NEW JERSEY
SHORE PROTECTION STUDY

US Army Corps
of Engineers
Philadelphia District

New Jersey Department
of Environmental
Protection

Hereford Inlet to Cape May Inlet

Final Feasibility Report and Integrated Environmental Assessment

Volume 1 Final Feasibility Report and Integrated Environmental Assessment

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New Jersey Shore Protection Study
Hereford Inlet to Cape May Inlet

Final Feasibility Report
And Integrated Environmental Assessment

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ABSTRACT: This Feasibility Report and Environmental Assessment (EA) presents the findings of a study to determine a hurricane and storm damage reduction plan for coastal communities located between Hereford Inlet and Cape May Inlet, Cape May County, NJ. The report describes the engineering, economic, social, and environmental analyses that were conducted to develop a selected plan of action. Potential impacts to cultural and environmental resources are evaluated herein in accordance with the National Environmental Policy Act (NEPA) and Section 106 of the National Historic Preservation Act.

NOTE TO READER: To provide full and convenient access to the environmental, economic, and engineering documentation prepared for the study, the EA for this project has been integrated into this feasibility report in accordance with Engineering Regulation 1105-2-100.

New Jersey Shore Protection Study
Hereford Inlet to Cape May Inlet

Final Feasibility Report and Integrated Environmental Assessment

New Jersey Shore Protection Study

Final Feasibility Report and Integrated Environmental Assessment (EA)

EXECUTIVE SUMMARY

Proposed Action: Dune and berm construction through the backpassing of sand from a beach borrow source in Wildwood, Wildwood Crest and Lower Township for all of the oceanfront communities between Hereford Inlet and Cape May, New Jersey.

Location of Action: Municipalities of North Wildwood, Wildwood, Wildwood Crest and Lower Township.

Type of Statement: Final Feasibility Report and Integrated Environmental Assessment (EA).

Lead Agency: U.S. Army Corps of Engineers, Philadelphia District.

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Executive Summary

This report presents the results of a feasibility study to determine a solution and the extent of Federal participation for a project that provides hurricane and storm damage reduction for communities located on the Atlantic coast of New Jersey between Hereford Inlet and Cape May Inlet (**Figure ES-1**). The plan will include backpassing sand from the beach in Wildwood Wildwood Crest and Lower Township into a dune and berm in North Wildwood, Wildwood, Wildwood Crest and Lower Township (**Figures ES-2, ES-3 and ES-4**). The lead agency for this study is the U.S. Army Corps of Engineers, Philadelphia District. The study was authorized by resolutions by the U.S. House of Representatives and U.S. Senate in December 1987.

This report was prepared based on recommendations of the reconnaissance study completed in 2001 that identified potential solutions to sand accretion, erosion and storm damage problems within the study area. The reconnaissance study determined that a solution was in the Federal interest and identified the non-Federal sponsor as the New Jersey Department of Environmental Protection (NJDEP) and proceeded to the more detailed Feasibility phase.

The feasibility study was cost shared between the Federal Government and the State of New Jersey Department of Environmental Protection (NJDEP) under provisions of the Feasibility Cost Sharing Agreement (FCSA) executed, 30 September 2002 and supplemental guidance from Public Law (P.L) 113-2, the Hurricane and Disaster Relief Appropriations Act, signed on 29 January 2013. Public Law 113-2 instructed the Corps to fund the remainder of the feasibility study at a 100% Federal cost.

The feasibility study evaluated various alternative plans to provide hurricane and storm damage reduction benefits. The study area is vulnerable to storm erosion, wave, and inundation damage produced by hurricanes and northeasters. It has also experienced a period of excessive beach growth that is causing problems with municipal drainage and safety. Severe storms in recent years have continued to erode the beaches and have exposed communities to the potential for catastrophic coastal erosion and flooding.

The Hereford Inlet to Cape May Inlet Study Area is unique to other projects in the New Jersey Shore Protection Study. It has two distinct problems; erosion at the northern portion of the island and the accretion of sand at the southern portion of the island. The northern portion of the island has experienced erosion over the past 10 years that has exposed property to storm damage. The southern portion of the project area is accreting sand rapidly. This accretion is clogging municipal outfalls that drain storm water from the interior portions of the island to the sea. Our investigations have evaluated adjusting this beach to address both the erosion and accretion problem. A Section 404(b) (1) evaluation has been prepared and is included in this Feasibility Report and Integrated Environmental Assessment. This evaluation concludes that the proposed action would not result in any significant environmental impacts relative to the areas of concern under Section 404 of the Federal Clean Water Act.

The selected plan has primary benefits based on hurricane and storm damage reduction. The plan provides average annual net benefits of $3,565,000 (March 2014 P.L.) and a benefit-to-cost ratio of 2.3.

The total initial project construction cost is estimated at $21,605,000 (March 2014 P.L.) Lands, Easements, Rights-of Ways, Relocations, and Dredged Material Disposal Areas (LERRD) costs are estimated at $1,273,511 and will be credited towards the non-Federal Sponsor's cash contribution.

Periodic nourishment is scheduled to occur at 4-year intervals subsequent to completion of initial construction (year 0). Over 50 years, total periodic nourishment cost is estimated at $82,428,000 (March 2014 P.L) and includes PE&D monitoring during construction.

Figure ES-1– Hereford Inlet to Cape May Inlet Project Area

Table ES-1 Hereford Inlet to Cape May Inlet Description of the Selected Plan

Design Component	Dimension/Quantity	Remarks
Berm Elevation	+6.5 NAVD 88	North Wildwood, Wildwood, Wildwood Crest and Lower Township
Berm Width	75 feet	Berm width measured from seaward base of dune to berm crest
Seaward Berm Slope	1:30	Same as average existing condition
Dune Elevation	+ 16 feet NAVD 88	Similar to surrounding regional beaches
Dune Width at Crest	25 feet	Standard Caldwell section
Dune Side Slopes	1:5	Standard Caldwell section
Dune Offset for Maintenance of Existing Structures	~30 feet	Required dune offsets are reflected in selected plan layout
Length of Project	25,000 feet	Project extends from North Wildwood to southern tip of Diamond Beach
Initial Sand Quantity	1,527,250	Includes advanced nourishment with overfill
Periodic Nourishment Quantity	391,000	Includes overfill
Major Replacement Quantity	544,250	Includes periodic nourishment with overfill; same dune grass and sand fence quantities as initial fill
Taper Section	Northern taper- 200 feet	The project will taper into Hereford Inlet and terminate at the USFW property.
Borrow Source Location	Beach in Wildwood, Wildwood Crest and Lower Township.	Overfill factor of 1.5 for borrow material
Dune Grass	64 acres	18” spacing
Sand Fence	28,000 feet	Along base of dune and at crossovers
Handicap Crossovers	7 existing, 6 new	
Pedestrian Dune Crossovers	44 existing, 7 new	Includes handicap access ramps
Vehicle Dune Crossovers	8 existing, 5 new	

Figure ES-2 North Wildwood

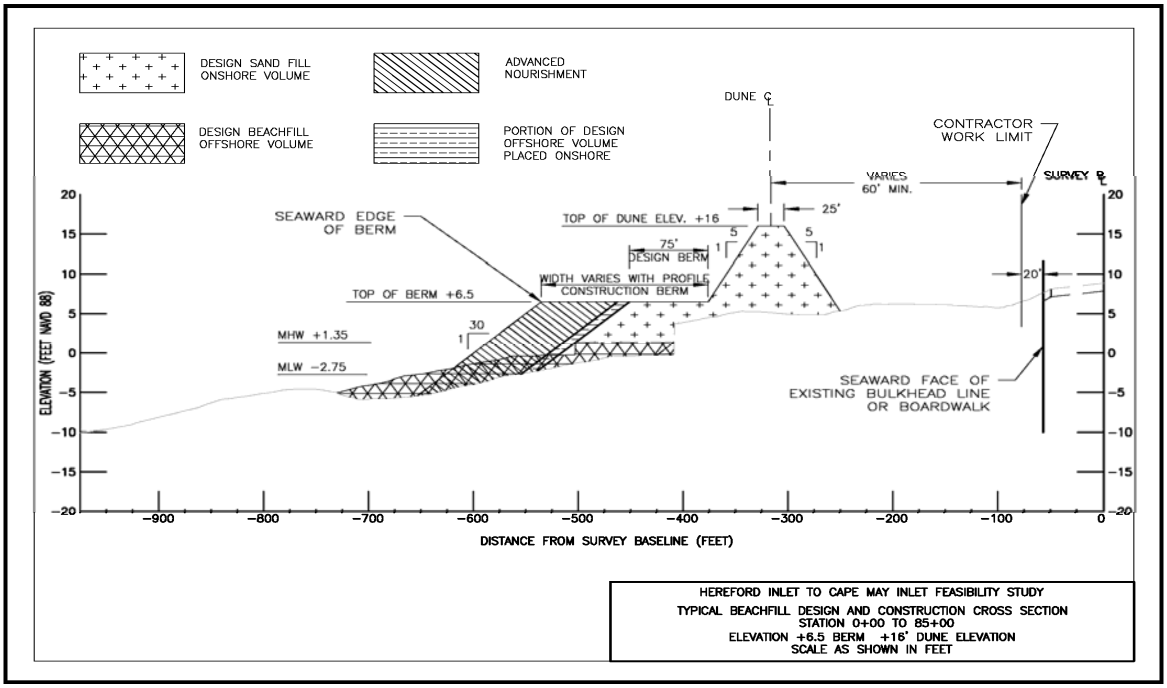


Figure ES-3 Wildwood and Wildwood Crest

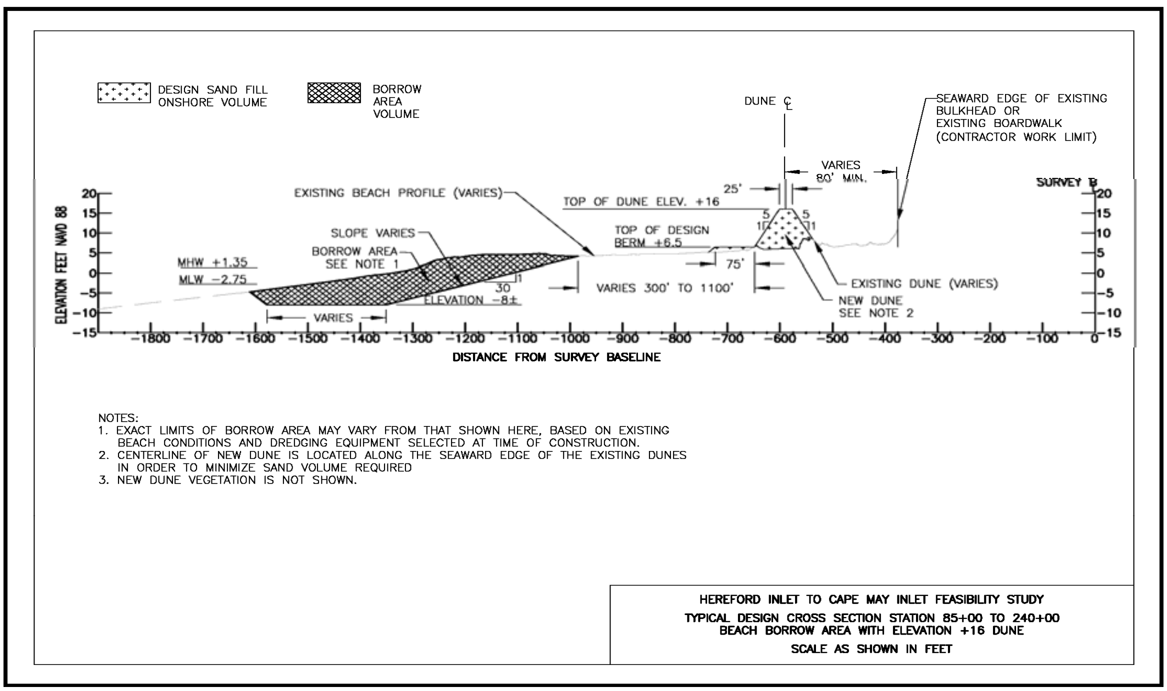
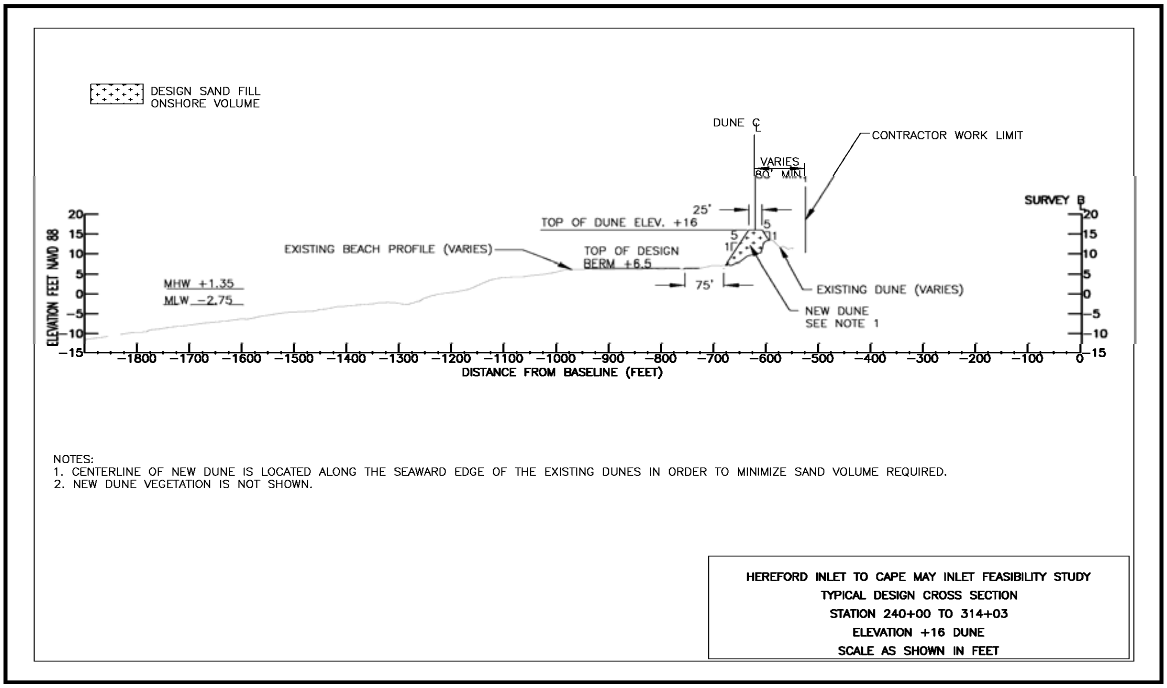


Figure ES-4 Lower Township.



FINDING OF NO SIGNIFICANT IMPACT (FONSI) FOR HEREFORD INLET TO CAPE MAY INLET STORM DAMAGE REDUCTION PROJECT, CAPE MAY COUNTY NEW JERSEY

The United States Army Corps of Engineers, Philadelphia District, has evaluated the potential environmental impacts associated with the construction of the Hereford Inlet to Cape May Inlet Storm Damage Reduction Project, and prepared an Environmental Assessment (EA). The selected plan involves backpassing sand obtained from the beaches of Wildwood, Wildwood Crest and Lower Township to construct a berm and dune for the purpose of storm damage reduction. Backpassing will be accomplished through the use of hydraulic backpassing techniques within the intertidal zone. Excess sand from Wildwood, Wildwood Crest and Lower Township will be used to form a continuous dune and a berm within North Wildwood, Wildwood, Wildwood Crest and Lower Township. The selected plan includes a dune at elevation +16 NAVD88 with a crest width of 25' and a 75' wide berm with an elevation of +6.5'. Slopes for the dune will be 1V:5H and 1:30 for the seaward slope of the berm. The plan includes the installation of approximately 64 acres of dune grass, 28,000 linear feet of sand fence, 44 extended crossovers, 7 new pedestrian crossovers, 7 extended handicap crossovers, 6 new handicap crossovers, 8 existing vehicle crossover extensions and 5 new vehicular crossovers. To maintain the design template, this plan also included periodic nourishment every four years. Initial construction for the project will remove approximately 1,527,250 cubic yards (cy) of sand from the approved borrow zone, which includes a design quantity of 1,136,250 cy and advanced nourishment of 391,000 cy. Following the initial construction, approximately 391,000 cy of material will be backpassed every four years for periodic nourishment of the selected plan.

In compliance with the National Environmental Policy Act of 1969, as amended, and CEQ regulations, the Philadelphia District has prepared an Environmental Assessment (EA) to document the potential impacts associated with the proposed plan. The EA for the project was forwarded to the U.S. Environmental Protection Agency, the U.S. Fish and Wildlife Service, the National Marine Fisheries Service, the New Jersey State Historic Preservation Office (SHPO), New Jersey Department of Environmental Protection (NJDEP), and all other known interested parties for comment.

The EA has determined that the hydraulic back-passing of sand from Wildwood and Wildwood Crest for beach nourishment and restoration activities in North Wildwood, Wildwood, Wildwood, Wildwood Crest and Lower Township would not likely jeopardize the continued existence of any species or the critical habitat of any fish, wildlife, or plant, which is designated as endangered or threatened pursuant to the Endangered Species Act of 1973, as amended by P.L. 96-159.

The EA has concluded that the project can be conducted in a manner which should not violate New Jersey's Water Quality Standards. Pursuant to Section 401 of the Clean Water Act, a 401 Water Quality Certificate was obtained from the NJDEP during the review of the Draft EA. Based on the information developed during preparation of the EA, it was determined in accordance with Section 307 (C) of the Coastal Zone Management Act of 1972 that the plan complies with and can be conducted in a manner that is consistent with the approved Coastal Zone Management Program of New Jersey. A Federal Consistency Determination and Water Quality Certificate were received from NJDEP on 7 March 2014.

There are no known properties listed on, or eligible for listing on, the National Register of Historic Places that would be affected by the proposed activity. The plan has been designed to avoid archaeologically sensitive areas, and is therefore not expected to impact any cultural resources. The NJSPO agreed with this determination in a letter dated 20 December 2013.

In accordance with the Clean Air Act, this project will comply with the General Conformity (GC) requirement (40CFR§90.153) through the following options that have been coordinated with the New Jersey Department of Environmental Protection (NJDEP); statutory exemption, emission reduction opportunities, use of the Joint Base McGuire/Lakehurst GC State Implementation Plan budget, and/or the purchase of Environmental Protection Agency (EPA) Clean Air Interstate Rule (CAIR) ozone season oxides of nitrogen (NOx) allowances. This project is not de minimis under 40CFR§90.153, therefore one or a combination of these options will be used to meet the GC requirements. The project specific option(s) for meeting GC are detailed in the Statement of Conformity (SOC), which is required under 40CFR§90.158.
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Because the EA concludes that the proposed project does not constitute a major Federal action significantly affecting the human environment, I have determined that an Environmental Impact Statement is not required.

________ ______________________________

Date

Michael A. Bliss, PE
Lieutenant Colonel,
Corps of Engineers
District Commander

Environmental Operating Principles

The United States Army Corps of Engineers Environmental Operating Principles were developed to ensure that Corps of Engineers missions include integrated and sustainable environmental practices. The Principles provided corporate direction to ensure the workforce recognized the Corps of Engineers role in, and responsibility for, sustainable use, stewardship, and restoration of natural resources across the Nation and, through the international reach of its support missions. Since the Environmental Operating Principles were introduced in 2002 they have instilled environmental stewardship across business practices from recycling and reduced energy use at Corps and customer facilities to a fuller consideration of the environmental impacts of Corps actions and meaningful collaboration within the larger environmental community. The concepts embedded in the original Principles remain vital to the success of the Corps and its missions. However, as the Nation's resource challenges and priorities have evolved, the Corps has responded by close examination and refinement of work processes and operating practices. This self-examination includes how the Corps considers environmental issues in all aspects of the corporate enterprise. In particular, the strong emphasis on sustainability must be translated into everyday actions that have an effect on the environmental conditions of today, as well as the uncertainties and risks of the future. These challenges are complex, ranging from global trends such as increasing and competing demands for water and energy, climate and sea level change, and declining biodiversity; to localized manifestations of these issues in extreme weather events, the spread of invasive species, and demographic shifts. Accordingly, the Corps of Engineers is re-invigorating commitment to the Environmental Operating Principles in light of this changing context. The Environmental Operating Principles relate to the human environment and apply to all aspects of business and operations. They apply across Military Programs, Civil Works, Research and Development, and across the Corps. The Principles require a recognition and acceptance of individual responsibility from senior leaders to the newest team members. Re-committing to these principles and environmental stewardship will lead to more efficient and effective solutions, and will enable the Corps of Engineers to further leverage resources through collaboration. This is essential for successful integrated resources management, restoration of the environment and sustainable and energy efficient approaches to all Corps of Engineers mission areas. It is also an essential component of the Corps of Engineers' risk management approach in decision making, allowing the organization to offset uncertainty by building flexibility into the management and construction of infrastructure. The Corps included integrated environmental practice by;

Environmental Operating Principles. The *Hereford Inlet to Cape May Shore Protection Study, Feasibility Report and EA* was conducted in a manner consistent with the intent of the USACE's Environmental Operating Principles, that is, to ensure its commitment to the environmental quality of the Hereford Inlet to Cape May area in balance with the economy of the region. This integrated feasibility study complies with the Environmental Operating Principles as follows:

1. Foster sustainability as a way of life throughout the organization. This integrated feasibility report/EA uses an approach that considers the sustainability of the project in order to maintain a healthy, diverse and sustainable condition needed to support life.

2. Proactively consider environmental consequences of all Corps activities and act accordingly. This integrated feasibility report/EA includes an analysis of the environmental consequences of the project on all resources within the Hereford to Cape May area, including socioeconomic resources, interdependently with shoreline protection plan formulation and project recommendations.

3. Create mutually supporting economic and environmentally sustainable solutions. The *Hereford Inlet to Cape May Shore Protection Study Draft Integrated Feasibility Report and EA* has been conducted in a multiagency, regional planning context to ensure that land use, residential, and commercial development patterns and economic considerations are incorporated into the development of sustainable and synergistic shoreline protection solutions. BMPs or restoration initiatives have been identified in a manner that achieves a balance between economic development and the environmental stewardship.

4. Continue to meet our corporate responsibility and accountability under the law for activities undertaken by the Corps, which may impact human and natural environments. Effective coordination between the project delivery team and the resources agencies, through stakeholder meetings, public meetings and day-to–day correspondence, has ensured that the Corps has met all of its responsibilities under law. The components of the tentatively selected Shoreline protection plan have been formulated to ensure that no significant adverse impacts to human health and welfare will result from project implementation.

5. Consider the environment in employing a risk management and systems approach throughout the life cycles of projects and programs. A detailed monitoring and adaptive management plan were developed for the Hereford Inlet to Cape May shoreline protection study as a strategy to manage the future risk of the project. A systems-based approach that considers all elements of the shoreline environment was applied to confirm that effects from project implementation on the environment are beneficial, as the project purpose is shoreline protection.

6. Leverage scientific, economic and social knowledge to understand the environmental context and effects of Corps actions in a collaborative manner. Effective coordination between the project delivery team, the project's steering comprised of a variety of basin stakeholders, public meetings and communication with the appropriate partnering agencies ensured that the project benefited from a range of diverse perspectives and ideas. This integrated knowledge base enhances the performance and sustainability of project features, through incorporation of a greater understanding of the Hereford Inlet to Cape May shoreline area.

7. Employ an open, transparent process that respects views of individuals and groups interested in Corps activities. The *Hereford Inlet to Cape May Shore Protection Study Draft Integrated Feasibility Report and EA* has benefitted from incorporating a range of diverse perspectives and regional technical expertise. Interagency collaboration has been fostered through the efforts of a steering committee and project delivery team meetings held regularly. By implementing a multiagency collaboration and public involvement strategy, a range of technical input was incorporated into the study analyses from multiple disciplines. This approach built trust and positive relationships, supporting innovative "win-win" solutions to identified shoreline protection issues.

Contributions to the USACE Campaign Plan

The U.S. Army Corps of Engineers is moving forward with a Campaign Plan to transform the way we do business. The Corps will grow stronger and become a great organization by delivering superior performance, setting the standard for our profession, making a positive impact on the Nation and other nations, and building to last, as evidenced by the strength of our team — educated, trained, experienced, and certified professionals. Our intent is for the Corps to be one disciplined team — in thought, word, and action — and to meet our commitments by saying what we will do, and doing what we say.

The USACE campaign plan is comprised of four separate goals; 1- Supporting the Warfighter, 2- Transforming Civil Works, 3- Reducing Disaster Risks, and 4- Preparing for Tomorrow.

Transforming Civil works will enable the Corps to deliver essential water resource solutions using effective transformation strategies through a systems based watershed approach. The Hereford project contributes to watershed sustainability by re- using excess sand in a way that will reduce hurricane and storm damages, reduce impacts to benthic resources and improve storm drainage.

Reducing Disaster Risk will be achieved through the reduction in storm risk offered by the protective dune and berm allowing the municipalities within the island to withstand the impacts from coastal storms, be more resilient in their recovery from storms and be more robust in the face of future sea level rise.

Preparing for Tomorrow contributions are through the employment of new technologies to regionally distribute sand resources through the use of mobile sediment backpassing technology to achieve Regional Sediment Management (RSM) goals, maintain a commitment to the project area through periodic nourishment and life cycle adaptive management while mitigating for increases in water levels and storm frequency.

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1.0 Introduction

1.1 Study Background

This analysis is part of the New Jersey Shore Protection Study authorized by Congress in 1987. It authorizes the Corps of Engineers to examine erosion, storm damage reduction and environmental problems from the ocean and back bays of coastal New Jersey.

The Hereford Inlet to Cape May Inlet Feasibility study is an examination of the specific water resource and shore protection needs for North Wildwood, Wildwood, Wildwood Crest and Lower Township, NJ **(Figure 1)** with a goal to reduce storm damage, maintain existing coastal recreation and provide information to planners, engineers, and scientists. The two primary problems within the study area are beach erosion in North Wildwood and the accumulation of sand in Wildwood and Wildwood Crest. The erosion in North Wildwood leaves the area vulnerable to storm damage, and the sand accumulation, in its present configuration, leaves Wildwood, Wildwood Crest and Lower Township vulnerable to storm damage and clogs the municipal outfall systems that drain storm water to the ocean.

The Hereford Inlet to Cape May Inlet General Investigation was undertaken by authority of The New Jersey Shore Protection Study, by resolutions adopted within the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environment and Public Works of the U.S. Senate in December 1987.

This 1987 authorization culminated in the September 1990 Report of Limited Reconnaissance and supported investigative studies along the New Jersey coast. Problems between the Hereford Inlet and Cape May Inlet were not critical at the time of that report. As a result, recommendations were made for studies in other areas along the New Jersey coastline that required immediate attention. However, conditions within the study area worsened in the early 1990's and renewed investigative studies were recommended by non-Federal interests.

By the mid 1990's a number of shoreline problems developed within the Hereford Inlet and Cape May Inlet study area including erosion and the excessive accumulation of sand along the study area's southern beaches. A January 2002 letter from the non- Federal sponsor, the NJDEP, recognized that the most urgent needs of the New Jersey coastline had been addressed but "*The situation in the Wildwoods has worsened and now requires being addressed immediately*" (**Appendix G**.). In response, the Hereford Inlet to Cape May Inlet Preliminary Financial Analysis (Reconnaissance Study) was initiated by the Philadelphia District. The District's Preliminary Financial Analysis was completed in January of 2002. The intent of this Analysis was to determine if Federal interest existed and to examine the erosion, storm damage vulnerability and public health issues that were not an imminent and critical threat at the time of the 1990 Report. The Preliminary Financial Analysis determined that Federal interest existed.

In a letter dated 28 January 2002 North Atlantic Division approved the District's Preliminary Financial Analysis and directed the District to proceed into the Feasibility phase (**Appendix G.**). A Feasibility Cost Sharing Agreement was signed between the District and the non-Federal

Sponsor, the New Jersey Department of Environmental Protection (NJDEP), on 30 September 2002.

1.2 Study Authorization

The New Jersey Shore Protection Study was authorized under resolutions adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environmental and Public Works of the U.S. Senate in December of 1987. The Senate Resolution adopted on December 17th 1987 by the Committee on Environmental and Public Works states:

> *That the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 13, 1902, be, and is hereby requested to review existing reports of the Chief of Engineers for the entire coast of New Jersey, with a view to study, in cooperation with the State of New Jersey, its political subdivisions and agencies and instrumentalities thereof, the changing coastal processes along the coast of New Jersey. Included in this study will be the development of a physical, environmental, and engineering database on coastal area changes and processes, including appropriate monitoring, as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage; and, in cooperation with the Environmental Protection Agency and other Federal agencies as appropriate, develop recommendations for actions and solutions needed to preclude further water quality degradation and coastal pollution from existing and anticipated uses of coastal waters affecting the New Jersey coast. Site specific studies for beach erosion control, hurricane protection, and related purposes should be undertaken in areas identified as having potential for a Federal project, action, or response.*

Supplemental Authority

The Disaster Relief Appropriations Act of 2013 was passed by Congress and signed into law by the President on January 29, 2013 as Public Law 113-2 (Act). The legislation provides supplemental appropriations to address damages caused by Hurricane Sandy and to reduce future flood risk in ways that will support the long-term sustainability of the coastal ecosystem and communities, and reduce the economic costs and risks associated with large-scale flood and storm events. The legislation provides funds to expedite and complete ongoing flood and storm damage protection (i.e., beach nourishment & other similar types of projects) impacted by Hurricane Sandy within the boundaries of the North Atlantic Division. Ongoing feasibility studies for shore protection projects that are already underway and that are located (a) in areas impacted by Sandy that (b) are within the North Atlantic Division of the Corps are eligible to be considered for initial construction funding under this provision. Periodic nourishment would not be authorized under PL 113-2, and a separate authorization would be required to carry out periodic nourishment activities for this project. If PL 113-2 funding is not available for initial construction then a separate authority would be pursued to authorize initial construction and periodic nourishment.

1.3 Study Purpose and Scope

The 2002 Reconnaissance effort (Preliminary Financial Analysis) identified the area as a candidate for Hurricane and Storm Damage Reduction feasibility study due to the severe erosion and related environmental issues. This Preliminary Financial Analysis identified problems, opportunities, a conceptual plan, benefits, environmental impacts; and outlined the costs for the more detailed Feasibility study. The problems identified within the feasibility study include:

- Damages due to erosion
- Damages due to flooding
- Damages due to waves
- Costs associated with clogged oceanfront storm-water outfalls
- Water quality issues associated with ponded water above the high tide line

The study area was recommended for a more detailed feasibility analysis after the Preliminary Financial Analysis was completed. This feasibility study is documented herein, and represents the plan formulation, environmental assessment, cost estimate and the selected plan.

1.4 Study Area

The study area is a barrier island bordered to the north by Hereford Inlet and to the south by Cape May Inlet (*formerly Cold Spring Inlet*). Municipalities on the island include; North Wildwood, Wildwood, Wildwood Crest and Lower Township. A natural area managed by the US Fish and Wildlife Service and a US Coast Guard Electronics Center is located at the southern boundary of the study area within Lower Township. The study area is shown in **Figure 1** through **Figure 11.** The island is separated from the mainland by three back- bay areas; Grassy Sound, Richardson Sound and Jarvis Sound. These are wide, shallow bays surrounded by marsh islands and thoroughfares connected to Hereford Inlet and Cape May Inlet.

Three roads connect the study area to the mainland and one road connects it to an adjacent barrier island. Route 147 connects the northern portion of the island to the mainland of Cape May County in the Anglesea section of North Wildwood, Route 47 connects Wildwood with the mainland at Rio Grande Avenue, and Ocean Drive connects the southern portion of the Island to the mainland near Cape May City. The island is also connected to Stone Harbor via the Grassy Sound Bridge which connects with Route 147 before entering North Wildwood.

The study area is located between two existing Federal shore protection projects. The Townsend's Inlet to Cape May Inlet shore protection project borders the study area to the north, and the Cape May Inlet to Lower Township project borders it to the south. Both projects are in partnership with the State of New Jersey Department of Environmental Protection and arose from investigations conducted by the New Jersey Shore Protection Authority. Initial construction has been completed on both projects, and they are currently in their periodic nourishment phase.

The Wildwood Boardwalk is located within the study area and receives hundreds of thousands of visitors per year. The first of the 70,000 planks that make up the Boardwalk were laid in 1900 along a 150 yard span between Oak and Maple Avenue in Wildwood City. Expansion of the boardwalk was soon to follow and by the first decade of the 20th century the boardwalk stretched from Cresse Avenue in Wildwood to 2nd Avenue in North Wildwood. The current boardwalk stretches from 15th street in North Wildwood to the border of Wildwood Crest and Wildwood at Cresse Avenue, a distance of approximately 1 3/4 miles.

Figure 1 Study Area

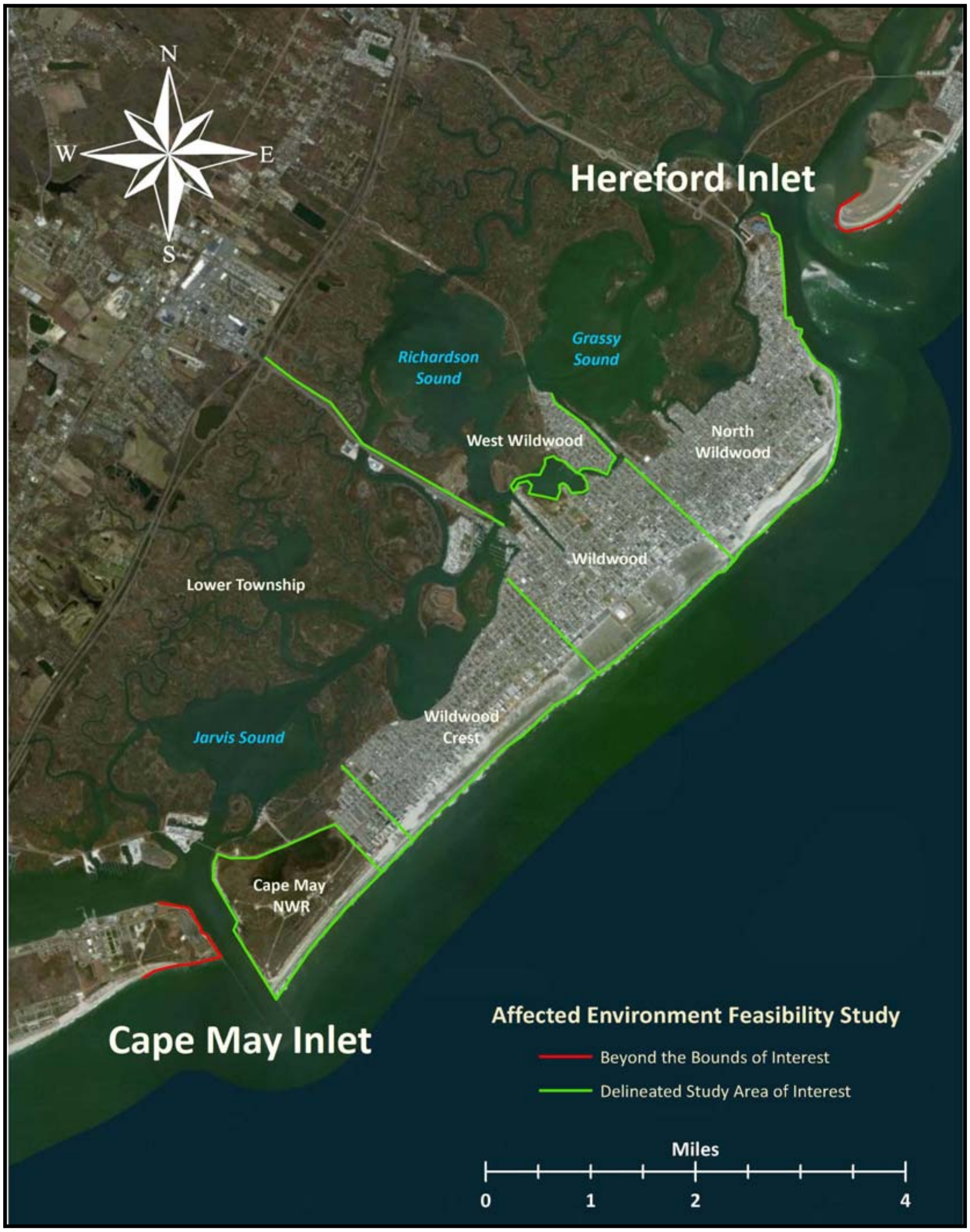


Figure 2 Hereford Inlet

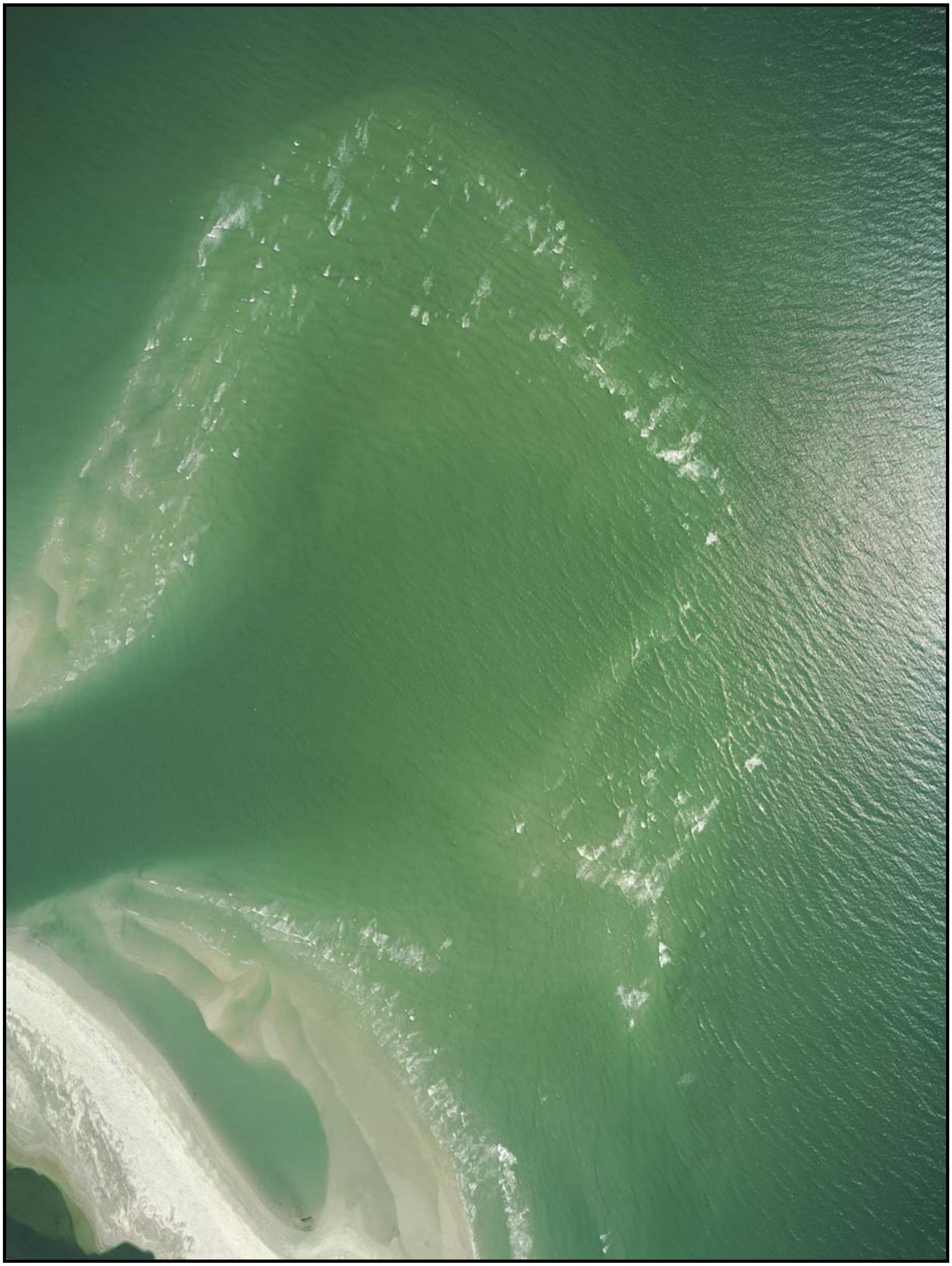


Figure 3 North Wildwood

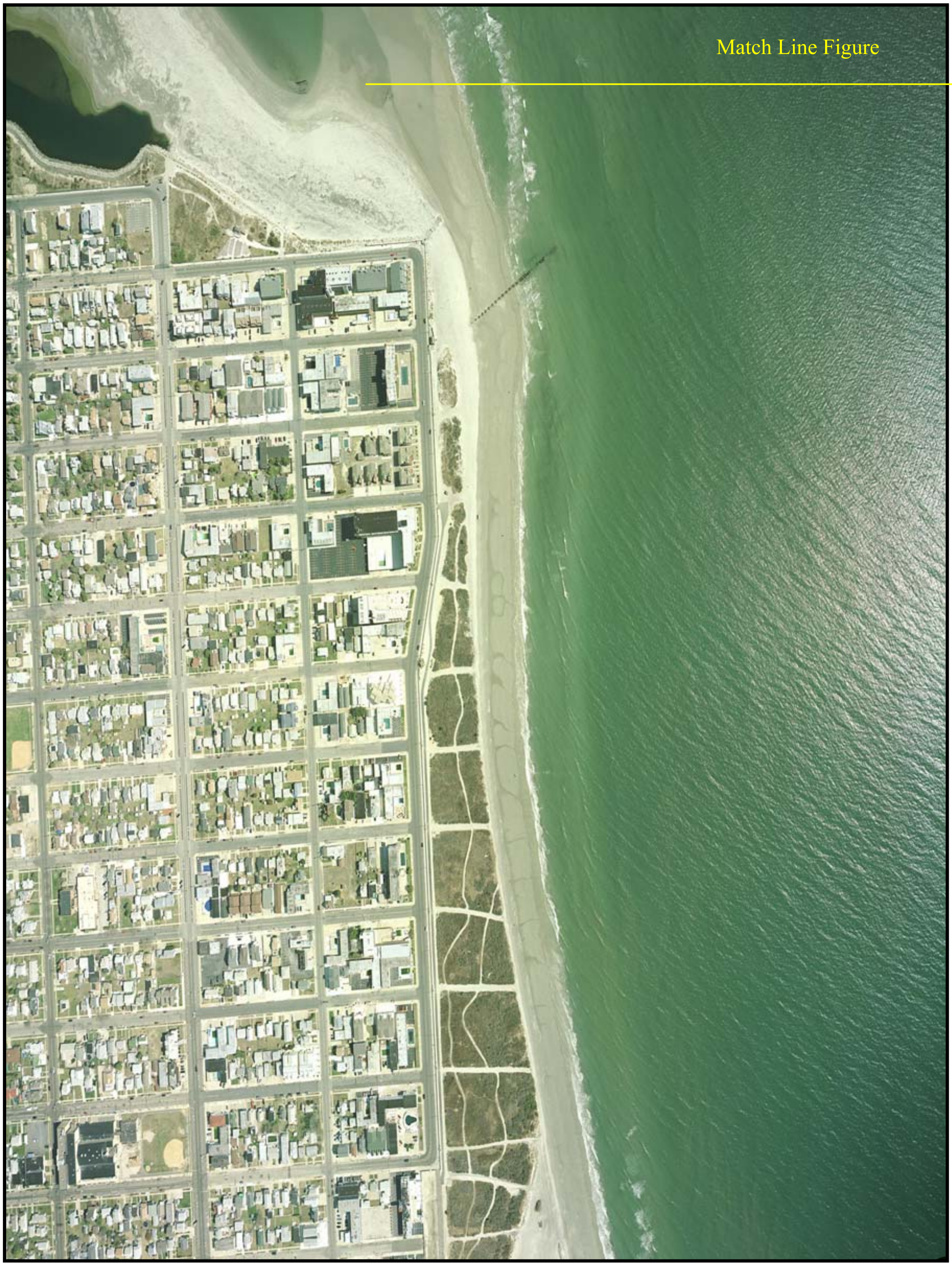


Figure 4 North Wildwood

Figure 5 North Wildwood and Wildwood

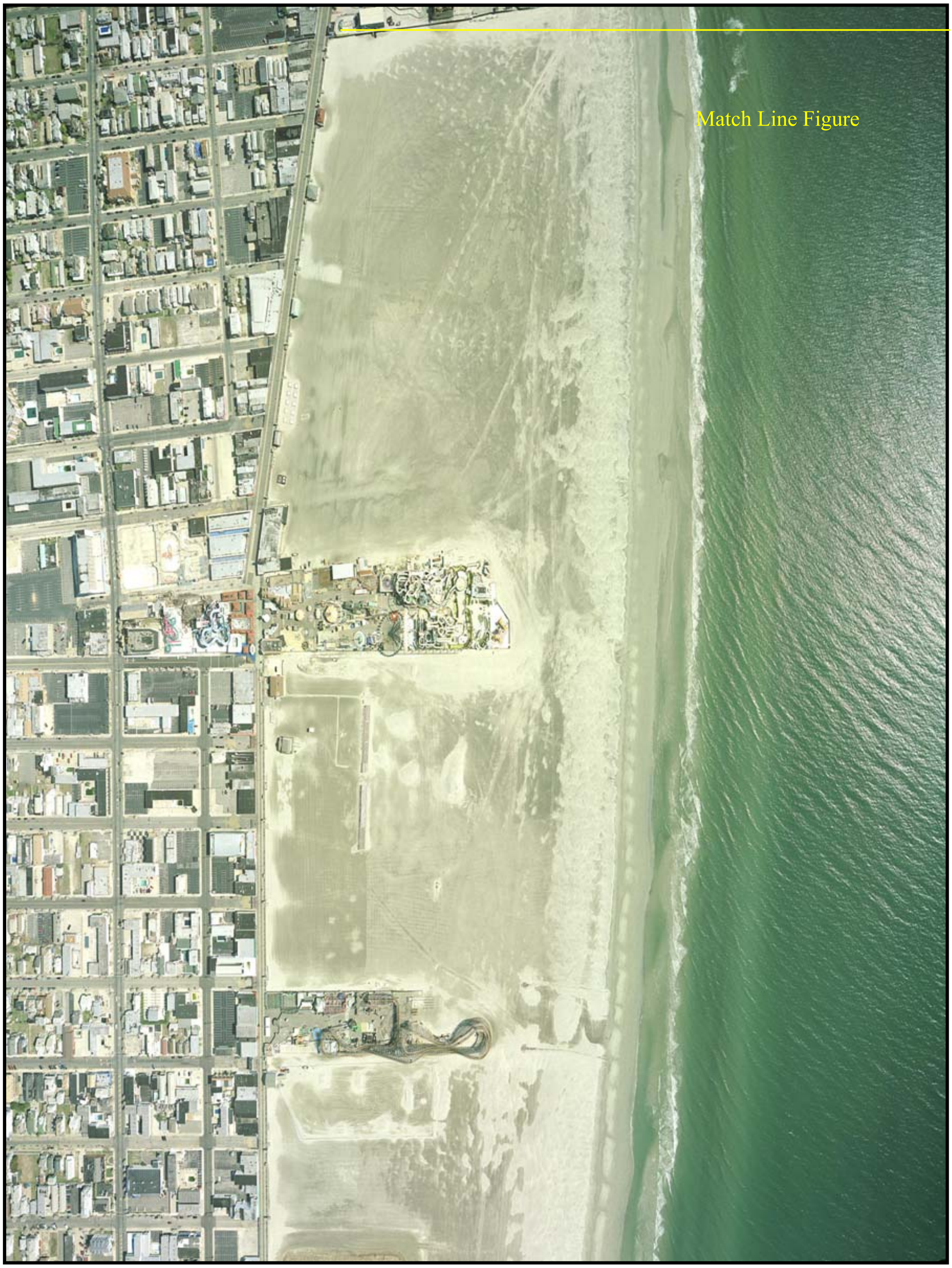


Figure 6 Wildwood and Wildwood Crest

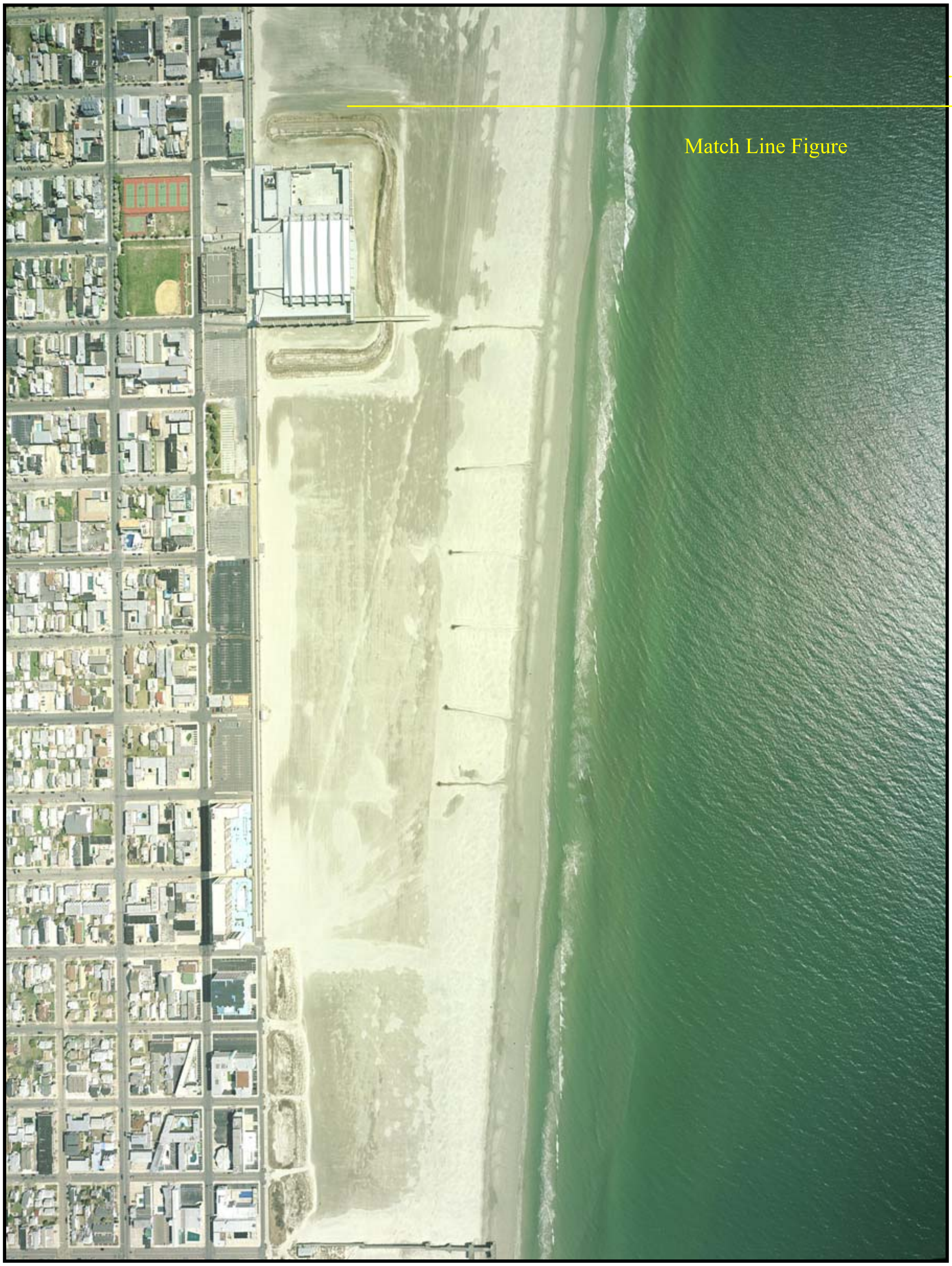


Figure 7 Wildwood and Wildwood Crest (Fishing Pier)

