mid-Atlantic region*. Open Journal of Ecology, 4: 77-86 http://dx.doi.org/10.4236/oje.2014.43010.

Kopp, R.E., A. Broccoli, B. Horton, D. Kreeger, R. Leichenko, J.A. Miller, J.K. Miller, P. Orton, A. Parris, D. Robinson, C.P. Weaver, M. Campo, M. Kaplan, M. Buchanan, J. Herb, L. Auermuller and C. Andrews. (2016). *Assessing New Jersey's Exposure to Sea-Level Rise and Coastal Storms: Report of the New Jersey Climate Adaptation Alliance Science and Technical Advisory Panel*. Prepared for the New Jersey Climate Adaptation Alliance. New Brunswick, New Jersey.

Kopp, R.E., C. Andrews, A. Broccoli, A. Garner, D. Kreeger, R. Leichenko, N. Lin, C. Little, J.A. Miller, J.K. Miller, K.G. Miller, R. Moss, P. Orton, A. Parris, D. Robinson, W. Sweet, J. Walker, C.P. Weaver, K. White, M. Campo, M. Kaplan, J. Herb, and L. Auermuller. *New Jersey's Rising Seas and Changing Coastal Storms: Report of the 2019 Science and Technical Advisory Panel. Rutgers, The State University of New Jersey*. Prepared for the New Jersey Department of Environmental Protection. Trenton, New Jersey.

Kreeger, D. (2010). *The Mid-Atlantic Coastal Wetland Assessment: Linking Tidal Wetland Status and Water Quality for New Jersey*. Partnership for the Delaware Estuary.

Lathrop Jr., R.G., Love, A. 2007. Vulnerability of New Jersey's Coastal Habitats to Sea Level Rise. Grant F. Walton Center for Remote Sensing & Spatial Analysis, Rutgers University.

Mohan, R., K. Goldberg, T. Pratt, A. Rizzo, M. McHugh, W. Mears and L. Bray. 2017. Improving Coastal Resiliency along America's Shorelines: One Wetland at a Time. WODCON XXI Proceedings.

Miller, K. G., R. E. Kopp, B. P. Horton, J. V. Browning, and A. C. Kemp (2017). *Sea-Level Rise in New Jersey Fact Sheet*. Rutgers Department of Earth and Planetary Sciences, Institute of Marine and Coastal Services.

Miller, K. G., R. E. Kopp, B. P. Horton, J. V. Browning, and A. C. Kemp (2013). *A geological perspective on sea-level rise and its impacts along the U.S. mid-Atlantic coast, Earth's Future*. 1, 3–18, doi:10.1002/2013EF000135.

New Jersey Department of Environmental Protection (NJDEP), Office of Mosquito Control Coordination (OMCC), State Mosquito Commission (Undated). *Open Marsh Water Management Standards for Salt Marsh Mosquito Control*.

NJDEP, Office of Coastal Management, (2011). New Jersey's Coastal Community Vulnerability Assessment and Mapping Protocol.

NJDEP (2013). *New Jersey Wetland Program Plan 2014-2018.*

NJDEP. Undated. Watershed Management Area 15 - Great Egg Harbor, www.nj.gov.waershedrestoration/wma15_info.html.

New Jersey Future, (2017) *Sustainable & Resilient Coastal Communities, A Comprehensive Coastal Hazard Mitigation Strategy*.

New Jersey Geological Survey (1998). *Sea Level Rise in New Jersey*.

New Jersey Resilient Coastlines Initiative (NJ RCI), (2016). *A Community Resource Guide for Planning Living Shorelines Projects*.

Scheule, R.E., (2015). *City of Ocean City Strategic Recovery Planning Report*.

Spanger-Siefried E., Fitzpatrick M, Dahl K. (October 2014). *Encroaching Tides: How Sea Level Rise and Tidal Flooding Threaten US East and Gulf Coast Communities over the Next 30 Years*.

Stralberg D, Brennan M, Callaway JC, Wood JK, Schile LM, et al. (2011) *Evaluating Tidal Marsh Sustainability in the Face of Sea-Level Rise: A Hybrid Modeling Approach Applied to San Francisco Bay*. PLoS ONE 6(11): e27388. doi:10.1371/journal.pone.0027388.

Strauss, B., C. Tebaldi, S. Kulp, S. Cutter, C. Emrich, D. Rizza, and D. Yawitz (2014). "New Jersey and the Surging Sea: A Vulnerability Assessment with Projections for Sea Level Rise and Coastal Flood Risk." Climate Central Research Report. pp 1-43.

State of New Jersey Department of Transportation (2008). *Mean High Water Manual*.

Schuster, E. and Doerr, P. (2015). A Guide for Incorporating Ecosystem Service Valuation into Coastal Restoration Projects. The Nature Conservancy, New Jersey Chapter. Delmont, NJ.