Figure 8 Wildwood Crest

Figure 9 Wildwood Crest Diamond Beach

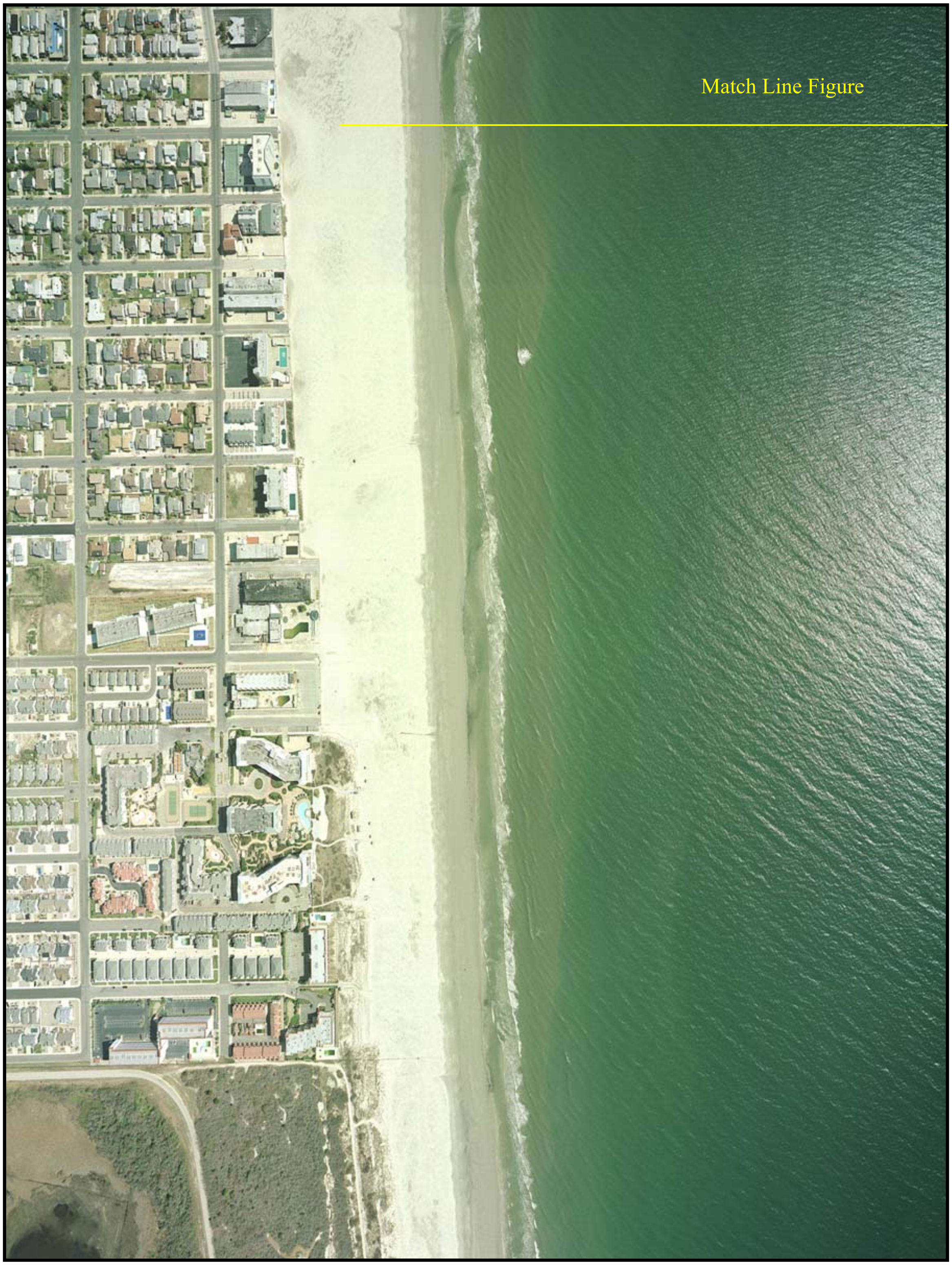
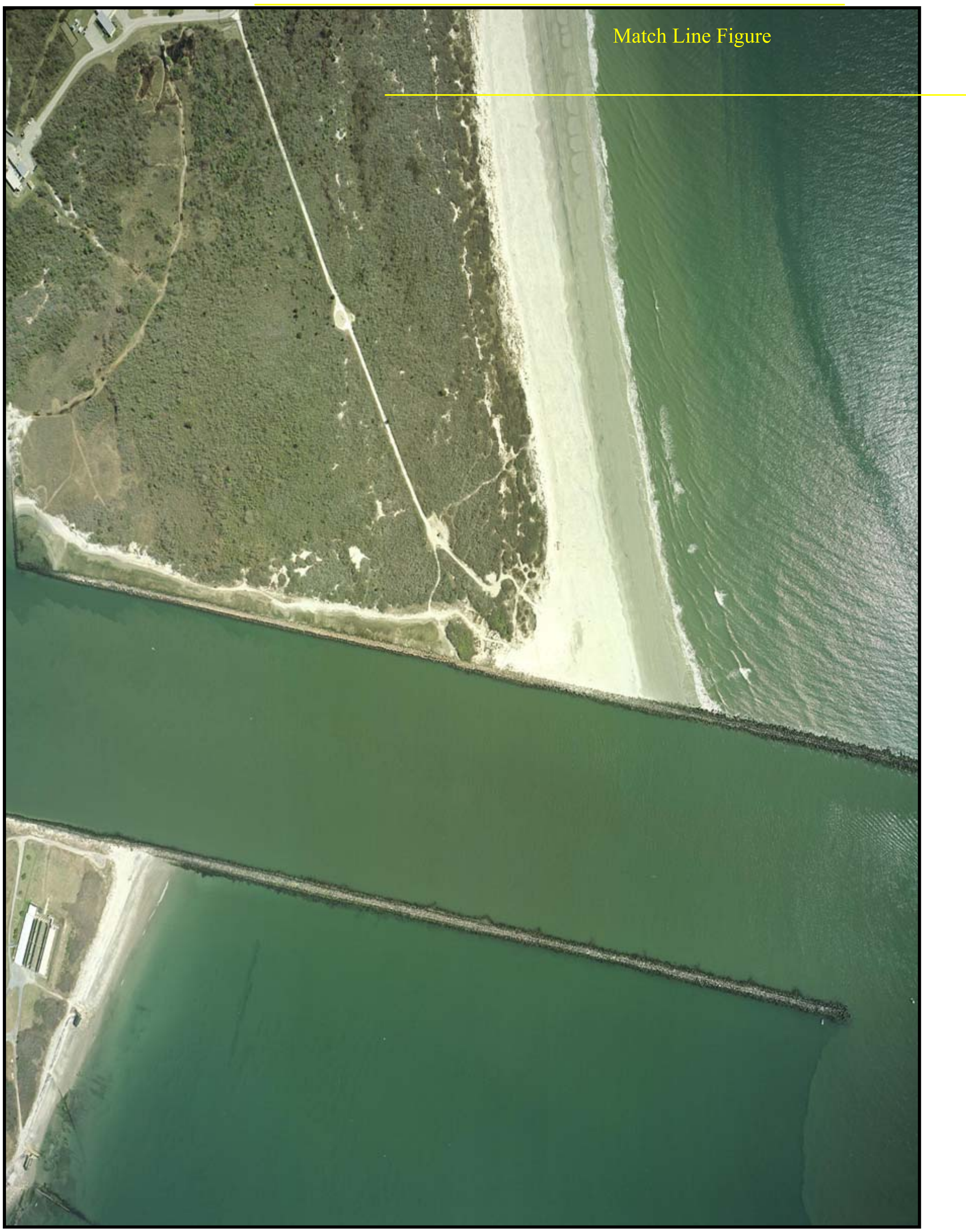


Figure 10 Lower Township. *This area contains the US Fish and Wildlife Property.*

Figure 11 Cape May Inlet *This area contains the USFW Property.*



The study area is located near multiple tourist thoroughfares. It is approximately 3 miles from the Garden State Parkway, 6 miles from the Cape May Ferry, 30 miles from the Atlantic City Expressway, 60 miles from the Delaware Memorial Bridge, Interstate 295 and Interstate 95 and approximately 70-75 miles from the Ben Franklin and Walt Whitman Bridges in Philadelphia.

The problems within the study area are illustrated in **Figure 12- 19** at the end of this section. **Figure 12** shows the historic extent of Stone Harbor Point within Hereford Inlet. This point goes through cycles of erosion and accretion that are thought to contribute to the sand deposition cycle in the study area. **Figure 14** and **15** show the rapid erosion of the shoreline in North Wildwood between 1991 and 2004. **Figure 16** and **17** show the clogged outfalls in Wildwood as a result of the excess sand at the southern portion of the island. **Figure 18** and **19** show the Wildwood Crest Fishing Pier reaching the ocean in the 1970's, and eventually consumed by sand in 2003.

1.5 The non –Federal Sponsor

The non-Federal sponsor for this study is the New Jersey Department of Environmental Protection (NJDEP). The agent for the NJDEP is the Bureau of Coastal Engineering (BCE), within the NJDEP. The BCE is under the Office of Engineering and Construction which is within the Natural and Historic Resources Department. The NJDEP, through the BCE, administers the New Jersey Shore Protection Program in order to preserve, protect and maintain coastal communities within the state of NJ. They often partner with the Philadelphia and New York Districts of the Corp of Engineers on beach nourishment projects and studies with their Shore Protection Program funds.

New Jersey's Shore Protection Program was created to provide for the protection of life and property along the 127 mile ocean coast of New Jersey and the 83 miles along the coast of Delaware Bay and Raritan Bay, and to preserve the vital coastal resources of New Jersey and maintain safe and navigable waterways. It was created after a series of severe storms hit the coast of New Jersey in the early 1990's. Historically, the State had tasked the DEP to repair and construct all necessary structures for shore protection in the early 1940s under N.J.S.A. 12:6A-1, based on yearly appropriations.

After the Halloween Storm of 1991 devastated New Jersey's shoreline, $25,000,000 was appropriated as an amendment to the State's Economic Recovery Fund for Shore Protection. Soon after, the January 1992 storm struck, overwhelming the State's fiscal resources and prompting a Presidential Disaster declaration.

The 1991 and 1992 storms prompted a Governor's Shore Protection Summit in February of 1992. As a result of the storms the Shore Protection and Tourism Act of 1992 was passed which created the first stable source of annual funding for shore protection of $15,000,000 a year. The current funding amount for coastal shore protection projects within the state is $25,000,000 a year.

The Bureau of Coastal Engineering is responsible for administering beach nourishment, shore protection and coastal dredging throughout the state with the Shore Protection and Tourism act funding. The Bureau is also responsible for conducting post storm surveys, damage assessments and emergency repairs from coastal storms impacting New Jersey.

The Bureau also contracts with two local institutions within New Jersey for data collection and consultation on coastal issues. The Richard Stockton College of New Jersey, Coastal Research Center, directed by Dr. Stew Farrell, publishes a yearly report on the New Jersey Beaches through marine surveying and also provides consultation and design work for beach nourishment projects. The Stevens Institute of Technology, Davidson Laboratory of Marine Hydrodynamics and Coastal Engineering also provide expertise in the fields of shore protection and engineering. The Davidson Laboratory is located in Hoboken, New Jersey and the Coastal Research Center is located in Pomona, New Jersey.

1.6 Prior Studies, Reports, Projects -Federal

Studies

No. 331, 65th Congress, 1st Session, Hereford Inlet, Letter from the Secretary of War, August 11, 1917 . On August 10, 1917 H.D. No 331, the 65th Congress of the United States, 1st Session, a report was submitted by the Chief of Engineers to the War Department on the preliminary examination of Hereford Inlet in compliance with the River and Harbor act approved on July 26, 1916. Based on testimony from local fishermen, commercial vessels and merchants, a maintenance dredging schedule was desired in order to maintain flow and volume of water for the fishing industry at Hereford Inlet and Anglesea in North Wildwood.

This report discussed the improvement of Hereford Inlet from 3' deep on the bar at the inlet to 8 or 9' deep at mean low water. The District Engineer stated that the amount of business dependent upon the inlet is large and the cost of giving relief comparatively small and he believes that the locality is worthy of improvement by the Federal government. The Division Engineer was not in concurrence and believed that the cost of periodic restoration of the channel would be great compared with the first cost, and he was unable to concur with the District Engineer that Hereford Inlet should be improved. W.M. Black, Brigadier General, concurred with the Division Engineer that improvement by the United States of Hereford Inlet, Cape May County N.J., was not advisable.

Beach erosion Control Report on Cooperative Study of the New Jersey Coast, Barnegat Inlet to Delaware Bay Entrance to the Cape May Canal, December 30, 1957. The purpose of this study was to develop a comprehensive and unified plan to restore adequate protective beaches, to provide recreational beaches and a program for providing continued stability to the shores within the study area.

The recommended improvements included a 1,000' timber and stone bulkhead at an elevation of 10' above MLW from the north end of the existing bulkhead to Pine Avenue, and a second bulkhead along Pine Avenue to New York Avenue. The plan for North Wildwood consisted of a beach fill from 16th Avenue to 26th Avenue. It also recommended placing beach fill to provide storm protection with a 50' wide berm at an elevation of 10' above MLW having a slope of 1 on 30.

The 1957 study concluded that the improvements recommended at; Brigantine, Sea Isle City, Townsends Inlet, Avalon and the south side of Hereford Inlet are found not to be economically justified since the cost of providing the improvements would be in excess of the benefits that are reasonably assured. However, it was determined that improvements to North Wildwood would be justified.

Interim Report on Hereford Inlet to the Delaware Bay Entrance of Cape May Canal, Department Of the Army, Philadelphia District, 1972. In July of 1972 The Study of New Jersey Coastal Inlets and Beaches, Interim Report on Hereford Inlet to the Delaware Bay Entrance of the Cape May Canal was published by the Philadelphia District of the Corps of Engineers. This report recommended improvements to the Hereford Inlet area as well as the beaches from Hereford Inlet to the entrance of Delaware Bay. The report recommended a jetty on the north and south side of Hereford Inlet, a breakwater on the easterly side of Cape May Inlet and provisions for bypassing material collected at the up-drift side of each inlet, a navigation channel 300' wide and 12 ft deep at Hereford Inlet, a bulkhead along the inlet frontage at North Wildwood, dikes at Cape May Point, a beach fill and dune fill with groins stabilized with dune-grass and sand fencing. No such project was constructed in the Hereford Inlet to Cape May Inlet area.

New Jersey Coastal Inlets and Beaches Hereford Inlet to Delaware Bay Entrance to Cape May Canal, Assistant Secretary of the Army, September 29, 1976. In September of 1976 The New Jersey Coastal Inlets and Beaches, Hereford Inlet to Delaware Bay Entrance to Cape May Canal, Communication from the Assistant Secretary of the Army (Civil Works) was submitted to congress. This letter from the Chief of Engineers found that the most suitable plan for correcting the problems would serve the purpose of; beach erosion control, navigation and storm protection. That plan would include jetties on both sides of Hereford Inlet, a breakwater on the easterly side of Cape May Inlet and provisions for bypassing material collected at the up-drift side of each inlet, a navigation channel 300' wide and 12' deep at Hereford Inlet, a bulkhead along the inlet frontage of North Wildwood, dikes at Cape May Point, groins, a beach fill 100 to 200' wide at an elevation 10' above MLW from 2nd Avenue in North Wildwood to Cape May Inlet, dunes with top widths of 25' at an elevation of 15' above MLW, construction of 2,700' of backfill along the inlet frontage of North Wildwood, construction of four groins along the inlet frontage of North Wildwood, maintenance of the groins and periodic nourishment of the beaches and maintenance of the dunes as required to maintain the recommended cross section during the life of the project. The project was not constructed.

Beach Creek City of North Wildwood Small Navigation Project, Reconnaissance Report, September 1983. The Beach Creek Small Navigation Project Reconnaissance Report was written in September of 1983 under authority of Section 107 of The River and Harbor Act of 1960. Beach Creek is a small navigation channel behind the Anglesea section of North Wildwood. The purpose of the study was to determine; 1- a means to improving and maintaining navigable access in Beach Creek; 2- the economic feasibility of Federal participation in the project under Section 107; and 3- the need and justification for a more detailed investigation. Based on the reconnaissance effort for Beach Creek it was not considered eligible under the authority of Section 107 of the River and Harbor Act of 1960. The District Engineer recommended that the reconnaissance be approved, but further recommended that no detailed studies of the navigation problem in Beach Creek in the City of North Wildwood be undertaken at that time.

A Study of Sand Bypassing Options at Cape May Inlet, New Jersey, Philadelphia District, June 1987. In 1987 the Philadelphia District conducted a study of sand by-passing options at Cape May Inlet New Jersey. The project recommended improvements for beach fill, two new groins, maintenance of the two new and seven existing groins, periodic nourishment obtained from a deposition basin located on the northeast side of the inlet and a weir breakwater at Cape May Inlet. The total estimated cost was $18,400,000 million (October 1986). The project was not constructed.

Engineering Manual 1110-2-1616 January 31, 1991. This Engineering .Manual discussed two options for bypassing sand across Cape May Inlet based on the findings of the 1987 report discussed above. It was meant to serve as a short example of the coastal processes and engineering analysis needed for a bypassing project.

Summary on Three Conceptual Designs and Cost Estimates for Bypassing Measures at Cape May Inlet, New Jersey, Philadelphia District, 2004. As part of the National Regional Sediment Management Program the US Army Corps of Engineers investigated 3 options for sand bypassing measures across Cape May Inlet, NJ. Alternative 1 was a fixed bypass plant, Alternative 2 was a floating dredge plant using the Cape May Inlet fillet, and Alternative 3 was a floating dredge plant using the City of Wildwood Beaches as a borrow area. The project was not constructed.

The New Jersey Shore Protection Study, 1988. This study investigated shoreline protection and water quality problems which exist along New Jersey's entire coast. Coastal processes and mechanisms occurring in the coastal zone which result in the movement of water, wind and littoral materials were examined to determine how to best alleviate the problems of erosion and property loss. Although it was demonstrated that existing numerical data was insufficient to provide long term solutions, the study suggested a future study of the near shore coastal processes. This feasibility report, along with many others including; Barnegat to Little Egg Inlet, Brigantine Inlet to Little Egg (Absecon Island and Brigantine Island), Townsends Inlet to Cape May Inlet, etc… were drafted under this Authority. The previously mentioned studies recommended projects that are currently in various stages of construction.

New Jersey Shore Protection Study, Report of Limited Reconnaissance, September 1990. The Limited Reconnaissance Phase of the New Jersey Shore Protection Study was complete in September of 1990. It identified and prioritized those coastal reaches identified within the report which have potential Federal interest based on shore protection and restoration opportunities. The Report of Limited Reconnaissance suggested further studies within the project reach identified as Townsends to Cape May Inlet, which includes the Hereford to Cape May study area.

Post Storm Report, Philadelphia District, December 1992. In November of 1993 The Army Corps of Engineers produced a Post Storm report for the Coastal Storm of 11-15 December 1992 along the Delaware and New Jersey Coast. This report quantified damages caused by the December of 1992 nor'easter. This report identified damages to the Herford to Cape May Inlet area.

Townsend's Inlet to Cape May Inlet Feasibility Study, Philadelphia District, 1998. The Townsend's Inlet to Cape May Inlet Feasibility Study was completed in 1998 and identified the area as in need of federal assistance and economically justifiable for the construction of a shore protection project. This project consists of a beach fill in Avalon and Stone Harbor as well as seawalls at Hereford Inlet and Townsends Inlet.

Public Law 113-2, the Disaster Relief Appropriations Act of 2013 instructed the Corps of Engineers to draft four reports to address the impacts of Hurricane Sandy to both constructed and unconstructed Federal projects and studies within North Atlantic Division of the Corps of Engineers. These reports were titled; The First Interim Report, The Second Interim Report, The Performance Evaluation Report and the Comprehensive Study. The Hereford to Cape May project was included in the Second Interim Report since this report was assigned with identifying previously authorized, but unconstructed projects, and projects currently under study. The Hereford to Cape May project is currently under study in the General Investigations phase of the Federal Feasibility process.

Projects

From 1908 to 1911 the Federal Government constructed the Cape May Inlet jetties to stabilize Cold Spring Inlet. The jetties are + 10' above MLW and extend 4,548' (east jetty) and 4,410' (west jetty) from their base into the ocean and are approximately 850' apart. The navigation project was authorized by Congress in 1907 and modified in 1945 to provide an entrance channel 25' deep at mean low water and 400' wide. The navigation portion is maintained and protected by the two parallel stone jetties and dredged to maintain the authorized depth.

In 1964 the Federal government built 4 groins east of the east jetty at Cape May Inlet. The groins are timber have inner elevations of 10', outer elevations of 5.5' and are approximately 639' in length.

The Hereford Inlet to Delaware Bay Entrance to Cape May Canal project was authorized for Phase I Advanced Engineering and Design in the Water Resources Development Act of 1976. The projects were subsequently reauthorized by Sections 831 and 501 of the Water Resources Development Act (WRDA) of 1986. The projects were included recommendations for jetties, groins, weirs, a beach fill and navigation channels, but were not constructed.

The Townsends Inlet to Cape May Inlet project was authorized for construction in WRDA 1999 and initially contained our current study area of the Wildwoods in the Feasibility analysis, but it was not included in the Authorization. The Townsends project authorization required two seawalls, one at Hereford Inlet and one at Townsends Inlet, a beach fill in Avalon and Stone Harbor consisting of a dune elevation of 14.75' NAVD 88, an 8'berm with a width of 150', and restoration of 116 acres of bayberry and red cedar habitat at Stone Harbor Point. The Avalon Seawall is complete, the Avalon and Stone Harbor beach fill is complete and seawall construction in North Wildwood is complete. The Hereford Inlet to Cape May Inlet area was excluded from the Townsend's to Cape May Feasibility's selected plan. The conditions in the Wildwoods at the time of that study did not warrant a Federal project. Subsequent to the conclusion of that report the conditions in Wildwood, Wildwood Crest and North Wildwood gradually worsened and required Federal and State attention.

1.7 Prior Studies, Reports and Projects -State

Studies

The State of New Jersey has been involved in providing technical and financial assistance to its shore towns for decades. The State officially asked the Department of Environmental Protection (formerly the Department of Conservation and Economic Development) to repair and construct all necessary structures for shore protection and damage prevention in the early 1940s (N.J.S.A. 12:6A-1). An annual appropriation of one million dollars was established and maintained until 1977. Due to the devastation and erosion of the shoreline from frequent storms an additional $30 million was appropriated in 1977. Two major storms during the winter of 1991-1992 prompted the Governor's Shore Protection Summit in February of 1992. As result of this summit the Shore Protection and Tourism Act of 1992 was passed creating the first stable source of funding, equaling $15 million annually to fund New Jersey shore protection projects.

New Jersey Beach Profile Network Report Analysis of Shoreline Changes for reaches 1-15, Raritan Bay to Delaware Bay, The Richard Stockton College of New Jersey, Coastal Research Center, published yearly since 1986**.** The state of New Jersey is in partnership with the Richard Stockton College in order to document shoreline change along the New Jersey coast. The Center provides the NJDEP, Division of Construction and Engineering, a detailed monitoring report on coastal processes along the entire New Jersey coast. The New Jersey Beach Profile Network (NJBPN) Report provides regional information on coastal processes with semiannual visits in the spring and fall for the 127 mile coastline of New Jersey and the Center surveys 113 cross shore beach profiles along the ocean and bay. The data is used to report coastal conditions to the NJDEP. There are 29 survey locations within Cape May County monitored by the Coastal Center, with 4 of those locations located in the Hereford Inlet to Cape May Inlet study area.

Nearshore Ridges and Underlying Upper Pleistocene Sediments on The Inner Continual Shelf, the Dept of Geological Sciences, Rutgers University October 1986. This report cataloged and classified vibracore samples taken along the New Jersey Shoreline.

Recommendations for Inlet Dredge Channel Placement Based on Analysis of Historic Change: Townsends and Hereford Inlets, New Jersey. Dept. of Geological Sciences, Rutgers University, New Brunswick, NJ 08903, December 1987. This report was written to develop conceptual models for geomorphic change for both inlets, develop historic patterns and rates of change, recommend the size and orientation of a dredged channel, and identify sources of beach nourishment material.

New Jersey Shore Protection Master Plan, In 1978, the legislature passed a Beaches and Harbors Bond Act , 1978, c. 157) and instructed the NJDEP to prepare a comprehensive Shore Protection Master Plan in order to reduce the impacts and conflicts between shoreline management and coastal development. .

After the Halloween Storm of 1991 devastated New Jersey's shoreline, $15 million was appropriated as an amendment to the States Economic Recovery Fund for Shore Protection. Soon thereafter, the January 1992 storm struck, overwhelming the States fiscal resources and prompting a Presidential Disaster declaration.

The issue of providing stable funding for shore protection at the State level had been raised on several occasions. The two storms during the winter of 1991-92 prompted a Governor's Shore Protection Summit in February of 1992. As a result, the Shore Protection and Tourism Act of 1992 was passed which created the first stable source of finding for shore protection in New Jersey.

The State of New Jersey in conjunction with the Municipality of North Wildwood has participated in two municipal beach fills in North Wildwood as a result of erosion and inundation from storms. The project placed a dune and berm from North Wildwood to the border of Wildwood Crest. Repeated storms and erosion have reduced the footprint and protection capability of these projects.

The NJDEP has participated in several related projects in the study area. The NJDEP built the original Hereford Inlet seawalls in North Wildwood in order to protect homes from storm damage in the neighborhood of Anglesea. The Townsends Inlet to Cape May Inlet feasibility study recommended a more robust wall for this area. These new seawalls replaced the existing state built structures.

1.8 Prior Studies, Reports, Projects- Municipal

Studies

Remington & Vernick and Walberg, Feasibility Study of 5 Options to Eliminate Beach Closures of five Mile Beach in the City of Wildwood, New Jersey, April 2003. The City of Wildwood, with funding assistance from the NJDEP, commissioned a study to examine methods to alleviate the problem of municipal storm water run-off and the clogged outfalls that prevent storm drainage on the beachfront. The proposal involved five solutions to the storm water problem that included; a pump station on the beach, two pump stations, extending the outfalls, beach grading and dune building and a no action plan. The plans did not involve the neighboring municipalities and the problems they had with erosion and storm damage. The estimate by Remington & Vernick places the cost of rerouting the municipal storm water system between $7,000,000-$12,000,000, not including operation and maintenance.

Coastal Processes Relevant to the Proposed Wildwood Convention Center Site, Wildwood NJ. The report detailed the shoreline processes of Five Mile Beach from the 1920's to the present in order to determine the suitability for construction of the Greater Wildwoods Convention Center on the seaward side of the boardwalk.

Cape May County Cooperative Coastal Monitoring Program , Cape May Department of Health, yearly. This report identified water quality hazards along the coastline. It identifies the coastal bathing areas along the ocean front and bay front within Cape May County that have elevated levels of fecal coliform bacteria. The Cape May County Health Department may close a recreational bathing area at any time to protect public welfare in the event of high fecal coliform concentrations.

Petrella, Ralph, JR. City Engineer, Cause of High Fecal Coliform Bacteria Being Discharged from the City of Wildwood Storm Sewer System. This report addressed the high frequency of beach closures and associated water resource problems in the City of Wildwood. The report determined that the impounded storm-water eventually discharged at rates higher than if water were free flowing continuously, and resulted in elevated levels of bacteria.

Projects

The City of North Wildwood has participated in three beach fills with the State of New Jersey and the Federal Emergency Management Agency to replenish the northern portion of the island with sand from Hereford Inlet. The original Project took place in 2009, was supplemented in 2010 and again after Hurricane Sandy in 2012. The original project placed over 1,400,000 cubic yards of sand on the shoreline in 2009 in the form of a dune and berm. The dune had an elevation of +14.75' NAVD 88 and the berm was approximately +6.75 NAVD 88. The original project extended from 2nd avenue and JFK Boulevard to approximately 26th street. The 2010 project was paid for by FEMA as part of their Disaster Relief Fund and placed approximately 499,000 cubic yards on the beach. After hurricane Sandy the City of North Wildwood placed 155,000 cubic yards of sand from 2nd avenue to 25th avenue to mitigate for erosion during the storm. The beach fill from 2nd Avenue to 26th had eroded significantly at the writing of this report.

The City of Wildwood Crest and North Wildwood participated in a sand back-passing operation in 2012 that moved 96,000 cubic yards of sand from surplus areas in Wildwood Crest to North Wildwood. A table listing the years and locations of these projects in included in Without Project conditions section of this report.

1.9 Project Area Photos

Figure 12 North Wildwood, Hereford Inlet and Stone Harbor Point
Figure 12 shows the large sand spit that extends into Hereford Inlet from Stone Harbor Point in the background and the Anglesea section of North Wildwood in the foreground.

Figure 13 North Wildwood (date unknown)

Figure 14 North Wildwood 1991

Figure 14 and 15 show the erosion of the wide beaches in North Wildwood from 1991 to 2004.

Figure 15 North Wildwood 2004

Figure 16 Clogged Outfall in Wildwood

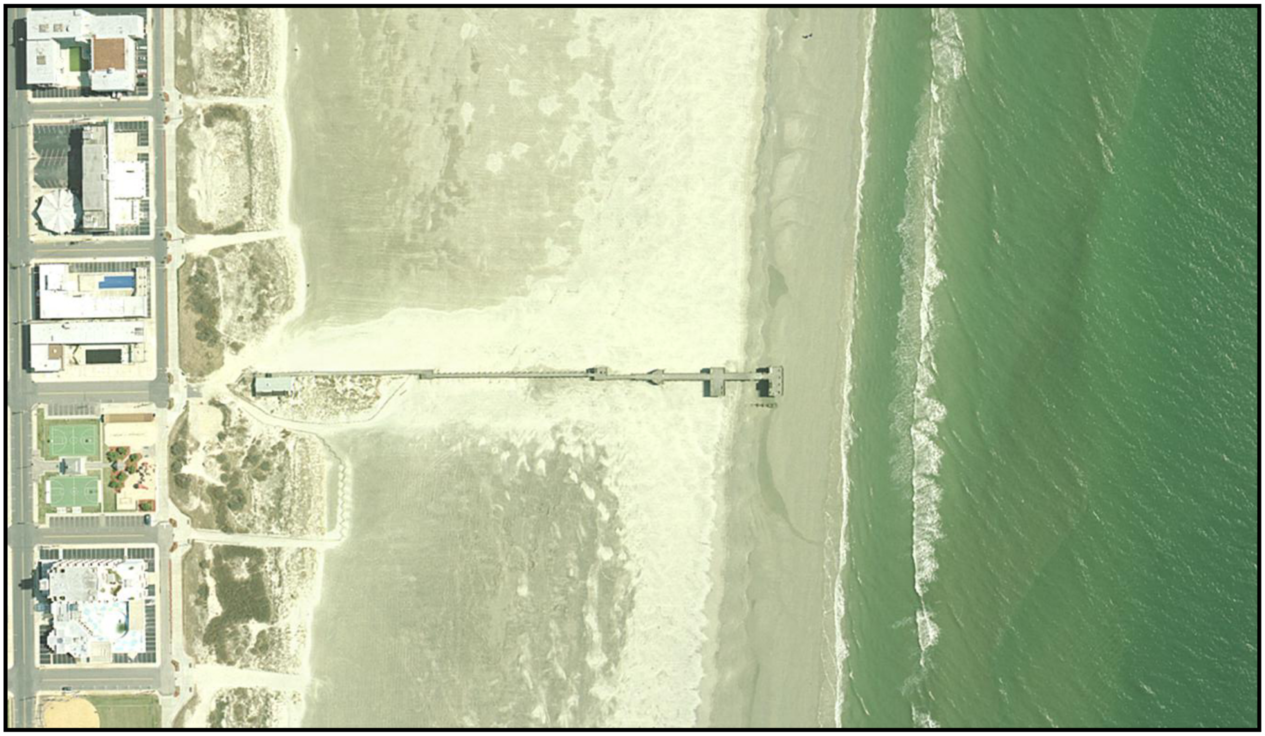
Figure 16 and 17 show the accumulation of sand and its impacts in Wildwood as a result of the sand eroded from North Wildwood .

Figure 17 Clogged Outfall in Wildwood, looking seaward

Figure 18 Wildwood Crest Fishing Pier, 1990s

Figures 18 and 19 show the accumulation of sand over time at the Wildwood Crest fishing pier.

Figure 19 Wildwood Crest Fishing Pier, 2003



2.0 Existing Conditions

2.1.1 Socioeconomic Resources

North Wildwood, Wildwood, and Wildwood Crest are three of the four municipalities contained within the barrier island located between the Hereford and Cape May Inlets. These three communities along with sound-side West Wildwood form a shore region known as the *Wildwoods' Five Mile Island,* or simply the *Wildwoods.* Benefit categories to be evaluated include reduction in storm, wave, and inundation damages, and increased recreation value. The basic underlying assumptions used an FY2014 discount rate of 3-½%, June 2007 price level, a 50-year period of analysis, and a base year of 2016. Project benefits for the tentatively selected plan (TSP) were updated to a March 2014 price level for comparison with the selected plan cost estimate.

2.1.2 Population and Land Use

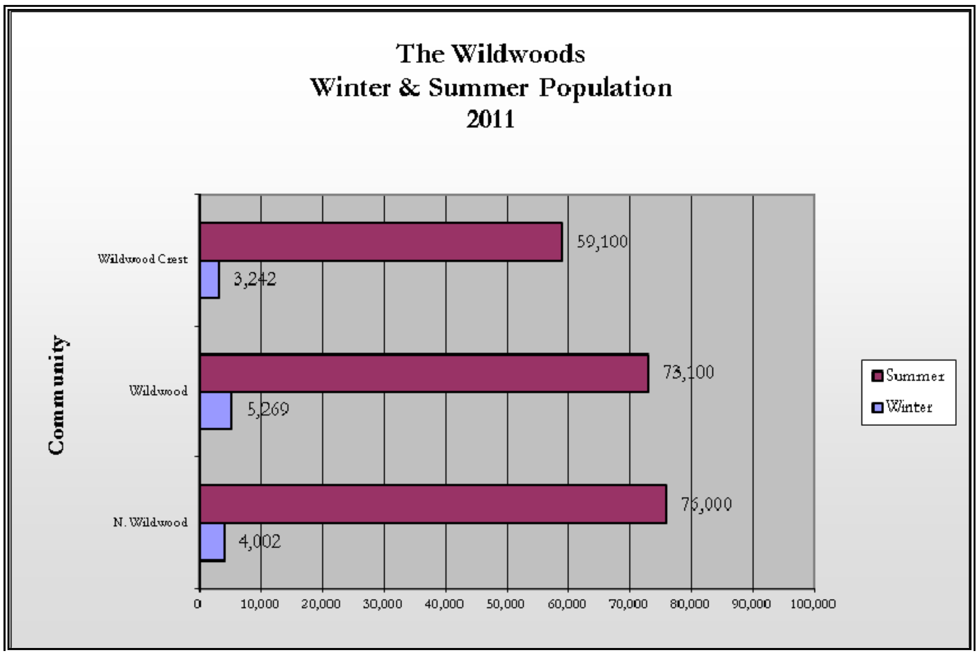
The study area is located on a barrier island community in Cape May County, New Jersey along the Atlantic Ocean. Within USACE- Philadelphia District boundaries, Cape May County is one of the four counties including Atlantic, Ocean, and Monmouth counties, located along the New Jersey coast. Cape May County is surrounded by the Atlantic Ocean on the east and south, borders the Delaware Bay on the west, and Atlantic County on the north. The county covers 454 square miles, with almost 60% consisting of usable land area and the remainder being marshes and flood plains. Two main transportation arteries in the county are the Garden State Parkway and Route 9. Other major nearby roads which allow residents and visitors to access the area include Routes 47 and 50, the Black and White Horse Pikes, and the Atlantic City Expressway. North Wildwood, Wildwood, and Wildwood Crest with a combined land area of 4.1 square miles cover approximately five linear miles along the coast. The three municipalities ranked six, seven, and eight respectively on the list of the ten largest municipalities in Cape May County, Wildwood was the most densely populated of the three communities with 4,096 people per square mile (U.S. Census, 2010) **Table 1**. More vacationers travel to Wildwood and North Wildwood than to Wildwood Crest as indicated by the estimated summer population in **Figure 20**.

The year-round population of many summer destination communities has increased as baby-boomers started to retire and housing development increased. The Wildwoods experienced substantial growth in population throughout most of the 20th century. The steepest increase in population for Wildwood occurred in the decade between 1920 and 1930, while the steepest increase for North Wildwood occurred between 1940 and 1950 and occurred for two decades in Wildwood Crest between 1940 and 1960.

Table 1 Year Round Population in the Study Area (2010)

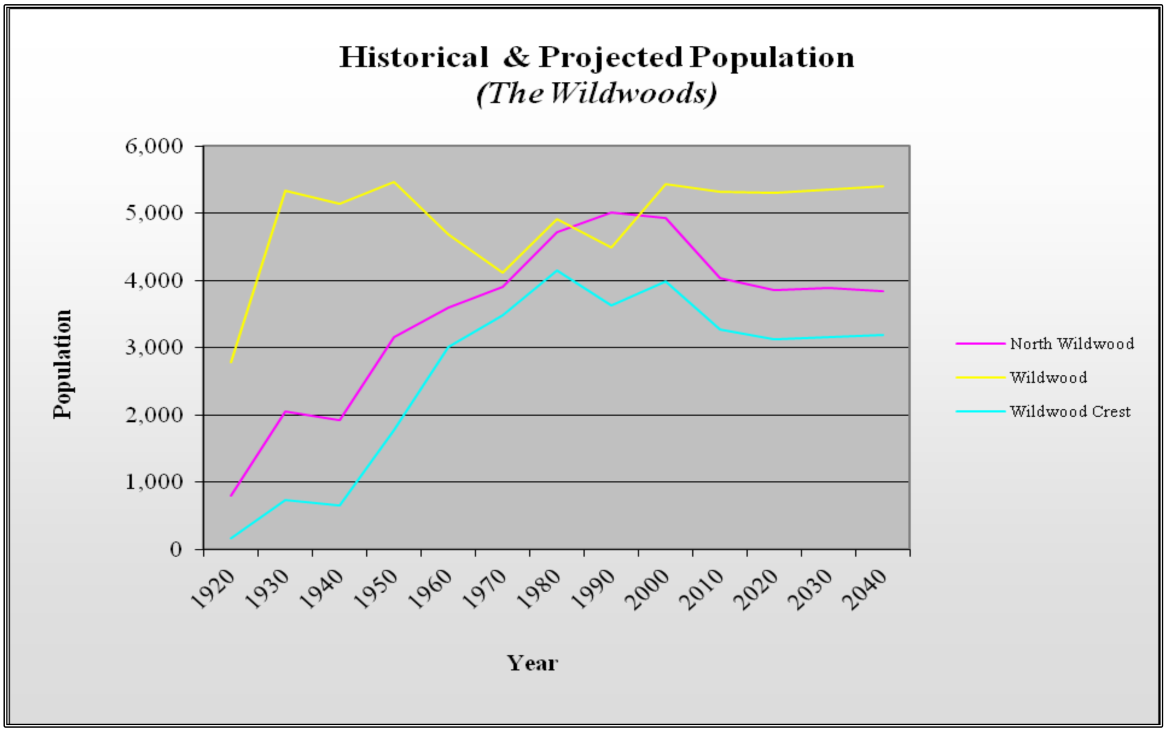
Municipality	Square Miles	Population	Persons Per Square Mile
North Wildwood	1.7	4,041	2,377
Wildwood	1.3	5,325	4,096
Wildwood Crest	1.1	3,270	2,973
The Wildwoods	*4.1*	*12,636*	*9,446*

Figure 20 Winter and Summer Population



Wildwood experienced a sharp decline in population over the period from 1950 to1970, population soared back up through 1980, dipped again through 1990 and spiked through 2000 nearly to the level of its peak population in the 1950s. Wildwood and Wildwood Crest are two communities that had increased year-round population for the ten years between 1990 and 2000. During this time period North Wildwood population growth remained relatively flat. Year-round population decreased slightly in all three municipalities during the initial years of the 21st century as seen in **Figure 21**.

Figure 21 Historic Population



2.1.3 Employment and Income

The tourism industry is one of the most important industries in the State of New Jersey and in Cape May County. Tourism generates 32,000 jobs, or one out of every three jobs in the county (Cape May County Planning Department). The economy of Cape May County and the adjacent coastal counties rely to some extent on a transient workforce to supply the tourism industry employees, especially in the summer. Businesses in coastal communities have supplemented their workforce with workers from overseas during the busy summer months. The importance of seasonal employment in Cape May County contributes to its higher unemployment rate when compared to that of the entire state as shown in **Table 2.** The data show lower unemployment rates in each successive northern coastal county. Employers within the service industry and the public sector account for many of the jobs in the county. Morey's Amusement Pier, the City of Wildwood, and the City of North Wildwood are among the top employers in Cape May County. The recent economic downturn in the financial services and retail industries has also negatively impacted employment in the region. Those industries have recently posted job losses in New Jersey.

The higher (2012) unemployment rate by county shown in **Table 2** and **Table 3** is due to the areas reliance on seasonal employment. The unemployment data updated for the most recent year shows the continued affect of the recession and possibly impacts from the devastating super-storm in 2012.The regional coastal economy has grown a healthy construction industry with new development, "tear downs" and renovations - a trend in which older structures are purchased, healthcare and educational services remain strong.

Table 2 Employment Comparison (2012)

	STATE	COASTAL COUNTY			
	New Jersey	Cape May	Atlantic	Ocean	Monmouth
Unemployment Rate	9.5	13.4	13.5	10.3	8.9
Unemployed	435,000	7,793	18,377	27,944	29,904
Employed	4,158,000	50,397	136,125	244,125	304,904

Table 3 Study Area Employment Comparison (2012)

	North Wildwood	Wildwood	Wildwood Crest
Unemployment Rate	21.6	30.6	24.6
Unemployed	618	1,036	598
Employed	2,238	2,351	1,829

Per capita income in both the State of New Jersey and Cape May County exceeds that of the United States. New Jersey and Cape May County's per capita incomes are about 25% and 12% more, respectively, than the 2010 U.S. per capita income (**Table 4)**. Per capita income in Wildwood Crest is about 10% more than the U.S. while that of North Wildwood and Wildwood falls below the national level. In 1999, at the time the study commenced, Wildwood per capita income was only half of state per capita income. Per capita income in Wildwood nearly doubled and increased at a faster rate than that of the state over the first decade of this century. Median household income and median home value was also lower in Wildwood when compared to the nation, the state and the other communities in *the Wildwoods*. Lower median home values may have existed in Wildwood than in the other summer destination communities because residents may pay a premium to live in areas away from high traffic volume and commercial activity.

Table 4 Income Comparison (2010)

Municipality	Per Capita	Median Household	Median Home Value
United States	$27,334	$51,914	$188,400
New Jersey	34,858	69,811	357,000
Cape May County	33,571	54,292	337,300
North Wildwood	$31,748	$45,041	$384,900
Wildwood	25,118	32,783	288,000
Wildwood Crest	40,032	46,111	398,400

2.1.4 Regional Economy and Development

Tourism, referencing 2006 data, was the top industry in Cape May County with over $4.8 billion (Cape May County Planning Department) in revenues generated from accommodations, food, retail, entertainment, and transportation. Cape May County is second only to Atlantic County in tourism dollars. Annual tourism revenue of Cape May and Atlantic Counties is more than three times the revenue produced by Ocean and Monmouth Counties. The popularity of the Jersey shore draws many visitors from neighboring states as well as from inland areas within the state. The seashore proximity to major population centers is ideal for attracting visitors especially with high fuel prices. A large percentage of tourists are repeat visitors who return each summer. Cape May County welcomes approximately 19 million visitors annually. More than three quarters of visitors come from outside New Jersey and the weakened value of the dollar is expected to attract more international visitors to the county as well.

The construction industry has also been important to the regional economy. Construction within some commercial sectors such as healthcare and education facilities has maintained a steady pace. However, residential construction has decreased significantly nationally and in the region since 2006. As shown in **Table 5**, the number of proposed residential site plans plummeted by more than half from 2005 to 2006 and dropped more sharply in 2007. The greatest number of dwellings proposed during the ten year period from 2003 to 2012 was in the City of Wildwood. The Wildwoods has a relatively limited area for new development and most of the new development occurs in the form of renovations and/or replacements. Historically, cyclical declines in housing starts have experienced several years of reductions. Currently, the slow but steady upturn in the U.S. economy following the deep 2008-2009 recession provides encouragement for housing starts going forward.

Table 5 Proposed Residential Site Plans

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total #
North Wildwood	245	414	356	70	4	5	0	0	2	26	1,122
Wildwood	840	441	1074	732	7	37	0	10	3	147	3,291
Wildwood Crest	117	607	345	12	0	0	0	0	0	0	1,081
The Wildwoods	1,202	1,462	1,775	814	11	42	0	10	5	173	5,494

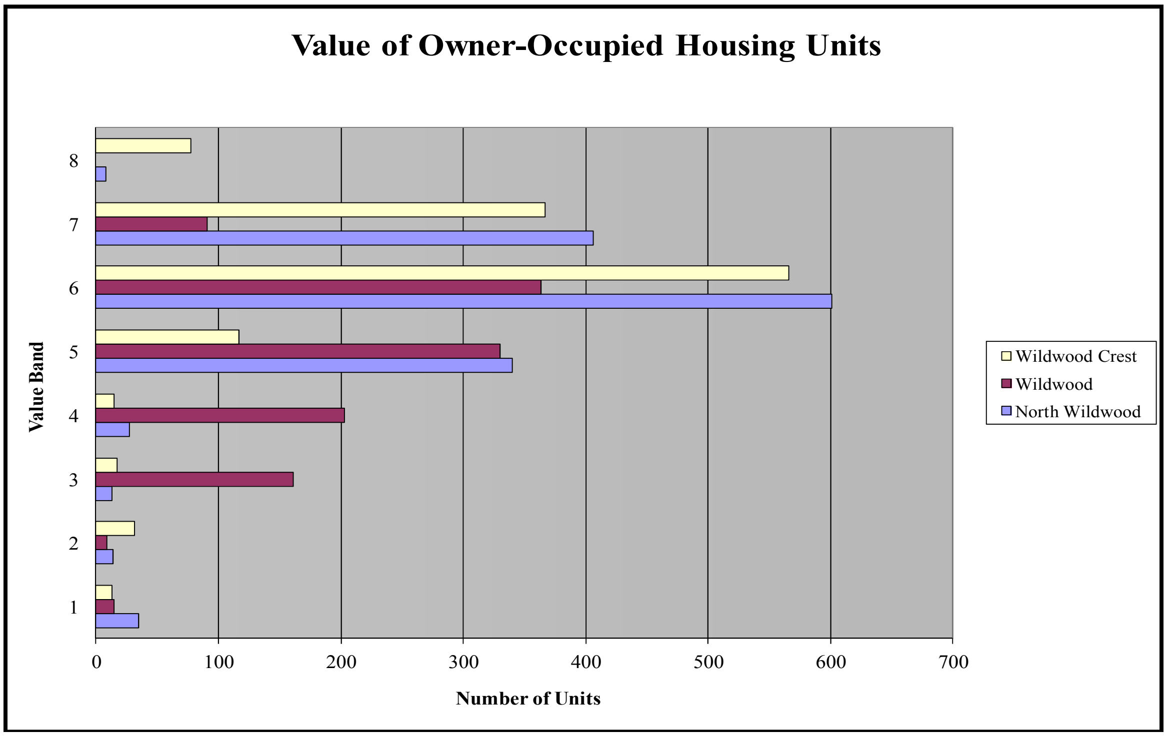
The number of housing units by usage category for the three coastal cities of *the Wildwoods* is displayed in **Table 6**. In 2010, seasonal and/or rental housing units represent a large percentage of housing units in the coastal counties of New Jersey. Almost half of the seasonal and/or rental properties in New Jersey are located in Cape May County and 47% of dwellings in the county are vacation homes. Consistent with other summer destination communities, the majority of housing units in *the Wildwoods* are vacant and categorized as seasonal, recreational, and occasional use units. Therefore, condominiums, townhouses, and vacation homes dominate the housing stock. **Figure 22** shows the *Value of Owner-Occupied Housing Units (2000)*, shows a concentration of more affordable housing located in Wildwood. According to data from the 2008-2012 American Community Survey (ACS) estimates, none of the housing units in Wildwood were valued at or above one million dollars. One third of the owner-occupied units in the City of Wildwood were valued below $200,000. Conversely, approximately 6% of the homes were valued at less than $200,000 in either North Wildwood or Wildwood Crest. House market values skyrocketed for the first five or six years of the new century and have only recently declined slightly in shore communities.

Table 6 Housing Units by Usage Category (2010)

	North Wildwood		Wildwood		Wildwood Crest	
Usage Category	**Housing Units**	**Percentage**	**Housing Units**	**Percentage**	**Housing Units**	**Percentage**
Occupied	**2,047**	**23.2%**	**2,251**	**32.9%**	**1,532**	**27.5%**
Owner	1,282	14.5%	798	11.7%	1,011	18.2%
Renter	765	8.7%	1,453	21.2%	521	9.4%
Vacant	**6,793**	**76.8%**	**4,592**	**67.1%**	**4,037**	**72.5%**
For Rent	504	5.7%	1,138	16.6%	307	5.5%
For sale only	91	1.0%	188	2.7%	130	2.3%
Rented or sold, not occupied	19	0.2%	35	0.5%	34	0.6%
For seasonal, recreational or occasional use	6,116	69.2%	3,035	44.4%	3,468	62.3%
Other vacant	63	0.7%	196	2.9%	98	1.8%
TOTAL	**8,840**	**100.0%**	**6,843**	**100.0%**	**5,569**	**100.0%**

Highlights in development include the completion of a new $70 million convention center in Wildwood in 2002. Portions of Wildwood have also been designated as an Urban Enterprise Zone (UEZ). This program encourages business investment and job creation through various incentives. Merchandise can be purchased at a reduced sales tax as a benefit to patronizing shops in these special zones. Most new development projects in all three communities cater to the tourism industry and are characterized as hotel/motel or multifamily dwellings such as condominiums as shown in the following listings from 2006 and 2012 data. Another new residential development with almost 70 new units located in Diamond Beach (Lower Township) was under construction during the time of this study. Major development projects are contained in **Table 7**and **Table 8.**

Figure 22 Value of Owner Occupied Housing Units



Value band

1 - Less than $50,000	*5 - $200,000 – 299,999*
2 - $50,000 – 99,999	*6 - $300,000 – 499,999*
3 - $100,000 – 149,999	*7 - $500,000 – 999,999*
4 - $150,000 – 199,999	*8 - $1,000,000 or more*

Table 7 Development Projects in the Wildwoods

Location	Project Name	Dwelling Type	# of Units/Lots
North Wildwood	Champagne Island Resorts	Hotel/Motel	24
North Wildwood Subtotal			*24*
Wildwood	The Riviera	Hotel/Motel	86
Wildwood	The Riviera	Multi Family	288
Wildwood	Martinique Resorts	Multi Family	254
Wildwood	Anchor Beach Condo	Multi Family	30
Wildwood	Petunia, LLC	Multi Family	22
Wildwood	Westgate Village	Multi Family	13
Wildwood Subtotal			*693*
Wildwood Crest	Sanzone Condos	Multi Family	13
Wildwood Crest Subtotal			*13*
The Wildwoods			***789***
Year - 2012			
North Wildwood	Hawaiian Beach Resort	Multi Family	22
Wildwood	Grand Wildwoodian	Multi Family	138
The Wildwoods			***160***

Table 8 Major non-residential Space

Location	Project Name	Description	Square Feet
North Wildwood	Champagne Island Resort	Commercial	16,275
North Wildwood	The Beach House	Commercial	9,442
Wildwood	Anchor Beach Condominium	Commercial	6,000

2.1.5 Cape May County Toll Volumes

Each summer tourists flock to Cape May County's beaches, boardwalks, promenades, and amusement piers for day trips and extended vacations. The county is also a popular birding destination for tourists seeking to catch a glimpse of the migratory birds that stop along the shoreline. A two-mile boardwalk with four amusement piers, water parks, roller coasters, arcade and carnival games, and shopping characterizes Wildwood.   *The Wildwoods* has received many distinctions and positive ratings from publications and organizations as “America’s Best Beaches”, “Top Tourist Town in the Northeast”, and “Best Sports Beach”. Recently, a survey conducted by the New Jersey Marine Sciences Consortium (NJMSC) to determine New Jersey’s top ten beaches ranked Wildwood as the best with approximately 14 percent of the vote. Wildwood won top honor in a field of over 60 beaches from Cape May to Monmouth Counties. Wildwood Crest and North Wildwood ranked second and fourth, respectively. According to the NJMSC, Wildwood Crest was chosen as the best location for a family vacation in a special category of the survey. Many shore communities have increased the number of off-season activities to draw tourists throughout the year. The Wildwoods have marketed this seashore location and garnered attention as an increasingly popular destination for conventioneers. The Wildwood Convention Center which was completed in 2002 has been a catalyst for drawing non-seasonal visitors to Five Mile Island and neighboring summer destination communities. **Table 9** shows double-digit increases in toll volumes in each decade since 1970 in each decade up to 2000 for which round-trip volumes were available.

Table 9 Cape May County Toll Volumes

Month	2000	1990	1980	1970
January	496,754	446,112	228,904	92,442
February	551,867	428,831	204,682	96,736
March	639,809	487,619	255,719	131,512
April	692,249	602,715	299,850	156,233
May	986,735	824,296	521,234	280,945
June	1,228,834	1,137,115	754,290	413,122
July	1,631,363	1,457,586	1,085,620	705,272
August	1,610,985	1,474,358	1,222,330	763,402
September	1,078,875	597,582	616,200	383,952
October	780,884	602,155	349,060	163,288
November	632,448	485,524	285,900	127,515
December	598,975	441,973	267,530	118,150
Total	*10,929,778*	*8,985,866*	*6,091,319*	*3,432,569*
% Change	*22%*	*48%*	*77%*	

2.2 Environmental Resources

2.2.1 Environmental Setting

The study area is located in coastal Cape May County, New Jersey . The area is a 7 mile long barrier island bordered to the north by Hereford Inlet and to the south by Cape May Inlet (*formerly Cold Spring Inlet*). Municipalities Boroughs and Townships on the island include;

North Wildwood, Wildwood, Wildwood Crest , West Wildwood, Diamond Beach, Wildwood Gables and Lower Township. A natural area managed by the US Fish and Wildlife Service (Cape May National Wildlife Refuge) is located at the northern boundary of Cape May Inlet, within Lower Township.

The study area, which has been heavily developed as a residential and recreational area, is characterized by estuarine intertidal emergent wetlands behind a marine intertidal beach/bar. The project area is separated from the mainland by three back bay areas including Grassy Sound, Richardson Sound and Jarvis Sound. These are wide, shallow bays surrounded by marsh islands and thoroughfares connected to Hereford Inlet and Cape May Inlet. Common species of the beach and dune area on the barrier island system include beach grass, sea-rocket, seaside goldenrod, poison ivy, groundsel-tree, and marsh elder.

The back bays are comprised of open water, a low marsh zone, tidal flats, a high marsh zone, and a transition zone. The low marsh zone is typically dominated by salt marsh cordgrass. Tidal flats are areas that are covered with water at high tide and exposed at low tide. They are important areas for algal growth, as producers of fish and wildlife organisms, and as nursery areas for many species of fish, mollusks and other organisms. Dominant species include sea lettuce and eelgrass. The high marsh zone, which is slightly lower in elevation than the transition zone is dominated by salt meadow cordgrass and salt grass. This zone is typically flooded by spring high-tide. Plants typical of the transition zone include both upland and marsh species including marsh elder, groundsel-tree, bayberry, salt grass, sea-blite, glasswort, poison ivy, and common reed.

2.2.2 Air Quality

Through the State Implementation Plan (SIP), the NJDEP Bureau of Air Monitoring, manages and monitors air quality in the state. The goal of the State Implementation Plan is to meet and enforce the primary and secondary national ambient air quality standards for pollutants. Management concerns are focused on any facility or combination of facilities, which emit high concentrations of air pollutants into the atmosphere. Manufacturing facilities, military bases and installations, oil and gas rigs, oil and gas storage or transportation facilities, power plants, deepwater ports, LNG facilities, geothermal facilities, highways, railroads, airports, ports, sewage treatment plants, and desalinization plants are facilities and activities that may cause air quality problems. In New Jersey, there are nine pollutant standards index-reporting regions. The study area falls within the Southern Coastal Region, which covers Cape May County.

The most detailed air monitoring station in the Southern Coastal Region is located in Brigantine. In 2011, the Brigantine station was actively monitoring for Visibility, Ozone, Sulfur Dioxide, Real-time Fine Particulates (2.5 microns or less), Mercury, and Acid Deposition. In 2011, the Air Quality Index Ratings for the Southern Coastal Region were “good” for 323 days, “moderate” for 40 days and “unhealthy for sensitive groups” only 2 days. (NJDEP, 2011).

Cape May County, NJ is classified as a non-attainment area for ozone for 2012. This means that the national primary health standard is not being met for ozone. There are varying degrees of non-attainment in New Jersey, which range from marginal (0.121 – 0.137 ppm) to severe #2 (0.191 – 0.279 ppm). Cape May County was also classified as a “marginal” non-attainment for ozone based on the May 2008 mandated 8-hour standard (USEPA, 2011). Ozone is caused by various photochemical reactions of volatile organic substances (hydrocarbons) with oxides of nitrogen on days with bright sunshine and warm temperatures. Thus ozone is only a potential problem in the late spring, summer, and early fall months (NJDEP, 2005). For ozone specifically, measurements at the Brigantine station exceeded the New Jersey and National Standards for the revised maximum daily 8-hour average primary standard on two occasions with hours above 0.075 ppm (USEPA, 2011).

2.2.3 Natural Forces

Coastal barrier island shorelines experience a number of natural forces, which affect erosion rates and transportation of pollutants to bay areas. These forces may include, but are not limited to: waves, currents (wave-induced and tidal), swells (wind-generated waves), winds, tides and storms.

Circulation patterns originate from physical transfers of water and energy to form currents, resulting in a mixture of several different water sources in the Bay. Bay currents are generated by winds, tidal forces, fluvial flow, and salinity gradients resulting from inputs of sea water, river and ground water.

Waves approach the study area from a northward orientation relative to the shoreline, generating a prevailing southward longshore current that carries with it littoral drift, sedimentation and deposition. Indicators of wave climate are generally height, period and direction. Wave energy can be determined knowing the spectral distribution of these parameters. The average wave height in the study area from the 1980 to 2000 Wave Information Station (WIS) data source are those derived for Station 147 offshore of the Wildwoods and range from 2.3’ in July to 3.9’ in January. The maximum monthly average wave height (Hmo) at Station 147 for the 1980 - 2000 hind cast in the month of January is reported as 19.0’, with an associated peak period of 11 seconds and a peak direction of 71 degrees.

Tidal currents may cause tangible effects on shore stability and water quality. These are generated by tidal driven water level differences between the ocean and back bay areas. The periodic rise and fall of the ocean water elevation adjacent to barrier islands, creates the ebb and flood cycle of tidal currents. The tidal currents at the inlets can facilitate the movement of sediments and pollutants in the coastal zone, particularly as they interact with longshore currents to form the typical morphological features associated with barrier island-tidal inlet zones.

The second class of currents important to coastal shoreline stability is longshore currents. These currents are set up near the breaker zone adjacent to beaches, and are caused by the longshore component of momentum in the waves breaking at an angle relative to the shore alignment. The turbulent force associated with breaking waves cause the suspension of sediments, which can then be transported in a direction parallel to the shore by longshore currents. Along the central portion of the barrier beach, longshore currents are instrumental in the movement of sand to adjacent areas. However, at the ends of the barrier beach where inlets are carved by the tides, sand transport particularly at the shoulder of the inlet is influenced more by tidal currents.

Recently, the importance of large scale currents has been recognized. A near shore current off the coast of New Jersey is being investigated by the University of Delaware, and it is believed that this may be caused by a density gradient. In addition, the ever-changing Gulf Stream, with its far reaching global effects on climate, may also impact local water quality to some extent.

Tides on the New Jersey coast are semi-diurnal. The average tidal period is 12 hours and 25 minutes. The mean tide range for the Atlantic Ocean at Wildwood Crest is reported as 4.31' in the Tide Tables published annually by the National Oceanic and Atmospheric Administration (NOAA). The spring tide range is reported as approximately 4.93'.

Recent climate research by the Intergovernmental Panel on Climate Change (IPCC) predicts continued or accelerated global warming for the 21st Century, and possibly beyond, which will cause a continued or accelerated rise in global mean sea-level. For all USACE Civil Works activities, analysts shall consider what effect changing relative sea-level rates could have on design measures, economic and environmental evaluation, and risk (EC-1165-2-185, dated October 2011). Sea-level rise is considered by many within the scientific and engineering community to be a contributing factor to long-term coastal erosion and the increased potential for coastal inundation. Because of the wide variability of factors that affect sea level rise, predicting trends with any certainty is difficult.

There are a number of scenarios of future sea level rise. Some considerations of the peer reviewed articles presenting current eustatic sea-level rise reflect data based upon tide stations, satellite observation, and historical duration data. Army Corps of Engineers Circular (EC-1165-2-185, dated October 2011) states that, "several peer reviewed publications have proposed maximum estimates of GMSL (global mean sea-level) rise by year 2100. Although the authors use different physical bases to arrive at the estimates, none of them propose a 21st Century GMSL rise greater than 2 meters." Consequently, if the rate of sea level rise increases in response to global warming, beaches could lose sand even more quickly than currently forecasted. Major (destructive) storms could also increase in frequency over the next 50 years, and this may also alter erosion rates.

2.2.4 Temperature and Salinity

Mixing occurs in near shore waters due to the turbulence created from wave energy contacting shallower depths. This mixing becomes less prominent in greater depths where stratification can develop during warm periods. Water temperatures generally fluctuate between seasonal changes. The average temperature range is from 3.7°C (January) to 21.4°C (October). The most pronounced temperature differences are found in the winter and summer months. Warming of coastal waters first becomes apparent near the coast in early spring, and by the end of April thermal stratification may develop. Under conditions of high solar radiation and light winds, the water column becomes more strongly stratified during the months of July to September. The mixed layer may extend to a depth of 12 to 13'. As warming continues, however, the thermocline may be depressed so that the upper layer of warm, mixed water extends to a depth of approximately 40'.

Salinity concentration is chiefly affected by freshwater dilution. Salinity cycles result from the cyclic flow of streams and intrusions of continental slope water from far offshore onto the shelf.

Continental shelf waters are the least affected by freshwater dilution, and have salinity concentrations varying between 30 parts per thousand (ppt) and 35 ppt. Coastal waters are more impacted by freshwater dilution, and may have salinities as low as 27 ppt. Salinity is generally at its maximum at the end of winter. The voluminous discharge of fresh water from the land in spring reduces salinity to its minimum by early summer. Surface salinity increases in autumn when intrusions from offshore more than counterbalance the inflow of river water, and when horizontal mixing becomes more active as horizontal stability is reduced.

Current near-bottom water quality parameters were measured within a sand fillet adjacent to the Cape May Inlet during the benthic sampling effort conducted in August 2005 (Versar, 2007). Surface and bottom water measurements were taken at one sampling site during the sampling period. A Hydrolab Surveyor II was used to measure dissolved oxygen concentration (DO), salinity, conductivity, temperature, and pH. Depth measurements were recorded at each station using the electronic depth meter on the sampling vessel. The results of the sampling showed little difference between the surface and bottom water quality parameters. Temperatures ranged from 23.3°C at the bottom to 25.7 °C at the surface. Dissolved oxygen ranged from 7.1 to 7.4 mg/l from bottom to surface and pH was 7.9 for both measurements. Salinity varied little from surface to bottom ranging from 29.7 to 30.0 ppt. The salinity in this area was slightly lower than full strength seawater, indicating this area may have some estuarine influence from the Delaware Bay. Similar water quality investigations were conducted within the northern project area at Hereford Inlet in September 2000 (Versar 2001). Bottom water quality measurements within the Inlet measured temperature at 21.1°C, pH at 8.0, salinity at 31.3 ppt and dissolved oxygen concentrations at 8.18 mg/l.

2.2.5 Water Quality Parameters

Water quality is generally indicated by measuring levels of the following: nutrients (nitrogen/phosphorus), pathogens, floatable wastes, and toxics. Rainfall is an important parameter for studying water quality; runoff leads to nonpoint source pollution, and fresh water (rainfall, ground water seepage, runoff, and river discharge) can ultimately affect hydrodynamic circulation in the ocean. Enterococci bacteria are used as indicators for pathogens in measuring water quality. According to the Cape May County Health Department (CMCHD), the enterococci portion of the fecal streptococcus group is a valuable indicator for determining the extent of fecal contamination in recreational surface water. When the enterococci level exceeds the state criteria for bathing beaches (i.e. greater than 104 enterococci per 100 ml of water/sample) for two consecutive water samples, taken 24 hours apart, beach closures may result. Many of the high readings recorded in southern New Jersey are temporary fluctuations caused by pollution that washes into the ocean through storm drains after a heavy rainfall. In many cases, the contamination readings return to normal the following day, so no closure is warranted (CMCHD, 2012). The geometric mean recommended by the State for enterococci is 35/100ml (NJDEP, 2000).

Elevated fecal coliform and enterococci counts along the coast of New Jersey may result from failing septic tanks, wastewater treatment plant discharges, combined sewer overflows, storm water drainage, runoff from developed areas, domestic animals, wildlife and sewage discharge from boats.

Nonpoint source pollution (NPS) is the primary pollution of back bay and near-shore coastal waters. NPS is the result of precipitation moving over and through land and carrying pollutants into surface and ground water. NPS generally correlates directly with the intensity of land development and contains nutrients, heavy metals, oil and grease, fecal coliform, and possibly some toxic substances. Since the enactment of the Clean Water Act, much progress has been made in controlling point source discharges of pollutants but due to its very nature, NPS is much more difficult to identify and control. The NJDEP estimates that between 40 and 70% of pollutant loads are due to nonpoint sources (NJDEP, 2008).

One indication of water quality is derived from the annual State of New Jersey Shellfish Growing Water Classification Charts. Waters are classified as approved, seasonal, special restricted or prohibited. In 2012, the near-shore waters from Hereford Inlet to Cape May Inlet were classified as prohibited for shellfish harvesting. The waters in the back bays and inlets immediately adjacent to the study area were for the most part classified as seasonally approved or special restricted areas.

The State of New Jersey's shellfish sampling and assessment program is overseen by the U.S. Food and Drug administration (FDA) and administered through the National Shellfish Sanitation Program (NSSP) to ensure the safe harvest and sale of shellfish within the state. The Bureau of Marine Water Monitoring assigns the shellfish classifications based on its sampling of coliform bacterial concentrations in the water column. The principle components of the sanitary report include: 1) an evaluation of all actual and potential sources of pollution, 2) an evaluation of the hydrography of the area and 3) an assessment of water quality. Emphasis is placed on the sanitary control of shellfish because of the direct relationship between pollution of shellfish growing areas and the transmission of diseases to humans. Waters not in compliance with the NSSP guidelines are closed to shellfish harvesting. This information is then integrated into shellfish classification charts by the Shellfisheries Bureau of NJDEP. New Jersey has been very successful in improving the water quality for shellfish harvesting and for the past 15 years has upgraded more waters than it has downgraded for shellfish harvesting. Current reports indicate that 90% of the State's shellfish waters are harvestable.

NJDEP research indicated that eating certain species of fish and shellfish from some State waters posed unacceptable health risks. As a result, New Jersey has been issuing consumption advisories for fish and shellfish contaminated with toxic chemicals since the 1980s. Since that time, NJDEP has published "statewide" advisories in coastal waters for striped bass, bluefish, American lobster, weakfish and American eel (NJDEP, 2012).

Water quality within the project area is also evaluated under the Cooperative Coastal Water Quality Monitoring Program. This program is designed to provide basic measures of the ecological health of New Jersey's coastal waters. The program measures parameters such as Dissolved Oxygen (DO), salinity, nitrogen, phosphorous, temperature and suspended solids at approximately 270 locations within the state on a quarterly basis. None of the assessment units sampled in 2007 met the criteria for general aquatic life use. This was generally due to a region containing low dissolved oxygen (DO) that forms off the coast between Sandy Hook and the Wildwoods during the summer months. During sampling, almost 50% of assessed coastal units exceeded the applicable DO criteria. It should be noted however, that surface water DO levels have historically met applicable criteria. While the cause of the low DO cell is not known, summer algal bloom die-offs have been implicated as a potential source.

For recreational beaches, the Cape May County Health Department works with NJDEP to monitor bathing beaches for enterococcus. As part of the Cooperative Coastal Monitoring Program (NJDEP – 3, 2012) the Cape May County Health Department monitors swimming beaches for enterococci at approximately 17 locations within the project area (NJDEP-1, 2012). Samples are collected on a weekly basis from May to September. If a sample indicates high bacterial counts, confirmatory re-sampling is conducted. If the counts are still above the bathing beach standard of 104 enterococci per 100 ml of sample, the beach is closed to swimming (NJDEP-2, 2012). The results of the recent monitoring showed that in 2007, ten samples within the project area exceeded the bathing beach standard but did not result in any beach closures. Monitoring results also did not warrant any beach closures (NJDEP, 2008).

The lack of beach closures can be credited, in part, to the fact that since 1988, there has been no discharge from wastewater treatment plants onto the beach as a result of the implementation of a regional wastewater treatment plan. The potential for contamination due to high levels of fecal coliform bacteria still exists however due to the presence of 19 storm water outfalls located along the beach within the project area. Storm water can be contaminated during overland flow during heavy rainfall events and during transport through underground conveyance systems before being discharged onto the beach or into a waterway. The storm water conveyance systems that are near sanitary systems may be contaminated by leaks in the sanitary system, or illegal direct connections. Sewage flows from surcharging sanitary lines through manholes in the street have been observed to enter the storm water catch basins, where it either contaminated the storm water or continued to waterways that normally receive storm water. In Wildwood, the locations of the ends of the ocean outfall pipes carrying this storm water are problematic, ranging 300-500’ from the mean high water line. Most of these outfalls are clogged with sand or have a pool of standing water at their outlet location which could pose a health risk to bathers. The City regularly excavates sand from around the outfalls to keep them clear of sand and allow standing water to drain towards the ocean. The City has been investigating measures to reduce the potential of beach closures due to high fecal coliform bacteria counts associated with storm water discharge from these outfall structures (Remington & Vernick Engineers, 2003).

2.2.6 Wetland Habitats

The study area encompasses both the barrier spit complex and back bay/coastal salt marsh systems. Wetlands are critical environmental components with regard to flood control, helping to preserve water quality, and they play a significant role as wildlife habitats, nursery habitats and refuges for juvenile finfish.

The back bays are comprised of open water, a low marsh zone, tidal flats, a high marsh zone, and a transition zone. The low marsh zone is typically dominated by salt marsh cordgrass (*Spartina alterniflora*). Tidal flats are areas that are covered with water at high tide and exposed at low tide. They are important areas for algal growth, as producers of fish and wildlife organisms, and as nursery areas for many species of fish, mollusks, and other organisms. The dominant algal species include sea lettuce (*Ulva lactuca*) and eelgrass (*Zostera marina*). The high marsh zone, which is slightly lower in elevation than the transition zone, is dominated by salt meadow cordgrass (*Spartina patens*) and salt grass (*Distichlis spicata*). This zone is typically flooded by spring high-tide.

The critical edge, or upland edge of the wetlands, is crucial for the survival of those coastal zone species identified above that rely on this habitat for breeding, food source, cover, and travel corridors. It also acts as a buffer from nonpoint source pollution and activities affecting wildlife. Plants typical of the transition zone include both upland and marsh species including marsh elder (*Iva frutescens*), groundsel-tree (*Baccharis halimifolia*), bayberry (*Myrica spp.*), salt grass (*D. spicata*), sea-blite (*Sueda maritima*), glasswort (*Salicornia spp.*), poison ivy (*Rhus radicans*), and common reed (*Phragmites australis*). As the critical edge disappears and wetlands are fragmented or isolated, the diversity of wildlife that depends on it decreases. As further development of the coastal and back bay shorelines is expected, the continued existence of brackish tidal salt marsh and coastal wetlands (fringe wetlands) is threatened; consequently elimination of habitat and degradation of water quality due to nonpoint sources of pollution may increase.

Wetlands in the vicinity of the project area also provide high quality habitat for a variety of migratory shorebirds. Shorebirds that use the beaches and surrounding estuarine wetlands in the vicinity of the project area include the Federally listed (threatened) piping plover (*Charadrius melodus*) and the red knot (Federal candidate species) (*Calidris canutus rufa*). Other species include the American oystercatcher (*Haematopus palliates*), short-billed dowitcher (*Limnodromus griseus*), black-bellied plover (*Pluvialis squatarola*), semipalmated plover (*Charadrius semipalmatus*), sanderling (*C. alba*), spotted sandpiper (*Actitis macularius*), willet (*Tringa semipalmatus*), and greater yellowlegs (*T. melanoleuca*) (US Fish and Wildlife Service, 2008).

2.2.7 Dune Habitat

Beaches and dunes are linked together to form the "littoral active zone". Even though there is active sand exchange occurring between them, the two systems are quite distinct. The beach/surf zone being a marine, wave-driven system, and the dune field a primarily wind-driven terrestrial ecosystem. Coastal dune fauna are generally not indigenous but display high diversity, while the floral species are typically unique to the area with moderate diversity.

Although typical beach dunes and the habitats associated with them are almost non-existent within Cape May County, many elements of natural beach dune flora and fauna are still present within portions of Wildwood Crest and the Cape May Wildlife Refuge (Refuge). The following discussion on beach dunes mainly pertains to healthy, undisturbed beach and dune areas, however, some of the dune flora and fauna discussed are still present within the project area and adjacent Refuge. However, large segments of the shoreline contain heavy development consisting primarily of residential houses or commercial structures with a maintained dune or no dune at all. The presence and sizes of dunes vary throughout the project area. In typical natural beach profiles along New Jersey’s Coast, more than one dune may exist. The primary dune is the first dune or sometimes the only dune landward from the beach. The flora of the primary dune are adapted to the harsh conditions present such as low fertility, heat, and high energy from the ocean and wind. The dominant plant on these dunes is American beach grass (*Ammophila breviligulata*), which is tolerant to salt spray, shifting sands and temperature extremes.

American beach grass is a rapid colonizer that can spread by horizontal rhizomes, and also has fibrous roots that can descend to depths of 3’ to reach moisture. Beach grass is instrumental in the development of dune stability, which opens up the dune to further colonization with more species like seaside goldenrod (*Solidago sempervirens*), sea-rocket (*Cakile edentula*), bitter panic grass (*Panicum amarulum*), American wormseed (*Chenopodium ambrosioides*), and beach cocklebur (*Xanthium echinatum*).

The secondary dunes lie landward of the primary dunes, and tend to be more stable resulting from the protection provided by the primary dunes. The increased stability also allows an increase in plant species diversity. Some of the plant species in this zone include: beach heather (*Hudsonia tomentosa*), coastal panic grass (*Panicum amarum*), salt meadow hay (*Spartina patens*), broom sedge (*Andropogon virginicus*), beach plum (*Prunus maritima*), sea beach evening primrose (*Oenothera humifusa*), sand spur (*Cenchrus tribuloides*), seaside spurge (*Ephorbia polygonifolia*), joint-weed (*Polygonella articulata*), black cherry (*Prunus serotina*), bayberry (*Myrica pennsylvanica*), and prickly pear (*Opuntia humifusa*).

2.2.8 Upper Beach Habitat

The upper beach, or supra-littoral zone, typically lies below the primary dune and above the intertidal zone. An upper beach is present within the study area: however, it is subject to high disturbance from human activity. The upper beach zone is only covered with water during periods of extremely high tides and large storm waves. Sparse vegetation and few animals characterize the upper beach habitat. This zone has fewer biological interactions than the dunes, and organic inputs are scarce. Many of the organisms are either terrestrial or semi-terrestrial. Although more common on southern beaches, the ghost crab (*Ocypode quadrata*) is the most active organism in this zone. This crab lives in semi-permanent burrows near the upland edge of the beach, and it is known to be a scavenger, predator, and deposit sorter. The ghost crab is nocturnal in its foraging activities, and it remains in its burrow during the day. In addition to ghost crabs, species of sand fleas or amphipods (Talitridae), predatory and scavenger beetles and other transient animals may be found in this zone.

2.2.9 Intertidal Zone Habitat

The upper marine intertidal zone is also primarily barren; however, more biological activity is present in comparison to the upper beach. Organic inputs are derived primarily from the ocean in the form of beach wrack, which is composed of drying seaweed, tidal marsh plant debris, decaying marine animals, and miscellaneous debris that washed up and deposited on the beach. The beach wrack provides a cooler, moist microhabitat suitable to crustaceans such as the amphipods: Orchestia *spp*. and *Talorchestia spp*., which are also known as beach fleas. Beach fleas are important prey to ghost crabs. Various foraging birds and some mammals are attracted to the beach fleas, ghost crabs, carrion and plant parts that are commonly found in beach wrack. The birds include gulls, shorebirds, fish crows, and grackles.

2.2.10 Benthos of Intertidal and Subtidal Zone

Benthic macro-invertebrates refer to those organisms living along the bottom of aquatic environments. They can be classified as those organisms dwelling in the substrate (infauna) or on the substrate (epifauna). Benthic invertebrates are an important link in the aquatic food chain, and provide a food source for a variety of bottom feeding fish species. Various factors such as hydrography, sediment type, depth, temperature, irregular patterns of recruitment and biotic interactions (predation and competition) may influence species dominance in benthic communities. Benthic assemblages in New Jersey coastal waters can exhibit seasonal and spatial variability. Generally, coarse sandy sediments are inhabited by filter feeders and areas of soft silt or mud are more utilized by deposit feeders, however, benthic investigations reveal that there is a lot of overlap of these feeding groups in these sediment types. Approximately 58 species of benthic organisms have been identified from Townsends Inlet to Cape May Inlet (Chaillou and Scott, 1996).

The intertidal zone contains more intensive biological activity than the other zones. Shifting sand and pounding surf dominate a habitat, which is inhabited by a specialized fauna. The beach fauna forms an extensive food-filtering system, which removes detritus, dissolved materials, plankton, and larger organisms from in-rushing water. The organisms inhabiting the beach intertidal zone have evolved special locomotory, respiratory, and morphological adaptations, which enable them to survive in this extreme habitat. Organisms of this zone are agile, mobile, and capable of resisting long periods of environmental stress. Most are excellent and rapid burrowers. Frequent inundation of water provides suitable habitat for benthic infauna; however, there may be a paucity in numbers of species. Intertidal benthic organisms tend to have a high rate of reproduction and a short (1 to 2 years) life span (Hurme and Pullen, 1988). This zone contains an admixture of deposit feeders and carnivores. A number of interstitial animals (meiofauna) are present feeding among the sand grains for bacteria and unicellular algae, which are important in the beach food chain. Meiofauna are generally < 0.5 mm in size and are either juveniles of larger macro fauna or exist as meiofauna during their entire life cycle. Some common meiofauna include Rotifera, Gastrotricha, Kinorhyncha, Nematoda, Archiannelida, Tardigrada, Copepoda, Ostracoda, Mystacocarida, Halacarida, and many groups of Turbellaria, Oligochaeta, and some Polychaeta.

Naturally occurring rocky intertidal zones are absent from the project area. However, man-made structures such as seawalls, jetties, and groins are present and provide suitable habitats for aquatic and avian species. Benthic macro invertebrates such as barnacles (*Balanus balanoides*), polychaetes, molluscs (*Donax sp.*), small crustaceans such as, mysid shrimp (*Heteromysis formosa*), amphipods (*Gammarus sp.*), and uropods (*Idotea baltica*), reside on and around these structures. The blue mussel, (*Mytilus edulis*), is a dominant member of this community.

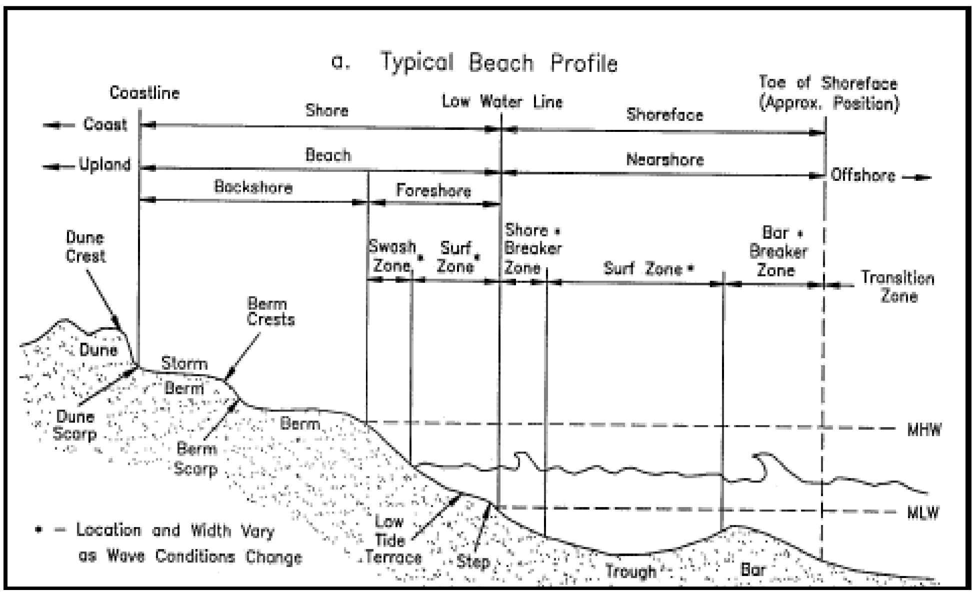
2.2.11 Nearshore and Offshore Zones

The near shore zone generally extends seaward from the sub-tidal zone at MLW to well beyond the breaker zone (U.S. Army Corps of Engineers, 1984) (**Figure 23**). This zone is characterized by intense wave energies that displace and transport coastal sediments. The offshore zone generally lies beyond the breakers and is a flat zone of variable width extending to the seaward edge of the Continental Shelf. Hurme and Pullen (1988) describe the near shore zone as an indefinite area that includes parts of the surf and offshore areas affected by near shore currents. The boundaries of these zones may vary depending on relative depths and wave heights present.

2.2.12 Benthos of Nearshore and Offshore Zones

New Jersey Atlantic near shore waters provide a dynamic environment heavily influenced by the tidal flows and long shore currents. The near shore and offshore waters of the New Jersey Coast contain a wide assemblage of invertebrate species inhabiting the benthic substrate and open water. Invertebrate Phyla existing along the coast are represented by Cnidaria (corals, anemones, and jellyfish), Annelida (Polychaetes, Oligochaetes), Platyhelminthes (flatworms), Nemertinea (ribbon worms), Nematoda (roundworms), Bryozoa, Mollusca (chitons, clams, mussels, etc.), Echinodermata (sea urchins, sea cucumbers, sand dollars, starfish), Arthropoda (Crustaceans), and the Urochordata (tunicates).

Figure 23 Beach Intertidal and Nearshore Zones



2.2.13 Plankton and Marine Macroalgae

Plankton are collectively a group of interacting minute organisms adrift in the water column. Plankton are commonly broken into two main categories: phytoplankton (plant kingdom) and zooplankton (animal kingdom). Phytoplankton are the primary producers in the aquatic marine ecosystem, and are assimilated by higher organisms in the food chain. Phytoplankton production is dependent on light penetration, available nutrients, temperature and wind stress. Phytoplankton production is generally highest in near shore waters. Seasonal shifts in species dominance of phytoplankton are frequent. Phytoplankton can be broken down into two major seasonal species associations. One is a spring-summer dinoflagellate dominated regime. October and November are periods of transition in the phytoplankton community. A second regime exists during the winter, which predominantly consists of diatoms.

A number of species of marine macroalgae have been identified in the project region. The habitats include jetties, sand beaches, enclosed bays, and tidal creeks. The productivity is primarily seasonal with the densest population occurring in June through August. Distribution and abundance of algae is closely related to seasonal temperature, salinity variations and nutrient levels coming from tributary streams. Rhodophyta (red algae) are the predominant benthic algae while Chlorophyta (green algae) comprise the largest number of intertidal algae species. Phaeophyta (brown algae) such as rockweed (*Fucus* spp.) may be found attached or floating free around rock jetties and pilings or washed onto the shore to make up part of the wrack line.

Zooplankton provide an essential trophic link between primary producers and higher organisms. Zooplankton represent the animals (vertebrates and invertebrates) that are adrift in the water column, and are generally unable to move against major ocean currents. Many organisms may be zooplankton at early stages in their respective life cycles only to be able to swim against the currents (nektonic) in a later life stage, or become part of the benthic community. Zooplankton are generally either microscopic or barely visible to the naked eye. Zooplankton typically exhibit seasonal variances in species abundance and distribution, which may be attributed to temperature, salinity and food availability. In marine environments, seasonal peaks in abundance of zooplankton distinctly correlate with seasonal phytoplankton peaks. These peaks usually occur in the spring and fall. Zooplankton species that are characteristic of coastal areas include: *Acartia tonsa, Centropages humatus, C. furatus, Temora longicornis, Tortanus discaudatus, Eucalanus pileatus, Mysidopsis bigelowi* (mysid shrimp), and *Crangon septemspinosa* (sand shrimp). Zooplankton species within the geographic area generally fall within two seasonal groups. The copepod, *Acartia clausi*, is a dominant species during winter-spring, and is replaced in spring by *A. tonsa*. Peak densities usually occur in late spring to early summer following the phytoplankton bloom.

2.2.14 Finfish

The coastal shores and estuaries of New Jersey provide important migratory pathways, spawning, feeding and nursery habitat for many commercial and sport fish (USFWS, 2008). Shoal areas along the Atlantic coast are especially productive for finfish. The proximity of several embayments allows the coastal waters of New Jersey to have a productive fishery. Many species utilize the estuaries behind the Wildwood beaches for forage and nursery grounds. The finfish found along the Atlantic Coast of New Jersey are principally seasonal migrants. Winter is a time of low abundance and diversity as most species leave the area for warmer waters offshore and southward. During the spring, increasing numbers of fish are attracted to the New Jersey Coast, because of its proximity to several estuaries, which are utilized by these fish for spawning and nurseries. Offshore shoals and sand ridges may also have a distinct influence on fish abundance and assemblages in New Jersey coastal waters. Vasslides and Able (2008) found that these features were important habitat for a number of fish, including many economically important species. In this study, overall species abundance and richness was the highest on either side of the offshore ridge sampled. In addition, near-ridge habitats had higher species abundance and richness compared to the surrounding inner continental shelf (Vasslides and Able, 2008).

The coastal waters within the project area support significant commercial and recreational fisheries. Commercially important species include: Atlantic croaker (*Micropogonias undulates*), Atlantic menhaden (*Brevoortia tyrannus*), summer flounder (*Paralichthys dentatus*), black sea bass (*Centropristis striata*), striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), winter flounder (*Pseudopleuronectes americanus*), tautog (*Tautoga onitis*), weakfish (*Cynoscion *regalis*), scup (*Stenotomus chrysops*), and white perch (*Morone americana*). Harvesting is generally accomplished by use of purse seines, otter trawls, pots, and gill nets. In 2011, the port of Cape May-Wildwood was the 6rd largest commercial fishing port on the East Coast in terms of volume, bringing in 40 million pounds of seafood at a value of $103 million. In 2010, the port harvested 43 million pounds of seafood product at a value of $81 million dollars, placing the port at a ranking of 7th in the National Commercial Fisheries Landing chart for dollar values (NMFS, 2011).

Important recreational fisheries within the near shore waters of New Jersey include many of the above-mentioned species plus red hake (*Urophycis chuss*), white hake (*Urophycis tenuis*), silver hake (*Merluccius bilinearis*), Atlantic mackerel (*Scomber scombrus*), chub mackerel (*S. japonicus*), Atlantic cod (*Gadus morhua*), and northern *kingfish (Menticirrhus saxatilis*). Northern puffer (*Sphaeroides maculatus*), spot (*Leiostomus xanthurus*), red drum (*Sciaenops ocellatus*), pollock (*Pollachius virens*), and Atlantic bonito (*Sarda sarda*) may also be taken occasionally.

2.2.15 Shellfish

Extensive shellfish beds, which fluctuate in quality and productivity are found in the back bays and shallow ocean waters of the study area. Atlantic surf clams *(Spisula solidissima*), hard clams (*Mercenaria mercenaria*), blue mussels (*Mytilus edulis*) and blue crabs (*Callinectes sapidus*) are common commercial and recreational shellfish within the coastal waters of the study area. Surf clams are the largest bivalve community found off the Atlantic coast from the Gulf of Saint Lawrence, Canada to North Carolina. The blue crab and the hard clam are two of the most important invertebrates of recreational and commercial value along the New Jersey Coast, and are common in back bays and inlets.

The surf clam has a wide distribution and abundance within the mid-Atlantic Region. Surf clams most commonly inhabit substrates composed of medium to coarse sand and gravel in turbulent waters just beyond the breaker zone (Fay *et al*., 1983; Ropes, 1980). The abundance of adults varies from loose, evenly distributed aggregations to patchy, dense aggregations in the substrate (Fay *et al*., 1983). Surf clams may reach sexual maturity their first year, with the entire population being sexually mature during their second year. Spawning may occur twice annually from mid-July to early August and from mid-October to early November. Historically, the surf clam fishery supported the largest molluscan fishery in New Jersey. This catch represents over 61% of the total Mid-Atlantic area catch for 2010, and 73.9% of the East Coast harvest in 2003. In the last few years there has been a significant decline of surf clams State-wide as well as in Federal waters off the Delmarva Peninsula.

The Bureau of Shellfisheries, Shellfish Growing Water Classification Charts, depict shellfish conservation and prohibited zones. The waters immediately offshore of the project area are classified as “prohibited” for the harvest of oysters, clams and mussels. Hereford Inlet is classified as “seasonally approved”, while the back bay areas surrounding the project are classified as “specially restricted” or “seasonally approved”.

In addition to supporting some of the best hard clam resources in the State, the bays in the project area also support other species of shellfish. American oysters (*Crassostrea virginica*) are not usually present in commercially harvestable densities, but can be found throughout the project area. Soft clams (*Mya arenaria*) and blue mussels are primarily harvested for recreation, but occasionally commercial densities are present. Blue crabs are an important species in the back bay estuaries. Of all New Jersey's marine fish and shellfish, more effort is expended in catching the blue crab than any other single species. Surveys indicate that three-quarters of the state's saltwater fishermen go crabbing and that crabbing accounts for roughly 30 percent of all marine fishing activity (NJDEP, 1998).

2.2.16 Essential Fish Habitat

Under provisions of the reauthorized Magnuson-Stevens Fishery Conservation and Management Act of 1996, the entire study area, including near shore and intertidal areas were designated as Essential Fish Habitat (EFH) for species with Fishery Management Plans (FMPs), and their important prey species. The National Marine Fisheries Service has identified EFH within 10 minute X 10 minute squares. The study area contains EFH for various life stages for 32 species of managed fish and shellfish. There are three 10’ X 10’ squares that encompass the project area. **Table 10** shows the managed species and their life stage that EFH is identified for within the corresponding 10 X 10 minute squares that cover the study area. These squares are within the seawater biosalinity zone. The habitat requirements for identified EFH species and their representative life stages are provided in **Table 11**.

Table 10 Essential Fish Habitat

SUMMARY OF SPECIES WITH EFH DESIGNATION IN THE APPLICABLE 10 min. x 10 min. SQUARES WITHIN THE PROJECT AREA (Squares 38507450, 38507440, and 39007440) (NOAA, 2013)				
MANAGED SPECIES	**EGGS**	**LARVAE**	**JUVENILES**	**ADULTS**
Atlantic cod *(Gadus morhua)*				X
Whiting (*Merluccius bilinearis*)	X	X	X	
Red hake *(Urophycis chuss)*	X	X	X	
Redfish *(Sebastes fasciatus)*	n/a			
Witch flounder (*Glyptocephalus cynoglossus)*	X			
Winter flounder (*Pseudopleuronectes americanus*)	X	X	X	X
Windowpane flounder *(Scopthalmus aquosus)*	X	X	X	X
Atlantic sea herring *(Clupea harengus)*			X	X
Monkfish *(Lophius americanus)*	X	X		
Bluefish *(Pomatomus saltatrix)*			X	X
Long finned squid *(Loligo pealei)*	n/a	n/a		
Short finned squid *(Illex ilecebrosus)*	n/a	n/a		
Atlantic butterfish *(Peprilus tricanthus)*		X	X	X
Summer flounder *(Paralicthys dentatus)*		X	X	X
Scup *(Stenotomus chrysops)*	n/a	n/a	X	X
Black sea bass *(Centropristus striata)*	n/a		X	X
Surf clam *(Spisula solidissima)*	n/a	n/a	X	
Ocean quahog *(Artica islandica)*	n/a	n/a		
Spiny dogfish *(Squalus acanthias)*	n/a	n/a		
King mackerel *(Scomberomorus cavalla)*	X	X	X	X
Spanish mackerel *(Scomberomorus maculatus)*	X	X	X	X
Cobia *(Rachycentron canadum)*	X	X	X	X
Sand tiger shark (*Odontaspis taurus*)*		X		X
Atlantic angel shark (*Squatina dumerili*)		X	X	X
Atl. sharpnose shark (*Rhizopriondon terraenovae*)				X
Dusky shark *(Charcharinus obscurus)*		X		
Sandbar shark *(Charcharinus plumbeus)*		X (HAPC)	X (HAPC)	X (HAPC)
Tiger shark *(Galeocerdo cuvieri)*		X		
Scalloped hammerhead shark (*Sphyrna lewini*)			X	
Clearnose skate (*Raja eglanteria*)			X	X
Little skate (*Raja erinacea*)			X	X
Winter skate (*Raja ocellata*)			X	

*Candidate species for listing under the endangered Species Act

Square Description (i.e. habitat, landmarks, coastline markers) : This square is bounded on the north and east at 39° 00.0' N, 74° 50.0' W and south and West at 38° 50.0' N, 75° 10.0' W. Waters within the Atlantic Ocean surrounding Cape May, NJ, from east of Wildwood Crest, NJ, south around the tip past Cape May Inlet, Sewell Pt., Cape May, NJ, Cape May Pt., Cape May Canal, up to just north of North Cape May, NJ. The waters within this square affect the New Jersey Inland Bay estuary and the following as well: Overfalls Shoal, Eph Shoal, McCrie Shoal, Prissy Wicks Shoal, Middle Shoal, North Shoal, Cape May Channel, Bay Shore Channel, Cape May Harbor, Skunk Sound, Cape Island Creek, Middle Thorofare, Jarvis Sound, Jones Creek, Swain Channel, Taylor Sound, Sunset Lake, and Richardson Channel. The waters on the northwest corner of the square, just south and just west of the tip of the cape, are found within the salt water salinity zone of the Delaware Bay Estuary. HAPC for sandbar shark is applicable for this square.

Square Description: This square is bounded on the north and east at 39° 00.0' N, 74° 40.0' W and south and West at 38° 50.0' N, 74° 50.0' W. Atlantic Ocean waters within the square within the one square east of the square affecting Cape May, NJ, southeast of Wildwood, NJ, from approximately ½ mile down Two Mile Beach east of Wildwood Crest, NJ, north to North Wildwood, NJ at the Hereford Inlet.

Square Description: The waters within the Atlantic Ocean within the square within the New Jersey Inland Bay estuary affecting from Sea Isle City, N.J. on the northeast corner, southwest to N. Wildwood, N.J., just south of Hereford Inlet . These waters affect the following within this square as well: Ludlam Thorofare, Townsend Sound, Mill Thorofare, Middle Thorofare, Mill Creek, Stites Sound, North Channel, Swainton, N.J., Townsends Inlet, South Channel, Ingram Thorofare, Graven Thorofare, Long Reach, Great Sound, Gull I., Gull I. Thorofare, Crease Thorofare, Scotch Bonnet, Nichols Channel, Avalon, N.J., Seven Mile Beach, Stone Harbor, N.J., Great Channel, Nummy I., Grassy Sound Channel, Old Turtle Thorofare, Grassy Sound, Beach Creek, Hereford Inlet, Dung Thorofare, Drum Thorofare, Jenkins Sound, Mayville, N.J., Shelled Ledge, Jenkins Channel, and N. Wildwood N.J.

Table 11 Habitat Utilization of EFH Species

HABITAT UTILIZATION OF IDENTIFIED EFH SPECIES AND THEIR SUMMARY OF SPECIES WITH EFH DESIGNATION IN THE 10 MIN. x 10 MIN. SQUARES WITHIN THE PROJECT AREA (NOAA, 2013)				
MANAGED SPECIES	**EGGS**	**LARVAE**	**JUVENILES**	**ADULTS**
Atlantic cod *(Gadus morhua)* (Fahay, 1998)				**Habitat:** Bottom (rocks, pebbles, or gravel) winter for Mid-Atlantic **Prey:** shellfish, crabs, and other crustaceans (amphipods) and polychaetes, squid and fish (capelin redfish, herring, plaice, haddock).
Whiting (*Merluccius bilinearis*)	**Habitat:** Surface waters, all year, peaking June – Oct.	**Habitat:** Surface waters, all year, peaks July – Sept.	**Habitat:** Bottom habitats of all substrate types, depths between 20 and 270 meters.	
Red hake *(Urophycis chuss)* (Steimle et al. 1998)	**Habitat:** Surface waters, May – Nov.	**Habitat:** Surface waters, May –Dec. Abundant in mid-and outer continental shelf of Mid-Atl. Bight. **Prey:** copepods and other microcrustaceans under floating eelgrass or algae.	**Habitat:** Pelagic at 25-30 mm and bottom at 35-40 mm. Young inhabit depressions on open seabed. Older juveniles inhabit shelter provided by shells and shell fragments. **Prey:** small benthic and pelagic crustaceans (decapod shrimp, crabs, mysids, euphasiids, and amphipods) and polychaetes).	
Redfish (*Sebastes fasciatus)*	n/a	n/a		
Witch flounder (*Glyptocephalus cynoglossus)* (Cargnelli et. al., 1998)	**Habitat:** Pelagic , generally over deep water in depths ranging from 10 – 1250 m.			
Winter Flounder (*Pseudopleuronectes americanus*) (Pereira et. al., 1998)	**Habitat:** Demersal, near shore low energy (primarily inlets and coves) shallows with sand, muddy sand, mud and gravel bottoms.	**Habitat:** Demersal, near shore low (primarily inlets and coves) energy shallows with sand, muddy sand, mud and gravel bottoms. **Prey:** Nauplii, invertebrate eggs, Protozoans, Polychaetes	**Habitat:** Young of the year (YOY) are demersal, near shore low (primarily inlets and coves) energy shallows with sand, muddy sand, mud and gravel bottoms. **Prey:** YOY Amphipods and annelids JUV – Sand dollar, Bivalve siphons, Annelids, Amphipods	**Habitat:** Demersal offshore (in spring) except when spawning where they are in shallow inshore waters (fall). **Prey:** Amphipods, Polychaetes, Bivalves or siphons, Capelin eggs, Crustaceans
Windowpane flounder *(Scopthalmus aquosus)* (Chang, 1998)	**Habitat:** Surface waters <70 m, Feb-July; Sept-Nov.	**Habitat:** Initially in pelagic waters, then bottom <70m,. May-July and Oct-Nov. **Prey:** copepods and other zooplankton	**Habitat:** Bottom (fine sands) 5-125m in depth, in near shore bays and estuaries less than 75 m **Prey**: small crustaceans (mysids and decapod shrimp) polychaetes and various fish larvae	**Habitat:** Bottom (fine sands), peak spawning in May , in near shore bays and estuaries less than 75 m **Prey**: small crustaceans (mysids and decapod shrimp) polychaetes and various fish larvae
Atlantic sea herring *(Clupea harengus)* (Reid et al., 1998)			**Habitat:** Pelagic waters and bottom, < 10 C and 15-130 m depths **Prey:** zooplankton (copepods, decapod larvae, cirriped larvae, cladocerans, and pelecypod larvae)	**Habitat:** Pelagic waters and bottom habitats; **Prey:** chaetognath, euphausiids, pteropods and copepods.
Monkfish *(Lophius americanus)* (Steimle et al., 1998)	**Habitat:** Surface waters, Mar. – Sept. peak in June in upper water column of inner to mid continental shelf	**Habitat:** Pelagic waters in depths of 15 – 1000 m along mid-shelf also found in surf zone **Prey:** zooplankton (copepods, crustacean larvae, chaetognaths)		
Bluefish *(Pomatomus saltatrix)*			**Habitat:** Pelagic waters of continental shelf and in Mid Atlantic estuaries from May-Oct. **Prey:** Squid, smaller fish	**Habitat:** Pelagic waters; found in Mid Atlantic estuaries April – Oct. **Prey:** Squid, smaller fish
Long finned squid *(Loligo pealei)*	n/a	n/a		
Short finned squid *(Illex ilecebrosus)*	n/a	n/a		
Atlantic butterfish *(Peprilus tricanthus)*		**Habitat:** Pelagic waters greater than 33' deep	**Habitat:** Pelagic waters in 10 – 360 m	**Habitat:** Pelagic waters **Prey:** Jellyfish, crustaceans, worms, small fish
Summer flounder *(Paralicthys dentatus)*		**Habitat:** Pelagic waters, near shore at depths of 10 – 70 m from Nov. – May	**Habitat:** Demersal waters (mud and sandy substrates) **Prey:** Mysid shrimp	**Habitat:** Demersal waters (mud and sandy substrates). Shallow coastal areas in warm months, offshore in cold months **Prey:** Fish, squid, shrimp, worms
Scup *(Stenotomus chrysops)*	n/a	n/a	**Habitat:** Demersal waters	**Habitat:** Demersal waters offshore from Nov – April **Prey:** Small benthic invertebrates
Black sea bass *(Centropristus striata)*	n/a		**Habitat:** Demersal waters over rough bottom, shellfish and eelgrass beds, man-made structures in sandy-shelly areas	**Habitat:** Demersal waters over structured habitats (natural and man-made), and sand and shell areas **Prey:** Benthic and near bottom inverts, small fish, squid
Surf clam *(Spisula solidissima)*	n/a	n/a	**Habitat:** Throughout bottom sandy substrate to 3' in depth from beach zone to 60 m	
Ocean quahog *(Artica islandica)*	n/a	n/a		
Spiny dogfish *(Squalus acanthias)*	n/a	n/a		
King mackerel *(Scomberomorus cavalla)*	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone.	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone **Prey:** Zooplankton, fish eggs	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone **Prey:** Zooplankton, shrimp, crab larvae, squid, herring	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone
Spanish mackerel *(Scomberomorus maculatus)*	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory **Prey:** Zooplankton, fish eggs	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory **Prey:** Zooplankton, shrimp, crab larvae, squid, herring	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory **Prey:** Squid, herring, silverside, lances
Cobia *(Rachycentron canadum)*	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone.	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory **Prey:** Crabs, shrimp, small fish	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory **Prey:** Crabs, shrimp, small fish
Sand tiger shark *(Odontaspis taurus)** *Candidate species for listing under Endangered Species Act		**Habitat:** Shallow coastal waters, bottom or demersal		**Habitat:** Shallow coastal waters, bottom or demersal **Prey**: Crabs, squid, small fish
Atlantic angel shark (*Squatina dumerili*)		**Habitat:** Shallow coastal waters	**Habitat:** Shallow coastal waters	**Habitat:** Shallow coastal waters, bottom (sand or mud near reefs)
Atl. sharpnose shark (*Rhizopriondon terraenovae*)				**Habitat:** Shallow coastal waters
Dusky shark *(Charcharinus obscurus)*		**Habitat:** Shallow coastal waters		
Sandbar shark *(Charcharinus plumbeus)*		**Habitat:** Shallow coastal waters	**Habitat:** Shallow coastal waters	**Habitat:** Shallow coastal waters
Tiger shark *(Galeocerdo cuvieri)*		**Habitat:** Shallow coastal waters		
Scalloped hammerhead shark (*Sphyrna lewini*)			**Habitat:** Shallow coastal waters	
Clearnose skate (*Raja eglanteria*)			**Habitat:** Shallow coastal waters with soft bottom, rocky or gravelly substrates	**Habitat:** Shallow coastal waters with soft bottom, rocky or gravelly substrates
Little skate (*Raja erinacea*)			**Habitat:** Shallow coastal waters with sandy, gravelly, or mud substrates	**Habitat:** Shallow coastal waters with sandy, gravelly, or mud substrates
Winter skate (*Raja ocellata*)			**Habitat:** Shallow coastal waters with a substrate of sand and gravel or mud	

2.2.17 Birds

The project area is located within the Atlantic Coast Joint Venture's New Jersey Waterfowl Focus Area under the North America Waterfowl Management Plan. Areas adjacent to the project area, including the Cape May National Wildlife Refuge, are important resting and feeding areas for migratory waterfowl within the Atlantic flyway. Species common to the area include: American widgeon (*Anas americana*), canvasback (*Aythya valisineria*), greater scaup (*Aythya marila*), common goldeneye (*Bucephala clangula*), oldsquaw (*Clangula hyemalis*), hooded merganser (*Lophodytes cucullatus*), Canada goose (*Branta canadensis*), Atlantic brant (*Branta bernicla*), American black duck (*Anas rubripes*), northern pintail (*Anas acuta*), mallard (*Anas platyrhynchos*), northern shoveler (*A. clypeata*) and tundra swan (*Cygnus columbianus*) (USFWS, 2008).