Parris, A., P. Bromirski, V. Burkett, D. Cayan, M. Culver, J. Hall, R. Horton, K. Knuuti, R. Moss, J. Obeysekera, A. Sallenger, and J. Weiss. (2012). *Global Sea Level Rise Scenarios for the US National Climate Assessment*. NOAA Tech Memo OAR CPO-1. 37 pp.

Passeri, D. L., S. C. Hagen, S. C. Medeiros, M. V. Bilskie, K. Alizad, and D. Wang (2015). *The dynamic effects of sea level rise on low-gradient coastal landscapes: A review*. Earth's Future, 3, 159–181, doi:10.1002/2015EF000298.

Sasaki, Rutgers, Arup (March 2014). *Resilience + The Beach: A Regional Strategy and Pilot Projects for the Jersey Shore Jury Brief, Letters of Support & Cost Benefit Analysis*.

Ray, Gary L. December 2007. Thin Layer Placement of Dredged Material on Coastal Wetlands: A Review of the Technical and Scientific Literature. ERDC/EL TN-07-1.

Rutgers – The State University of New Jersey (1983). *New Jersey's Barrier Islands: An Ever-Changing Public Resource*. Center for Coastal and Environmental Studies.

Teal, J. (1969). *Life and Death of the Salt Marsh*. Little, Brown & Canada Publishers, Canada.

Tetra Tech, (2016). *DMA 2000 Hazard Mitigation Plan Update – Cape May County, New Jersey. Section 9.9: City of Ocean City*.

Tiner, R., (1998). *In Search of Swampland, a Wetlands Sourcebook and Field Guide*. Rutgers University Press, New Brunswick, New Jersey, and London.

Titus, J.G. et al (1991). *Greenhouse Effect and Sea Level Rise: The Cost of Holding Back the Sea*. Coastal Management, Volume 19, pp. 171-204 (1991).

Titus, J. G. (1990). *Greenhouse Effect, Sea Level Rise, and Barrier Islands: Case Study of Long Beach Island, New Jersey*. Environmental Protection Agency Office of Policy Analysis Coastal Management (1990), Volume 18: 65-90.

U.S. Army Corps of Engineers (USACE) (2013). *Coastal Risk Reduction and Resilience*, US Army Corps of Engineers Civil Works Directorate: Washington, DC.

USACE (2018) Coastal System Resilience Research paper. ERDC/CHL SR-18-4.

U.S. Army Corps of Engineers (2015). Dredging and Dredged Material Management. EM 1110-2-5025.

USACE. Engineering Manual 1110-2-1003 Hydrographic Surveying. November 2013.

USACE (2019). New Jersey Back Bays Coastal Storm Risk Management Interim Feasibility Saturday and Environmental Scoping Document. Main Report. March 2019.

USACE (2015). North Atlantic Coast Comprehensive Study: Resilient Adaptation to Increasing Risk.

USACE IWR Dynamic Sustainability: Shoreline Management on Maryland's Atlantic Coast. November 2009.

United States Census Bureau (2010). *Profile of General Population and Housing Characteristics: 2010 for Ocean City, Cape May County, New Jersey.*

U.S. Environmental Protection Agency. (2016). *Climate change indicators in the United States, 2016*. Fourth edition. EPA 430-R-16-004.

US Environmental Protection Agency. October 2007. Identifying, Planning and Financing Beneficial Use Projects Using Dredged Material, Beneficial Use Planning Manual. EPA842-B-07-001.

US Environmental Protection Agency. October 2007. The Role of the Federal Standard in the Beneficial Use of Dredged Material from U.S. Army Corps of Engineers New and Maintenance Navigation Projects, Beneficial Uses of Dredged Materials. EPA842-B-07-002.

U.S. Environmental Protection Agency. (2016a). *What Climate Change Means for New Jersey. EPA 430-F-16-032*.

U.S. Fish and Wildlife Service (USFWS). 1997. Significant Habitats and Habitat Complexes of the New York Bight Watershed, USFWS, Southern New England – New York Bight Coastal Ecosystems Program.

Wicker, C.F. (Undated). *History of the New Jersey Coastline*. Philadelphia District Corps of Engineers.

Wilber, P. 1992. "Thin Layer Disposal: Concepts and Terminology." *U.S. Army Corps of Engineers, Information Exchange Bulletin*. Vol. D-92-1, Vicksburg, Mississippi.

Wilson, C. and Allison, M. (2008). *An Equilibrium Profile Model for Retreating Marsh Shorelines in Southeast Louisiana*. Estuarine, Coastal and Shelf Science 80 (2008) 483–494.

Woodruff et al. 2013. Coastal flooding by tropical cyclones and sea-level rise. Nature 504, 44–52 (05 December 2013) doi:10.1038/nature1285.

Yepsen, M., Moody, J., Schuster, E., (2016). *A Framework for developing monitoring plans for coastal wetland restoration and living shoreline projects in New Jersey*. New Jersey Measures and Monitoring Workgroup of the NJ Resilient Coastlines Initiative, with support from the NOAA National Oceanic and Atmospheric Administration (NOAA) Coastal Resilience (CRest) Grant program (NA14NOS4830006).