The project area and the surrounding wetlands also support a wide variety of migratory shorebird and colonial nesting waterbird species. The shorebirds include species such as the ruddy turnstone (*Arenaria interpres*), dunlin (*Calidris alpina*) pectoral sandpiper (*C. melanotos*) and black-bellied plover (*Pluvialis squatarola*). Colonial nesting waterbirds include the State-listed (endangered) least tern (*Sterna antillarum*) and black skimmer (*Rynchops niger*); State-listed (threatened) little blue heron (*Egretta caerulea*) and yellow-crowned night heron (*Nyctanassa violacea*) as well as glossy ibis (*Plegadis falcinellus*), snowy egret (*Egretta thula*), great egret (*Casmerodius albus)*, black-crowned night heron (*Nycticorax nyticorax*), great black-backed gull (*Larus marinus*), herring gull (*Larus argentatus*), laughing gull (*Larus atricilla*), royal tern (*Sterna maxima*) and common tern (*Sterna hirundo*).

2.2.18 Mammals, Amphibians, Reptiles

Mammals typically occurring along streams and on the marsh near woodlands, in and around the study area, include the opossum (*Didelphis sp.*), short-tailed shrew (*Blarina brevicauda*), least shrew (*Cryptotis parva*), star-nosed mole (*Condylura cristata*), and masked shrew (*Sorex cinereus*). Bat species sighted along watercourses and in wooded areas include the little brown bat (*Myotis lucifugus*), silver-haired bat (*Lasionycteris noctivagans*), Eastern pipistrelle (*Pipistrellus subflavus*), big brown bat (*Eptesicus fuscus*), and red bat (*Lasiurus borealis*). Upland fields and woodlands support the Eastern chipmunk (*Tamias striatus*), Eastern muskrat (*Ondatra zibethicus*), raccoon (*Procyon lotor*), long-tailed weasel (*Mustela frenata*), and striped skunk (*Mephitis mephitis*). In addition, gray fox (*Urocyon cinereoargenteus*), and river otter (*Lutra canadensis*) have been identified on colonial seabird islands.

A number of upland and fresh water species of reptiles and amphibians occur in the study area. Common reptiles include the following turtles and snakes: the snapping turtle (*Chelydra serpentina*), stinkpot (*Sternotherus sp.*), eastern mud turtle (*Kinosternon subrubrum*), eastern box turtle (*Terrapene carolina*), northern diamondback terrapin (*Malaclemys terrapin terrapin*), eastern painted turtle (*Chrysemys picta*), northern water snake (*Natrix sipedon*), eastern garter snake (*Thamnophis sirtalis*), northern black racer (*Coluber constrictor*), and northern red-bellied snake (*Storeria occipitomaculata*). The red-backed salamander (*Plethodon cinereus*), four-toed salamander (*Hemidactylium scutatum*), Fowler's toad (*Bufo woodhousei*), northern spring peeper (*Hyla crucifer*), New Jersey chorus frog (*Pseudarcris triseriata*), and southern leopard frog

(*Rana utricularia*) are all common species of amphibians found in the study area. Sea turtles, although present int eh project areaare not known to nest on project are beaches.

2.2.19 Threatened and Endangered Species

The federally-listed (threatened) and state-listed (endangered) piping plover (Charadrius melodus) has previously nested adjacent to the project in North Wildwood, the US Coast Guard Property and more recently within the US Fish and Wildlife Refuge, according to NJDEP and U.S. Fish and Wildlife field surveys. Piping plovers nest above the high tide line on mainland coastal beaches, sand flats, and barrier island coastal beaches. Nesting sites are typically located on gently sloping foredunes, blowout areas behind primary dunes, wash over areas cut into or between dunes, ends of sand spits, and on sites with deposits of suitable dredged or pumped sand. The nesting season usually begins in March when the birds arrive and can extend as late as the end of August. Shortly after hatching, the young leave the nest and begin foraging within the intertidal zone.

Food for adult plover and chicks consists of invertebrates such as marine worms, fly larvae, beetles, crustaceans, or mollusks. Feeding areas include intertidal portions of ocean beaches, ocean wash over areas, mudflats, sand flats, wrack lines (organic material left behind by high tide), shorelines of coastal ponds, lagoons, and salt marshes.

The red knot (*Calidris canutus rufa*) is a Federal Candidate Species and is present at the adjacent Cape May National Wildlife Refuge as well as the nearby Stone Harbor Point during spring and fall migration. Some birds may also be found lingering at the sites through the early winter. The red knot's spring migration to this area is timed with the release of horseshoe crab eggs. This generally abundant food supply helps the red knot to increase its body weight enough to be able to continue its migration to the red knot's Arctic breeding grounds.

The State listed (endangered) black skimmer (*Rynchops niger*) and least tern (*Sterna antillarum*) are known to nest within Hereford Inlet (Champagne Island) and at Stone Harbor Point to the north of the project area. The back bay islands and marshes also host nesting colonies of a State endangered species. The State threatened wading birds, little blue heron (*Egretta caerulea*) and yellow-crowned night heron (*Nyctanassa violacea*), are also found in the back bay of the coastal barrier system.

The seabeach amaranth (*Amaranthus pumilus*) is a Federally-listed threatened plant. The seabeach amaranth is an annual plant, endemic to Atlantic coastal plain beaches, and primarily occurs on over wash flats at the accreting ends of barrier beach islands and lower foredunes of non-eroding beaches. The species occasionally establishes small temporary populations in other areas, including bayside beaches, blowouts in foredunes, and sand and shell material placed as beach fill. Although no extant occurrences of the seabeach amaranth are known within the proposed project area, the species has recently naturally recolonized coastal sites within Northern New Jersey, New York and Maryland and was present in the nearby Coast Guard LORAN property in 2003 and 2004.

The U.S. Fish and Wildlife Service protects migratory shorebirds as a Federal trust resource. Many species utilize high energy beaches (e.g., ocean and bay beaches) for feeding, including:

ringed plovers (*Charadrius sp.*), golden plovers (*Pluvialis sp.*), stints (*Calidris sp.*), willet (*Catoptrophorus semipalmatus*), oystercatcher (*Haematopus palliatus*), and ruddy turnstone (*Arenaria interpres*). Both the biomass and species composition of infaunal beach communities are critical for supplying the nutritional needs of shorebirds, especially during spring and fall migrations.

The National Marine Fisheries Service (NMFS) has jurisdiction over four (4) Federally-designated sea turtles: the endangered leatherback (*Dermochelys coriacea*), Kemp's Ridley (*Lepidochelys kempii*), and green (*Chelonia mydas*) sea turtles, and the threatened loggerhead sea turtle (*Caretta caretta*). These sea turtles may be found in New Jersey's continental shelf waters, inshore bays and estuaries from late spring to mid-fall but do not nest on the beach. Sea turtles feed primarily on mollusks, crustaceans, sponges and a variety of marine grasses and seaweeds. The endangered leatherback sea turtle may forage on jellyfish, as well. The northern diamondback terrapin (*Malaclemys terrapin terrapin*) is a Federal Category 2 candidate species that occupies shallow bay waters, and nests on the sandy portions of bay islands as well as the barrier islands themselves. The diamondback terrapin is considered a candidate species, as its nesting habitat is dwindling.

Federally endangered finback whales (*Balaenoptera physalus*) are the most common whales to occur in New Jersey coastal waters. Finback whales increase in relative abundance in late winter and spring, east of the Delaware peninsula, but may be found in New Jersey coastal waters in all seasons. The endangered humpback (*Megaptera novaeangliae*) and right whales (*Eubalaena spp.*) are known to occur in the nearshore waters of the mid-Atlantic on a seasonal basis, and may be found within the vicinity of the proposed borrow area(s) from late winter through early spring.

The Atlantic sturgeon (*Acipenser oxyrinchus oxyrinchus*) population has been divided into 5 distinct population segments (DPSs) (Gulf of Maine, New York Bight, Chesapeake Bay, Carolina, and South Atlantic). These DPSs were configured to account for the marked difference in physical, genetic, and physiological factors within the species, as well as the unique ecological settings and unique genetic characteristics that would leave a significant gap in the range of the taxon if one of them were to become extinct (ASSRT, 2007). On February 6, 2012, the Northeast Region of NMFS listed the Gulf of Maine population as threatened and the New York Bight (NYB) and Chesapeake Bay (CB) DPSs as endangered. The Hereford Inlet to Cape May Inlet Project falls within the boundaries of the NYB population.

Atlantic sturgeon are anadromous, spending the majority of their adult phase in marine waters, migrating up rivers to spawn in freshwater and migrating to brackish waters in juvenile growth phases. Adults return to their natal freshwater rivers to spawn (Dovel and Berggren, 1983). After emigration from the natal estuary, sub-adults and adults travel within the marine environment, typically in waters less than 40 m in depth, using coastal bays, sounds, and ocean waters (Vladykov and Greeley, 1963; Murawski and Pacheco, 1977; Dovel and Berggren, 1983; Smith, 1985; Collins and Smith, 1997; Savoy and Pacileo, 2003; Stein et al., 2004; Laney *et al*., 2007; Dunton *et al*., 2010; Erickson *et al*., 2011; D. Fox, pers. comm.; T. Savoy, pers. comm.). Tracking and tagging studies reveal seasonal movements of Atlantic sturgeon along the coast.

The harbor porpoise (*Phocoena phocoena*), has been proposed for listing as threatened under the Endangered Species Act. While mid-Atlantic waters are the southern extreme of their distribution, stranding data indicate a strong presence of harbor porpoise off the coast of New Jersey, predominately during spring. The US Fish and Wildlife Service has not designated any areas in the project area as Critical Habitat for any protected species.

2.2.20 Recreation

Recreational opportunities abound within the study area, drawing millions of people to Cape May County each year. The beaches are the primary attraction, however varieties of wildlife-oriented activities are also available. The beaches along the Cape May National Wildlife Refuge and the back bays and marshes of the surrounding areas contain numerous recreational opportunities. The ocean side offers visitors activities such as boating, swimming, surfing, and sunbathing. Surf fishing is also popular within the study area. The offshore areas in the Atlantic Ocean offer good fishing opportunities for private or charter boats. State designated Prime Fishing Areas such as Eph Shoal and Prissy Wicks Shoal are popular destinations for sport fishermen. The Cape May National Wildlife Refuge offers bird watching and hiking opportunities. The back bay estuaries and all of the tidal tributaries and waterways offer recreational opportunities such as clamming, crabbing, fishing, boating, sailing, windsurfing, and bird watching.

2.2.21 Visual and Aesthetic Values

Aesthetics refer to the sensory quality of the resources (sight, sound, smell, taste, and touch) and especially with respect to judgment about their pleasurable qualities (Canter, 1993; Smardon et al. 1986). The aesthetic quality of the study area is influenced by the natural and developed environment. Except for the Cape May National Wildlife Refuge, the beachfront of the study area is developed with homes, condominiums, businesses, amusement piers, boardwalks and promenades. However, these summer destination towns draw on the high aesthetic values of the seashore environment, which includes sandy beaches, dunes, and ocean views. Beachgoers and residents are attracted to the area for the beach scenery and clean, attractive beaches and structures that are present in the study area. The Cape May National Wildlife Refuge offers visitors a more natural aesthetic quality with natural beaches, vegetation, wildlife, and surf.

2.2.22 Noise

Noise is of environmental concern because it can cause annoyance and adverse health effects to humans and animal life. Noise can impact such activities as conversing, reading, recreation, listening to music, working, and sleeping. Wildlife behaviors can be disrupted by noises also, which can disrupt feeding and nesting activities. Because of the developed nature of the study area, noises are common and can come in the form of restaurant and entertainment facilities, automobiles, boats, and recreational visitors. However, these communities impose local restrictive noise ordinances to minimize noise pollution.

2.3 Cultural Resources

2.3.1 Historic Background

The historic information presented below comes from multiple published and Internet sources with particular reliance on the fine popular history *Wildwood by the Sea: The History of an American Resort* by Francis, Francis, and Scully. It also contains information obtained from the West Jersey History Project, and the North Wildwood, Wildwood, Wildwood Crest websites. Information on the websites was obtained by the Wildwood Historical Society, the George F. Boyer Historical Museum and from George F Boyers Book, "Wildwood-Middle of the Island".

At the height of the last (Wisconsin) Pleistocene ice age the Mid-Atlantic coast may have been located 60 miles further east. As the huge continental glaciers began to melt around 12,000 years B.P., sea levels rose and the Atlantic coast retreated westward. As many regional archaeologists have noted, Paleo-Indian and later Archaic peoples would have occupied these gradually retreating coastal areas and produced shell middens (piles) and artifact layers, which now lie submerged and buried on the continental shelf. Fossil remains of Pleistocene megafauna, such as mastodon, mammoth, and other species have been dredged from the continental shelf up and down the Mid-Atlantic region as well.

Later prehistoric peoples (Woodland Period) occupied the coast seasonally and exploited the rich marine resources (shellfish, fish, and sea mammals) during the spring and summer. Evidence of this seasonal occupation may now lie buried beneath the asphalt and concrete of the modern day towns of the Wildwoods. These prehistoric Indian travelers normally retreated inland during the fall and winter to hunt deer, bear, and other food and fur-bearing species. Their successful hunting and gathering lifestyle has been characterized by regional archaeologists as indicative of "primary forest efficiency." Later Woodland (Pre-Contact) horticulturists practiced a temperate zone variety of swidden or "slash and burn" agriculture that required the periodic or cyclic movement of villages to bring more productive land under cultivation. Yet even during this later time, and even after the time when Europeans came on the scene (late 15th and early 16th century), Native American peoples relied on the rich seasonal maritime resources of the Mid-Atlantic coast. Traces of this aboriginal occupation have been ephemeral in the Wildwoods region, largely due to the destructive impacts of modern day construction where late prehistoric or proto-historic sites may have been located. The likelihood of disturbing prehistoric sites buried in the sand of the modern beach is negligible. The Wildwoods beach in its current configuration is an artificial construction, the result of a process begun in the early part of the 20th century and still going strong in the 21st. Early Euro-American chroniclers noted that the first settlers of the area now known as the Wildwoods were the native Lenni Lenape people who summered on the Jersey Cape. The Algonquin speaking Lenape, who later came to be called the Delaware, frequently made trips to Five Mile Beach via the historic King Nummy Trail. This trail was used by Native Americans to access southern New Jersey hunting and fishing grounds. The King Nummy Trail followed a pathway parallel to the shore along what is now the Garden State Parkway & Route 9 corridor. It branched off at the north end of the island and provided access to Five Mile Beach and proceeded southward to what is now New Jersey Avenue. Another trail entered the island where the Rio Grande Bridge was later built and met the Five Mile Beach section of the King Nummy Trail in what is now Wildwood City. The Lenape people were gradually replaced in the Wildwoods by 18th century bay fisherman, primarily of

Scandinavian decent, and mainland farmers who grazed cattle and horses on the island. The Farmers ferried the animals back and forth across the inlets and back bays on flatboats. The farmers used the Five Mile Beach grazing area until the end of the 19th century when permanent settlement interests began to take shape.

From a European perspective regional history begins in the early 17th century when on August 28, 1609 Henry Hudson, sailing with the Dutch East India Company, entered Delaware Bay and upon confronting the River's shoals, and convinced the stream was not the sought after northwest passage, turned his ship the "Half Moon" about and proceeded north past Five Mile Beach. Robert Juet, sailing with Hudson, wrote in his log book "a very good land to fall in with- and a pleasant land to see" after observing Five Mile Beach from the ship "Half Moon".

In the 1620s, the Dutch West India Company sent Cornelius Jacobson Mey with three ships to the Delaware Bay and New York region. During this voyage he named the bay's south cape, Cape Cornelius and the North, Cape Mey. The south cape is now Cape Henlopen and the North is now Cape May. No further written records of Five Mile Beach occurred until a land grant from Charles II to James, Duke of York in 1664. Various deeds occurred later, and on August 21, 1717 the West Jersey Society conveyed "all of its title and interest in Five Mile Beach" to Aaron Leaming, Humphrey Hughes, David Wells and Jonathan Swain.

The first known European settlement in Cape May County was established by whalers in 1685 on the banks of Delaware Bay. The settlement was first called Portsmouth, then New England Village, then later Cape May Town and finally Town Bank. The county was formally created in 1692 from land held by the West Jersey Society. The first Census for the county in 1726 listed a population of 668. In 1723 the county was divided into three precincts, Upper, Middle and Lower Township. In 1745 Cape May Courthouse became the County Seat. The tranquility of the colonial period Wildwoods was shattered by the American Revolutionary War.

On June 28th 1776 Turtle Gut Inlet, previously located near Toledo Avenue in Wildwood Crest and subsequently filled by the County in 1922, was the site of a historic Naval Battle between the Continental Navy and the British Empire. On the 28th the brigantine "Nancy" was sighted on the shoals of Turtle Gut Inlet by the British Warship the "Kingfisher". The "Kingfisher" had been barricading the entrance to Delaware Bay and preventing Continental ships from accessing the port of Philadelphia. To thwart this blockade local boats-men began to lead ships through the various inner waterways and coastal inlets around New Jersey's barrier islands. The "Nancy" was bound from the Virgin Islands with a cargo of munitions for the Colonial Army. After the "Nancy" run-aground in Turtle Gut she sent word to Captain John Barry of the Continental Frigate "Lexington" that two British Warships were pursuing her. The "Lexington" commanded by Captain John Barry, later Commodore Barry father of the US Navy, joined by the "Wasp", set out to aid the "Nancy". Captain Barry and his men manned "Nancy's" guns and unloaded as many munitions as possible. After 2/3 of the munitions had been removed Barry ordered his men to abandon ship. Barry then ordered fifty pounds of gunpowder to be poured into the "Nancy's" main-sail and wrapped as tightly as possible acting as a fuse for the rest of the powder below deck. The mainsail was set afire the men jumped overboard with the ship's flag in tow. The British sailors approaching in longboats took the removal of the flag as an act of surrender and boarded the ship. The British sailors boarded the "Nancy" and raised a cheer to victory, only to be extinguished by the explosion of the rest of the gunpowder below. Seven British Sailors were reported to have died in the blast. The explosion was said to be heard forty miles above Philadelphia. By 1794 Captain John Barry would be known as Commodore Barry, the father of the American Navy.

Militias comprised of rifle toting minutemen were common in Cape May County and several had seen action in the Battle of Germantown and several small skirmishes during the Revolutionary War. The War of 1812 saw British Warships return to blockade the mouth of Delaware Bay. Raiding parties would come ashore for provisions from local farms and fresh water. Lake Lily, located in Cape May, to the south of Five Mile beach, was a watering hole the British used frequently. To thwart the British raids for water to the lake the local citizens dug a canal to the sea to spoil the freshwater with saltwater from the ocean.

Most of the barrier islands south of Atlantic City did not witness the development of towns until after the Civil War. Nearby Cape May to the south was among America's earliest and most distinguished summer destinations. Cape May, first known as Cape Island, may have hosted summer visitors a decade before the American Revolution. By the 1850s Cape May was immensely popular with Southerners seeking to escape the heat and malaria of Virginia and the Carolinas. But the Civil War ended the annual influx of Southern vacationers and tragic fires in 1869 and 1878 destroyed much of the city, including many of the Victorian hotels. Cape May never fully recovered and was soon overshadowed by the developing summer destinations in Ocean City, Wildwoods, Asbury Park and Atlantic City. During the mid-nineteenth century one group of entrepreneurs built an excursion house, called the Surf House, in a small town north of Cape May called Atlantic City. Starting from a year round population of 250 in 1855 Atlantic City grew rapidly and by 1888 the summer destination offered an incredible 506 hotels and boarding houses.

The first full time white settlers to Five Mile Beach were fishermen. By 1870 they erected shacks at the north end of the island and later named the settlement "Anglesea". The settlers followed the native trails across the meadows and then reached the island by boat. In 1874 the government built a lighthouse at Hereford Inlet to aid the fishermen accessing the community of Anglesea. The historic Hereford Inlet lighthouse still stands today.

Located between Cape May and raucous Atlantic City the group of southern New Jersey summer destination communities known collectively as "The Wildwoods" began development during the 1880s. The original name of the largest settlement, Florida City, was changed by the developers to the Wildwoods to reflect the dense, twisted forest growth of the region. The driving force behind the founding of Wildwood was Philip Pontius Baker (1846-1920), a merchant and hotel operator from Vineland who had been an original investor in earlier seaside communities like Sea Isle City and the original town of Holly Beach which merged and became the city of Wildwood in 1912.

In 1883 Baker and his brother had walked north of Holly Beach and along an old Indian Path into a tangled forest of maple, oak, poplar, magnolia, holly, and cherry trees all covered with Spanish moss. The Baker brothers were impressed with the natural beauty of the area and imagined a summer destination and cottage colony set against the backdrop of this primitive but beautiful forest. But first they had to deal with the problem of wild and aggressive cattle. Before the age of summer destination development, mainland farmers transported cattle in flat-bottomed boats to graze on Five Mile Island. Many were left on the island where they thrived on native grasses and grew in numbers. Early accounts report that these cattle were so wild and aggressive that a man walking across the island was advised to carry a rifle and a good supply of cartridges. As the town developed, the cattle became quite bold, wandering the streets, harassing the citizens, and raiding fruit and vegetable stands. Finally, the Baker brothers hired hunters to eliminate the wild cattle problem.

During the 1880s, Aaron Andrews took his wife Sarah Andrews to Townsend's Inlet to recuperate from an illness. There the Andrews' became friends with the Joseph Taylor family of Philadelphia. So impressed with the area they all returned the following year determined to buy homes. John Burke, a real estate salesman from Vineland, brought them to look at Five Mile Beach. The trio, joined with Nelson Robert, Latimer Baker and Robert Young eventually formed the Holly Beach Improvement Society, and in 1885 Holly Beach Borough was incorporated. By the end of the 19th Century the increasing number of Five Mile Beach landowners had begun to incorporate their interests into Boroughs and Cities. Holly Beach Borough was incorporated in 1885, Wildwood Borough was incorporated in 1895 and the two subsequently joined interests with Holly Beach to form Wildwood City in 1912. North Wildwood Borough was combined with Anglesea Borough to form the City of North Wildwood in 1917. Wildwood Crest Borough was incorporated in 1910. West Wildwood was incorporated as a borough in 1920.

The coming of the railroad set the course of Wildwood's future as a summer destination for working class families. Once trains began running from Philadelphia and other northern cities, Wildwood's popularity as a public summer destination and cottage colony was assured. The Wildwoods never attracted the high society set as did Cape May. They also did not have the religious foundation and strict Protestant moral code of nearby Ocean City. While they were not as permissive as Atlantic City they did tolerate a limited amount of gambling, illegal liquor sales, and prostitution. What gave The Wildwoods its unique character, however, is that from the beginning its founders set out to appeal to the American working class family interested in escaping from the heat and dirt of the big cities of Philadelphia and New York.

The hotels and cottages, and the amusement piers and rides of the Wildwoods were all geared to appeal to the working man and his family. A key element of this appeal was the boardwalk, which put the working family in close but comfortable proximity to the ocean and its cooling offshore breezes. Many nineteenth century seaside resorts in England and continental Europe offered visitors' promenades near the ocean but the "boardwalk" lined on the land side with hotels and shops and on the ocean side with amusement piers, is truly a New Jersey innovation. The first boardwalk in Atlantic City was opened on June 26, 1870. Other seaside communities saw the value of a wooden promenade and followed Atlantic City's example. Ocean City built its first boardwalk in 1883. Wildwood built its first small non-elevated boardwalk in 1891 and a larger one in 1900. The first boardwalk was constructed in Wildwood by railroad conductor Alexander Boardman. Boardman was tired of cleaning sand from his trains so he constructed a wooden walkway to disperse sand from the patron's feet and the Boardwalk was born. About 30 years later The Five Mile Beach Boardwalk was constructed directly on the sand along Atlantic

Avenue and stretched 150 yards from Oak to Maple Ave in Wildwood Borough. In 1903 Wildwood's leaders decided to provide an elevated walkway closer to the ocean. This boardwalk extended from 2nd avenue in North Wildwood to Cresse Avenue in Wildwood.

Development and growth of the Wildwoods exploded in the decades to come. Just four years after its initial founding Wildwood Crest boasted "hundreds of handsome homes, big hotels, apartment houses and business blocks, twenty miles of cement sidewalks, all streets graveled with sanitary sewer system, trolley line through property, a storm proof sea wall, boardwalk along entire oceanfront, gas, electricity, underground telephone system, artesian water, no public debt." Shortly after this, the historic Turtle Gut Inlet, an impediment to developing the rest of the island, was closed in 1922 by Cape May County interests. The 1920's saw more rapid growth and expansion in the Wildwoods, both inland and onshore. One reason is that unlike many other shore summer destination s Wildwood had no problem with beach erosion. They had instead the unique challenge of an ever-widening beach. Even as the new boardwalk was being moved eastward to be closer to the sea in the 1920's the beach continued to widen. The process was accelerated during the 1920s when a jetty built at Cold Spring Inlet to protect Cape May Harbor proved even more of a benefit to the beach at the Wildwoods. The fame of the broad Wildwood beach spread across the country and crowds reached record numbers during the 1920's. On August 23, 1926 the captain of the Wildwood Beach Patrol estimated that more than twenty thousand people were cavorting on the sand beneath a sea of vividly colored beach umbrellas. In order to accommodate the immense crowds, in 1920 almost 2,600 individual bathhouses were constructed along the boardwalk.

The growth of the Wildwoods after World War I and the relative prosperity of the decade brought increased numbers of conventions and one-day excursions to the summer destination . Competition among the Jersey Shore summer destinations for large conventions was keen and Wildwood struggled to compete against Atlantic City. This ultimately led to the construction in 1927 of a new convention hall and many more hotels in Wildwood. One history of the period notes that the defining character of the Wildwoods in the roaring twenties would be the real estate boom that lasted for most of the decade. Those lucky individuals who bought and sold real estate at the shore often made great profits in just a short period of time. So profitable was the real estate business that some bootleggers complained that there was more money to be made in selling land than in selling illegal liquor and beer. During the 1930s and 40s in the Wildwoods were heavily influenced by the Great Depression and World War II. The numerous ballrooms that located along the boardwalk in Wildwood did bring larger crowds to the summer destination but there was little money to spend. There was also little money for the city to spend on boardwalk repairs and damage done by storms. In 1932 the Miss American beauty pageant was held in Wildwood. The pageant was not held again until 1935 when it moved to Atlantic City. Major fires in 1930 again in 1939 damaged many important buildings. With the assistance of the Works Progress Administration (WPA), and other programs of the Roosevelt Administration, the city began to recover in 1939, when funds became available for new boardwalk construction and repairs. Also during the 1930's Wildwood's officials tried to clean up the boardwalk by banning barkers, loudspeakers, fortune telling and mind reading. They also worked to enforce a dress code that required proper garments over swim suits when not on the beach. Auction houses became popular on the boardwalk during this time and those houses found guilty of operating fake auctions were closed and charged by the police.

During the World War II era manpower shortages became so acute in the Wildwoods that some restaurant owners were forced to cut back services or close. Food rationing proved an even greater hardship on restaurants. Coffee rationing began late in 1942 and such necessary foods as eggs, sugar, meat, and butter were almost impossible to obtain on a regular basis. By 1944 restaurants were applying to the War Price and Rationing Board for more rations. Although the war imposed many other restrictions and caused many shortages it apparently had little effect on beach crowds which were continued to be quite large during this period. It was also during the war that a decision was made that would change the streets, and the look, of Wildwood forever. In 1944 the electric railway company announced that it would terminate all streetcar service in Wildwood. The tracks were removed from roadways and streetcars were replaced by buses, bring an end to a Wildwood institution that dated back to the turn of the century.

The period after WW II was one of great prosperity and summer destination growth. It saw the development of Wildwood as a major center for live entertainment. Many nightclubs and auditoriums were built that became the nucleus of what came to be called the " Doo Wop" District. Except for the business recessions of 1948-49 and 1957-1958 the years between the end of the year and the end of the Eisenhower Administration could be described in anthropological terms as a cultural florescence, a time that was relatively carefree, bringing record crowds and unequalled growth to the Wildwoods. From the cultural resources perspective the late 1950s and early 1960s saw the development of numerous nightclubs that earned Wildwood the nickname of "Little Las Vegas." By 1963 the boardwalk piers were experiencing serious competition from the nightclubs of the Doo Wop District. For example, the new nightclub called "Fort Apache" was designed and built with a Western theme. Fort Apache offered stagecoach, burro, and covered wagon rides, a passenger train pulled by a steam locomotive and Mississippi River steamboat ride. There was also continuous entertainment with Sioux war dancers, can-can dancers in the Silver Dollar saloon, and cowboy shoot-outs in the streets. A saloon, bank, hotel, barber shop, restaurant, confectionary, stable, and other period structures made a main street straight out of the Old West.

One historian notes that the nightclubs located west of the Boardwalk were now booking the kind of big name entertainment that one normally associated with Las Vegas. The entertainment industry's most famous names appeared at clubs like The Surf, The Hurricane, the Beachcomber, the Rainbow, and the Manor Supper Club, but numerous smaller clubs also flourished throughout the summer destination . Within a four-block area of Atlantic Avenue, fifteen clubs were in full-swing by 1960. By the mid 1960s the country was wild for "go-go" entertainment and Wildwood provided it. Francis et al reports that there risqué clubs like Joe Cavalier's Frenchee. A-Go-Go Review at the Hurricane East, and Giselle's International Go-Go Review at the Rainbow Club. There were many others of varying sizes and quality. Wildwood became inundated with teenager's intent on dancing the latest craze. Large record hops were held nightly at the Starlight Ballroom on the Boardwalk. The records hops around the city were hosted by big-name disc jockeys, including the young Dick Clark who would later make his name with American Bandstand.

With such a wealth of attractions and entertainment, Wildwood's hotel and motel industry grew enormously during the 1960s. The summer destination 's hotel, motel, boarding-house and cottage owners were soon providing rooms for up to two hundred thousand people per week. By the early 1960's, the height of the Doo Wop era, the summer destination 's motel community had developed a unique personality influenced by space-age themes and rock and roll music. The playful facades of these motels pulled visitors into another world of fun, sun, and excitement. During this period sixty-nine motels were built in Wildwood, sixty-five in North Wildwood, and fifty-two in Wildwood Crest. Many of these motels were classed as Miami Beach-type, usually no more than two stories high. The cheap cost of construction and the high occupancy rates made many people rich. Given this incentive investors also began building taller, hotel-style structures, especially along the shore in Wildwood Crest. Several deluxe hotels like the Pan American and the Diamond Beach were also constructed. Unfortunately, several older historic hotels were destroyed by fire in the 1960s or torn down to make room for new construction that could turn a higher profit.

The period from the mid-1960s through the 1980s was a difficult one for the Wildwoods and many other summer destinations. Due to a number of sociological and economic factors, many summer destination s and parks began a long painful decline. The Wildwoods have survived and recovered remarkably well. Perhaps part of the reason it has come to be regarded as the "Queen of the Jersey Shore Resorts" is that its beach continues to widen at the rate of 35' per year. Francis et al notes that while Atlantic City has experienced an amazing rebirth thanks to gambling casinos, it can no longer be regarded as a true summer destination. Only the Wildwoods are now left to remind us of what summer "down the shore" really meant to Delaware Valley parents and grandparents. The Wildwoods have weathered hurricanes, fires, Prohibition, two World Wars, ocean pollution, devastating publicity, and a host of other challenges to emerge as one of America's best, and best-loved, summer destinations.

2.3.2 Cultural Environment

There are no prehistoric or recorded archaeological sites on the existing Wildwood Beach and little likelihood that any would be encountered. The natural process of beach growth in the Wildwoods precludes the potential for intact prehistoric or historic archaeological deposits in the modern beach area. The natural long shore transport flowing down the Mid-Atlantic coast has been partially blocked down-shore by the Cape May Inlet jetty and this sand has been accumulating in the Wildwoods since the jetty's creation. Nevertheless, there are some potential archaeological sites related to buried prehistoric areas on the offshore continental shelf. These concerns would only be prioritized if an offshore borrow site would ever be needed (e.g. in the North Wildwood area). In addition to the aforementioned Hereford Inlet Lighthouse, there are two major cultural resources in the general project area, neither of which appears to be within the current project's area of potential effect:

- The unexplored archeological record associated with Battle of Turtle Gut Inlet (1776)
- The Wildwoods Shore Resort (Doo-Wop) National Register Historic District

Turtle Gut Inlet was previously bisected the study area between Five Mile Beach to the north and Two Mile Beach to the south as seen in **Figure 24** and **Figure 25**. The location of the former inlet is in the vicinity of Toledo Avenue in today's Wildwood Crest. The Battle of Turtle Gut Inlet is a little- known but authentically documented Revolutionary War naval encounter which took place on June 29, 1776. During this period merchant ships bound for Philadelphia were forced to elude the British blockage. To accomplish this they needed assistance from pilots of the sloops and brigs native to Cape May. These pilots were adept at dodging in and out of the small harbors and inlets like Turtle Gut to escape capture by the British navy.

2.3.3 The Battle of Turtle Gut Inlet

On June 28, 1776 the brigantine Nancy was sighted off the coast of Cape May bound for Philadelphia with a cargo of munitions from the Virgin Islands. These munitions were urgently needed by the Continental Army. As the Nancy came into view an urgent message was sent to Captain John Barry of the Continental frigate Lexington, anchored near the mouth of the Delaware Bay, relating that two British warships were in hot pursuit. Captain John Barry ordered out the barges from the Lexington and another continental frigate, The Wasp, and directed his oarsmen toward the Nancy.

They found the brigantine hard aground in Turtle Gut Inlet and under heavy fire from the two British warships. Barry and his men boarded the Nancy and began unloading the much need munitions while manning the Nancy's guns to ward off the attack. When about two-thirds of the precious cargo of gunpowder had been unloaded Barry ordered the men to abandon the ship. He also ordered that fifty pounds of gunpowder to be poured in the ship's mainsail and wrapped as tightly as possible. This served as a fuse leading to remaining powder below deck. Barry and the Nancy's captain set fire to the mainsail and jumped over the side. The gunpowder exploded with tremendous force just as the first seven British sailors reached the Nancy and climbed aboard. By noon of June 29, 1776 the enemy British ships had retreated and the precious gunpowder was loaded onto the frigate Wasp and sent safely up the Delaware Bay

Figure 24 Turtle Gut Inlet

The Battle of Turtle Gut Inlet is historically significant for its strategic importance in getting munitions to the struggling Continental Army but also for its association with the young Captain

John Barry. By 1794 Barry had advanced in rank to Commodore and been acclaimed as "the father of the American Navy."

There is a marker commemorating the Battle of Turtle Gut Inlet at Miami and New Jersey Avenues, across from Sunset Lake in Wildwood Crest. Whether there are any archeological remains of the brigantine Nancy or artifacts from the British warships in the area where Turtle Gut Inlet once existed is not known. Coordination with the New Jersey SHPO indicates that there have been no professional archaeological surveys of the current study area and no known archaeological surveys incorporating deep test trenching in the area where Turtle Gut Inlet once existed.

Figure 25 Turtle Gut Inlet Locality Sketch from the War Department

2.3.4 "Doo Wop" Architecture

The *Wildwoods Shore Resort Historic District*, best known as the Doo Wop District, is primarily bounded by Atlanta Avenue to the south, Atlantic Avenue to the west, Morning Road to the north and Beach Avenue to the east. Comprising about 275 buildings the district celebrates the soaring designs and imaginative architecture of the 1950s and 1960s, a time when America's early space exploration and doo-wop rock and roll music joined together to influence and create a unique architectural style which has been well preserved in the Wildwoods. The seashore architecture of this era reflected the brash and optimistic spirit of the times. The motels, diners, gas stations, and offices presented a varied and exaggerated spectacle of designs. Angular elements, space-age imagery, tropical themes and colors, with spectacular neon signage reinforced and contributed to this brash and fun-loving spirit.

In Wildwood's official handbook of design guidelines (*How to Doo Wop)* for restoration projects and new construction it is noted that the motels of The Wildwoods were originally designed to celebrate the automobile, allowing views of your car from your room. The buildings were usually situated perpendicular to the beach, allowing generous views of Wildwood's great beach. Rooms were arranged around a central court, containing the pool which was considered an essential element. Often the historic pools, lobbies, signage, and colors are thematic and representative of the Doo Wop movement. The motels of the Doo Wop District capture the social history of an era by reflecting the upward mobility of working class and lower middle-class Americans of the time. The design of these buildings also participated in the shift from serious "modern" architecture playful architectural styling. Ranch houses, restaurants, and especially motels used modern elements to decorate essentially simple boxes. The more outlandish and playful the decorative motifs were the better.

Wildwood's design handbook notes that there is a close parallel between the Doo Wop and the Victorian eras. During the Victorian era, the new white collar workers became middle class after the industrial revolution of the mid-nineteenth century. Their buildings combined conventional construction and with a wide variety of surface ornament to lend style to the structure. A wide variety of grand architectural elements were borrowed and adapted to give the house "style."

In the late 1950s and early 1960s when many of the buildings of the Doo Wop District were being constructed working class and lower middle-class families wanted new and stylish products. To fill this demand, cars, appliances, split-level houses, and motels were created by grafting symbols of modernism on to conventional structures. Borrowed from art, science, and high-style architecture, the motifs of modernity added a layer of decoration. Where Cape May Victorians borrowed elements of Italianate, Gothic, and French Second Empire styles, the playful builders and architects of the Doo Wop era borrowed space themes, flat roofs and angular elements of modernism when building the nightclubs and motels of the hip Wildwoods summer destination .

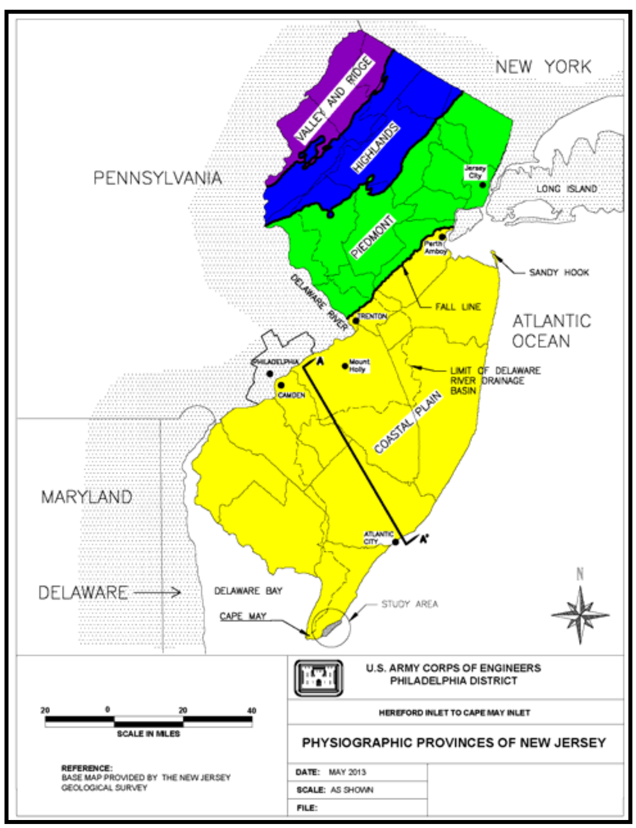
Styles of "Doo-Wop" architecture include; Modern/Blast Off, a glass walled, angular roof style that brings to mind the jet-age airports of the 1950s and 1960s (Satellite and Admiral Motels), Vroom, an architectural movement expressed in angular, forward-thrusting and pointed building elements (Ebb Tide, Pan American and Bel Air Motels; Surfside Restaurant). Tiki/Polynesian, which reflects the fascination with the South Pacific, incorporating plastic palm trees and tiki heads in abundance (Ala Kai, Tahiti, Waikiki, Kona Kai and Casa Bahama Motels). Chinatown Revival reflects interest in exotic foreign travel, particularly the orient (Singapore Motel). and Phony Colonee, a patriotic style that reflects Colonial American brick and lamppost elements (Saratoga and Carriage Stop Motels). (Courtesy of the Wildwood Crest Historical Society)

2.4 Geotechnical Analysis

2.4.1 Geomorphology

The study area is situated within the southern portion of the New Jersey section of the Coastal Plain Physiographic Province of Eastern North America (**Figure 26**). In New Jersey, the Coastal Plain Province extends from the southern terminus of the Piedmont Physiographic Province southeastward for approximately 155 miles (250 kilometers) to the edge of the Continental Shelf. The boundary between the rock units of the Piedmont and unconsolidated sediments of the Coastal Plain Physiographic Provinces is known as the Fall Line, which extends southwest across the state from Perth Amboy through Princeton Junction to Trenton. It is termed the Fall Line due to its linearity and the distinct elevation change that occurs across this border between the more rugged, generally higher rock terrain of the Piedmont and generally lower terrain of the soil materials comprising the Coastal Plain.

Figure 26 Physiographic Provinces.



The Fall Line separates areas with major differences in topography, geology, and hydrology. The Piedmont Physiographic Province, situated northwest of the Fall Line, is mainly underlain by slightly folded and faulted sedimentary rocks, with some localized bands of highly metamorphosed rocks near Trenton and Jersey City. The major linear ridges in this province are underlain by intruded igneous rock, primarily diabase. These intrusions are represented by sills and dikes, as well as lava flows, such as those represented by the most prominent feature in the eastern part of the Piedmont Province known as the Palisades overlooking the Hudson River northwest of New York City.

The Coastal Plain Province, lying southeast of the Fall Line, is part of the Atlantic Coastal Plain that extends along the entire eastern Atlantic Ocean coastline from Newfoundland to Florida. The Plain is the largest physiographic province in the state and covers approximately sixty percent of the surface area of New Jersey. This province encompasses an area of approximately 4,667 square miles (12,087 square kilometers), almost 3 million acres. More than half of the land area in the Coastal Plain is below an elevation of 50’ (15.24 meters) above sea level (NGVD). The terrestrial portion of the Coastal Plain Province is bounded on the west and southwest by the Delaware River and Delaware Bay, on the north by the Fall Line and on the northeast by the Raritan Bay and Staten Island. The remaining portions of the Coastal Plain Province in New Jersey are bordered by the Atlantic Ocean. The Coastal Plain area is largely surrounded by salty or brackish water, which gradually diminishes in salinity upstream in the Delaware River around the Delaware/Pennsylvania state-line. The eastern boundary of the Coastal Plain includes many barrier bars, bays, estuaries, marshes and meadowlands along the Atlantic coast extending from Sandy Hook in the north to Cape May Point at the southern tip of New Jersey. The study area is situated at the southern end of the Coastal Plain Physiographic Province in New Jersey immediately north of Cape May.

In the northern portion of the New Jersey Coastal Plain, the line of maximum elevation runs from the Navesink Highlands southeastward to the Mount Holly area, with the land rising gradually from the sea as a moderately dissected plain to an elevation of almost 400’ (121 meters) in the north in Monmouth County to less than 100’ (30.5 meters) near the center in Burlington County. From this divide, the ground surface slopes down toward the Delaware River on the west and toward the Raritan River drainage system on the east. From Burlington County south, the divide is less pronounced with more subtle topographic control. The drainage basins diverge in the southern Coastal Plain with rivers and streams flowing in a radial pattern to the Delaware River, Delaware Bay, or the Atlantic Ocean.

The surface of the submerged portion of the Coastal Plain slopes gently southeastward at grades ranging from 2.6 ft to 7.9 ft per mile (0.8 meters to 1.5 meters per kilometer) for nearly 104 miles (167 kilometers) to the edge of the continental shelf. The Atlantic coastal shelf is essentially sand structure with occasional silt, gravel or stone deposits. It extends from Cape Cod in Massachusetts to the southern tip of Florida, and is believed to be the world's largest sandy continental shelf. The surface of the submerged portion of the shelf consists of broad swell and shallow depressions with evidence of former shorelines and extensions of river drainage systems that developed during glacial periods when sea level was much lower.

2.4.2 Physiography

The New Jersey shoreline can be divided into those sections where the sea meets the mainland, at the northern and extreme southern ends of the State, and where the sea meets the barrier islands, in the central to southern portion of the State. The barrier islands extend from Bay Head, down the coast for approximately 90 miles (145 km), to just north of Cape May Inlet and are generally continuous, except for the interruption by 10 inlets. The shoreline of the study area extends for approximately 6 miles (10 km), from Hereford Inlet to Cape May Inlet (also known as Cold Springs Inlet) and lies entirely within the southern portion of the barrier beach section. The populated portion of the beach is often referred to as the 5-Mile Beach, with the remainder of the southern end of the beach occupied by the northern portion of the Coast Guard Station and the National Wildlife Refuge of the U.S. Fish and Wildlife Service.

2.4.3 Drainage of the Coastal Plain.

The land surface in the Coastal Plain of New Jersey is divided into drainage basins, based on the area that contributes runoff to streams and their tributaries in a particular region. A drainage divide marks the topographic boundary between adjacent drainage basins. A major drainage divide in the Coastal Plain separates streams flowing to the Delaware River on the west and to the Atlantic Ocean on the east and southeast.

The surface drainage system of the New Jersey Coastal Plain was developed at a time when sea level was lower than at present. The subsequent rise in sea level has drowned the mouth of coastal streams where tidal action takes place. This tidal effect extends up the Delaware River to Trenton, New Jersey, a distance of 139 miles (224 kilometers). The formation of the barrier islands removed all direct stream connection with the ocean between Barnegat Bay and Cape May Inlet. These streams now flow into the lagoons formed in the back of these barrier beaches and their waters reach the Atlantic Ocean by way of the thoroughfares and inlets, discussed above. The significance of these features to the drainage system in the study area is that the Coastal Plain streams, whose upper courses carry little sediment, lose that little sediment in their estuaries, and in the lagoons, and supply virtually no beach nourishment to the ocean front areas.

2.4.4 Geologic Conditions

The New Jersey Coastal Plain Physiographic Province consists of sedimentary formations overlying crystalline bedrock known as the "basement complex." From well drilling logs, it is known that the basement surface slopes at about 155’ per mile (30 meters per kilometer) to a depth of more than 5,000 to 6,000’ (1,500 to 1,800 meters) near the coast. Geophysical investigations have corroborated well-log findings and have permitted determination of the profile seaward to the edge of the continental shelf. A short distance offshore, the basement surface drops abruptly but rises again gradually near the edge of the continental shelf. Overlying the basement are semi-consolidated sedimentary formations of Lower to Middle Cretaceous sediments. The beds vary greatly in thickness, increasing seaward to a maximum thickness of 2.5 miles (4,000 meters) then decreasing to 1.5 miles (2,500 meters) near the edge of the continental shelf. On top of the semi-consolidated beds lie unconsolidated sediments of Upper Cretaceous and Tertiary formations. These sediments range from relatively thin beds along the northwestern margin at the Fall Line, to around 4,500’ (1,370 meters) beneath Atlantic City to over 40,000’ (12,200 meters) in the area of the Baltimore Canyon Trough located around 50 miles (80.5 kilometers) offshore of Atlantic City.

Based on information provided by the New Jersey Geological Survey (NJGS) and United States Geological Survey (USGS), the wedge shaped mass of unconsolidated sediments that comprise the New Jersey Coastal Plain discussed above are composed of sand, gravel, silt and clay. The wedge thins to a featheredge along the Fall Line and attains a thickness of over 6,500’ (1,980 meters) in the southern part of Cape May County, New Jersey. The system is comprised of relatively highly permeable sand and gravel layers separated by semi-permeable to impermeable silt and clay layers that form confining layers and restrict the vertical flow of groundwater. These sediments range in age from Cretaceous to Upper Tertiary (i.e. Miocene - 144 to 5 Ma) (Ma = mega annum = million years ago), and can be classified as continental, coastal or marine deposits. The Cretaceous and Tertiary age sediments generally strike on a northeast-southwest direction and dip gently to the southeast from ten to sixty feet per mile. The Coastal Plain is mantled by discontinuous deposits of Late Tertiary to Quaternary (geologically recent) sediments, which, where present are basically flat lying. The unconsolidated Coastal Plain deposits are unconformably underlain by a Pre-Cretaceous crystalline basement bedrock complex, which consists primarily of Precambrian and early Paleozoic age (>540 Ma to 400 Ma) rocks. Locally, along the Fall Line in Mercer and Middlesex Counties, Triassic age (circa 225 Ma) rocks overlie the crystalline basement rocks and underlie the unconsolidated sediments.

2.4.5 Surface Deposits

As indicated above, the Coastal Plain of New Jersey consists of beds of gravel, sand, silt and clay, which dip gently towards the southeast. Fossil evidence indicates that these sediments range from the Cretaceous to Quaternary Period, with some more recent glacial period Quaternary sediments mantling the surface. The older and lower layers outcrop at the surface along the northwest margin of the Coastal Plain and pass beneath successively younger strata in the direction of their dip. Since the formations dip toward the southeast, this results in a series of successive generally parallel outcrops with a northeast-southwest strike, with successively younger layers outcropping at the surface towards the southeast and progressing southward along the shore.

The sea successfully advanced and retreated across the 155 mile (250-kilometer) width of the Coastal Plain during the Cretaceous through Quaternary Periods (144 Ma to present). Many sedimentary formations were deposited, exposed to erosion, submerged again and buried by younger sediments. The types of sorting, the stratification, and the fossil types in the deposits indicate that deposition took place offshore as well as in lagoons and estuaries, and on beaches and bars. Considerable changes in sea level continued to take place during Pleistocene time. Glacial periods brought a lowering in sea level as water was locked up in the large terrestrial ice masses. As the sea level fell to a beach line thousands of feet seaward of the present shoreline, Pleistocene sediments were deposited in valleys cut into older formations. The water released through glacial melt during interglacial periods brought a rising of sea level and beaches were formed far inland of the present shore.

Between Bay Head and Cape May City, the coastal lagoons, tidal marshes and barrier beaches that fringe the coast have contributed to the sands of the present beaches. During Quaternary time, changes in sea level caused the streams alternately to spread deposits of sand and gravel along drainage outlets and later to remove, rework, and redeposit the material over considerable areas, concealing earlier marine formations. One of these, the Cape May Formation consisting largely of sand and gravel, was deposited during the last interglacial stage, when the sea level stood 33 to 46’ (10 to 14 meters) higher than at present. The material was deposited along valley bottoms, grading into the estuarine and marine deposits of the former shoreline. In most places along the New Jersey coast, there is a capping of a few feet of Cape May Formation. This capping is of irregular thickness and distribution, but generally forms a terrace about 25 to 35’ (7.5 to 10.5 meters) above sea level. The barrier beaches, being of relatively recent origin, are generally composed of the same material as that found on the offshore bottom.

2.4.6 Subsurface Geology (Principal Stratigraphy and Aquifers)

Based on information provided by the NJGS, the principal aquifers of New Jersey are subdivided into two main groups. These include the Coastal Plain aquifers south of the Fall Line and non-Coastal Plain aquifers north of the Fall Line. The Coastal Plain aquifers and their relative position in geologic time that underlie the study area are described below and are illustrated in **Figure 27** from youngest to oldest; a generalized cross section of the Coastal Plane stratigraphy is shown in **Figure 28**.

The Coastal Plain aquifers are comprised primarily of older unconsolidated sedimentary soil materials of Lower Cretaceous to Tertiary age dipping gently southeastward, and covered intermittently by more recent Pleistocene interglacial sands and gravels that cap the hills and watershed divides. The primary aquifers are situated in the older Coastal Plain sediments, which range in thickness from a thin edge at the Fall Line to over 6,500’ at the southern tip of Cape May County.

The wedge of sediments underlying the Coastal Plain forms a massive, somewhat interrelated aquifer system that includes several individual aquifers and confining units. These sediments are generally classified as continental, coastal or marine deposits. In general, aquifers and confining units in the Coastal Plain Aquifer System correspond to the geologic formations present in the System. However, the boundaries of the aquifers and confining beds may not be the same as the geologic formations for the following reasons: (1) the formations may change in physical character from place to place and may act as an aquifer in one area or a confining bed in another; (2) some formations are divided into several aquifers and confining beds; and (3) adjacent formations may form a single aquifer or confining bed in some areas.

There are five major aquifers in the New Jersey Coastal Plain; the Potomac-Raritan-Magothy, Englishtown, Wenonah-Mount Laurel, lower "Atlantic City 800 foot sand” aquifer of the Kirkwood Formation and the Kirkwood-Cohansey.

Figure 27 Coastal Plain Aquifers

Age (Mya)	PERIOD	EPOCH	FORMATIONS*
5	Quaternary	Pleistocene	Cape May
	Tertiary	Pliocene	Pennsauken
		Miocene	Bridgeton, Beacon Hill Cohansey Kirkwood
24		Oligocene	Piney Point
33		Eocene	Shark River Manasquan
54		Paleocene	Vincentown/Hornerstown
66	Cretaceous	Upper Cretaceous	Red Bank/Navesink Mt. Laurel/Wenonah Marshalltown Englistown Woodbury Merchantville Cheesquake
88			Magothy
			Raritan
98		Lower Cretaceous	Potomac
144	Jurassic/Triassic		
250	Paleozoic		Metamorphic Basement
540			

REFERENCE:

N.J. Geological Survey, Rutgers University Department of Geological Sciences

*** Some formations listed are not identified in Southern New Jersey**

U.S. ARMY CORPS OF ENGINEERS
PHILADELPHIA DISTRICT

Hereford Inlet to Cape May Inlet

STRATIGRAPHIC SECTION

DATE: FEBRUARY 2009

SCALE: AS SHOWN

FILE:

All but the Kirkwood-Cohansey aquifer are confined except where they crop out or are overlain by permeable surface deposits. There are also two other smaller, discontinuous aquifers situated between the Wenonah-Mount Laurel aquifer and, lower "Atlantic City 800 foot sand" aquifer and another localized aquifer, the Rio Grande aquifer between the "Atlantic City 800 foot sand" aquifer and the Kirkwood-Cohansey aquifer. The aquifers are recharged directly by precipitation in outcrop areas, by vertical leakage through confining beds, and by seepage from surface-water bodies. The major aquifers and their respective confining units are described as follows in ascending order from the basement bedrock surface.

Overlying the basement bedrock is the Potomac-Raritan-Magothy aquifer system. This wedge shaped mass of sediments of Cretaceous age is composed of alternating layers of clay, silt, sand, and gravel. These deposits range in thickness from a featheredge along the Fall Line to more than 4,100' beneath Cape May County. The Potomac-Raritan-Magothy aquifer system is exposed in a narrow outcrop along the Fall Line and the Delaware River. The aquifer is confined except in outcrop areas by the underlying crystalline basement rocks and the overlying Merchantville-Woodbury confining unit.

The Merchantville Formation and Woodbury Clay form a major confining unit throughout most of the Coastal Plain of New Jersey. Although their permeability is very low, the Merchantville-Woodbury confining unit can transmit significant quantities of water when sizeable differences in hydrostatic head exist between overlying and underlying aquifers.

The Englishtown aquifer overlies the Merchantville and Woodbury confining unit in the central and northern parts of the Coastal Plain. The aquifer is a significant source of water for Ocean and Monmouth Counties.

The Marshalltown Formation overlies the Englishtown sand in most of the Coastal Plain but overlies the Woodbury Clay in the majority of Salem County. The formation has a maximum thickness of 30' (9.14 meters). Because the Marshalltown Formation is thin and contains some slightly too moderately permeable beds, it acts as a leaky confining bed.

Although the Wenonah Formation and Mount Laurel Sand are distinct lithologic units, they are hydraulically connected and together form the Wenonah-Mount Laurel aquifer. The Mount Laurel Sand, a coarser sand unit than the Wenonah Formation, is the major component of the aquifer. The combined thickness of the Wenonah Formation and Mount Laurel Sand in outcrop is as much as 100' (30.5 meters). In the subsurface they range in thickness from 40' (12 meters) to slightly more than 200' (61 meters) and are an important water producing aquifer in the northern and western parts of the Coastal Plain.

Overlying the Wenonah-Mount Laurel aquifer is a confining unit that comprises several geologic units. The confining unit consists of the Navesink Formation, Red Bank Sand, Tinton Sand, Hornerstown Sand, Vincentown Formation, Manasquan Formation, Shark River Marl, Piney Point Formation and the basal clay of the Kirkwood Formation. Some of these geologic units may act as aquifers on a local basis

The overlying Kirkwood Formation includes several water bearing units. The major Kirkwood aquifer is the principal artesian aquifer within the Kirkwood Formation, which is also known as the "Atlantic City 800 foot sand" and extends along the Atlantic Coast from Cape May to Barnegat Light and some distance inland. In Cape May and Cumberland Counties, the upper artesian aquifer of the Kirkwood Formation is defined as the Rio Grande water bearing zone. This aquifer is productive only locally in Cape May County. Along the coast north of Barnegat Light and inland from the coast in Ocean, Burlington, Atlantic, and the western part of Cumberland Counties, the sands of the upper part of the Kirkwood Formation are hydraulically connected to the overlying Cohansey Sand.

The Cohansey Sand is typically light colored quartzose sand with lenses of silt and clay. The Cohansey Sand is exposed throughout most of the outer part of the Coastal Plain and attains a maximum thickness of about 250' (76.2 meters). Ground water in the Cohansey aquifer occurs generally under water table conditions except in Cape May County, where the aquifer is confined. Inland from the coast and in the northern part of Ocean County, the upper part of the Kirkwood Formation is in hydraulic connection with the Cohansey Sand and together they act as a single aquifer.

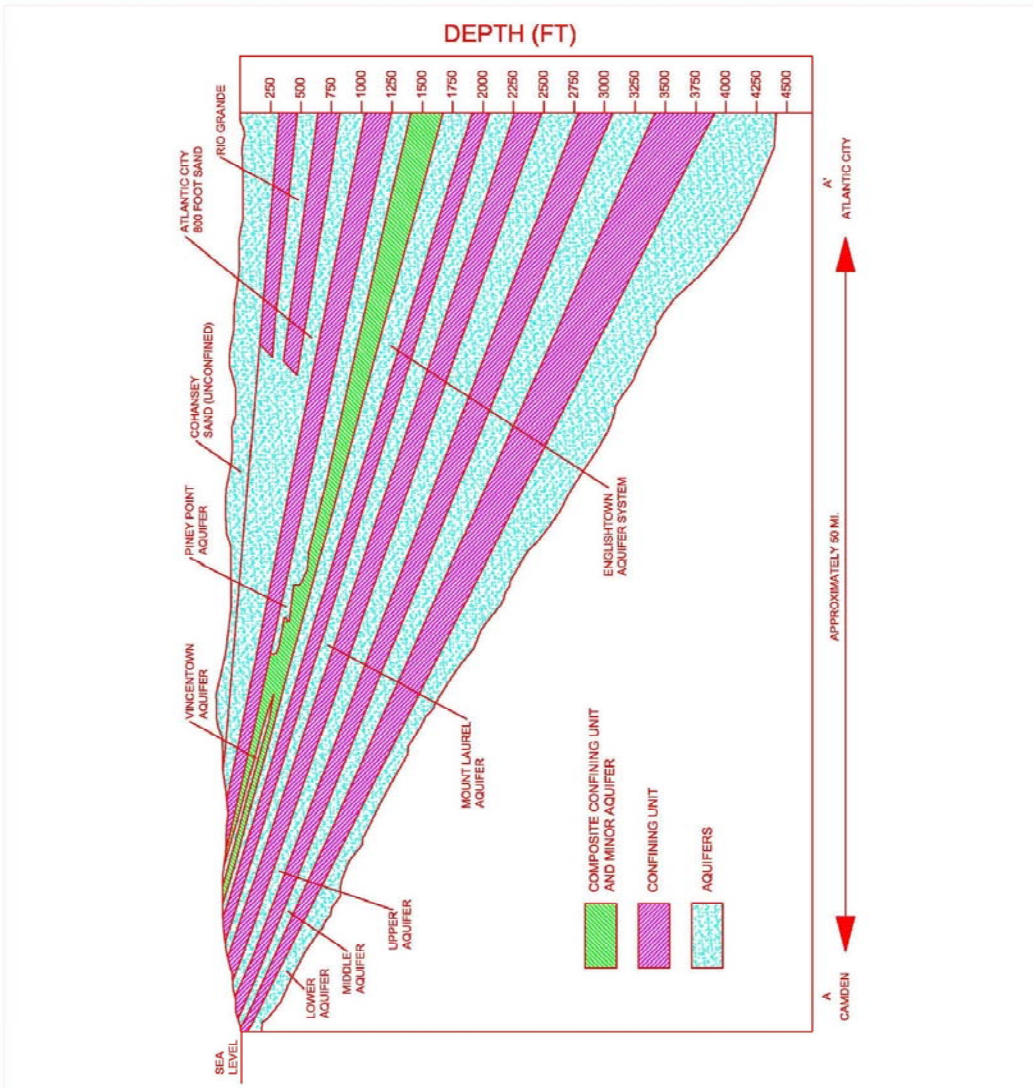
NJGS reports indicate that more than 75 percent of the freshwater supply in the New Jersey Coastal Plain is derived from ground water resources. In the Coastal Plain, high-capacity production wells used for public supply commonly yield from around 500 to 1,000 gallons per minute (gpm), and many exceed 1,000 gpm. Water quality is satisfactory except for local elevated iron levels in several aquifers, including the lowest aquifer system, the Potomac-Raritan-Magothy System, and for local contamination from saltwater intrusion and waste disposal and agricultural derived residues in shallower aquifer systems. In the unconfined Kirkwood-Cohansey aquifer system water is brackish or salty in some coastal areas. In confined aquifers, salinity generally increases with depth in the southern and southeastern parts of the Coastal Plain.

2.4.7 Local Geology

The geology of the Wildwoods, consists of Holocene deposits of beach and near shore marine sands, along the beaches and the developed portions of the island, and salt marsh and estuarine deposits, located with back bays and the mainland. The Holocene deposits are underlain by the Quaternary deposits of the Cape May Formation, which is underlain by the Tertiary deposits consisting of the Cohansey Sand.

The beach and near shore marine sands consists of sand and pebble gravel, very pale brown to light gray, extending to depths as much as 50 feet, but generally less than 20 feet thick. The salt marsh and estuarine deposits generally consist of silt, sand, peat, clay and minor pebble gravel, with abundant organic matter. The Cape May Formation is present beneath the Holocene deposits and generally consists of inter-bedded gravels, sands and silts/clays, varying in color from very pale brown, yellow, reddish yellow, white, olive yellow and gray. The Cape May Formation has been reported to be as much as 200 feet thick on the Cape May Peninsula. The Cape May Formation is underlain by the Cohansey Sand, which consists of quartz sands or gray silty clay, ranging in thickness between 50 to 225 feet.

Figure 28 Stratigraphic Cross Section



Reference: Information provided by the New Jersey Geological Survey, Rutgers' University Department of Geological Sciences, and the Delaware Geological Survey

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NEW JERSEY COASTAL PLAIN HYDROGEOLOGIC STUDY

STRATIGRAPHIC SECTION

DATE: FEBRUARY 2009

SCALE: AS SHOWN

FILE:

FIGURE

2.4.8 Native Beach and Borrow Source Data Collection

A beach monumentation and shoreline/profile survey was conducted by Offshore & Coastal Technologies, Inc. - East Coast (OCTI - EC) along the Wildwood beaches between September 24 and 29, 2003. The results of this study were presented in a report submitted to USACE dated December 17, 2003. The study area extended from Hereford Inlet to Cape May Inlet. As part of this study, a total of 25 beach profiles were taken during the measurement period and beach surface soil samples were taken along selected profile lines for identification and analysis. The beach profiles extended from the building construction line seaward to beyond a water depth of 25’ below NAVD 88. Beach soil samples were obtained along 10 preselected survey lines extending from 200’ landward of the beach crest to a water depth of 18’ below NAVD 88.

The survey utilized North American Vertical Datum (NAVD) 1988 as the vertical datum. The North American Datum (NAD) 1983 was used as the horizontal datum. The New Jersey State Plane Coordinate System was used where actual geo-positioning was required.

Beach samples were collected along survey lines distributed along the entire length of the beach survey area. The distance between consecutive soil sampling lines ranged from between 1,000 to 2,000’ of separation. **Table 12** shows the survey lines that were sampled.

Table 12 Beach and Survey Sampling Locations

Location	Survey Line	Approximate Distance South of Hereford Inlet
North Wildwood City	WW1	along inlet
“ “ “	WW2	2,200 feet
“ “ “	WW2B	3,500 feet
Wildwood City	WW4	6,500 feet
“ “	WW7	10,700 feet
Wildwood Crest	WW10	14,900 feet
“ “	WW13	20,800 feet
“ “	WW15	24,400 feet
Lower Township	WW17	27,100 feet

Samples were collected during September of 2003. Samples were obtained at the following locations along the survey lines indicated above:

Beach Crest minus 200’ (BC-200)
Beach Crest (BC)
Tidal Zone Composite (Tidal)
Depth -6’ (-1.8 meters)*
Depth -18’ (-5.5 meters)*

** Depth is referenced to NAVD 88 datum*

With the exception of the tidal zone composite samples, each individual sample was identified with a separate S-# symbol. Tidal component samples were identified with a "Tidal Composite" designation.

All recovered soil samples were subjected to gradation analyses using ASTM Method ASTM D 422 by OCTI -EC to determine the distribution of particle sizes in samples collected. The results of this testing were presented in OCTI - EC's report and were utilized to determine the existing conditions of the sacrificial beach sediments in our geotechnical analysis.

2.4.9 Acoustic Sub-bottom Profiles

Acoustic sub bottom profiling has been performed within the study area on a number of different occasions. The earliest of those used for this study are those performed by Coastal Engineering Research Center (CERC) of the USACE Waterways Experiment Station in 1980 and 1982. These studies indicated several potential borrow sources in the area offshore of the Cape May region. Subsequent studies by CERC and others, most notably, the New Jersey Geological Survey, Rutgers University and the NJDEP, have provided additional information to assist in defining the potential borrow areas selected for incorporation into this study.

2.4.10 Investigation of Potential Borrow Areas

Numerous vibracores were collected by several firms under contract to U.S. Army Corps of Engineers, Philadelphia District and the New Jersey Department of Environmental Protection (NJDEP) during the period 1980 to 2007 in the Atlantic Ocean off the coast of New Jersey from Avalon south to Cape May. Except for those collected in July 1999, the depth of penetration for the vibracores was 20' (6.10 meters). The fieldwork included positioning of the vessel using a DGPS navigation system and obtaining continuous core samples with penetration records. All fieldwork was conducted aboard contracted vessels. Particle size analysis of the sediment samples retrieved in the vibracores was performed in both consultants' and the Philadelphia District's geotechnical laboratories.

The samples collected in July 1999 were obtained to a depth of penetration of 10' (3.05 meters). The fieldwork was similar to that detailed above, however the vibracoring was conducted aboard a 20' by 50' (6.10 meters by 15.24 meters) barge positioned by a tugboat. The vibracores were advanced utilizing an 8-inch (20.3 centimeter) Alpine pneumatic vibracore. Duffield Associates visually classified and conducted particle size analysis of the sediment retrieved in the vibracores.

The latest investigations for the Hereford Inlet to Cape May Inlet Feasibility Study were conducted to better define several possible borrow sources for future beach replenishments at the eroding beach in North Wildwood. In order to identify potential sources of replenishment sand, a series of vibracore and test boring investigations were conducted by Schnabel Engineering under contract to the Philadelphia District. These investigations were performed in 2006 and 2007, respectively. Details of these investigations are provided in the following paragraphs.

Between April 14 and 15, 2006 a series of 8 additional vibracores were obtained offshore from the Wildwood beach area between Hereford Inlet and Cape May Inlet. The vibracores were performed by Schnabel Engineering and their subcontractor Alpine Drilling. Three of the vibracores, NJV-745, NJV-746 and NJV-747, were obtained in Hereford Inlet immediately west of the former borrow area in this inlet. The other five vibracores were obtained in areas selected by the USACE approximately 1500' (457.2 meters) offshore of the beach area (NJV-748 through NJV-751). These vibracores were obtained to characterize the coastal sediments as possible sand borrow sources for future beach renourishment. Continuous soil samples were obtained from the vibracore samples from each five-foot or less interval and subjected to grain size analysis. The results of this investigation, which were incorporated into the current feasibility study, were presented in Schnabel Engineering's report dated June 30, 2006.

Between February 12 and March 5, 2007 a series of 14 standard penetration test (SPT) borings were advanced along the Wildwood beach area extending between Hereford Inlet and Cape May Inlet. The test borings were performed by Tabasco Drilling under the direction of Schnabel Engineering. The borings were obtained in locations selected by the USACE along the beach to characterize the sediments underlying the existing surface beach materials. These borings provided better definition of potential borrow source in the vicinity of the accreting beaches in Wildwood, Wildwood Crest and Lower Township for evaluation for potential use in renourishment of the eroding beach at North Wildwood. The 14 borings were designated NVB-01 through NVB-14 and were advanced to depths of 26' (7.9 meters) below the surface at each location. Soil samples were collected continuously in all borings. Recovered soil samples were examined and composited in primarily 4-foot (1.2 meter) intervals in the borings and subjected to gradational analyses for use in our beach design computations. The results of this investigation, which were also incorporated into the current feasibility study, were presented in Schnabel Engineering's report dated April 17, 2007.

Several additional vibracores were collected during the latter part of 2007 in or near the proposed Hereford Inlet borrow source. Those used in the evaluation of that source were NJV- 797, 799 and 800. Selected vibracore logs and gradation data obtained from all of the investigations mentioned in the foregoing paragraphs were reviewed to obtain information about borrow sources being considered.

2.4.11 Native Beach Characteristics

All beach survey line sample data used in the development of the composite grain size curves for the North Wildwood, Wildwood, Wildwood Crest and Lower Township beaches were taken from OCTI-EC sampling performed in September/October 2003. Comparisons were made with the upper samples 0 to 4' (0 to 1.2 meters) depth in the NVB series of borings performed by Schnabel Engineering in February and March, 2007. Only minor differences were found in the gradations of the winter and late summer samplings. The North Wildwood beach has been severely eroded according to observations and surveys made during the period 2003 to 2007. The beach areas south of Line WW-7 in Wildwood, Wildwood Crest and Lower Township show accretion based on surveys made during the same period.

The beach material for the North Wildwood beach consists primarily of poorly graded, fine-grained, quartz sand with a mean grain size M_{φ} of 2.34 phi/ 0.2 mm, and minor amounts of silt. Grain size curves, for the native beach area are included in the Geotechnical Appendix. Cumulative grain size distribution (GSD) plots were also developed from samples, from the

North Wildwood beach area (native beach) and the proposed borrow areas, to visually illustrate the compatibility of the native beach and borrow area sediments. The cumulative GSD plots for the North Wildwood beach are included in the Geotechnical Appendix.

The North Wildwood beach area has suffered erosion since 2003 with the high tide level retreating an average of 5' per year during the 2003 to 2007 period. This figure is based on surveys conducted along the beach in this area over this period.

As customarily utilized in beach analysis, grain size calculations were made using phi units in lieu of metric size units. The phi units are used since they represent whole numbers at the limits of the Wentworth scale for sediment size sorting and because they allow comparison of different size distributions as they are dimensionless. **Figure 29** reproduced from Table III-1-2 from EM 1110-2-1100 (Part III) illustrates size terminology and particle size comparisons for sediments

The average grain size distribution of the native beach was determined using the weighted average of the composite of surface samples from Lines WW - 1, 2 and 2B with SPT boring samples from NVB – 1, 2 and 3 (0 to 4' depths). This resulted in design parameters of $M_{\varphi} = 2.34$ phi/0.20 mm and $\sigma_{\varphi} = 0.46$ phi (**Table 13**).

This value is weighted more to the characteristics of the surface soil materials that were present during the investigation. These values were used in the determination of overfill and re-nourishment factors for each of the recommended borrow areas.

Figure 29 Soil Classification System

Comparison of the Soil Classification Systems compiled from various sources							
Wentworth	Burmister	USCS	USDA	mm	in	Phi	US Stan. Sieve Size
				4026		-11.98	
				2048		-11	
boulders		boulders		1024		-10	
			cobbles	512		-9	
				256	10.08	-8	
		cobbles		128		-7	
cobbles				64	2.52	-6	No. 5+
	coarse gravel	coarse gravel	medium gravel	32	1.26	-5	
	medium gravel			16	0.63	-4	
v. coarse coarse pebbel gravel medium fine		fine gravel		8	0.31	-3	
	fine gravel		fine gravel	4	0.16	-2	
gran. (vf) gravel		coarse sand		2	0.08	-1	No. 5-10
v. coarse sand	coarse sand	medium sand	v. coarse sand	1	0.04	0	No. 10-18
coarse sand			coarse sand	0.5	0.02	1	No. 18-35
medium sand	medium sand		medium sand	0.25	0.01	2	No. 35-60
fine sand			fine sand	0.125	0.005	3	No. 60-120
v. fine sand	fine sand	fine sand	v. fine sand	0.101	0.002	5.01	No. 120-230
	coarse silt						
coarse silt		silts & clays	silt	0.0625		4	< No. 230
medium silt	fine silt			0.0156		6	
fine silt				0.0078		7	
v. fine silt				0.0039	0.0002	8	
clay			clay	<.0039	<0.0002		

2.4.12 Borrow Area Suitability Analysis

Borrow material should be approximately the same size or slightly coarser than the native material on the beach to be nourished. If the borrow material has a significantly smaller grain size, the profile will be out of equilibrium with the local wave and current environment, and will therefore be quickly eroded either offshore or alongshore. This analysis compares the native sediment characteristics to the borrow material characteristics. The analysis was completed using the methodology put forth in the Coastal Engineering Manual (2003). Overfill factors (R_a) were calculated for each potential borrow area. The overfill factor estimates the volume of fill material needed to produce one cubic yard of stable beach material after equilibrium in gradation has been reached between the fill and native materials by wave action and erosion processes. Consequently, overfill factors are greater than or equal to one. For example, an overfill factor of 1.2 would indicate that 1.2 cubic yards of borrow material would be required to produce 1.0 cubic yards of stable material. This technique assumes that both the native and composite borrow material distributions are nearly log normal distribution.

In order to determine an estimate of the renourishment factors, we deviated from the design procedures presented in the 2003 edition of the Coastal Engineering Manual and evaluated the renourishment factors using the methodology presented in the 1984 edition of the manual. The renourishment factor is a measure of the stability of the placed borrow material relative to the native beach material. Desirable values of the renourishment factor are those less than or equal to one. For example, a renourishment factor of R_j =0.33 would mean that renourishment, using the borrow material, would be required one third as often as renourishment using the same type of material that is currently on the beach. North Wildwood sediment data is contained below in **Table 13.**

Table 13 North Wildwood Composite Values

Beach Sample Line	Average Value BC+200 to El-18		SPT Boring Number	Depth (ft)	Average Value		REMARKS	Depth (ft)	Composite Value	
	Geometric Mean M_ϕ (Phi)	Inclusive Graphic Deviation σ_ϕ (Phi)			Geometric Mean M_ϕ (Phi)	Inclusive Graphic Deviation σ_ϕ (Phi)			Geometric Mean M_ϕ (Phi)	Inclusive Graphic Deviation σ_ϕ (Phi)
WW-1	2.36	0.46	NVB-1	0-4 0-8 0-12	2.38 2.47 2.54	0.40 0.40 0.41	Compare NVB-1 (0-4') to WW-1 values	0-4	2.37	0.43
WW-2	2.24	0.49	NVB-2	0-4 0-8 0-12	2.37 2.60 2.54	0.40 0.48 0.52	Compare NVB-2(0-4') to WW-2 values	0-4	2.30	0.44
WW-2B	2.23	0.48	NVB-3	0-4 0-8 0-12	2.46 2.57 2.70	0.52 0.53 0.51	Compare NVB-3(0-4') to WW-2B values	0-4	2.35	0.50
									2.34	**0.46**

2.4.13 Potential Borrow Areas

There were eight potential borrow areas identified in this phase of study . Four of these areas are in the Hereford Inlet area and are designated H-1, H-2, H-3, and H-4. The 5th potential borrow area is the Wildwood and Wildwood Crest beach area which is designated WW/WC. There were also three other offshore areas that were considered for potential borrow areas, located southeast of Wildwood, which were designated OS-1, OS-2 and OS-3. Another potential borrow source area, Area K, which is a designated part of OS-3, was also originally considered for evaluation, but this area was later selected and designated for another replenishment project in Cape May and was therefore excluded from this current study. The actual limits of these potential borrow sources will have to be determined by detailed bathymetric survey and additional subsurface investigation. The locations of the borrow area relative to the project area are shown in **Figure 30-33**.

The vibracores that fell within the anticipated limits of the potential borrow areas were analyzed for suitability with the native beach material at North Wildwood. In order to perform borrow area suitability analyses the mean grain size and standard deviation, both in phi units, were computed for each five foot or less depth increments of the vibracores. The final composite for a particular borrow area was developed from the individually composited section of the vibracores for that particular borrow area. Overfill and renourishment factors were then computed using the native beach and borrow area design parameters. These factors were then evaluated to determine the borrow material's suitability for the North Wildwood beach.

It should be noted that renourishment of the North Wildwood Beach in the near future is currently under consideration and is being planned by the State of New Jersey due to the current erosion cycle in this area. The contemplated plan calls for using material from a source located in Hereford Inlet area. This renourishment work will be using state and local funding.

Figure 30 Wildwood Borrow Areas Evaluated for Feasibility

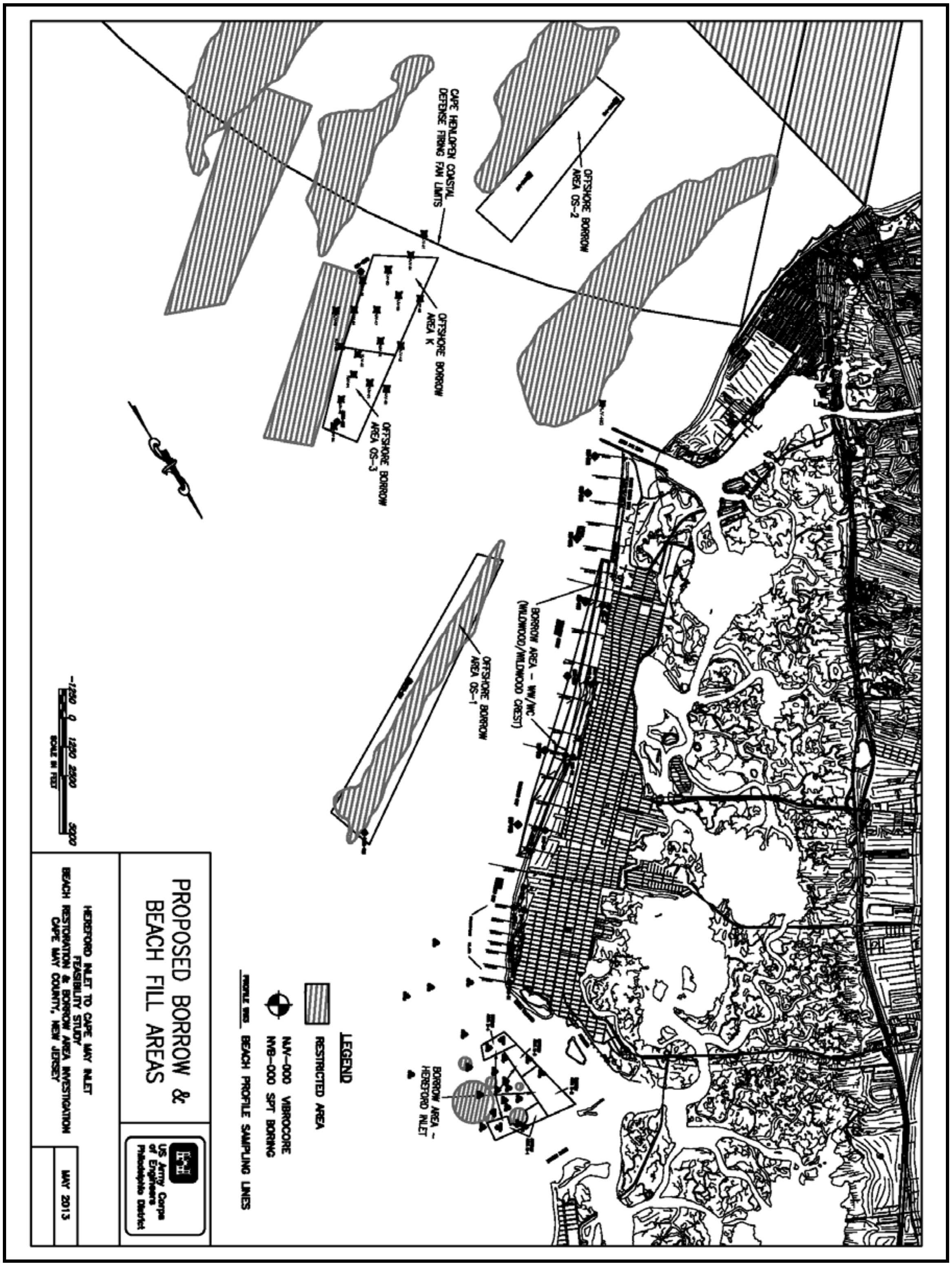


Figure 31 Hereford Inlet Borrow Area

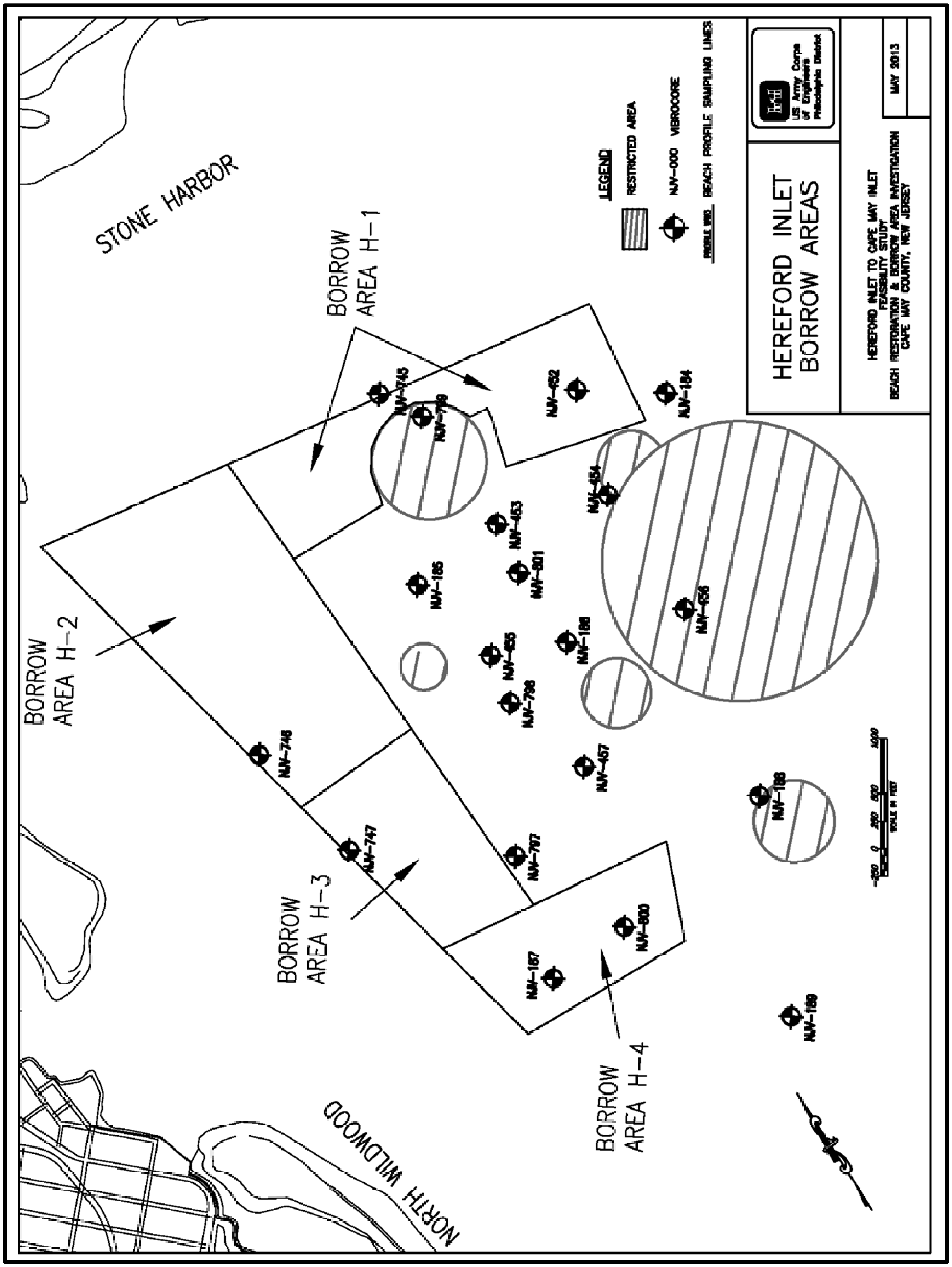


Figure 32 Wildwood and Wildwood Crest Borrow Area

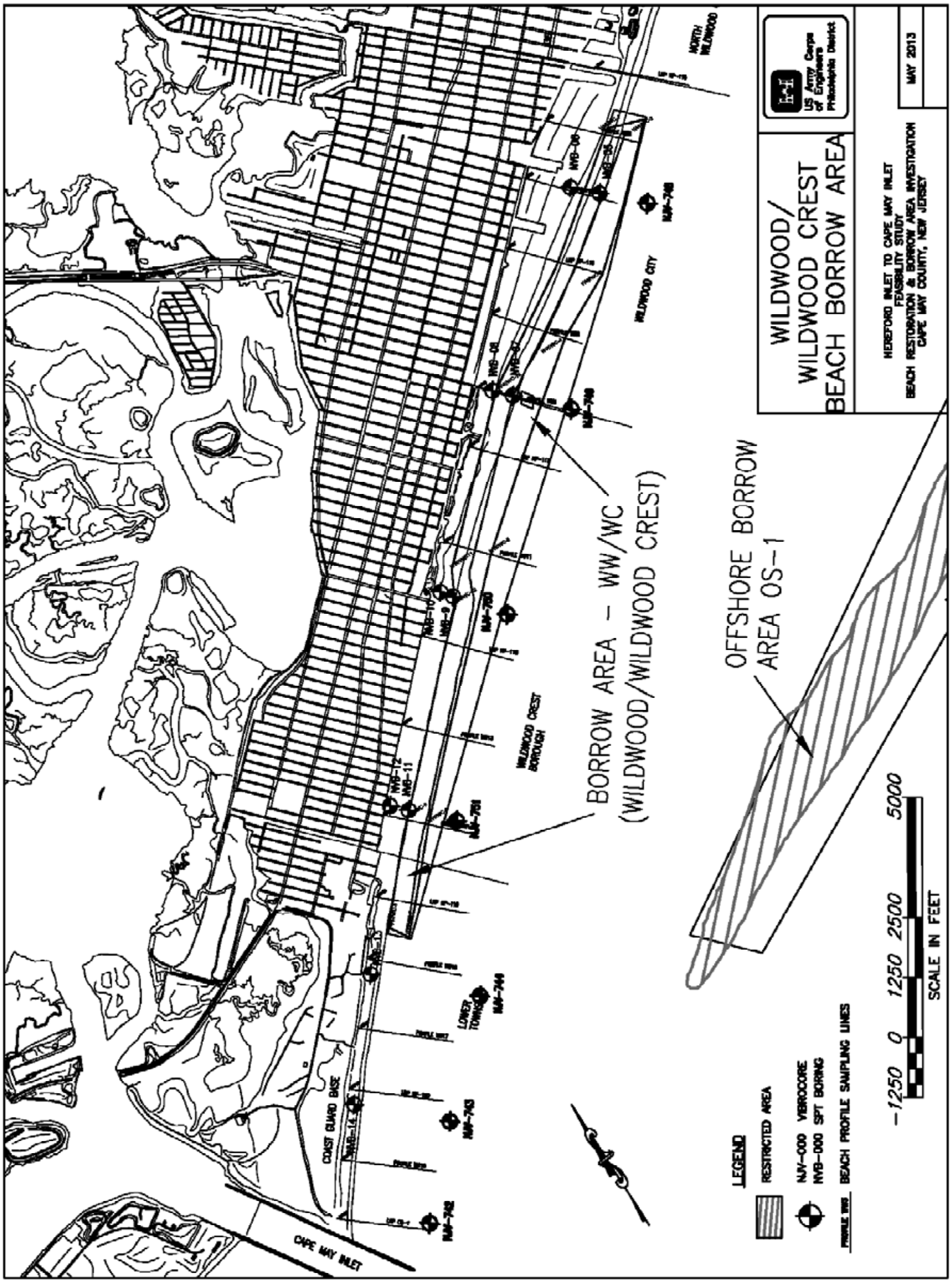
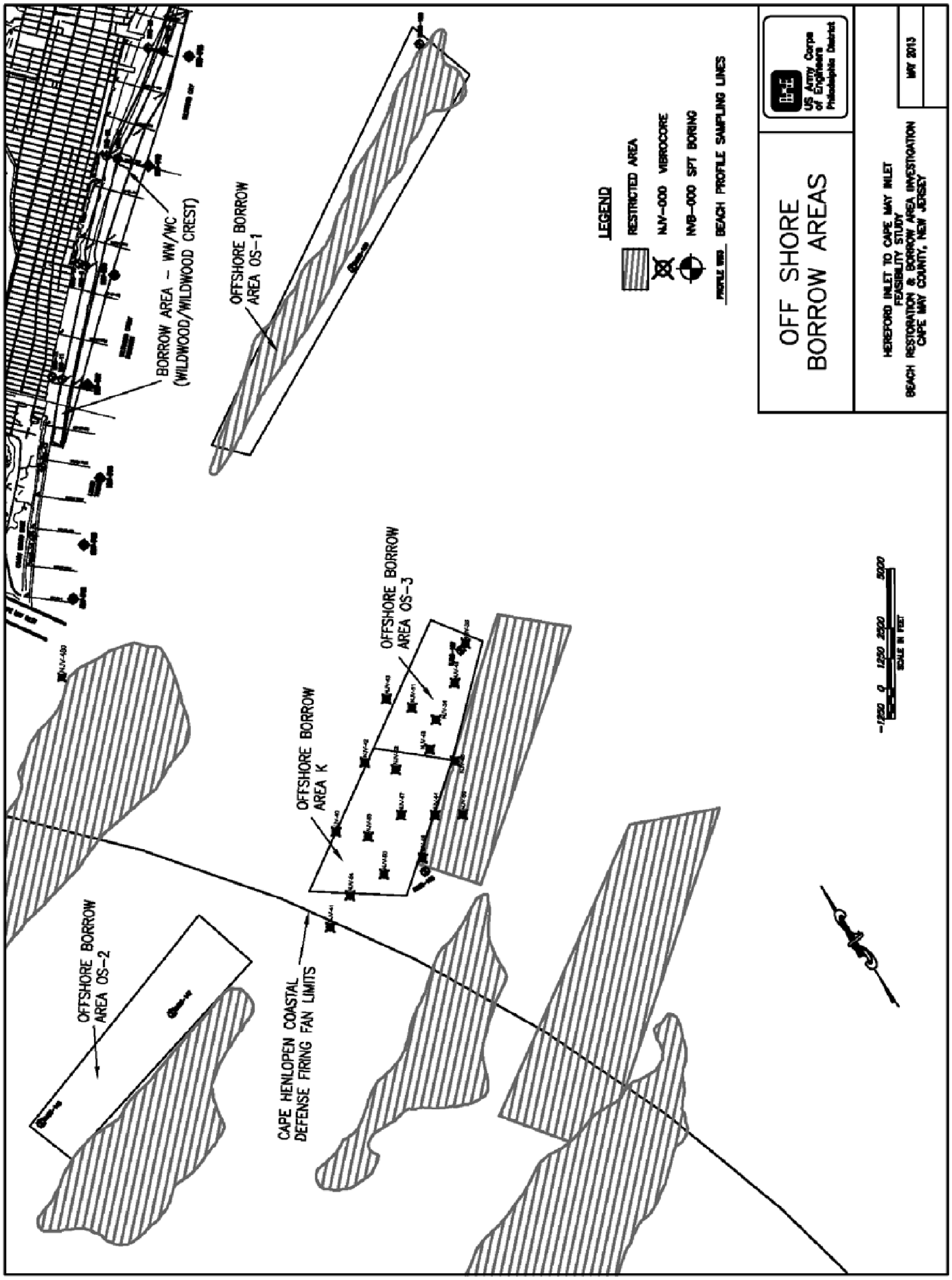


Figure 33 Offshore Borrow Area



2.4.15 Approximate Perimeter Coordinates of Potential Borrow Areas

Borrow area perimeter coordinate points are shown below in **Table 14**. Perimeter coordinates are in New Jersey State Plane .

Table 14 Borrow Area Coordinates

COORDINATE	NORTHING (ft)	EASTING (ft)
H-1		
H-1a	69002	413059
H-1b	68441	416450
H-1c	68194	415055
H-1d	68560	414697
H-1e	68433	414187
H-1f	67974	413399
H-1g	68005	413097
H-2		
H-2a	69291	411308
H-2b	69002	413059
H-2c	66229	413165
H-2d	66184	411993
H-3		
H-3a	66184	411993
H-3b	66229	413165
H-3c	64379	413235
H-3d	64494	412366
H-4		
H-4a	64494	412366
H-4b	64211	414500
H-4c	63404	414170
H-4d	63475	412591
WW/WWC Beach		
WW/WC -1	56064	405741
WW/WC -2	55441	406186
WW/WC -3	50394	399387
WW/WC-4	45415	394069
WW/WC-5	45793	393747
WW/WC-6	50866	398944
OS-1		
OS-1a	50047	413429
OS-1b	47252	404307
OS-1c	39477	398911
OS-1d	40617	397844
OS-2		
OS-2a	25462	387402
OS-2b	22816	388161
OS-2c	20190	377978
OS-2d	22177	377295
OS-3		
OS-3a	30167	401380
OS-3b	28358	402639
OS-3c	25113	399113
OS-3d	27201	396756

2.4.16 Details of Borrow Area Design Analyses

The beach borrow design analysis was accomplished as part of the Hereford Inlet to Cape May (also known as Cold Springs) Inlet Feasibility Study. The methodology used is that recommended in the 2003 Edition of the USAE Coastal Engineering Manual (EM 1110-2-1000) Chapters I and IV. As previously stated, the one exception was the use of the 1984 Edition methodology to calculate the renourishment factor (R_j). This calculation has been dropped from later editions due to changes in the concept of determining the time required between renourishment of beach fills. It is our understanding that current practice favors a more historically based method to determine the frequency of renourishment rather than the older method based on grain size distributions of the native beach and borrow materials.

A significant amount of older information was available for this investigation that was used in our analysis. This information consisted of gradation curves for the collected samples, that could not be readily used in the ACES method for calculating overfill and re-nourishment factors. The ACES method requires phi diameters and sample weights for analysis. The available data was organized and analyzed using EXCEL to determine the required parameters and average values of the median grain size and mean standard deviation for the native beach and borrow areas. The overfill and re-nourishment factors where then determined using the methods present in EM 1110-2-1000, and checked using the ACES method. A description of the method utilized to analyze the data is presented in the Geotechnical Appendix and discussed on the following pages.

In addition, cumulative GSD plots and a composite distribution plot for the native beach and potential borrow areas are included in the Geotechnical Appendix. The graphical plots provides for visual comparison of the compatibility of the native beach sediments and the borrow area materials.

2.4.17 Hereford Inlet Borrow Area – Subareas H-1, H-2, H-3, H-4 and Total Area "H"

The Hereford Inlet Borrow Area is located immediately to the north of the proposed beach restoration project in North Wildwood. Pumping distances would range from 0.8 miles at the southern end of the area (subarea H-4) to 1.6 miles at the northern end (subarea H-1).

Nine (9) vibracores taken in the Hereford Inlet area during the period 1994 to 2007 were used to evaluate this area. These included NJV 185 and 187 (1994); NJV-452 (1997); NJV-745, 746 and 747 (2006.) and NJV-797, 799 and 800 (2007). It should be noted that NJV 185 and 452 were taken in areas subsequently excavated for borrow used for other beach fill projects in North Wildwood and Stone Harbor. However, data from these vibracores was used in the determination of averages used in the design parameters for the area. It is further noted that the material encountered in NVB-187 was significantly coarser than that encountered elsewhere in the area and could possibly be an anomaly. If so, it possibly has skewed the overall design parameters used for the Hereford Inlet source. However, for the purposes of this investigation, the value was used in determining the average M_ϕ and σ_ϕ for the borrow area.

There is concern regarding the use of material from subareas H-3 and H-4 of the Hereford Inlet borrow area. The removal of this material is likely to change the character and ferocity of wave attack on the North Wildwood shore of the inlet. It has been reported that the parameters used in the design of the shoreline protection in this area would likely be changed if this shoal is removed and the shoreline protection could be inadequate due to the changed conditions. The total volume of fill contained within the proposed limits of the area to El. -28 NAVD is estimated to be 5,815,000 C.Y. It should be noted that this area was designated as a potential borrow source for Stone Harbor beach renourishment. The overfill and renourishment factors for the North Wildwood area from the Hereford Inlet borrow areas considered suitable for use are summarized in **Table 15.**

Table 15 Overfill and Renourishment Factors for Hereford Inlet Borrow Areas

Area and Vibracore Designation	Mean Grain Size $M_{\phi b}$ (Phi)	Standard Deviation $\sigma_{\phi b}$ (Phi)	$\frac{\sigma_{\phi b}}{\sigma_{\phi n}}$	$\frac{M_{\phi b} - M_{\phi n}}{\sigma_{\phi n}}$	Overfill Factor (R_a) and Quadrant	Renourishment Factor (R_j)
H1 NJV-745	2.41	0.36	0.78	0.14		
H1 NJV-799	2.22	0.68	1.44	-0.25		
H1 NJV-452.	2.61	0.40	0.84	0.59		
H1 Composite*	2.40	0.48	1.04	0.16	1.25	1.2/1
H2 NJV-185	2.25	0.65	1.40	-0.20		
H2 NJV-746	2.51	0.33	0.72	0.38		
H2 Composite*	2.39	0.47	1.07	0. 09	1.2	1.2/1
H3 NJV-747	2.38	0.41	0.90	0.08		
H3 NJV-797	2.57	0.43	0.93	0.50		
H3 Composite*	2.46	0.42	0.91	0.25	1.6	1.4/1
H4 NJV-187	2.43	0.42	1.45	0.19		
H4 NJV-800	2.42	0.66	1.42	0.16		
H4 Composite[1]	2.42	0.51	1.35	-0.70	1.3	.7/1
H-1 thru H-4[2]	2.42	0.51	1.10	0.17	1.25	1.2/1

1. Composite based on weighted average of samples from each vibracore based on length of sample multiplied by the depth of cut represented by each sample.

2. Results based on weighted values by height to determine average M_Φ and σ_Φ
3. Subscript "n" indicates a native beach material property; subscript "b" indicates a borrow material property;

2.4.18 Wildwood – Wildwood Crest – Area "WW/WC" (Formerly Area "D")

Area "WW/WC", which was formerly designated as Area "D", is situated immediately south of the North Wildwood Beach renourishment area. It is located in the accretion area extending from the north end of Wildwood City beach to the south end of the Wildwood Crest beach. The distances from the north and south ends of this borrow area to the renourishment area at north Wildwood range from around 1 to 4 miles, respectively.

Investigations used to define the borrow area design parameters for Area "WW/WC" consisted of surface samples taken from Beach Lines WW-4 to WW-15 in Wildwood and Wildwood Crest (5 samples per line at BC+200, BC, tidal zone, El. -6 NAVD and El. -18 NAVD.)

The initial trials included only the surface sample data to define the borrow area's design characteristics, primarily because we had little expectation that the communities involved would allow the use of this material for the project. Subsequent discussions between local, state and COE personnel indicated some interest on the part of the local people due to benefits which may be derived from the reduction of the beach width in these communities; i.e. reduction in the need to extend storm sewer outfalls; and reduction in the width of beach traverse required to reach the prime recreation areas near the water's edge.

Based on this, it was determined that better definition of these potential borrow materials was required and a series of Standard Penetration Test (SPT) borings was performed in 2007 to determine material quality at depths up to 26 ft.

The grain size characteristics of Area "WW/WC" were computed using a method similar to that used to determine the native beach material characteristics at the North Wildwood beach restoration area. Composites were developed for three sections of the borrow area using summations of the surface samples on each side of the seaward boring of each SPT pair located between the individual sampled beach lines and the seaward SPT boring. The SPT boring design characteristics were determined for depths from ground surface of both 12' and 16' **(**

The design parameters for Area "WW/WC" are M_f = 2.40 phi/0.19 mm and σ_f = 0.45 for excavation to El. -8 NAVD and M_f = 2.42 phi/0.19 mm and σ_f = 0.47 for excavation to El. -12 NAVD. Excavation levels below these elevations were not considered due primarily to the finer grained materials encountered there. Use of these design parameters with the North Wildwood native beach design parameters resulted in a value of R_a = 1.25 and R_j = 1.2/1for excavation to El. -8 NAVD and R_a = 1.25 and R_j = 1.25/1 for excavation to El. -12 NAVD. The overfill factors for Area WW/WC are shown in **Table 16**.

The total borrow quantity available in this area to El -8 NAVD is 2,257,000 CY. The quantity available to El. -12 NAVD is 3,010,000 CY. In order to make this area most attractive to local interests, consideration needs to be given to maximizing their benefits at the earliest stages of the project. This action should also maximize the benefits to be realized, particularly with regards to reducing the need for extending storm sewer outfall lines.

Table 16 Overfill and Renourishment Factors for WW/WWC

Borrow Area	Mean Grain Size $M_{\phi b}$ (Phi)	Standard Deviation $\sigma_{\phi b}$ (Phi)	$\frac{\sigma_{\phi b}}{\sigma_{\phi n}}$	$\frac{M_{\phi b} - M_{\phi n}}{\sigma_{\phi n}}$	Overfill Factor (R_a)	Renourishment Factor (R_j)
0 to 8 ft depth	2.40	0.45	0.99	0.14	1.25	1.2/1
0 to 12 ft depth	2.42	0.47	1.02	0.17	1.25	1.25/1

2.4.19 Offshore Borrow Areas

The overfill and renourishment factors for areas OS-1, OS-2 and OS-3 are summarized in the tables below. All vibracore samples collected in these areas are compatible with the native beach materials.

Offshore Borrow Area "OS -1" (formerly designated OS-2) – Offshore Area "OS-1 " is located approximately 1.7 miles off of Wildwood beach. The northern end of the area is 2 miles from the North Wildwood beach restoration area, while the southern end of the borrow area is 4 miles from that beach fill area. This shoal area widens as it extends northward from its southern terminus. Investigations in the area are very limited, consisting of 2 vibracores, NJV-158 and NJV-159, plus several acoustic sub-bottom profile lines running both longitudinally and transversely across the area. The limited investigations performed to date indicate the borrow material occurs to a depth of 10 ft. below the mud line (to El. -35 NAVD). This material is underlain by gravelly and/or finer material considered unsatisfactory for beach fill at the North Wildwood beach restoration project.

The design parameters computed for "OS-1" are M_f = 2.26/.2mm and σ_f = 0.98 for a 10 ft. depth of cut. Use of these values with the North Wildwood native Beach parameters result in values of R_a = 1.35 and R_j = 1/10 for this area. The volume of borrow available at this location is estimated to be 14,387,000 CY. It should be noted that: (1) the information used to determine the design for this area is extremely limited and (2) the area has recently been designated a prime fishery habitat by the NJDEP. Further explorations in this area may be inadvisable. The overfill factors for OS-1 Area are shown in
Table 17.

Offshore Borrow Area "OS -2" (formerly designated OS -1) – Offshore Area "OS-2 " is located approximately 2.8 miles off of Cape May City. The northern and southern ends of the area are approximately 7 and 9 miles, respectively, south of the North Wildwood beach restoration area The shoal area averages 0.5 miles in width. As with OS-1, the investigations in this area are very limited. They consist of 2 vibracores, NJV-147 and NJV-148, plus several acoustic sub-bottom profile lines running both longitudinally and transversely across the area. The limited investigations performed to date indicate suitable borrow material occurs to a depth of 10 ft. below the mud line (El. -35 NAVD). This material is underlain by gravelly and/or finer material

Table 17 Overfill and Renourishment Factors for Borrow Area OS-1

Area and Vibracore Designation	Mean Grain Size $M_{\phi b}$ (Phi)	Standard Deviation $\sigma_{\phi b}$ (Phi)	$\frac{\sigma_{\phi b}}{\sigma_{\phi n}}$	$\frac{M_{\phi b} - M_{\phi n}}{\sigma_{\phi n}}$	Overfill Factor (R_a) and Quadrant	Renourishment Factor (R_j)
OS-1 NJGS-158	2.15	1.35	2.93	-0.41		
OS-1 NJGS-159	2.36	0.61	1.33	0.04		
OS-1 Composite	2.26	0.98	2.13	-0.18	1.35	1/10

considered unsatisfactory for beach fill at the North Wildwood beach restoration project. The design parameters computed for "OS-2" are M_f = 1.53/.35mm and σ_f = 1.25 for a 10 ft. depth of cut. Use of these values with the North Wildwood native beach parameters result in a value of R_a = 1.22 and R_j = stable. The overfill factors for OS-2 Area are shown in **Table 18**.

The volume of borrow available at this location is estimated to be 9,493,000 CY There are no known negatives for use of this site other than the obvious ones of distance from the restoration area and lack of sufficient data to fully evaluate the area.

Table 18 Overfill and Renourishment Factors for Borrow Area OS-2

Area and Vibracore Designation	Mean Grain Size $M_{\phi b}$ (Phi)	Standard Deviation $\sigma_{\phi b}$ (Phi)	$\frac{\sigma_{\phi b}}{\sigma_{\phi n}}$	$\frac{M_{\phi b} - M_{\phi n}}{\sigma_{\phi n}}$	Overfill Factor (R_a) and Quadrant	Renourishment Factor (R_j)
OS-2 NJGS-147	1.64	1.07	2.33	-1.53		
OS-2 NJGS-148	1.42	1.43	3.12	-2.00		
OS-2 Composite	1.53	1.25	2.72	-1.77	1.22	Stable

<u>Offshore Borrow Area "OS -3"</u> – Offshore Area "OS-3 " is located approximately 3.3 miles off of Cape May Inlet.. The northern and southern ends of the area are approximately 6 and 7 miles, respectively, SSE of the North Wildwood beach restoration area. The shoal area averages 0.5 miles in width.

Explorations in the area consist of 5 vibracores, NJV 34, 45, 48, 49 and 51, in addition to a series of sub-bottom profile lines. To the best of our knowledge, no mining of these materials for beach fill or other purposes has been performed since these investigations were accomplished. Suitable borrow occurs to a depth of 10 ft. below the mud line (El. -40 NAVD). This material is generally underlain by gravelly and/or finer material considered unsatisfactory for beach fill at the North Wildwood beach restoration project.

Design parameters were computed for a 10 ft depth of cut over the area. These weighted parameters averaged M_f = 1.46/.36mm and σ_f = 0.8. Use of these values with the North Wildwood native beach parameters result in values of R_a = 1.02 and R_j = 1/18. Overfill and Renourishment Factors for Borrow Area OS-3 are shown on **Table 19.** The volume of borrow available at this location is estimated to be 5,021,000 CY.

Table 19 Overfill and Renourishment Factors for Borrow Area OS-3

Area and Vibracore Designation	Mean Grain Size $M_{\phi b}$ (Phi)	Standard Deviation $\sigma_{\phi b}$ (Phi)	$\sigma_{\phi b}$ / $\sigma_{\phi n}$	$M_{\phi b} - M_{\phi n}$ / $\sigma_{\phi n}$	Overfill Factor (R_a) and Quadrant	Renourishment Factor (R_j)
OS-3 NJV-34	1.29	0.54	1.18	-2.290		
OS-3 NJV-45	2.08	1.78	3.88	-0.56		
OS-3 NJV-48	1.28	0.26	0.56	-2.30		
OS-3 NJV-49	1.64	0.59	1.29	-1.52		
OS-3 NJV-51	1.19	0.87	1.90	-2.50		
OS-3 Composite*	1.46	0.80	1.76	-1.85	1.02	1/18

2.4.20 Supplemental Investigations

Supplemental investigations should be performed prior to use of any of the individual borrow areas recommended above in any areas where the existing conditions have changed since the original investigation of that particular area was performed, or where only a limited number of initial investigations were performed.

The extent of these investigations will vary considerably depending upon the area being considered for use. For instance, the scope of investigations required in the Hereford Inlet, W/WC and OS-3 areas would be considerably less than those required for the OS-1 and OS-2 areas.. It is anticipated that additional vibracore sampling will be required in all areas except the WW/WC borrow source. Hydrographic, acoustic sub-bottom and terrestrial surveys and benthic investigations will also be required to define the borrow areas depending on location. Additional geophysical or other new innovative technological exploration methods can also be utilized to assist in the definition of the materials and subsurface conditions in the selected or future proposed borrow areas.

2.5 Structure Inventory

The structures on the beach within the project area were listed using The 1990 Report on Limited

Reconnaissance by the Philadelphia District and a GIS shape file of shore protection structures from the New Jersey Geographic Information Systems (NJGIS) database. This includes structures constructed to control erosion and storm damage (groins, bulkheads and seawalls) and outfall structures. There are approximately 16 shore protection structures and 19 municipal outfall pipes within the project area.

2.5.1 Shore Protection Structure Inventory

The project areas shore protection structures consist of revetments and bulkheads made of stone and timber These structures are listed in **Table 20.** Elevations are in NGVD. A table of recent local beach protection efforts in contained in **Table 21** and elevations are in NAVD 88.

Table 20 Shore Protection Structure Inventory

Street	Structure	Construction Type	El. In feet	El. Out feet	Width	Length	Built	Authority	Condition
Hereford Inlet Frontage seawall	seawall	stone, concrete	14.75	14.75	12	8,660	2006	U.S. Gov.	excellent
West of Central	revetment	stone, timber, rubble							variable
Atlantic-1st	bulkhead	concrete, stone, brick							poor
Central to Surf	revetment	concrete, rubble							fair
Surf to JFK	revetment	stone, grout	12	8					fair
2nd & Surf Road	groin	rubble, concrete	12	8	14	77		State	fair
2nd and Ocean	groin	rubble, concrete	12	8	14	187.5		State	fair
2nd and JFK	groin	rubble, concrete	11	8	14	111			good
Central to Pine Ave.	bulkhead	steel piling, stone toe	12	12	0.5	933	1940	County	fair
Pine to Hoffman Ave.	bulkhead	timber pile, stone	11.3	11.3	1	1480	1931	Mun.	good
2nd to 13th Avenues	bulkhead	timber pile	12.5	12.5	1	3050	1962	Mun.	good
Rambler Ave.	bulkhead	varies	11	11	varies	5200		Priv./Mun.	varies
East of CMI jetty	groin	timber	10	5.5		640	1964	U.S.Gov	fair
East of CMI jetty	groin	timber	10	5.5		640	1964	U.S.Gov	fair
East of CMI jetty	groin	timber	10	5.5		640	1964	U.S.Gov	fair
East of CMI jetty	groin	timber	10	5.5		640	1964	U.S.Gov	fair

Table 21 Local Beachfills

Project	Year	Mun.	Placement Area	Volume	Entity	Source	Dune	Berm
North Wildwood	2009	North Wildwood	2nd Ave to Poplar Ave	1,320,287	State/Local	Hereford Inlet	14.75' NAVD	6.75' NAVD
North Wildwood	2010	North Wildwood	2nd-5th Ave, 11th to Poplar Ave.	499,367	State/Local	Hereford Inlet	14.75' NAVD	6.75' NAVD
Wildwood Crest to North Wildwood	2012	North Wildwood	2nd to 7th	96,000	Local	Wildwood Crest (backpassed)	na	6.75' NAVD
North Wildwood	2013	North Wildwood	2nd to 5th, 21st to 25th	155,300	State/Local/ FEMA	Hereford Inlet	14.75 NAVD	6.75' NAVD

2.5.2 Municipal Outfall Inventory

The outfalls contained in the project area are listed below, from south to north, in **Table 22. The o**utfalls that are most impacted by the excessive beach width are 1through 17. These outfalls are routinely clogged with sand and require daily excavation by Public Works crews or they have been extended by the local municipality. The costs to excavate or extend these outfalls were accounted for and included as a Local Costs Forgone benefit in the economic analysis .

Table 22 Municipal Outfalls

Outfall	Street	Municipality
1	Memphis	LT
2	Washington	WWC
3	Hollywood	WWC
4	Miami	WWC
5	Atlanta	WWC
6	Fern	WWC
7	Heather	WWC
8	Cresse	WWC/WW
9	Bennet	WW
10	Leaming	WW
11	Hand	WW
12	Rio Grande	WW
13	Taylor	WW
14	Burk	WW
15	Youngs	WW
16	Spencer	WW
17	Poplar	WW
18	19th	NWW
19	3rd	NWW

2.5.3 Pier Inventory

There are seven piers within the Hereford to Cape May study area. From north to south they are; Municipal, Sportland, Surfside, Hunt's, Mariner's, Adventure, and the Wildwood Crest Fishing Pier (**Table 23**). Three of the seven piers (Surfside, Morey's, and Adventure) are built with their landward sections on elevated pile foundations at approximately 14-16' NAVD, but with their seaward most sections built on the beach. Previous efforts to build a dune in front of the piers by the NJDEP have failed, and the dune eroded rapidly after placement.

The owners of Surfside Pier recently constructed a steel sheet pile bulkhead to protect their rides and amusements from future storm damages as a result of a May 2008 storm. The May storm produced water elevations at the Atlantic City tide gauge of +4.4' NAVD88. Surfside Pier, Adventure Pier and Morey's Pier were inventoried for their damage potential for the project's formulation phase. Damage elements on the pier included electric utilities, gas utilities and the amusement rides.

Table 23 Piers in the Project Area

North Wildwood Piers			
1	Municipal	22nd Ave	elevated
2	Sportland	23-24th	elevated
3	Surfside	25-26th	elevated/on grade
Wildwood Piers			
4	Hunts	Juniper-Poplar	elevated/on grade
5	Mariner's Landing	Cedar-Schellinger	elevated/on grade
6	Adventure	Spencer -Youngs	elevated/on grade
Wildwood Crest Piers			
7	Fishing Pier	Heather Rd.	elevated

2.6 Coastal Processes

A number of coastal hydraulic processes that affect the study area were investigated. The following paragraphs summarize these critical elements which include historic and existing wind, wave, water level and sediment conditions for the study site. A discussion of historic and existing shoreline conditions is also provided.

2.6.1 Waves

Several hindcast data sources were available to generate wave statistics for the study area (**Figure 34)** . One source was from a report entitled "Hindcast Wave Information for the U. S. Atlantic Coast" (Wave Information Study (WIS) Report 30) prepared by Hubertz, *et al*., 1993. WIS Report 30 provided revised wave data for 108 locations along the U. S. Atlantic coast, and superseded WIS Report 2 (Corson, *et al*. 1981), WIS Report 6 (Corson, *et al*. 1982) and WIS Report 9 (Jensen 1983). The wave information for each location was derived from wind fields developed in a previous hindcast covering the period 1956 through 1975, exclusive of hurricanes, and the WIS wave model, WISWAVE 2.0 (Hubertz 1992). Wave heights were universally higher for the revised hindcast than for the original hindcast since the values more closely corresponded to maximum measured (buoy) values. A separate report (WIS Report 19) documented hindcast wave information for Atlantic Coast hurricanes during the 1976-1995 time period. The WIS output results are a verified source of information for wind and wave climate along the U.S. Atlantic Coast and have been used to gain a basic understanding of the wind and wave climate for the study area.

A second source of wave information was from an analysis of general wave statistics that covered the time period of 1976 - 1993 and is presented in WIS Report 33. To better represent a realistic wave climate, tropical storms and hurricanes were included in the 1976-1993 hindcast. The update hindcast was performed using an updated version of WISWAVE 2.0, referred to as WISWAVE. Extra tropical and tropical events were analyzed separately, but combined to form complete time series and annual statistics.

A third source of wave information for the study area of wave information was completed by the Corps which was a reanalysis to improve the quality of the Atlantic hindcasts using an advanced version of the wave hindcast model WISWAVE. More accurate and more highly resolved input winds, and better representation of shallow water topographic effects and sheltering by land forms through use of more highly resolved model domains was used in this reanalysis. This updated wave hindcast is for a 20-year period from 1980 to 2000 and is presented at: http://wis.usace.army.mil/wis.shtml. Data is available as time series every 3-hr for the 20-yr period or as tabular summaries.

The wave statistics pertinent to the study from the 1980 to 2000 WIS data source are those derived for Station 147. The location of Station 147 is Latitude 39.00 N, Longitude 74.50 W, in a water depth of approximately 56'. Monthly mean wave heights at Station 147 for the entire 1980-2000 hindcast range from 2.3' in July to 3.9' in January. The maximum monthly average wave height (H_{mo}) at Station 147 for the 1980 - 2000 hindcast is in the month of January and is reported as 19.0 ', with an associated peak period of 11 seconds and a peak direction of 71 deg. Summary statistics and plots for WIS Station 147 are provided in **Table 24** through **Table 27** and **Figure 35** through **39** and for the years 1980-2000.

A fourth source of offshore wave data was used for shoreline change and storm erosion modeling. The wave data used for storm erosion modeling was taken from a wave hindcast study conducted by OCTI for the Philadelphia District. Hindcast station I22J23 located offshore of Hereford Inlet and station I19J19 located offshore of Wildwood Crest are the two closest OCTI hindcast stations to the study area. Utilizing the OCTI wave hindcast; historic storm data were generated in the hindcast using a series of numerical models applied to two storm populations. The hindcast used 15 historic hurricanes and 15 historic northeasters that have affected district coastal areas in order to formulate the storm criteria. In addition to the storm data, the OCTI wave hindcast consisted of a continuous time series of wave heights, periods, and direction from 1987 to 1997. The computational points in the wave analysis were in water depths of about 39' situated offshore of the study area. OCTI transformed the offshore hindcast data to the nearshore over varying bathymetry and provided to the District the storm hydrographs used for the "without project" and "with project" storm erosion SBEACH modeling as described in Section 3.1.

The wave statistics from the 1987 to 1997 OCTI data source for Station I19J19 at Latitude 38.95 N, Longitude 74.80 W, in a water depth of approximately 39 ‘ are as follows: monthly mean wave heights range from 1.9’ in July to 2.5’ in April with the maximum monthly average wave height (H_{mo}) of 2.20’. Summary wave data plots from the OCTI hindcast for station I19J19 are shown in **Figures 36-37** for the years 1987-1997.

It should be noted that the actual wave spectrum experienced at any particular time along the project shoreline may show considerable local variation. This variability is largely due to the interaction of incident waves with: tidal currents at Hereford Inlet, ebb shoal morphology at the inlet, local shoreline alignment, near shore bathymetry, and presence of shoreline stabilization structures. Therefore, the hindcast wave statistics should be viewed as a very general representation of the wave climate of the study area. offshore. Inshore of the station location, the effects listed above will modify the incident waves such that significant alongshore differences may exist with respect to breaking wave height and angle relative to the shoreline. Note that the wave heights from the near shore OCTI station are lower than the heights at the offshore WIS station due to wave transformation. Changes in wave directions can also be seen when comparing the offshore WIS station to the near shore OCTI station. Computer programs which transform offshore waves over varying bathymetry must be used to further investigate wave conditions even closer to the shoreline.

Figure 34 Wave Hindcast Stations

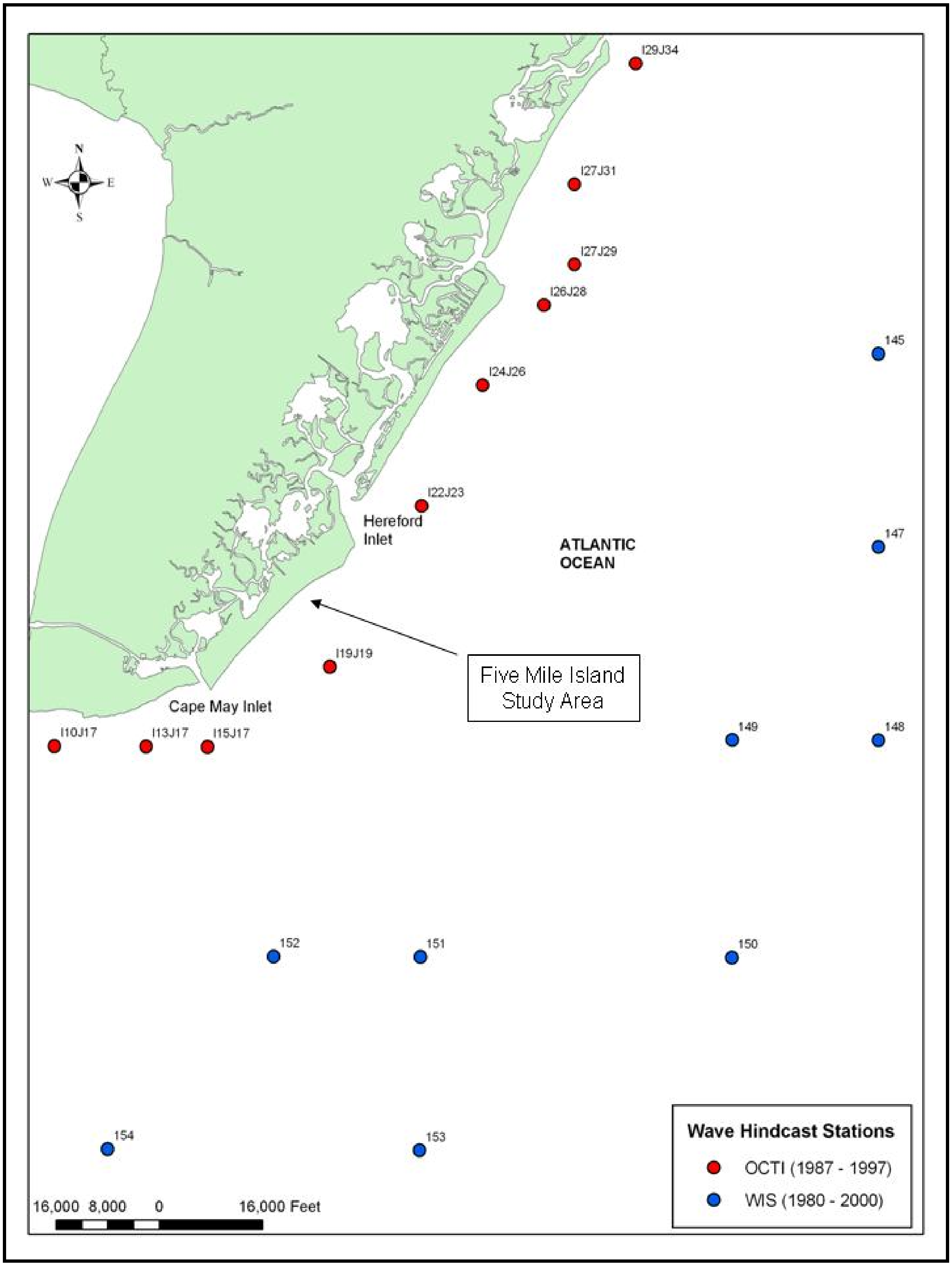


Table 24 Percent Occurrence of Wave Height by Month WIS-147

Hmo (meters)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	CASES	PCT
0.00 - 0.49	0.81	0.93	1.3	1.74	1.61	2.11	2.55	1.91	1.23	1.17	0.91	1	30259	17.3
0.50 - 0.99	2.97	2.62	2.98	3.21	4.21	4.39	4.53	4.72	3.49	3.55	2.96	2.92	74569	**42.5**
1.00 - 1.49	2.64	2.42	2.39	2.02	1.82	1.29	1.1	1.27	2.34	2.38	2.42	2.61	43266	**24.7**
1.50 - 1.99	1.16	1.03	1.05	0.77	0.52	0.33	0.23	0.34	0.68	0.83	1.12	1.2	16207	**9.2**
2.00 - 2.49	0.47	0.42	0.41	0.33	0.21	0.08	0.06	0.1	0.24	0.32	0.44	0.46	6204	**3.5**
2.50 - 2.99	0.22	0.19	0.19	0.1	0.09	0.01	0.01	0.07	0.14	0.11	0.21	0.18	2679	**1.5**
3.00 - 3.49	0.12	0.08	0.12	0.03	0.03	0	0.01	0.04	0.05	0.06	0.08	0.05	1185	**0.7**
3.50 - 3.99	0.04	0.02	0.02	0.02	0.01	.	0	0.02	0.04	0.03	0.05	0.04	541	**0.3**
4.00 - 4.49	0.02	0.01	0.01	.	0	.	0	0.02	0.01	0.01	0.03	0.01	224	**0.1**
4.50 - 4.99	0.01	0.01	0.01	.	.	.	0	0	0	0.02	0	0.01	117	**0.1**
5.00 - GREATER	0.01	0.01	0	.	.	.	.	.	0	0	.	0.01	43	**0**

Table 25 Percent Occurrence of Peak Period by Month WIS -147

Tp(sec)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	CASES	PCT
3.0 - 3.9	2.24	1.86	1.97	1.79	1.39	1.74	1.88	1.7	1.6	2.28	2.31	2.37	40554	**23.1**
4.0 - 4.9	2.01	1.65	1.61	1.35	1.41	1.64	1.8	1.62	1.48	1.76	1.73	2.11	35332	**20.2**
5.0 - 5.9	0.68	0.66	0.86	0.92	1.31	1.64	1.81	1.87	1.14	0.88	0.71	0.64	22993	**13.1**
6.0 - 6.9	0.62	0.62	0.67	0.86	1.63	1.64	1.57	1.66	1.04	0.76	0.73	0.53	21603	**12.3**
7.0 - 7.9	0.69	0.66	0.7	0.96	1.46	1	0.96	0.75	0.85	0.76	0.78	0.56	17783	**10.1**
8.0 - 8.9	0.61	0.7	0.71	1	0.74	0.36	0.22	0.22	0.45	0.73	0.65	0.62	12303	**7**
9.0 - 9.9	0.61	0.63	0.7	0.6	0.29	0.12	0.14	0.12	0.27	0.46	0.46	0.54	8662	**4.9**
10.0 - 10.9	0.46	0.43	0.52	0.35	0.1	0.05	0.03	0.09	0.19	0.28	0.36	0.38	5704	**3.3**
11.0 - 13.9	0.53	0.47	0.68	0.37	0.15	0.01	0.07	0.31	0.85	0.45	0.43	0.66	8737	**5**
14.0 - LONGER	0.03	0.06	0.07	0	0.01	.	0.01	0.14	0.34	0.12	0.06	0.08	1623	**0.9**

Table 26 Percent Occurrence of Mean Direction by Month WIS – 147

Direction Band (deg)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	CASES	PCT
348.75 - 11.24	0.42	0.4	0.36	0.17	0.11	0.09	0.06	0.1	0.17	0.27	0.34	0.5	5260	**3**
11.25 - 33.74	0.46	0.4	0.39	0.25	0.18	0.13	0.08	0.16	0.27	0.46	0.39	0.46	6379	**3.6**
33.75 - 56.24	0.66	0.64	0.66	0.46	0.43	0.26	0.11	0.43	0.44	0.75	0.51	0.59	10434	**6**
56.25 - 78.74	0.55	0.67	0.7	0.68	0.79	0.51	0.27	0.71	0.85	0.8	0.57	0.55	13389	**7.6**
78.75 - 101.24	0.5	0.63	0.77	0.81	1.08	0.67	0.54	0.88	1.17	0.96	0.69	0.61	16321	**9.3**
101.25 - 123.74	0.55	0.48	0.54	0.84	0.94	0.88	0.73	1.09	1.16	0.92	0.63	0.52	16272	**9.3**
123.75 - 146.24	0.54	0.61	0.87	0.91	1.01	1.15	1.23	1.42	1.26	0.74	0.55	0.45	18810	**10.7**
146.25 - 168.74	0.77	0.61	0.91	1.28	1.52	1.62	1.73	1.49	1	0.74	0.67	0.5	22536	**12.9**
168.75 - 191.24	0.76	0.83	0.99	1.37	1.62	2.01	2.63	1.41	0.83	0.79	0.79	0.77	25959	**14.8**
191.25 - 213.74	0.69	0.54	0.53	0.43	0.33	0.51	0.75	0.47	0.43	0.54	0.67	0.74	11629	**6.6**
213.75 - 236.24	0.4	0.24	0.22	0.19	0.13	0.14	0.14	0.11	0.18	0.28	0.48	0.51	5268	**3**
236.25 - 258.74	0.4	0.26	0.2	0.16	0.1	0.07	0.07	0.06	0.1	0.23	0.37	0.45	4314	**2.5**
258.75 - 281.24	0.49	0.31	0.31	0.2	0.06	0.05	0.06	0.04	0.06	0.27	0.41	0.5	4842	**2.8**
281.25 - 303.74	0.48	0.34	0.34	0.16	0.06	0.04	0.03	0.04	0.08	0.23	0.41	0.51	4758	**2.7**
303.75 - 326.24	0.42	0.36	0.34	0.17	0.05	0.05	0.03	0.04	0.09	0.26	0.39	0.4	4541	**2.6**
326.25 - 348.74	0.38	0.41	0.36	0.14	0.09	0.03	0.04	0.04	0.12	0.25	0.33	0.42	4582	**2.6**

Table 27 Summary of Mean Wave Height by Year 1980-1999

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	MEAN
1980	4.23	3.12	4.00	3.31	1.94	2.23	2.33	2.26	2.59	3.31	3.51	3.81	**3.05**
1981	2.92	4.23	3.28	2.99	3.05	2.10	2.46	2.59	3.08	3.51	3.97	3.81	**3.15**
1982	4.10	4.20	2.95	3.15	1.84	2.40	1.84	2.03	2.69	3.18	3.71	3.28	**2.95**
1983	4.07	4.17	4.49	3.25	2.62	2.33	1.64	2.23	2.99	3.87	3.45	4.36	**3.28**
1984	3.54	4.40	4.40	2.92	3.81	2.76	2.69	2.03	3.41	3.90	3.77	3.25	**3.41**
1985	3.61	3.45	2.95	2.92	3.02	2.17	2.43	2.43	2.69	3.22	4.46	3.67	**3.08**
1986	3.77	3.18	3.02	2.89	2.46	3.02	1.87	2.76	2.66	2.85	3.41	3.90	**2.99**
1987	3.74	2.79	3.41	4.49	3.41	2.30	1.97	2.36	2.72	3.48	4.20	3.22	**3.18**
1988	3.28	3.87	3.08	3.31	2.69	2.56	2.20	2.26	2.43	3.31	3.48	3.41	**2.99**
1989	3.22	3.67	4.20	2.69	2.95	2.20	2.20	2.72	3.81	2.99	3.81	3.71	**3.18**
1990	2.89	3.38	3.15	2.92	2.72	2.26	2.13	2.43	3.28	4.10	3.02	4.04	**3.02**
1991	4.20	3.35	3.77	3.41	2.36	2.26	2.53	2.92	3.51	3.64	3.94	3.67	**3.28**
1992	4.23	3.67	3.87	2.89	3.77	2.43	2.53	2.59	4.20	3.58	3.71	4.59	**3.51**
1993	4.23	4.17	3.81	3.77	2.56	2.17	2.20	2.69	3.05	3.35	3.90	3.94	**3.31**
1994	4.17	3.31	3.51	2.92	3.08	2.79	2.36	2.33	2.79	2.56	4.82	4.00	**3.22**
1995	4.49	3.74	2.92	2.76	2.69	2.82	2.62	4.69	4.92	3.67	4.27	3.74	**3.61**
1996	4.72	4.10	4.04	4.07	3.25	2.66	3.18	2.62	4.20	4.07	3.51	4.33	**3.74**
1997	4.17	4.13	3.84	3.08	3.22	2.76	2.72	2.30	2.99	3.02	4.13	3.28	**3.28**
1998	4.40	5.09	4.10	2.92	3.38	2.36	2.00	3.41	3.12	3.35	3.08	3.22	**3.35**
1999	4.43	3.64	4.00	2.49	3.54	3.31	2.43	3.45	5.18	3.31	4.23	3.84	**3.64**
MEAN	**3.90**	**3.77**	**3.64**	**3.15**	**2.92**	**2.49**	**2.33**	**2.66**	**3.31**	**3.41**	**3.81**	**3.74**	

Figure 35 Percent Occurrence Histogram

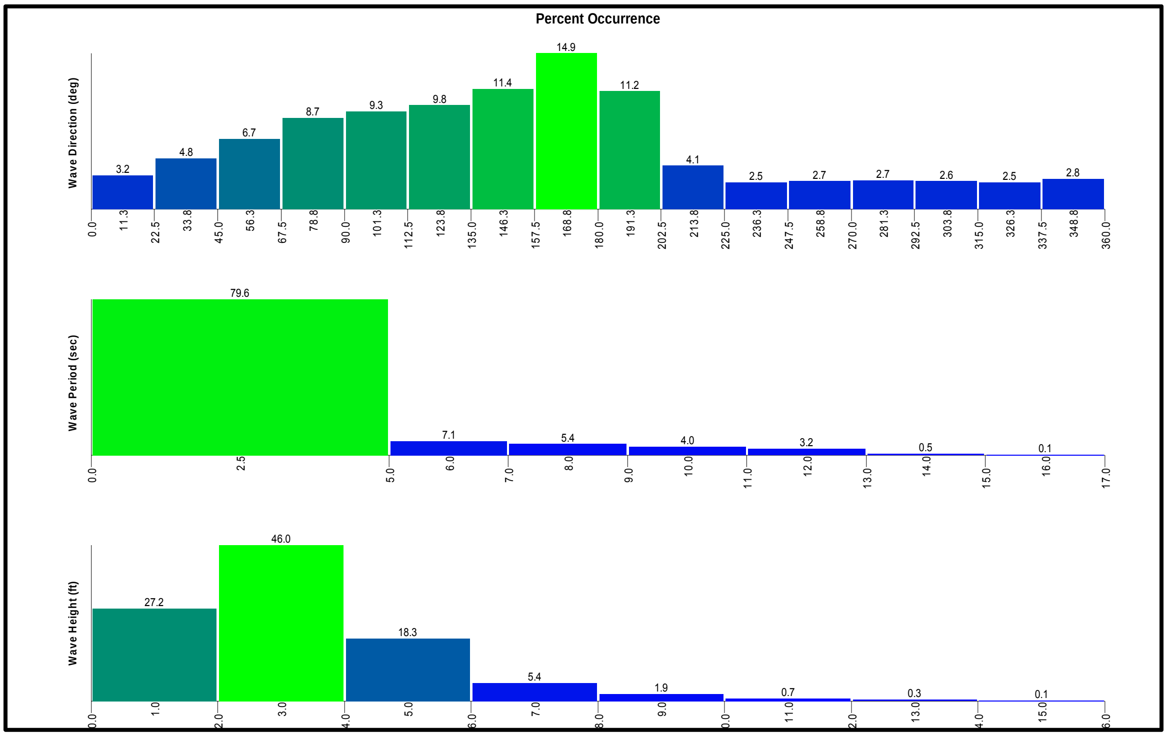


Figure 36 Wave Rose of Station 147

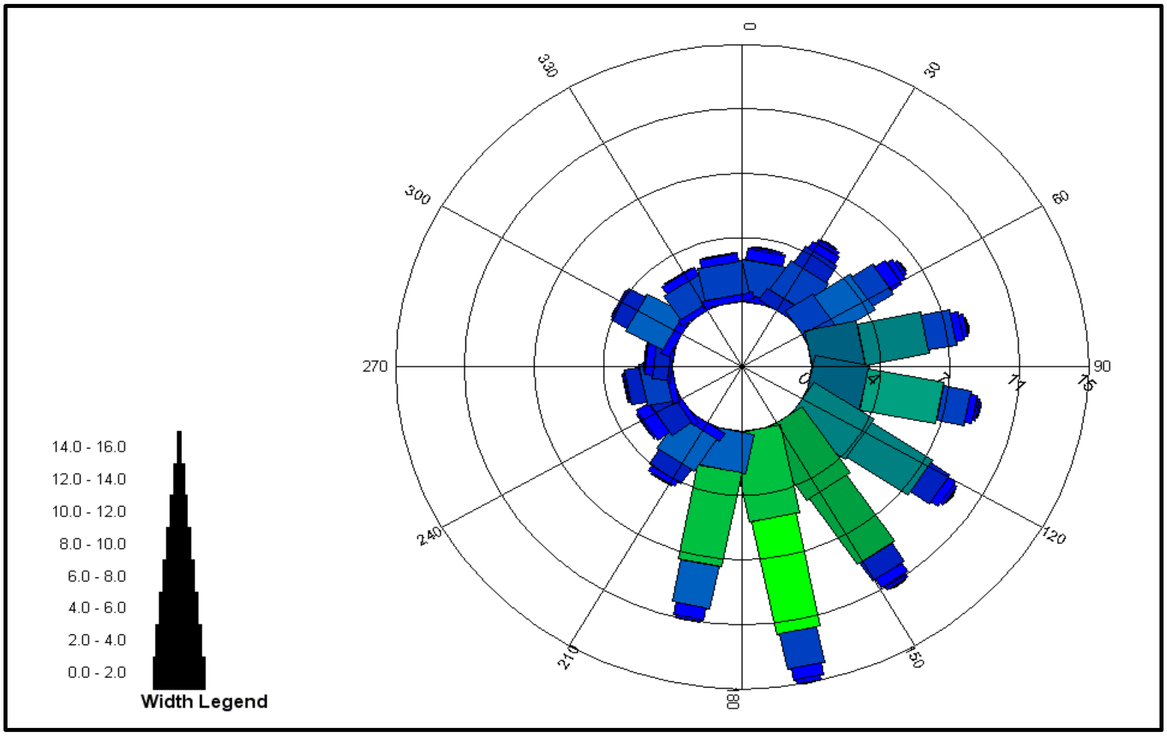


Figure 37 Wave Rose of Station 147

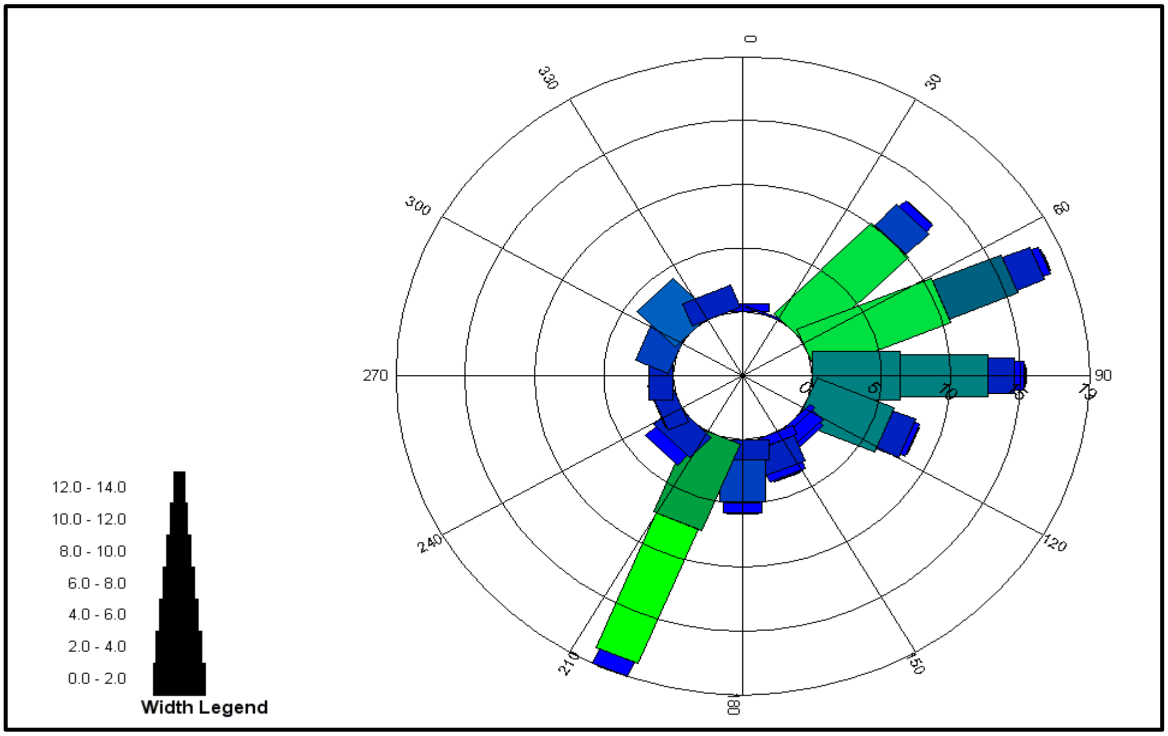
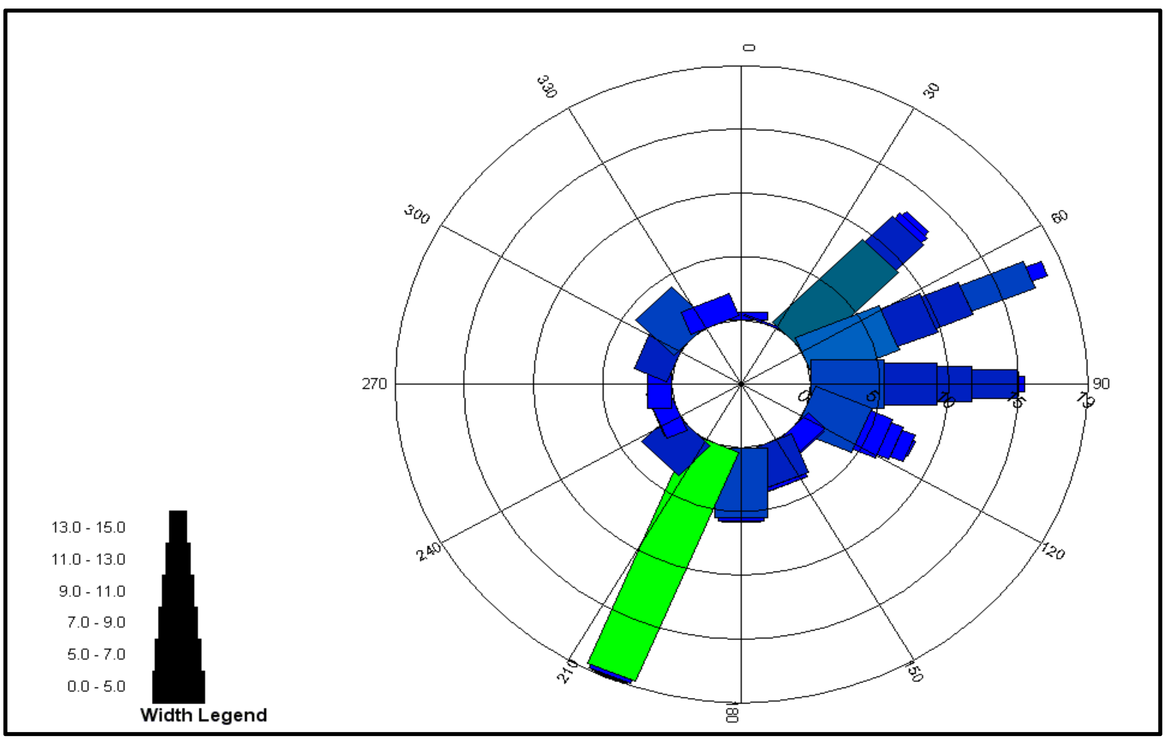


Figure 38 Wave Rose of Station 147



2.6.2 Winds

The site closest to the study area for which long-term systematic wind and climatic data are available is Atlantic City. Weather data were recorded at the Absecon Lighthouse from about 1902 to 1958. In 1943, systematic weather observations were initiated at the U. S. Naval Air Station located about 16 km (9.9 mi) northwest of the Absecon Light. Records have been made continuously at the Air Station site (presently, National Aviation Facilities Experimental Center, Pomona) to the present. In 1958, the weather observation site in Atlantic City proper was relocated from Absecon Light about 1.8 km (1.1 mi) northwest to the Atlantic City State Marina. The station was then moved nearby to the Atlantic City Coast Guard Facility.

The following paragraphs are quoted from the 1992 Annual Summary of Local Climatological Data, and are considered to be representative of conditions along the study area.

1. *"Atlantic City is located on Absecon Island on the southeast coast of New Jersey. Surrounding terrain, composed of tidal marshes and beach sand, is flat and lies slightly above sea level. The climate is principally continental in character. However, the moderating influence of the Atlantic Ocean is apparent throughout the year, being more marked in the city than at the airport. As a result, summers are relatively cooler and winters milder than elsewhere at the same latitude."*

2. *"Land and sea breezes, local circulations resulting from the differential heating and cooling of the land and sea, often prevail. These winds occur when moderate or intense storms are not present in the area, thus enabling the local circulation to overcome the general wind pattern. During the warm season sea breezes in the late morning and afternoon hours prevent excessive heating. Frequently, the temperature at Atlantic City during the afternoon hours in the summer averages several degrees lower than at the airport and the airport averages several degrees lower than the localities farther inland. On occasions, sea breezes have lowered the temperature as much as 8 to 11 deg C within a half hour. However, the major effect of the sea breeze at the airport is preventing the temperature from rising above the upper 20's. Because the change in ocean temperature lags behind the air temperature from season to season, the weather tends to remain comparatively mild late into the fall, but on the other hand, warming is retarded in the spring. Normal ocean temperatures range from an average near 3 deg C in January to near 22 deg C in August."*

3. *"Precipitation is moderate and well distributed throughout the year, with June the driest month and August the wettest. Tropical storms or hurricanes occasionally bring excessive rainfall to the area. The bulk of winter precipitation results from storms which move northeastward along, or in close proximity to, the east coast of the United States. Snowfall is considerably less than elsewhere at the same latitude and does not remain long on the ground. Precipitation, often beginning as snow, will frequently become mixed with or change to rain while continuing as snow over more interior sections. In addition, ice storms and resultant glaze are relatively infrequent.*

As referenced in the 1984 Annual Summary from the State Marina site, prevailing winds are from the south and of moderate velocity (22 to 45 km/hr or 14 to 28 mph), and winds from the northeast have the greatest average velocity (between 31 and 32 km/hr or 19.2 and 19.9 mph).

Wind data from this period also show that winds in excess of 45 km/hr (28 mph) occur from the northeast more than twice as frequently as from any other direction. The maximum five minute average velocity at Atlantic City was recorded during the hurricane of September 1944, with a value of 132 km/hr (82 mph) from the north. This storm also caused the largest recorded storm surge along the coast of New Jersey. The fastest "mile" wind speed at the Atlantic City Marina site from 1960 to 1984 was recorded during Hurricane Doria in August 1971 at 101 km/hr (63 mph) from the southeast. Wind records generally reflect the fact that the almost extreme, but infrequent, winds accompany hurricanes during the August to October period. Less extreme but more frequent high winds occur during the November to March period accompanying northeasters. Wind information was also obtained for the study area at Station 147 from the 1980-2000 WIS reanalysis. **Table 28** and **Table 29** provide information on monthly distribution of wind magnitude and direction.

Table 28 Percent Occurrence of Wind Speed by Month

WS(m/sec)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	CASES	PCT
0. - 1.99	0.07	0.16	0.25	0.41	0.69	0.72	0.62	0.55	0.29	0.24	0.11	0.09	7342	**4.20**
2.00 - 3.99	0.84	1.03	1.44	1.95	2.60	2.84	3.16	2.93	2.04	1.48	0.89	0.88	38726	**22.10**
4.00 - 5.99	1.62	1.61	1.98	2.25	2.60	2.68	2.93	2.86	2.59	2.16	1.69	1.76	46855	**26.70**
6.00 - 7.99	1.93	1.65	1.68	1.79	1.50	1.31	1.31	1.36	1.76	1.96	2.00	1.82	35176	**20.10**
8.00 - 9.99	1.74	1.45	1.39	1.00	0.65	0.51	0.36	0.57	0.96	1.51	1.57	1.57	23277	**13.30**
10.00 - 11.99	1.14	0.88	0.95	0.50	0.32	0.14	0.09	0.12	0.40	0.70	1.04	1.18	13079	**7.50**
12.00 - 13.99	0.71	0.56	0.49	0.22	0.11	0.02	0.01	0.06	0.14	0.28	0.60	0.74	6914	**3.90**
14.00 - 15.99	0.29	0.24	0.20	0.07	0.01	.	0.00	0.03	0.03	0.10	0.22	0.30	2623	**1.50**
16.00 - 17.99	0.09	0.11	0.08	0.02	0.00	.	0.00	0.00	0.01	0.03	0.08	0.12	950	**0.50**
18.00 - 19.99	0.04	0.03	0.02	0.01	.	.	0.00	0.00	0.00	0.01	0.02	0.03	290	**0.20**
+ 20.00 -	0.01	0.01	0.01	.	.	.	0.00	0.00	0.00	.	0.00	0.00	62	**0.00**

Table 29 Percent Occurrence of Winds Speed by Direction

Direction Band (deg)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	CASES	PCT
348.75 - 11.24	0.62	0.61	0.72	0.47	0.40	0.40	0.34	0.50	0.61	0.66	0.54	0.71	11519	**6.60**
11.25 - 33.74	0.49	0.46	0.44	0.38	0.54	0.30	0.26	0.56	0.53	0.50	0.33	0.39	9074	**5.20**
33.75 - 56.24	0.45	0.50	0.47	0.51	0.57	0.48	0.33	0.61	0.82	0.67	0.40	0.38	10842	**6.20**
56.25 - 78.74	0.25	0.23	0.35	0.37	0.36	0.33	0.23	0.45	0.54	0.39	0.32	0.18	7027	**4.00**
78.75 - 101.24	0.23	0.24	0.25	0.31	0.36	0.36	0.29	0.43	0.47	0.40	0.24	0.24	6695	**3.80**
101.25 - 123.74	0.14	0.17	0.20	0.32	0.32	0.25	0.27	0.29	0.29	0.28	0.18	0.16	5039	**2.90**
123.75 - 146.24	0.21	0.22	0.34	0.41	0.38	0.37	0.34	0.36	0.34	0.31	0.26	0.16	6500	**3.70**
146.25 - 168.74	0.23	0.21	0.36	0.47	0.50	0.53	0.45	0.47	0.34	0.33	0.26	0.17	7602	**4.30**
168.75 - 191.24	0.50	0.59	0.76	0.99	1.28	1.25	1.23	1.07	0.86	0.70	0.67	0.41	18072	**10.30**
191.25 - 213.74	0.55	0.51	0.67	0.71	0.93	1.29	1.45	1.11	0.74	0.72	0.67	0.63	17471	**10.00**
213.75 - 236.24	0.56	0.42	0.45	0.50	0.62	0.90	1.24	0.88	0.67	0.63	0.61	0.76	14437	**8.20**
236.25 - 258.74	0.35	0.31	0.28	0.37	0.41	0.43	0.56	0.45	0.41	0.34	0.45	0.45	8437	**4.80**
258.75 - 281.24	0.75	0.58	0.59	0.59	0.49	0.37	0.48	0.39	0.32	0.49	0.60	0.76	11261	**6.40**
281.25 - 303.74	1.12	0.84	0.78	0.64	0.43	0.33	0.33	0.29	0.33	0.65	0.95	1.02	13482	**7.70**
303.75 - 326.24	1.29	1.13	1.09	0.70	0.51	0.38	0.38	0.35	0.51	0.79	1.12	1.23	16625	**9.50**
326.25 - 348.74	0.73	0.71	0.75	0.47	0.41	0.24	0.27	0.29	0.44	0.62	0.62	0.84	11211	**6.40**

2.6.3 Tides.

The tides affecting the study area are classified as semi diurnal with two nearly equal high tides and two nearly equal low tides per day. The average tidal period is actually 12 hours and 25 minutes, such that two full tidal periods require 24 hours and 50 minutes. Thus, tide height extremes (highs and lows) appear to occur almost one hour (average is 50 minutes) later each day. The mean tide range for the Atlantic Ocean shoreline is reported as 4.31' at Wildwood Crest Ocean Pier in the Tide Tables published annually by the National Oceanic and Atmospheric Administration (NOAA). The spring tide range is reported as 4.93 ft.

Elevations relative to station datum from NOAA within the study area were obtained from NOAA at Station 8535835 located at Wildwood Crest. No official datum relationship has been established between NAVD 88 and the tidal elevations at Station 8535835 within the study area. Therefore, tidal elevations were referenced to NAVD 88 by interpolating values for the study area utilizing nearby stations. Mean High Water (MHW) was calculated to be 1.45 ft. NAVD 88 and Mean Low Water (MLW) was calculated to be -2.85 ft. NAVD 88. **Table 30** summarizes commonly used tidal datum elevations and ranges at Station 8535835 relative to the project datum of NAVD88.

Table 30 Wildwood Crest Station Datum Elevations Summary for 8535835

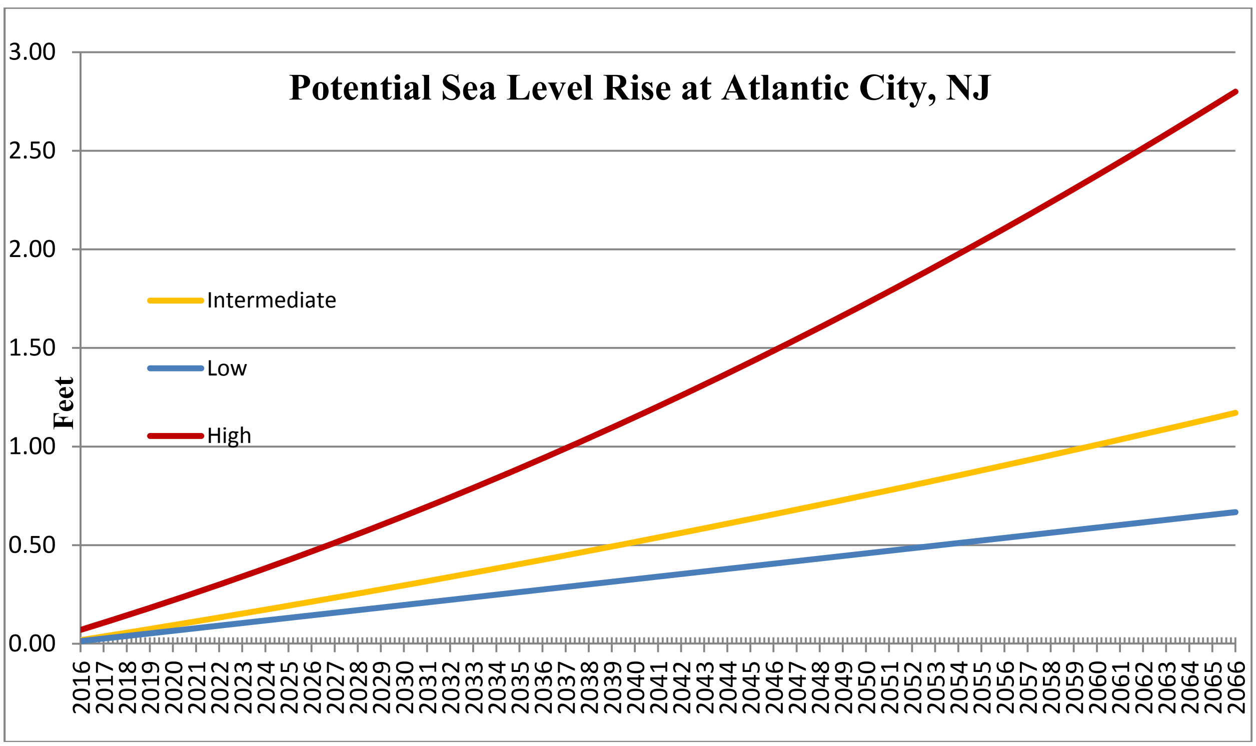
Station: 8535835		
Name: Wildwood Crest, NJ Epoch: 1983 - 2001		
Elevation Values Referenced to NAVD88		
Datum	**Value (feet)**	**Description**
MHHW	1.89	Mean Higher-High Water
MHW	1.45	Mean High Water
DTL	-0.57	Mean Diurnal Tide Level
MTL	-0.70	Mean Tide Level
MSL	-0.68	Mean Sea Level
MLW	-2.85	Mean Low Water
MLLW	-3.04	Mean Lower-Low Water
GT	4.93	Great Diurnal Range
MN	4.31	Mean Range of Tide

No official datum relationship has been established between NAVD 88 and the tidal elevations shown in the table above within the study area. Tidal elevations were referenced to NAVD 88 by interpolating values for the study area utilizing nearby stations. Mean High Water (MHW) was calculated to be 1.45'NAVD 88 and Mean Low Water (MLW) was calculated to be -2.85' NAVD 88.

2.6.4 Sea Level Rise

Global Mean Sea Level (GMSL) is rising at the majority of tide gage locations around the world (National Research Council, 1987), although local mean sea level is falling in some areas where local tectonic effects cause the land to rise faster than GMSL. Major implications of sea level rise include increased shoreline erosion and coastal flooding. Other issues include the change in extent and distribution of wetlands, and salinity intrusion into upper portions of estuaries and into groundwater systems. The principal international effort to evaluate risks associated with climate change and sea level rise is the Intergovernmental Panel on Climate Change (IPCC). The most recent report issued by the IPCC, "Climate Change 2007: Impacts, Adaptation and Vulnerability", adopts a rate of GMSL rise of 1.7 mm/yr (~ 0.6 ft/century). Although there is substantial local variability, relative mean sea level has risen at a rate of about 1 ft/century over the past century along the East Coast of the United States. Atlantic City, NJ, is the location of the NOAA/NOS tide gage used for this study area. Over the period of record, 1911 to 2014, the Atlantic City tide gage records indicate a local rate of sea level rise equivalent to 1.3 ft/century and its current yearly rate is 3.99 mm/yr. To account for uncertainty in future rates of Sea Level Rise (SLR) three potential possibilities were calculated for this study based on National Research Council curves (NRC I- Orange Line, NRCIII-Red Line) and presented along with the historic Atlantic City tide gauge (Blue Line) rates projected forward for the 50 year length of the project (**Figure 39**). This curve is based on guidance contained in Engineering Regulation 1100-2-8862. These estimates indicate that sea level has the potential to rise between 0.66' to 2.7'over the 50 year length of the project from the 2016 economic base year to 2066. The risk and uncertainty analysis in **Section 5** of this report evaluated the impacts on project benefits from the high & low level of SLR calculated from the graphic below. Those results can be seen in **Table 91** and indicate that the study area damages will increase with the increases in sea level.

Figure 39 Sea Level Trends Atlantic City



The risk of accelerated mean sea level rise as a contributing factor to long-term erosion and increased potential for coastal inundation is sufficiently documented to warrant consideration in the planning and design of coastal projects. Because of the variability and uncertainty of the climatic factors that affect sea level rise, predicting future trends with any certainty is difficult, and many varying scenarios exist for future sea level rise. Engineer Regulation 1105-2-100 states that the potential for relative sea level change should be considered in every coastal and estuarine (as far inland as the new head of tide) feasibility study that the Corps undertakes and that the National Research Council study, *Responding to Changes in Sea Level: Engineering Implications, 1987*, should be used until more definitive data become available. USACE is in the process of updating its policy and guidance on sea level rise, and the latest Engineering Circular (EC) on the topic is ER 1100-2-8862. This ER was used to project sea level rise at the Atlantic City Tide gauge shown in **Figure 39**.

USACE policy calls for consideration of designs which are most appropriate for a range of possible future rates of rise. Strategies such as beach fills, which can be augmented in the future as more definitive information becomes available, should receive preference over those that would be optimal for a particular rate of rise, but unsuccessful for other possible outcomes. Potential sea level rise should be considered in every coastal study, with the degree of consideration dependent also on the quality of the historical record for the study site. Based on the measured rate of relative mean sea level rise Atlantic City (1.3 ft/century), it is assumed that sea level will rise by approximately 0.66 ft. over the fifty-year period of analysis for this project. This potential rise in sea level was incorporated into the ocean stage frequency analysis and in other project design aspects such as nourishment quantities.

2.6.5 Storms

Storms of two basic types present a significant threat to New Jersey's coastal zone. Hurricanes are the most severe storms affecting the Atlantic Coast. Extra-tropical storms from easterly quadrants, particularly the northeast, also cause extensive damage to beaches and structures along the coast.

Tropical storms and hurricanes, spawned over the warm low latitude waters of the Atlantic Ocean, are probably the best known and most feared storms. Hurricanes, characterized by winds of seventy-five miles per hour or greater and heavy rain, plague the Gulf and Atlantic seaboards in the late summer and autumn.

Extra-tropical storms, often called "northeasters", present a particular problem to the Atlantic seaboard. Such storms may develop as strong, low pressure areas over land and move slowly offshore. The winds, though not of hurricane force, blow onshore from a northeasterly or easterly direction for sustained periods of time and over very long fetches. The damage by these storms may ultimately exceed the destruction from a hurricane

The intensity and thus the damage-producing potential of coastal storms are related to certain meteorological factors such as winds, storm track, and amount and duration of precipitation. However, the major causes of coastal damage tend to be related to storm surge, storm duration, and wave action. Storm surge and wave setup will be discussed in the storm erosion and inundation analysis included in a later section.

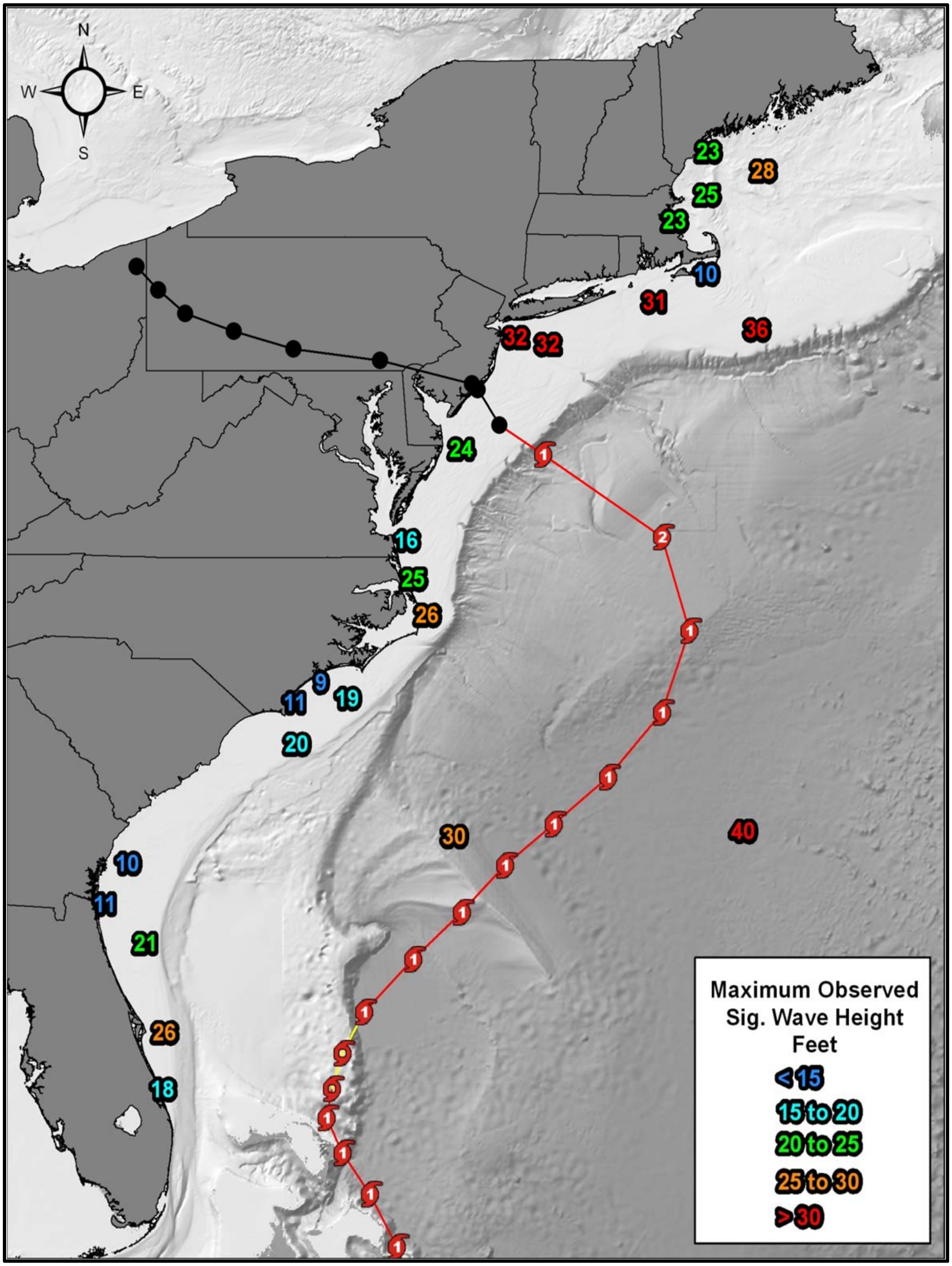
Table 31 shows the 10 highest observed water levels at the Atlantic City tidal station relative to the 1983-2001 tidal epoch. These observed stages have not been adjusted for sea-level rise and are considered as representative of the water levels experienced at the study area over the same period. Hurricane Sandy currently ranks second at 6.28 NAVD88 on the list of the highest storm water elevations at the Atlantic City tide gauge for the past 100 years of data collection. Water elevations in northern New Jersey and New York City were higher during Hurricane Sandy due to the nature of a Hurricane's wind field since the north east quadrant of a hurricane has the highest wind speeds which correlate to higher surge levels. Subsequently, the tide gauges north of the Wildwoods experienced much higher water levels and wave heights. Sandy Hook, NJ recorded a maximum water level of +10.49 NAVD 88 before the gauge failed during the storm and the Battery in New York City recorded a total water level of +11.28 NAVD 88.

Table 31 The 10 Highest Observed Stages at Atlantic City, NJ 1912-2012

Year	Date	Rank	(ft. NAVD 88)	Type
1992	11-Dec-92	1	6.37	NE
2012	29-Oct-12	2	6.28	HUR
1944	14-Sep-44	3	6.23	HUR
1985	27-Sep-85	4	5.96	HUR
1991	31-Oct-91	5	5.85	NE
1962	6-Mar-62	6	5.83	NE
1976	9-Aug-76	7	5.83	HUR
1950	25-Nov-50	8	5.63	NE
1984	29-Mar-84	9	5.38	NE
1980	25-Oct-80	10	5.21	NE

Hurricane Sandy developed from a tropical wave in the western Caribbean on 22 October and was soon upgraded to Tropical Storm (**Figure 40**). On 24 October 2012, Sandy became a hurricane and made landfall near Kingston, Jamaica, then re-emerged into the Caribbean and strengthened to Category 2 hurricane and early on 26 October, Sandy moved through the Bahamas. During 27 and 28 October, Sandy moved alongshore of the southeast US coast, and reached a secondary peak of 90 mph on 29 October with a diameter of over 1,000 nautical miles. Sandy turned to the north-northwest and made landfall as a post-tropical cyclone at ~2000 EDT at Brigantine Island, NJ with winds of 90 mph, causing extensive flooding, beach erosion, and coastal damage along the shorelines of Delaware, New Jersey, and New York. As Sandy approached landfall, it generated intense onshore winds, waves, and a storm surge that was augmented by astronomical spring tides associated with the full moon of 29 October. The remnants eventually weakened over Pennsylvania and the storm degenerated into a remnant storm trough 31 October. The combined effects of wind, waves, and elevated tidal water levels led to significant erosion damage to the project area. **Figure 40** shows the track of Sandy combined with wave heights recorded by the National Data Buoy Center.

Figure 40 Hurricane Sandy Track



Hurricane Sandy caused severe beach erosion in the project area. A profile comparison between the most recent pre-storm surveys obtained in March of 2012 (black line) and the post-storm surveys obtained in November of 2012 (red line) indicate that Sandy removed 346,000 cubic yards of sand from 2nd Ave in North Wildwood to Trenton Ave. in Wildwood Crest. **Figure 41** through **Figure 46** show the pre- storm and post-storm Sandy profiles.

Figure 41 North Wildwood 2nd Avenue pre and post Sandy Surveys

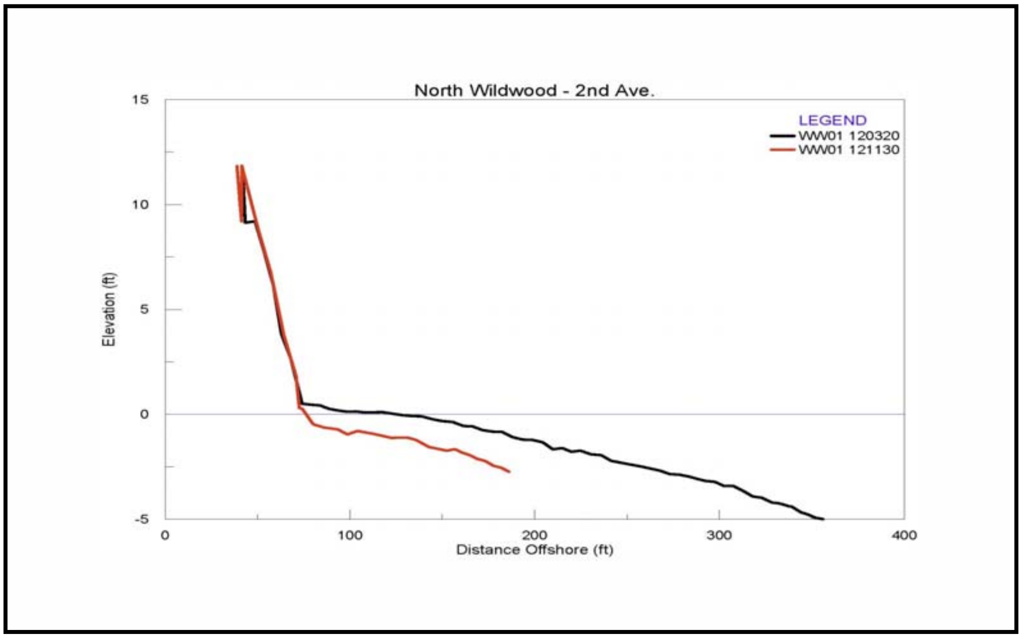


Figure 42 10th Avenue in Wildwood pre and post Sandy Surveys

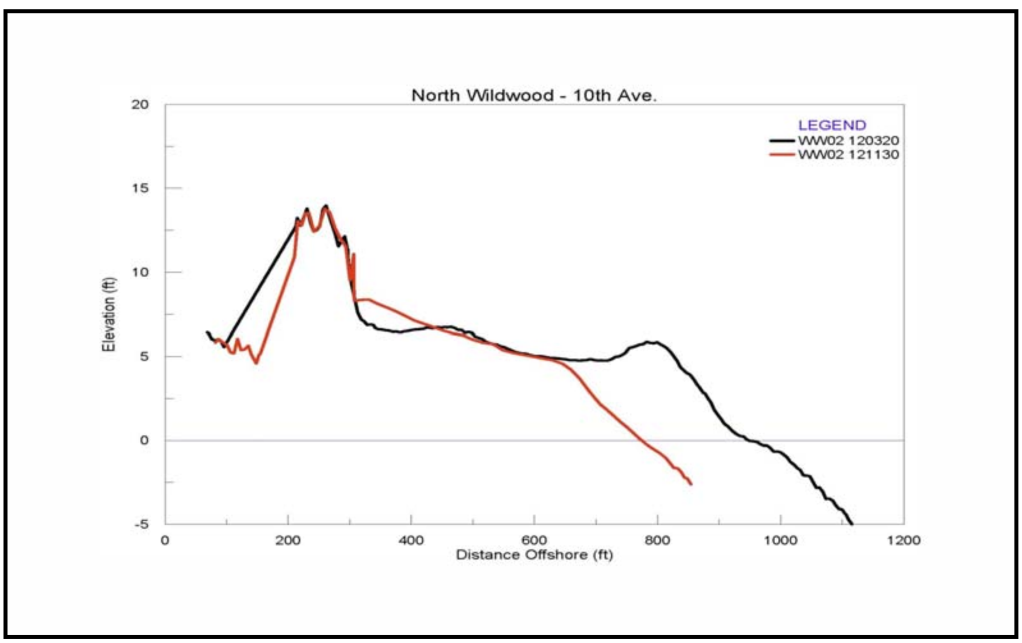


Figure 43 26th Avenue in North Wildwood/Wildwood pre and post Sandy Profiles

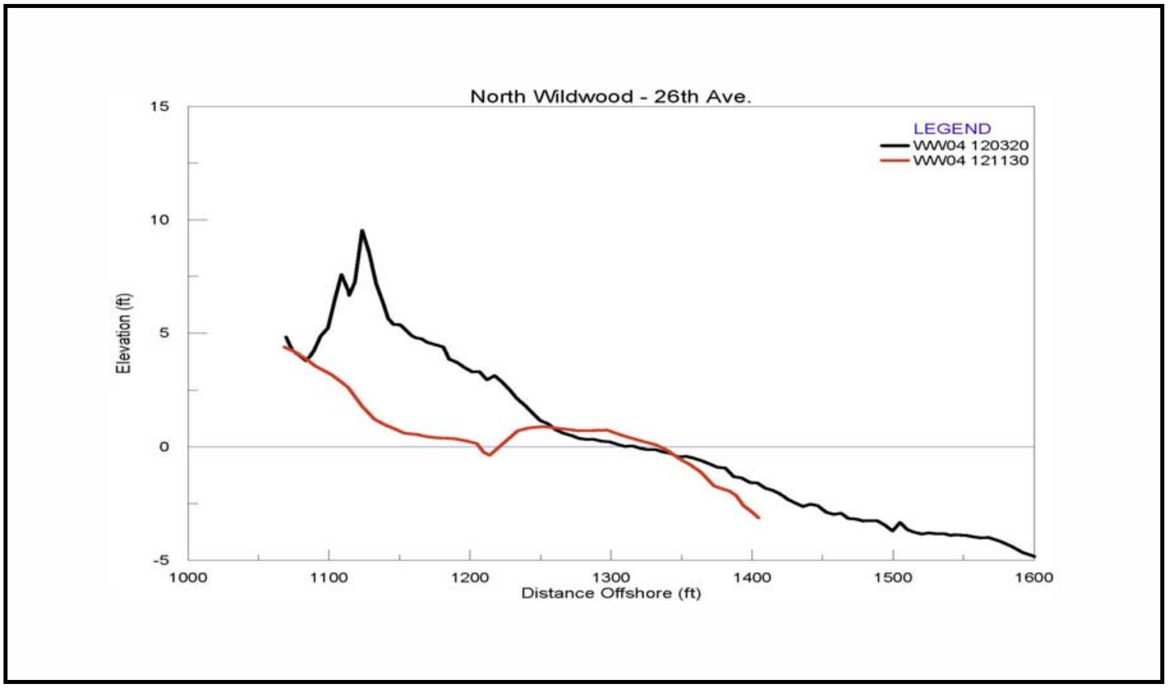


Figure 44 Baker Avenue in Wildwood pre and post Sandy Surveys

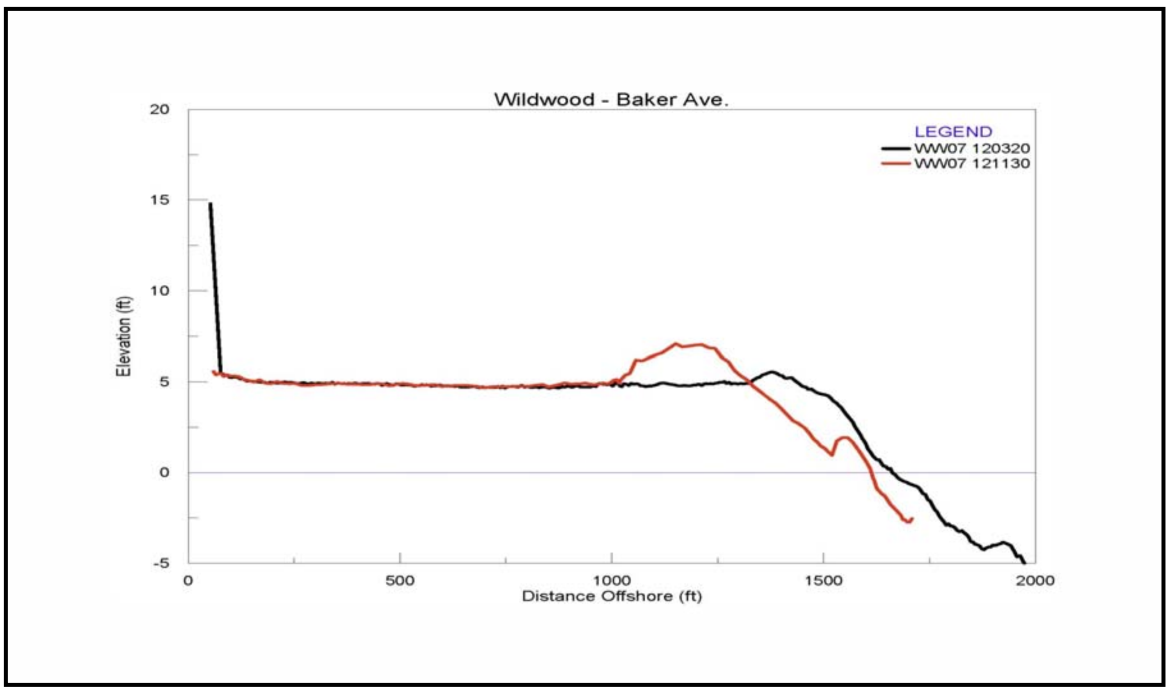


Figure 45 Wildwood Crest Fern Road pre and post Sandy Surveys

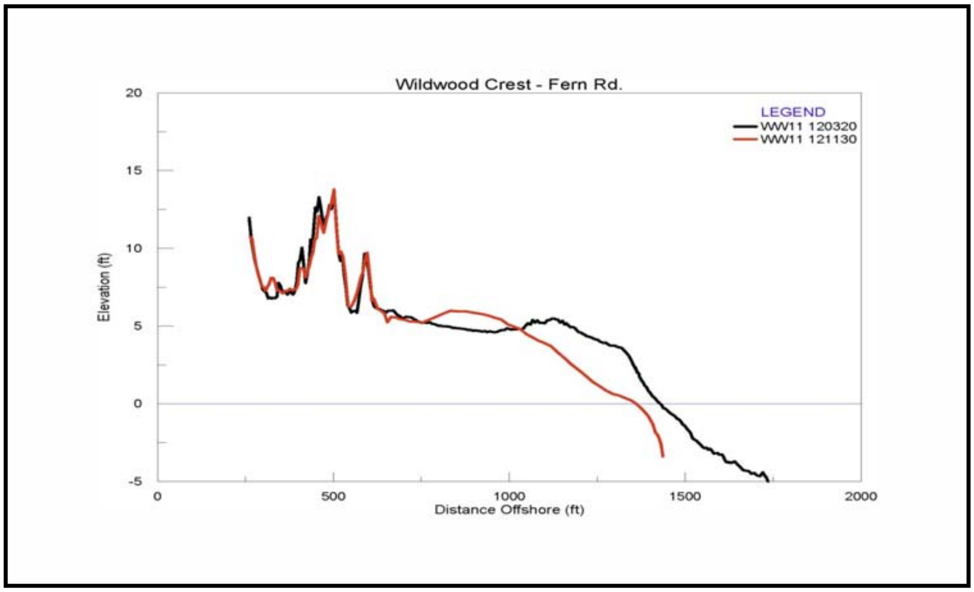


Figure 46 Wildwood Crest Trenton Ave pre and post Sandy Surveys

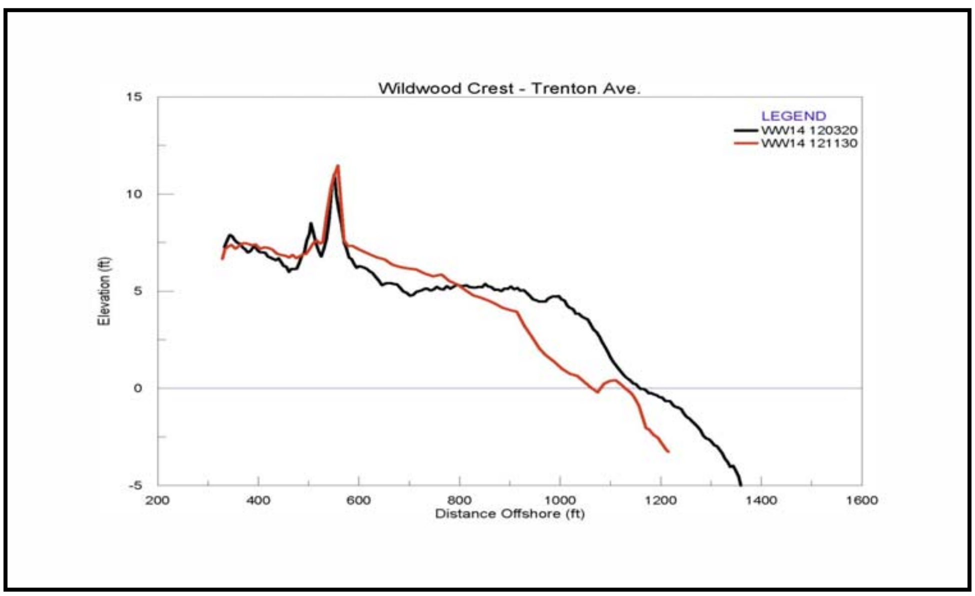


Figure 47 and **Figure 48** show storm surge in North Wildwood that penetrated a small dune and overtopped the existing bulkhead between 2nd and 6th Avenues. **Figure 49** and **Figure 50** show a berm in Wildwood that was overtopped by storm surge during the storm.

Figure 47 Bulkhead Overtopping at 2nd Avenue in North Wildwood During Sandy

Figure 48 Bulkhead Overtopping During Hurricane Sandy North Wildwood

Figure 49 Wildwood Post Storm

Figure 50 Wildwood Crest Post Storm

SBEACH model simulations for the 20 year and the 50 year storm events were compared to pre and post storm Hurricane Sandy beach profiles from March 2012 and November 2012 . The beach volume losses for each profile are contained in **Table 32**. The table shows the volume lost as cubic yards per linear foot of beach and this volume is then multiplied by the distance between the profiles to obtain a total volume lost for that cell that is displayed below the table.

The results of the SBEACH model indicate that the 20 year storm event would erode approximately 183,212 cubic yards of sand from the study areas beaches, Hurricane Sandy (~30 year event) eroded approximately 346, 736 cubic yards of sand from the beaches and the SBEACH modeled 50 year event eroded approximately 317,182 cubic yards of sand from the beach.

Table 32 SBEACH Volume Losses Compared to Sandy profiles

Profile	Distance btw Profiles (ft)	Predicted Volumetric Loss Rate for a 20-yr Event (cy/lf)	Hurricane Sandy~30 -yr Volumetric Loss Rate (cy/lf)	Predicted Volumetric Loss Rate for a 50-yr Event (cy/lf)
WW01				
	2,137	N/A	16.8	N/A
WW02				
	2,172	13.94	26.12	26.30
WW03				
	2,232	8.34	26.12	16.12
WW04				
	4,103	8.34	11.8	16.12
WW07				
	4,203	7.75	11.73	12.77
WW10				
	2,057	8.51	11.73	13.26
WW11				
	3,935	8.51	12.64	13.26
WW13				
	1,916	8.63	12.64	12.95
WW14				
	1,726	8.63	N/A	12.95
WW15				
TOTALS	24,481			

Predicted 20-yr Event = 183,212 cy loss from WW02 to WW15 (22,344 ft) = 8.20 cy/ft average loss rate
Hurricane Sandy ~ 30 year = 346,736 cy loss from WW01 to WW14 (22,755 ft) = 15.24 cy/ft average loss rate
Predicted 50-yr Event = 317,182 cy loss from WW02 to WW15 (22,344 ft) = 14.20 cy/ft average loss rate

2.6.6 Ocean Stage Frequency

The ocean stage frequency curve recommended for the study area was developed from NOAA tide gage data obtained at Atlantic City and Ventnor, New Jersey. The current Atlantic City NOAA gage is approximately 30 miles north of the study area. Previous to its current location in Atlantic City, the gage was located just south of Atlantic City in the town of Ventnor, NJ. Table 30 has the highest observed stages at the gage when it was located first at Ventnor and later moved to Atlantic City. In order to adjust for sea-level rise, a base year was established and the annual peak stages were adjusted using the annual rate of rise multiplied by the years in between the base year and the year the peak stage was observed. From the adjusted annual series a stage frequency curve was constructed using Weibul plotting positions for each of the gage values and drawing the best fit curve through the points. Values of stage at selected reference frequencies are shown in **Table 33**. For reference, Hurricane Sandy would fall somewhere between the 20-50 year event.

Table 33 Ocean Stage Frequency Data

Year Event	Annual Probability of Exceedence	Water Surface Elevation (ft. NAVD 88)
5	0.20	5.0
10	0.10	5.5
20	0.05	6.1
50	0.02	7.1
100	0.01	7.9
200	0.005	8.9
500	0.002	10.0

2.6.7 Longshore Sediment Transport

Longshore or littoral transport can both supply and remove sand from coastal compartments. In order to determine the balance of sediment losses and gains in a system, net, rather than gross, transport rates are required. Net long shore transport refers to the difference between volume of material moving in one direction along the coast and that moving in the opposite direction.

The most recent investigation of the magnitude and direction of long shore sediment transport was done by USACE in 2003 as part of the District's Regional Sediment Management (RSM) Demonstration Project for Cape May Inlet Sand Bypassing. As part of that investigation, potential long shore transport rates due to waves were computed. Wave-driven transport potential was calculated using the CERC energy flux method with the computer program SEDTRAN. Four wave hindcast stations (I10J17, I13J17, I15J17, and I19J19) from the OCTI Wave Hindcast database off the coast of New Jersey were used as inputs to the model. Records were extracted representing peak wave components from 1987 to 1996. The wave conditions in this time period would be representative of wave conditions as a whole between the available shorelines of 1986 and 1998. A WIS Phase III transformation was performed on the data using the NEMOS program available through the Coastal and Hydraulics Laboratory (CHL). These transformations were done for calculated historical shoreline angles for the study area. The wave gage file created from the WIS Phase III transformation was then used as input to determine potential sediment transport rates using the program SEDTRAN. The resulting long shore transport rates are shown in **Table 34**.

A GENESIS shoreline change model was not employed to predict longshore transport rates for this study due to several factors. GENESIS was designed to describe long-term trends of a beach plan shape in the course of its approach to an equilibrium form and it best calculates shoreline movement in transition from one equilibrium state to another. It can be shown that there is no clear erosion or accretion trend when referring to the shoreline change rates that were developed based upon observed shoreline position data from 1899-2003. Over the long term the study area fluctuates between periods of erosion and periods of accretion based on a spatial and temporal scale. The shorelines adjacent to Hereford Inlet have undergone dramatic changes of extreme erosion and accretion depending on the period of analysis and GENESIS was not developed to handle an environment as dynamic as this study area. Development of a 2-D wave model, such as STWAVE, was also not considered to be necessary for a feasibility-level of effort. In lieu of such models, an analysis based upon observed shoreline data as described in Section 2.7.3 and experience of Philadelphia District personnel of conducting similar coastal storm-damage reduction projects was utilized based on historic shoreline interpretation, historic aerial photography interpretation, historic profile interpretation/ generation and SBEACH cross shore modeling results. The District Project Development Team was not confident in the predictive capability of GENESIS or STWAVE for this feasibility study.

Table 34 Potential Longshore Sediment Transport Rates

Analysis Segment	Shoreline Angle	Community	Left Directed (to the North) (cu. yds / yr)	Right Directed (to the South) (cu. yds / yr)	Net (to the South) (cu. yds / yr)	Gross (cu. yds / yr)
WW1	47	North Wildwood	-300,000	720,000	420,000	1,020,000
WW2	52	Wildwood	-300,000	670,000	370,000	970,000
WW3	46	Wildwood Crest	-300,000	720,000	420,000	1,020,000
WW4	42	Lower Township	-300,000	750,000	440,000	1,050,000

The results consist of "potential" sediment transport rates based on the computed wave energy and its angle with respect to the shoreline, assuming an unlimited supply of sediment. The methodology used is very sensitive to shoreline angle and results should only be examined for general transport trends. Actual sediment transport rates for the site may be slightly less when considering the impact of Hereford Inlet and coastal structures.

The values indicate that there is a net southward transport which may vary from 370,000 to 440,000 cubic yards per year within the study area. The trends in the estimates for the net long shore transport show that southward transport to be almost doubled of northward transport. This trend makes sense when examining the shoreline change in the study area which will be presented later in the report.

The values are also representative of potential average conditions over a span of 12 years. It can be expected, however, that changes in long shore sediment transport could happen in a seasonal manner and could contribute significantly to both the short- and long-term behavioral patterns of the shoreline especially in the vicinity of Hereford Inlet in North Wildwood. Depending on the duration of the antecedent incident wave directions and intensities, a specific pattern may exist for an extended period time or change in a matter of a day or so. It is not unreasonable to expect that northern transport from North Wildwood into Hereford Inlet could be larger during some times than southern transport from Hereford Inlet depending on certain wave conditions and Hereford Inlet morphology. The southerly long shore sand transport from North Wildwood to Wildwood along with the lack of a consistent long shore sand transport from Hereford Inlet to replenish the beaches in North Wildwood is one reason for the eroding shoreline in North Wildwood.

2.6.8 Beach Profile Characteristics

An analysis of recent and historic beach profile data was performed to identify the temporal and spatial variability in beach profile characteristics throughout the study area (**Table 35)**. The main profile characteristics of interest included: Dune Crest Elevation, Berm Elevation, Berm Width, MHW Location, Volume of Material above MHW, Foreshore Slope and Closure Depth. Results of the analysis were used to develop representative profile conditions. Additional analyses were performed using the temporal changes in MHW position and volumetric change rates for each profile to assess long-term shoreline change rates and estimated nourishment requirements. Several sources of beach profile data were assembled and analyzed. A wide array of survey techniques were utilized in the collection of the various sources of data. Onshore portions of the surveys were typically surveyed using the standard land surveying techniques. Near shore and offshore portions of the surveys utilized fathometers and sea sleds. All data sources were adjusted to a common datum and analyzed. **Table 35** and **Table 36** and **Figure 51** summarizes the profile data available in the study area. The stationing scheme presented begins at Hereford Inlet and extends to Cape May Inlet. Specifically, the beach profile data sources are:

1. Line Reference Points. Onshore and offshore profile surveys referred to as *Line Reference Point* (*LRP*) *Surveys* after the nomenclature used on the survey control sheets to designate the profile reference points, conducted by the USACE, Philadelphia District, were initiated in 1955 and subsequently repeated in 1963, 1965, and 1984. Twenty-eight (28) profiles were originally collected for the 1955 survey. The number of profiles decreased for the 1984 survey. The numbering sequence for the LRP profiles increases from north to south, and the vertical datums were MLW for the 1965 surveys and NAVD for the 1984 surveys. Several of the LRP profiles were re-surveyed by Offshore and Coastal Technologies Inc. - East Coast (OCTI) as described below.

2. NJDEP Surveys. Onshore and near shore profile surveys conducted by the Coastal Research Center, Stockton State College under contract to NJDEP were collected annually, beginning in 1986. Four profiles have been collected within the study area as part of a general NJDEP program of monitoring the state's beaches. These profiles, referred herein as NJ profiles, are numbered in the state's designation system: NJ Profile Nos. CM 111, CM 110, CM 109, and CM 208. New Jersey profile surveys available for this investigation are the annual surveys from 1986 to 1994 and semi-annual surveys from 1995 to present. The numbering sequence for the New Jersey profiles increases from south to north, and the vertical datum is NAVD. The beach profile are collected using typical land based surveying techniques with the offshore limits of the surveys extending to wading depth.

The NJDEP profiles were analyzed to assess the variability of the shoreline along the study area. That analysis summarized the MHW contour locations from 1986 to 2006 for two NJDEP profiles CM 111 and CM 110. At profile CM 111 at 15th Street in North Wildwood, the location of MHW has retreated over 1,100' at an average of 53' per year from 1986 to 2006 and at CM 110 the MHW location accreted over 565' at an average of 27' per year. Additional shoreline change information regarding the NJDEP surveys is presented in the Summary of Shoreline Conditions section in the report.

3. OCTI Surveys. Onshore and offshore profile data were collected by OCTI for the Philadelphia District October 2001 and September 2003 to document existing conditions. Twenty (20) profiles were collected in October 2001 and the same twenty along with five additional profiles were collected in September 2003. OCTI utilized a sea sled beach profiling system which provides a highly accurate depiction of the entire profile from the upper beach to beyond the theoretical closure depth. Locations of several of the profiles were selected to correspond to locations of previously surveyed LRP profiles, allowing comparative analyses. As discussed in a later section in this report, select OCTI profiles were assembled and used as input for numerical modeling of storm-induced damages.

The OCTI profiles were analyzed from 2001 to 2003 in order to compare the variability in profile characteristics at profile locations where two surveys were done. **Table 37** summarizes differences in the locations of the 0.0 ft. NAVD 88 contour and the -10.0 ft. NAVD 88 contour between the two surveys. In general, the North Wildwood profiles retreated at the 0.0 ft. NAVD 88 contour by an average of 122' with the largest retreat being at profile WW 03 of 255'. Offshore at the -10 ft. NAVD 88 contour the location moved seaward indicating profile growth in the offshore. This offshore growth offsets the profile's retreat in North Wildwood at the 0.0 ft. NAVD 88 contour which suggests movement of sand from the onshore to the offshore.

Table 35 Study Area Profiles

	Municipality	Location	Station	E. NJSP NAD 83 (ft)	N. NJSP NAD 83 (ft)	Notes
WW 1	N. Wildwood	2nd Ave	0+20	410,609.74	61,439.60	LRP H-11 prof
WW 1A	N. Wildwood	5th Ave	8+32	410,050.71	60,850.02	
WW 1B	N. Wildwood	8th Ave	16+79	409,389.08	60,331.73	
WW 2	N. Wildwood	10th Ave	21+68	409,045.92	59,983.76	LRP NP-114 prof
WW 2A	N. Wildwood	12th Ave	27+36	408,646.95	59,579.19	
WW 2B	N. Wildwood	15th Ave	35+10	408,103.39	59,028.00	
CM 111	N. Wildwood	15th Ave	35+92	407,991.49	59,027.56	
WW 3	N. Wildwood	18th Ave	43+40	407,520.72	58,437.17	
WW 3A	N. Wildwood	23rd Ave	57+31	406,388.97	57,628.34	
WW 4	N. Wildwood	26th Ave	65+82	405,633.22	57,246.81	LRP NP-115 prof
WW 5	Wildwood	Pine Ave	79+40	404,461.33	56,570.57	
WW 6	Wildwood	Lincoln	92+41	403,456.58	55,752.41	
WW 7	Wildwood	Baker	107+15	402,385.58	54,739.20	LRP NP-116 prof
WW 8	Wildwood	Taylor	121+30	401,215.08	53,946.88	
WW 9	Wildwood	Cresse	136+84	400,077.35	52,887.38	
CM 110	Wildwood	Cresse	136+87	400,242.56	52,727.56	
WW 10	Wildwood Crest	Crocus	149+31	399,165.24	52,037.99	LRP NP-117 prof
WW 11	Wildwood Crest	Fern	169+88	397,659.59	50,635.86	
WW 12	Wildwood Crest	Stanton	189+96	396,238.94	49,218.95	LRP NP-118 prof
WW 13	Wildwood Crest	Toledo Ave	209+25	394,921.00	47,810.09	
WW 14	Wildwood Crest	Trenton	228+42	393,571.43	46,450.07	
WW 15	Lower Township	Seapoint	245+68	392,307.33	45,275.17	LRP NP-119 prof
CM 109	Lower Township	Raleigh	249+97	392,197.68	44,797.79	
WW 16	Lower Township	Coast Guard	258+70	391,374.95	44,367.10	
WW 17	Lower Township	Coast Guard	273+57	390,308.20	43,331.09	
WW 18	Lower Township	Coast Guard	286+72	389,322.73	42,460.97	LRP NP-120 prof
CM 208	Lower Township	Coast Guard	287+09	389,950.36	41,936.55	
WW 19	Lower Township	Coast Guard	301+63	388,406.87	41,300.91	
WW 20	Lower Township	CM Inlet N.	314+04	387,741.09	40,255.00	LRP CS-1 prof

Table 36 Elevation Parameters

Profile	Town	Dune Crest Elev. (ft. NAVD 88)			Avg. Berm Elev. (ft. NAVD88)		
		Sept. 2001	Oct. 2003	Diff.	Sept. 2001	Oct. 2003	Diff.
WW01	North Wildwood	10.3	10.2	-0.1	4.4	5.8	1.4
WW1A	North Wildwood		10.3			5.3	
WW1B	North Wildwood		10.4			5.4	
WW02	North Wildwood	9.8	10.4	0.6	4.2	5.0	0.8
WW2A	North Wildwood		10.4			5.6	
WW2B	North Wildwood		none			5.5	
WW03	North Wildwood	10.8	9.5	-1.3	4.7	5.4	0.7
WW3A	North Wildwood		13.5			6.1	
WW04	North Wildwood	none	12.0		5.5	5.8	0.3
WW05	Wildwood	none	none		4.5	4.5	0.0
WW06	Wildwood	none	none		4.8	5.4	0.6
WW07	Wildwood	none	none		4.4	4.6	0.2
WW08	Wildwood	none	none		4.4	4.6	0.2
WW09	Wildwood	12.6	12.5	-0.1	4.8	4.8	0.0
WW10	Wildwood Crest	10.4	10.6	0.2	4.6	4.6	0.0
WW11	Wildwood Crest	14.2	16.0	1.8	4.5	4.8	0.3
WW12	Wildwood Crest	none	none		5.1	5.4	0.3
WW13	Wildwood Crest	none	none		5.0	5.2	0.2
WW14	Wildwood Crest	none	none		5.4	5.8	0.4
WW15	Lower Township	11.6	11.6	0.0	5.9	5.9	0.0
WW16	Lower Township	14.1	14.4	0.3	4.9	5.1	0.2
WW17	Lower Township	14.7	15.0	0.3	5.5	6.1	0.6
WW18	Lower Township	21.4	22.3	0.9	5.3	6.1	0.8
WW19	Lower Township	18.9	18.6	-0.3	5.6	5.9	0.3
WW20	Lower Township	14.4	15.7	1.3	4.9	6.2	1.3

Table 37 Contour Locations

Profile	Town	0.0 ft. ft. NAVD 88 Location			-10 ft. NAVD 88 Location		
		Sept. 2001	Oct. 2003	Diff.	Sept. 2001	Oct. 2003	Diff.
WW01	North Wildwood	298.0	244.0	-54.0	1221.0		
WW1A	North Wildwood		398.0				
WW1B	North Wildwood		411.0			1212.0	
WW02	North Wildwood	495.0	391.0	-104.0	929.0	1082.0	153.0
WW2A	North Wildwood		403.0			976.0	
WW2B	North Wildwood		597.0			1075.0	
WW03	North Wildwood	908.0	653.0	-255.0	1155.0	1334.0	179.0
WW3A	North Wildwood		1129.0			1715.0	
WW04	North Wildwood	1455.0	1379.0	-76.0	1914.0	1919.0	5.0
WW05	Wildwood	1759.0	1641.0	-118.0	2060.0	2229.0	169.0
WW06	Wildwood	1736.0	1728.0	-8.0	2314.0	2324.0	10.0
WW07	Wildwood	1563.0	1581.0	18.0	2160.0	2218.0	58.0
WW08	Wildwood	1578.0	1608.0	30.0	2200.0	2307.0	107.0
WW09	Wildwood	1382.0	1386.0	4.0	1996.0	2156.0	160.0
WW10	Wildwood Crest	1260.0	1300.0	40.0	1888.0	2069.0	181.0
WW11	Wildwood Crest	1138.0	1128.0	-10.0	1748.0	1952.0	204.0
WW12	Wildwood Crest	1062.0	1034.0	-28.0	1699.0	1920.0	221.0
WW13	Wildwood Crest	946.0	946.0	0.0	1569.0	1841.0	272.0
WW14	Wildwood Crest	943.0	919.0	-24.0	1552.0	1815.0	263.0
WW15	Lower Township	1045.0	1026.0	-19.0	1602.0	1886.0	284.0
WW16	Lower Township	1099.0	1062.0	-37.0	1727.0	1968.0	241.0
WW17	Lower Township	1210.0	1176.0	-34.0	1752.0	1979.0	227.0
WW18	Lower Township	1375.0	1365.0	-10.0	1842.0	1934.0	92.0
WW19	Lower Township	1363.0	1333.0	-30.0	1863.0	1915.0	52.0
WW20	Lower Township	1271.0	1232.0	-39.0	1857.0	1759.0	-98.0

Figure 51 Beach Profile Locations

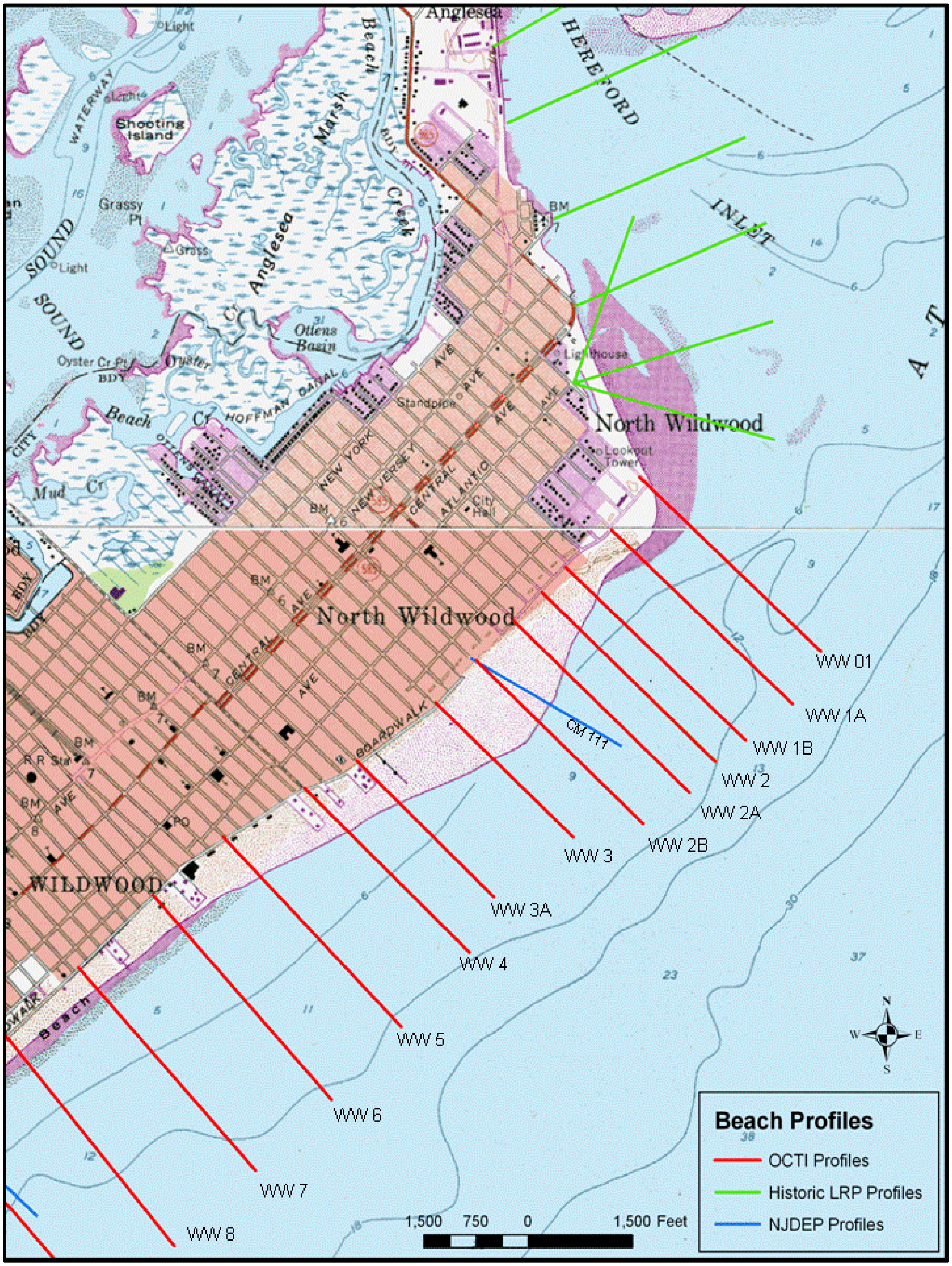
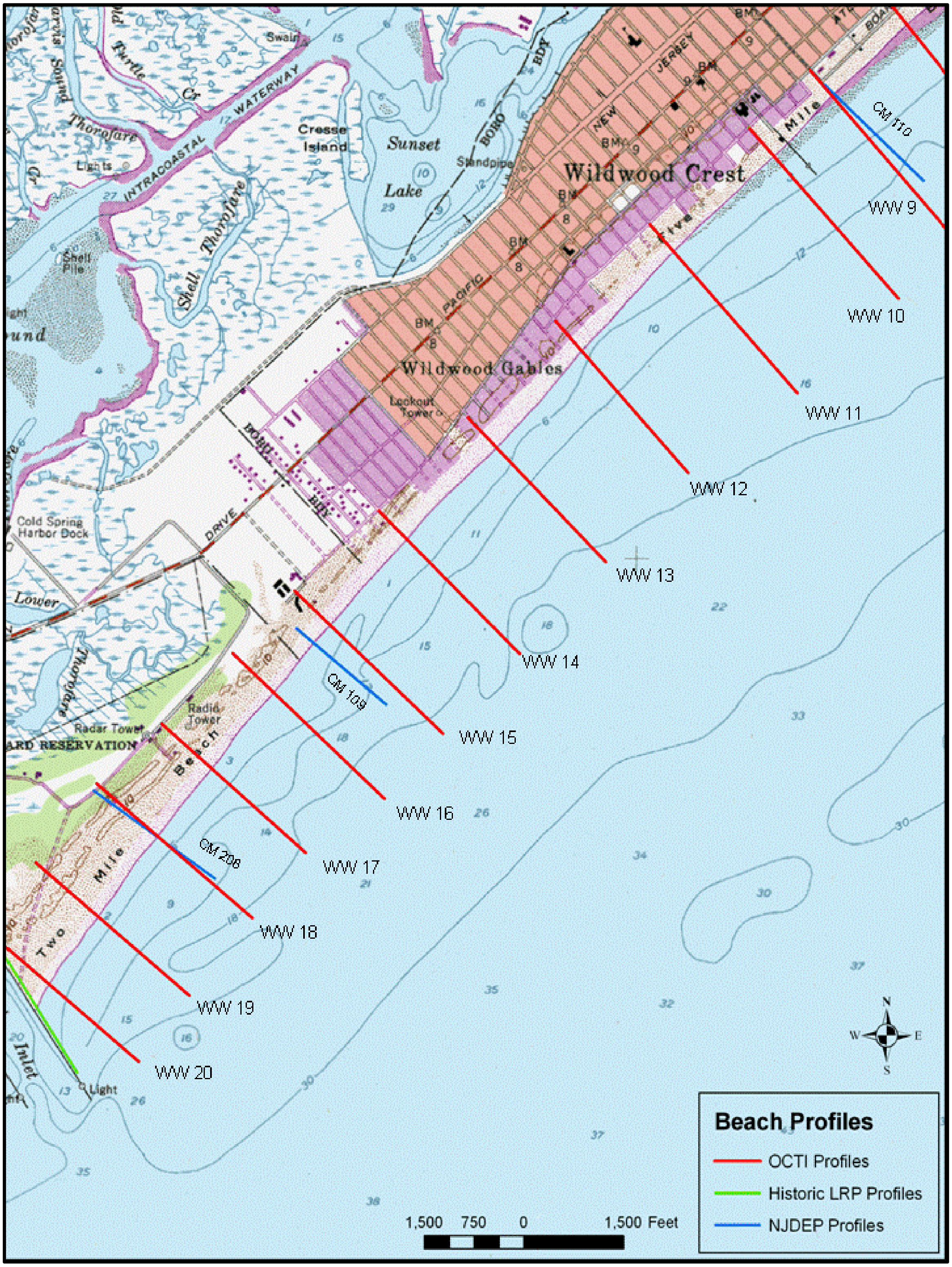


Figure 51continued



2.6.9 Bathymetry

An analysis of offshore and Hereford Inlet bathymetric data was conducted to identify important geomorphic features which may impact near shore wave transformation and resulting sediment transport patterns.

A search of the National Oceanographic Service (NOS) bathymetric database for the study area resulted in limited data available offshore of the study area, with the most recent surveys being performed from 1999-2004. Older NOS surveys were found from 1937-1940 and from 1970-1977, as well. Contours were generated for each of the survey datasets using the computer program SMS. A plot of the 1937-1940 NOS surveys is shown in **Figure 52**. The 1937-1940 surveys were primarily offshore in deep water with only minimal amount of data in the near shore. The best picture of the near shore bathymetry for the study area was surveyed 1970-1977 by the NOS (**Figure 53**) As the figure shows, the near shore bathymetry was steeper on the southern half of the barrier island as compared to the northern half of the island. For example, the location of the -5.0 ft. MLW contour varied from 3,700' offshore of Wildwood to 1,000' offshore of the Coast Guard Base. Further offshore the steepness of the southern half of the barrier island is not as apparent. The -10.0 ft. MLW contour parallels the shoreline approximately 5,000' offshore. The 1999-2004 NOS surveys were located in deep water offshore as shown in **Figure 54**. The same offshore features at approximately -20 ft. MLW (areas shaded in blue) do not appear to change significantly from 1970 to 2004.

An analysis of available hydrographic surveys to quantify changes at Hereford Inlet was conducted using the computer program SMS. The program was used to contour, compare, and quantify any changes between the surveys for Hereford Inlet. Available hydrographic data that surveyed the entire inlet and not just navigation channels existed for the years of 1994, 1998, and 2002. These surveys were done by Contractors for the District and the results from this analysis were used later during the development of the sediment budget for the study area. The contour plots from Hereford Inlet for the 1994, 1998, and 2002 surveys respectively are shown in **Figure 55** through **Figure 57**.

Comparing these three figures it can be seen that shoaling has taken place on the inlet frontage of North Wildwood from 1994 to 2002. Aerial photography taken during these times also confirms the additional sand at the inlet frontage of North Wildwood. Examining these figures also shows an apparent slug of material at the seaward end of the natural deep-water channel in 2002 that did not exist in 1998. This slug of material most likely broke off from the shoal and was in the process of transporting south towards North Wildwood. Another notable difference between the figures is the evolution of the deep-water channel in the northern part of the inlet near Stone Harbor Point. In 1994 this channel was not well defined at all, but by 2002, the channel deepened and became longer. It is reasonable to assume that all of these bathymetric changes in Hereford Inlet from 1994 to 2002 in conjunction with the complex wave dynamics in the inlet impacts the beaches of North Wildwood.

Figure 52 Wildwoods Bathymetry 1937-1940

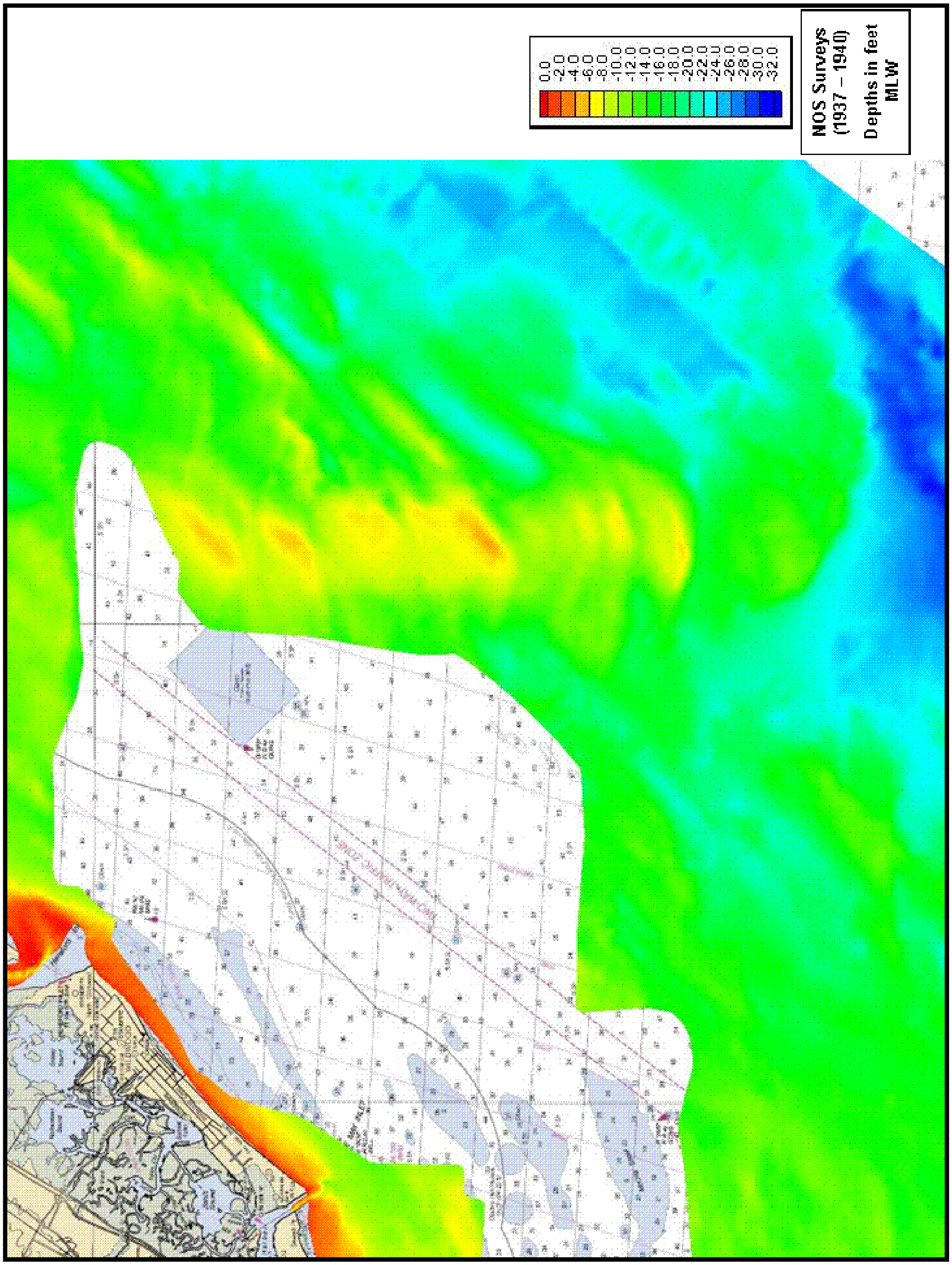


Figure 53 Wildwoods Bathymetry 1970-1977

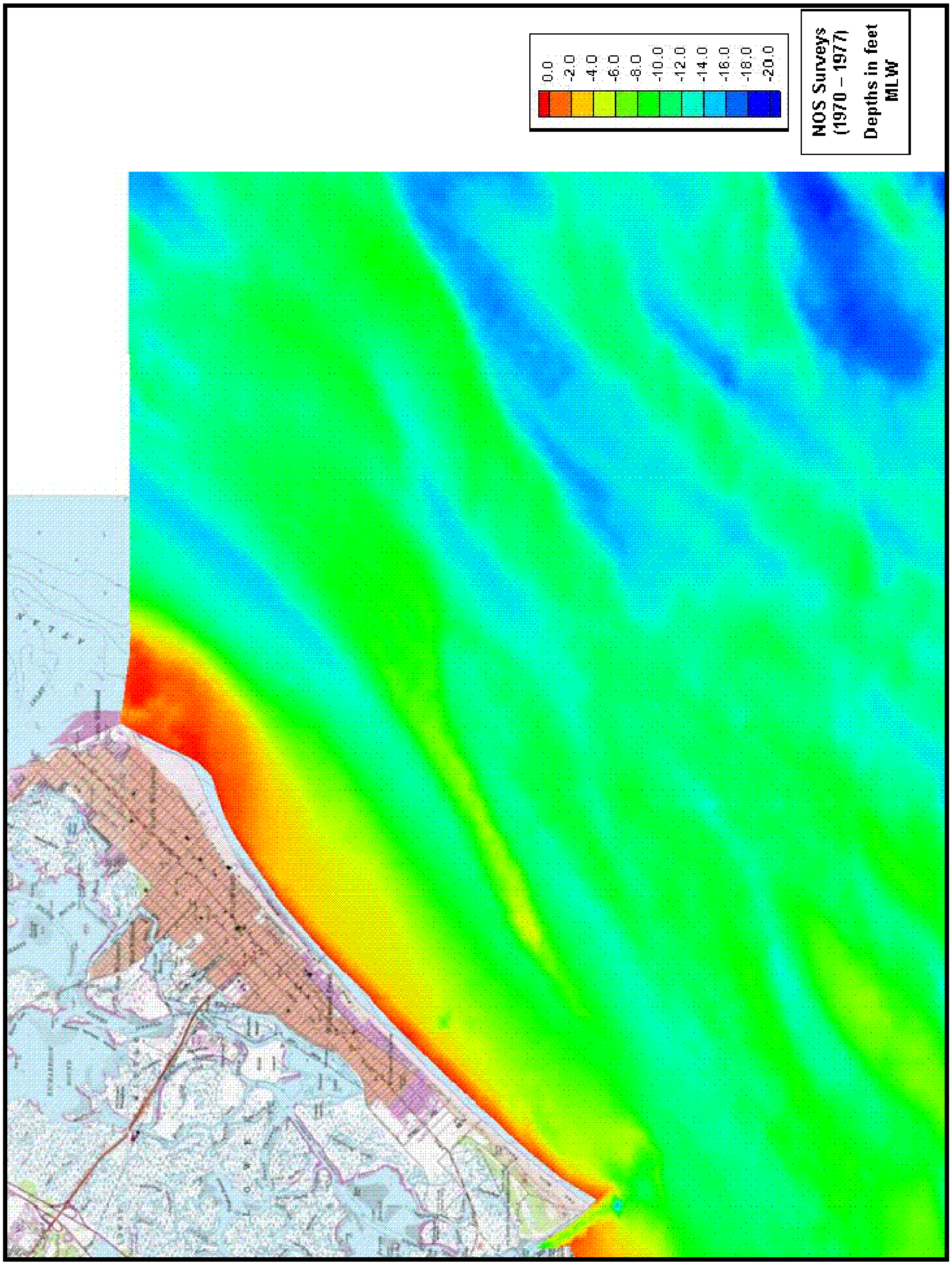


Figure 54 Wildwoods Bathymetry 1999-2004

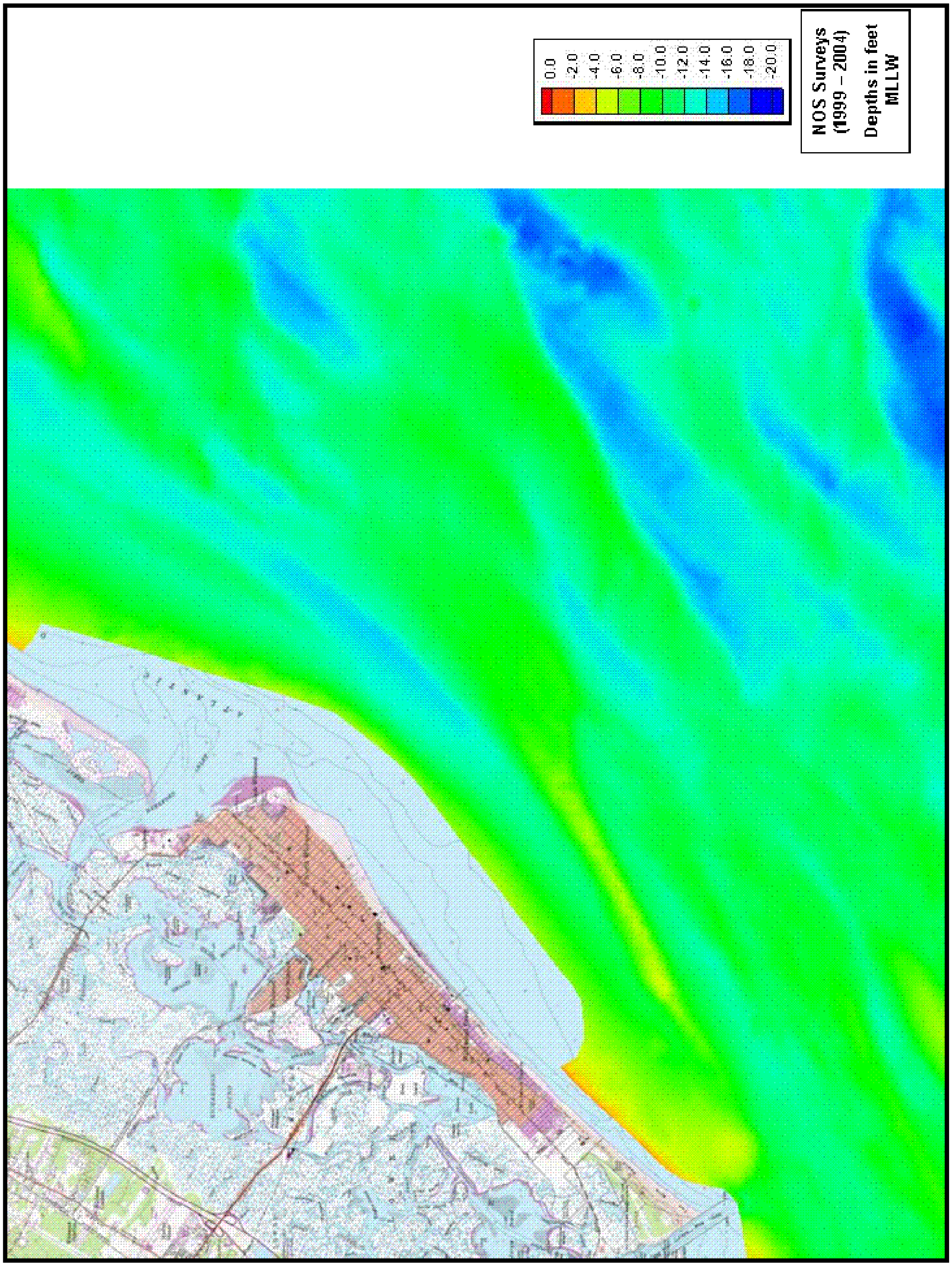


Figure 55 Hereford Inlet Bathymetry 1994

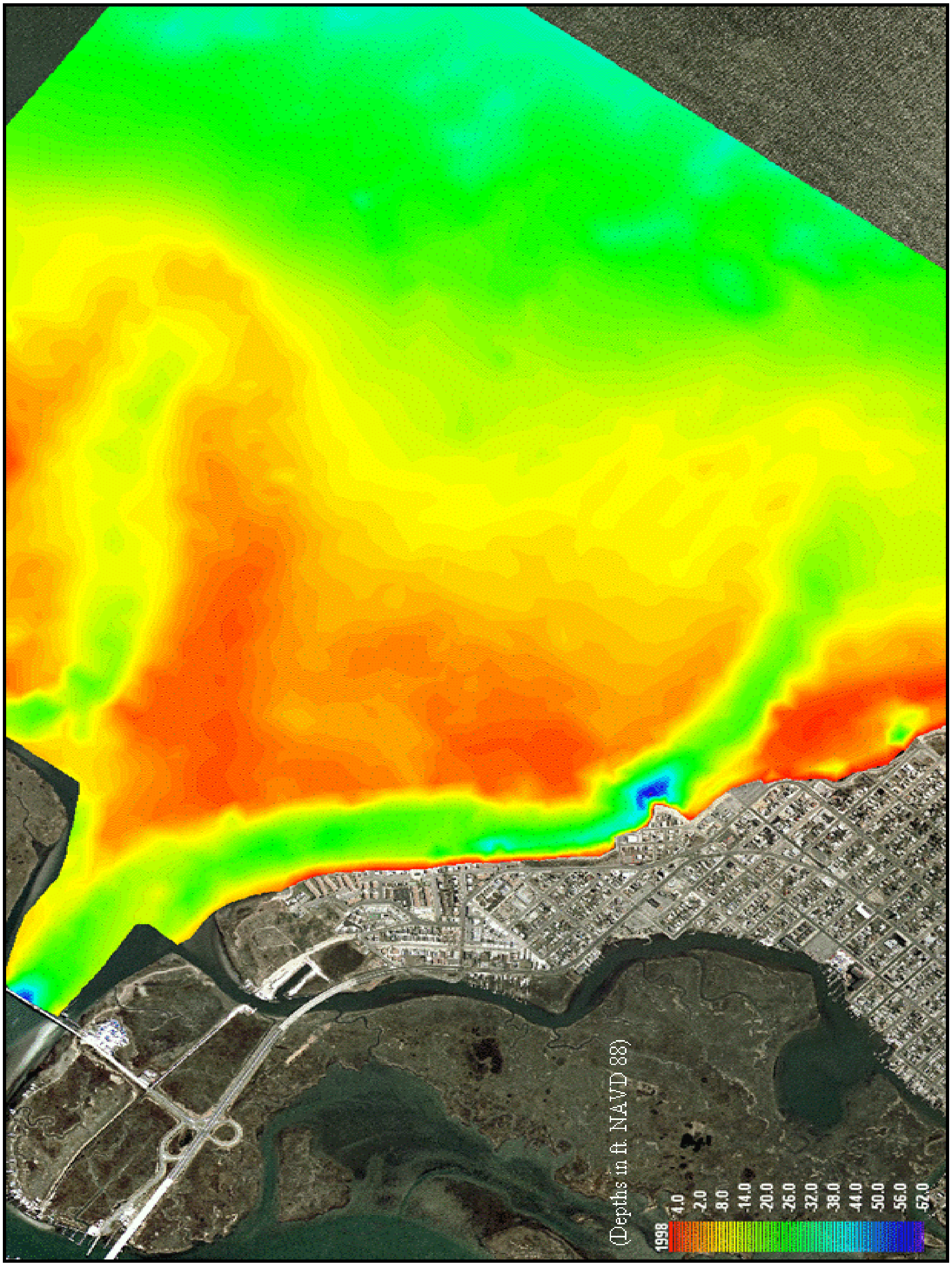


Figure 56 Hereford Inlet Bathymetry 1999

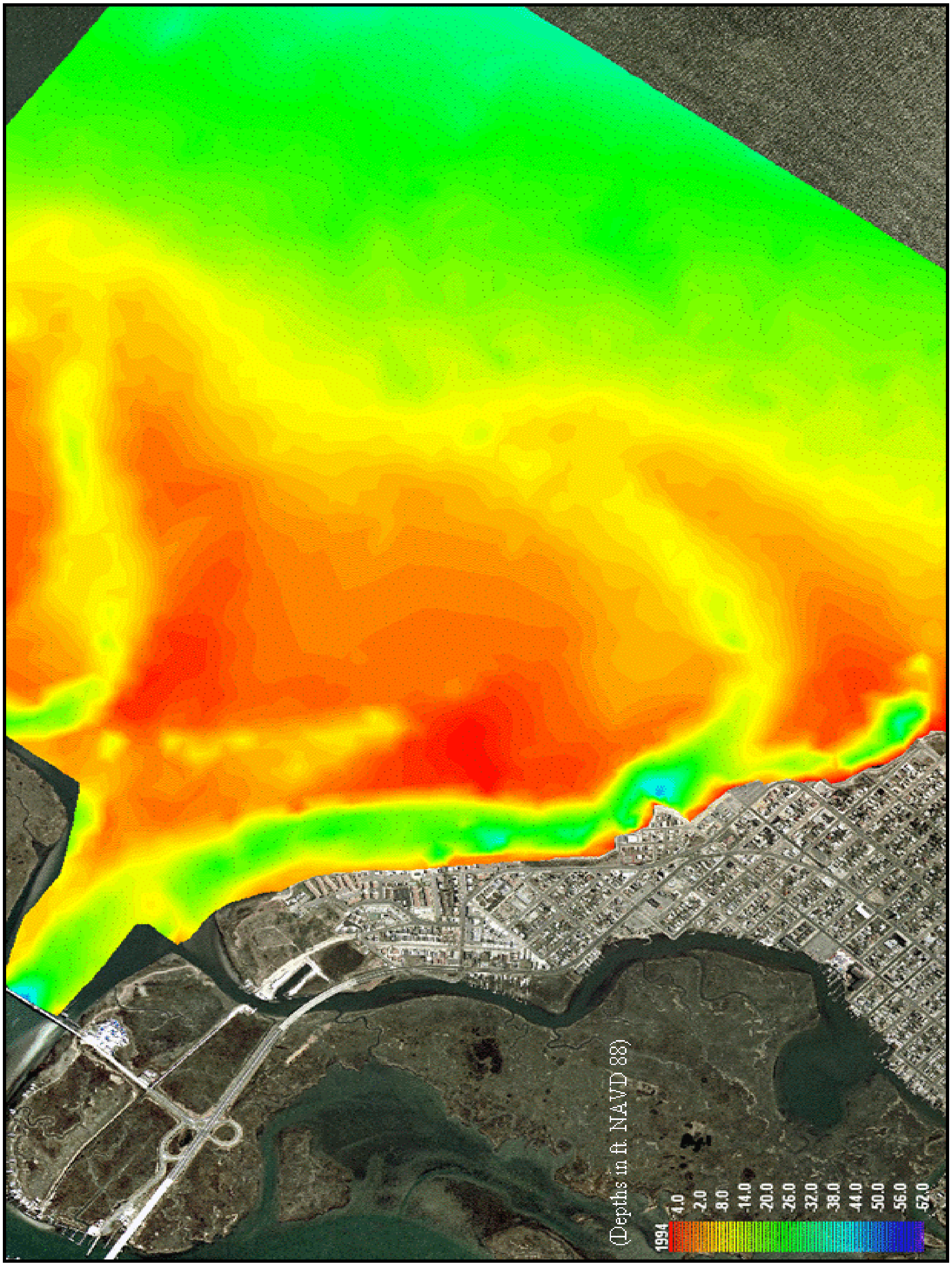
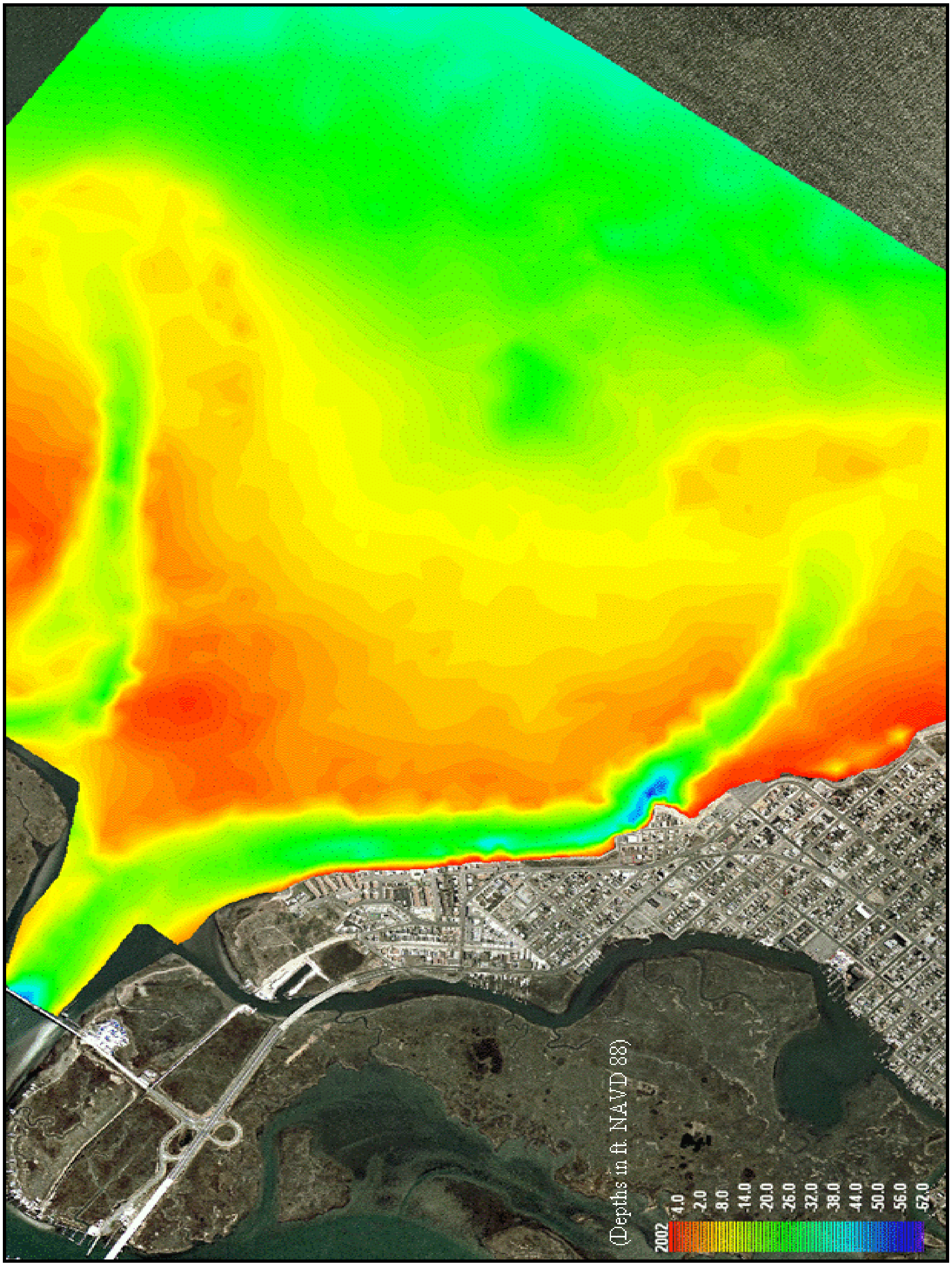


Figure 57 Hereford Inlet Bathymetry 2002



2.6.10 Inlet Sediment Bypassing

Hereford Inlet stores and transports sediment across its main channel through a natural process termed "inlet sediment by-passing"(**Figure 58)**. This process occurs in mixed energy barrier islands where tidal forces and wave forces are equal and long shore transport is dominant in one direction. The characteristic shape of barrier islands in these environments is a drumstick, with the beaches receiving the sediment from the bypassing mechanism having a large seaward protruding beach near the inlet and thinner beaches down drift of the inlet. This shape can be seen in the historic photos of the project area contained in **Figure 5** and **Figure 66**.

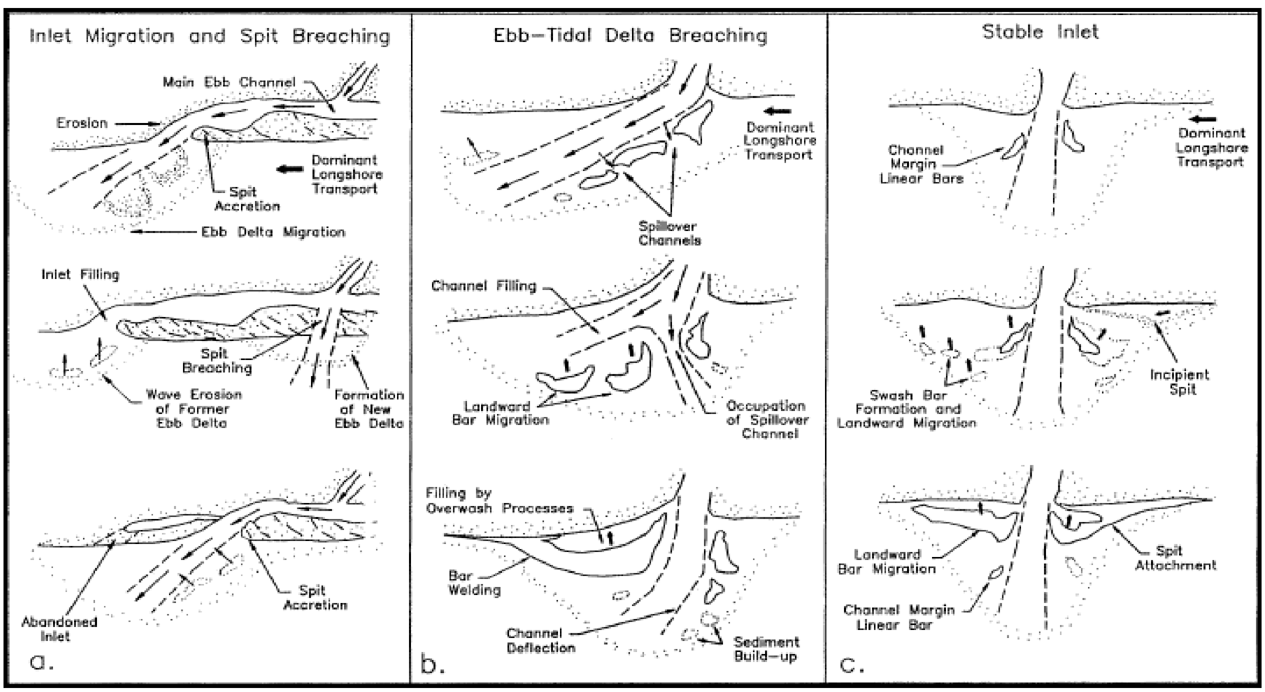
The driving force behind this process is the equal interaction of the wave forces and tide range in combination with dominant longshore sand transport direction (south). Wave dominated coastlines develop where wave forces are dominant and tide dominated coastlines develop where tidal forces are dominant. An example of a wave dominated coastline in New Jersey is Long Beach Island (LBI). LBI is approximately 60 miles to the north of our project area and has a higher average wave heights relative to its tidal range. The barrier islands in wave dominated coasts are traditionally longer and have more sand stored in the flood shoals on the bay side, while mixed energy barriers are shorter and store more sediments in their ebb shoals and swash bars on the ocean side. Long Beach Island is approximately 18 miles long while the Wildwood is approximately 7 miles long. The importance of the wave and tidal environment becomes apparent when we look at the historic aerial photography in order to evaluate the geomorphologic history of the project area. **Figure 67** shows the large drumstick barrier island shape that is common in South Jersey mixed energy barrier islands. The sand that created that drumstick shape was once in the Hereford Inlet ebb shoal. The material welded to the beach sometime between the 1933 aerial photo (**Figure 64**) and the1970 aerial photo (**Figure 66)** through natural processes.

Historic shoreline analysis indicates that Stone Harbor point grows south into Hereford Inlet to a terminal length of approximately 6,000 ft. feet into the inlet, then tidal forces breach the sand spit and the sand is trapped within the Hereford Inlet complex and stored in the ebb and flood shoal. The spit complex grew to these lengths twice in the historic shoreline record dating back to 1870's, once in 1943 and again in 1970. The 1943 breach event of Stone Harbor point was thought to have contributed to the sediment supply of North Wildwood and subsequently, the North Wildwood Shoreline grew consistently in every shoreline record from the moment of the 1943 breach to the 1970 survey, presumably from the material that accumulated in the ebb shoal and transported onshore in the direction of littoral transport to the south through an onshore bar welding processes. Stone Harbor Spit grew into Hereford Inlet a second time in 1977 and again reached a length of approximately 6,000 ft. before breaching and presumably distributing sand into the ebb flood complex. The North Wildwood Shoreline grew tremendously after the initial 1943 breach event, and it is though that the growth could be attributed to a well documented and studied inlet sediment bypassing process as described by noted geologist Dr. Miles Hayes and later modified by others (Davis, Fitzgerald).

The drumstick shape of the barrier island as described above occurs on the down drift side of the inlet at North Wildwood during bypassing cycles, as material travels in the direction of long shore transport which is to the south. North Wildwood was the beneficiary of this material from the 1943 breach and grew steadily until the 1970-1980's, only to have that material slowly erode over time into Wildwood and Wildwood Crest.

The onshore sand migration caused by the interaction of wave and tidal forces is illustrated in section a. and b. of **Figure 58**. This processes is similar to the interaction of Stone Harbor Point and North Wildwood within Hereford Inlet. Stone Harbor is north of Hereford Inlet and over time a large sand spit forms at its southern end, which migrates south into Hereford Inlet. Once the sand spit becomes too large, the inlet's ebb and flood tidal forces breach the spit in order to maintain the tidal flow between the bay and ocean. This breach causes large quantities of sand to accumulate within the Hereford Inlet ebb- tidal delta and flood tidal delta. The ebb-tidal delta eventually stores the sediment from the breached spit and slowly deposits the material on the shoreline of North Wildwood through landward bar migration, potentially based on the position of the main Hereford Inlet Channel. Hereford Inlet goes through similar by-passing cycles illustrated below, and inlet sediment bypassing is thought to be a large source of the sand in the project area. A historic beach profile analysis of this process in section 2.7.3 indicates that millions of cubic yards of sand have been added to the study area's shoreline through natural sediment transport from the Stone Harbor Point/Hereford Inlet complex through sediment by-passing cycles.

Figure 58 Inlet Sediment Bypassing



The 1943 breach event of Stone Harbor point was thought to have contributed to the sediment supply of North Wildwood and subsequently, the North Wildwood Shoreline grew consistently in every shoreline record from the moment of the 1943 breach to the 1970 survey, presumably from the material that accumulated in the ebb shoal and transported onshore in the direction of littoral transport to the south through an onshore bar welding processes. Stone Harbor Spit grew into Hereford Inlet a second time in 1977 and again reached a length of approximately 6,000' before breaching and presumably distributing sand into the ebb flood complex. The North

Wildwood Shoreline grew tremendously after the initial 1943 breach event, and it is though that the growth could be attributed to a well documented and studied inlet sediment bypassing process.

The processes at Hereford Inlet correlates well with inlet sediment by-passing processes described in the reviewed literature by the Project Development Team. The island has the characteristic “drumstick barrier” island shape, with a large bulbous northern end and skinny interior section (historically). The drumstick shape usually occurs on the down drift side of the inlet (North Wildwood) during sand bypassing cycles, as material travels south in the direction of long shore transport. North Wildwood was the beneficiary of this material from the 1943 breach of Stone Harbor Point and had grown steadily until the 1970-1980’s, only to have that sand erode over time and be deposited in Wildwood and Wildwood Crest.

2.6.12 Section 111—Shore Damage Attributable to Federal Navigation Projects

Section 111 of the 1968 River and Harbor Act (PL 90-483) provides authority for the Corps of Engineers to develop and construct projects to prevent or mitigate damages caused by federal navigation work. It is not intended to restore shorelines to historic dimensions, but only to reduce erosion to the level that would have existed without the construction of a Federal navigation project. The costs of implementing measures under this authority must be shared in the same proportion as the cost sharing provisions applicable to the project causing the shore damage.

The Cape May Inlet navigation project was constructed in 1911 in order to stabilize Cold Spring Inlet. The project included a dredged navigation channel from the ocean to Cape May Harbor, parallel stone jetties ~4,400’ long on the southwest and ~4,500’ long on the northeast with a crest elevation of 10’ NGVD. The jetties interrupted long shore sediment transport and impacted the shorelines to the northeast (updrift) and southwest (down drift) of the inlet. Downdrift beaches in Cape May were deprived of sand, whereas the updrift beach, referred to at the time as “Two Mile Beach”, accreted sand. Section 111 authority was subsequently applied (1988) in the cost-sharing for the authorized “Cold Spring Inlet to Lower Township” shore protection project to mitigate erosion damages in Cape May as a result of the navigation project.

The fillet area northeast of Cape May Inlet in Lower Township accreted after 1911, at a rate of 22’ per year between 1899 and 1932, but at a reduced rate thereafter indicating that the accretion from the construction of the inlet was isolated to the post construction timeframe rather than a continuous accumulation that migrated northward to Wildwood and North Wildwood and eventually caused problems with the municipal outfalls, **Figure 59.** The large peak in the shoreline accretion rate in NWW, (dark blue line) represents the addition of sand in 1943-197,1well after construction of the 1911 construction of the inlet . In Wildwood Crest, the rate of shoreline accretion also peaked between 1899 and 1932 at 20’ per year. However, shoreline changes from 1899 to 1932 also include a significant addition of sand related to the 1926 closure of Turtle Gut Inlet as shown in **Figure 60** and **Figure 61**. After the inlet closed the beach stabilized and sand, possibly from offshore ebb shoals, was added to the beach. The inlet closure connected Two Mile Island with the adjacent, up-drift Five Mile Island, resulting in the present configuration of the continuous barrier island study area (“Five Mile Island”) that extends from Hereford Inlet on the northeast to Cape May Inlet on the southwest.

The closure of Turtle Gut Inlet and the regional long shore transport of sand from Hereford Inlet as a result of inlet by-passing cycles are thought to be the principal causes of the excessive beach width in Wildwood and Wildwood Crest. Further, it is concluded that the impacts of the Cape May Inlet jetties on Five Mile Island are minor and localized to its extreme southern end near the inlet, confined to the southwest end of the study area in Lower Township. Thus, Section 111 authority is not consider appropriate for application to the damages that result from excessive beach width within the study area.

Figure 59 Historic Shoreline Yearly Accretion Rates in Segments 1,2,3,4

Figure 59 shows the historic yearly shoreline accretion rates in the four island segments used in the coastal engineering analysis**;** Segment -1 NWW refers to North Wildwood (dark blue line), Segment -2 WW refers to Wildwood (pink line), Segment -3 WWC refers to Wildwood Crest (green line)and Segment -4 LT refers to Lower Township (light blue line). The rates indicate that North Wildwood went through a rapid accretion period from the 1934-1971 surveys, and eroded rapidly thereafter, with the shoreline of Wildwood and Wildwood Crest gaining sand from the 1977 to 2003 time period.

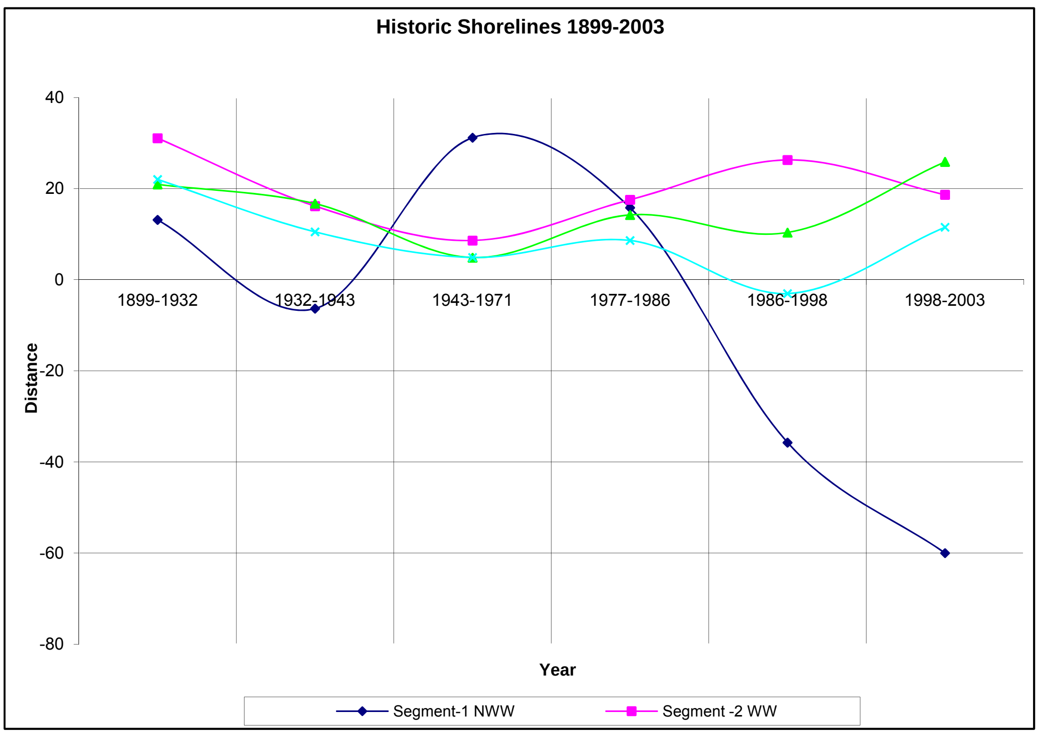


Figure 60 1920 Aerial Photograph

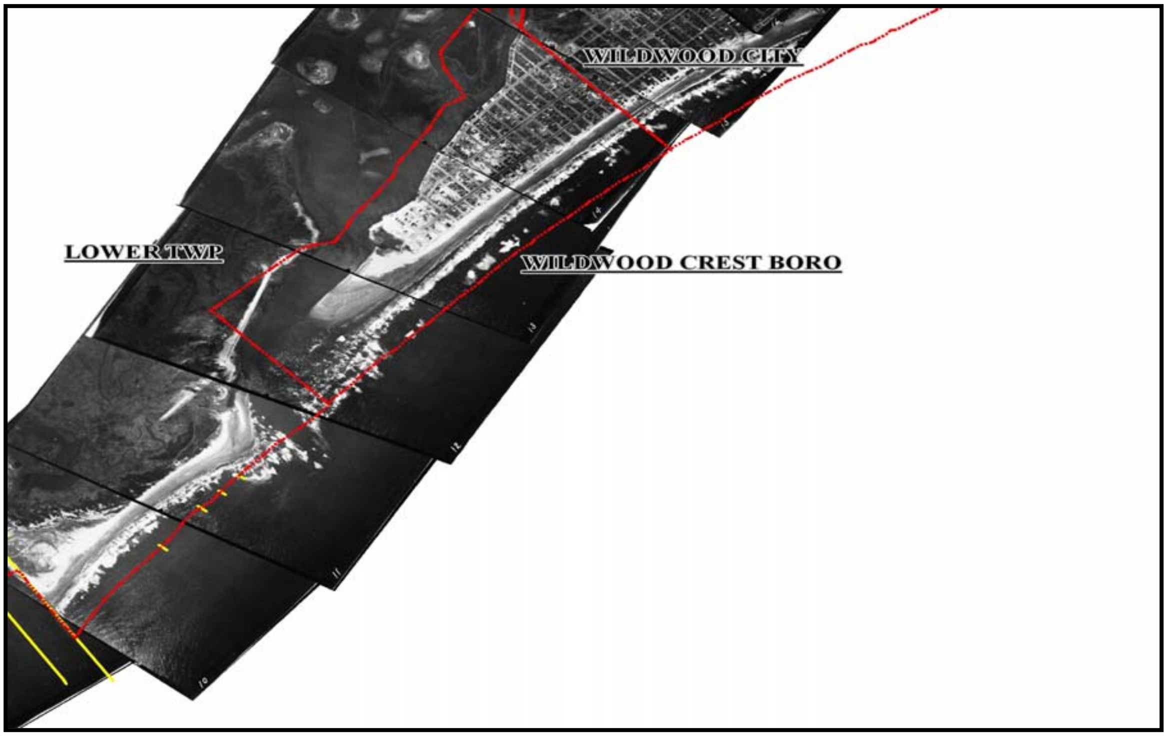
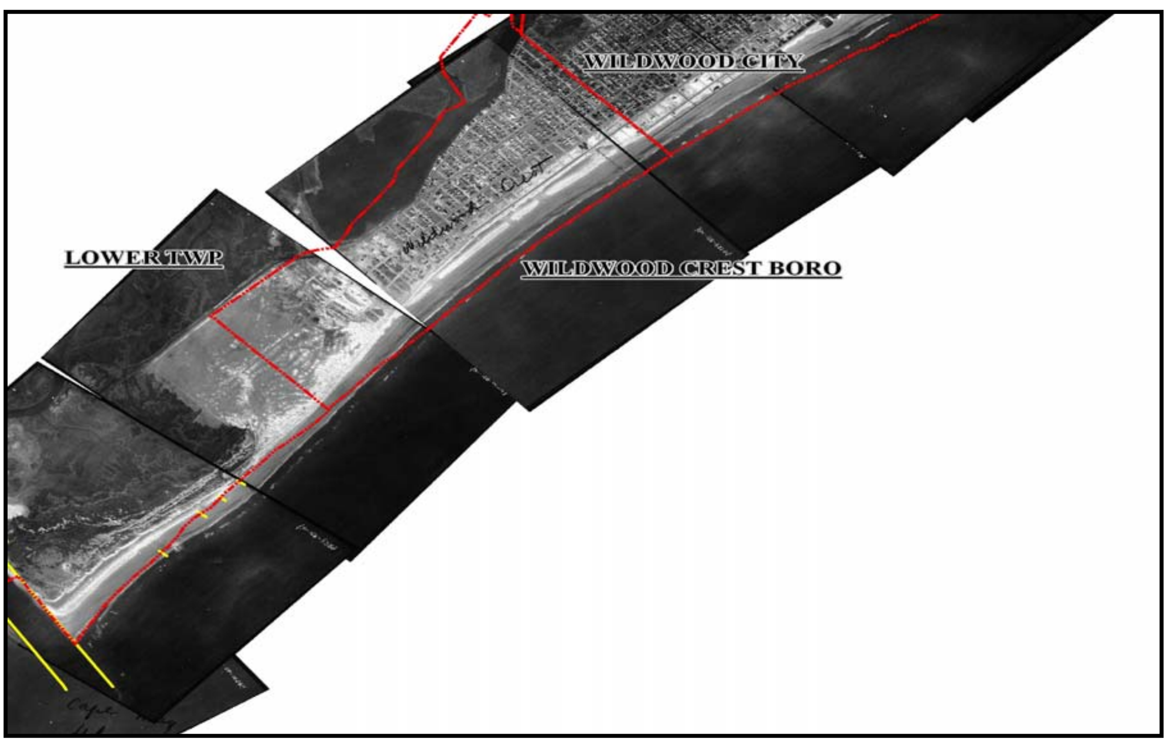


Figure 61 1933 Aerial Photograph



2.7 Summary of Historic Shoreline Conditions

Reports pertinent to the study area were compiled and reviewed for this historic shoreline change evaluation. This information was used to develop a quantitative understanding of historic behavior of the study area shorelines. Shoreline change rates can vary significantly depending on the methodology used and time period analyzed. The reports reviewed include:

1. Ashley, Gail. 1987. "Recommendations for Inlet Dredge Channel Placement Based on Analysis of Historic Change: Townsends and Hereford Inlets, New Jersey" Department of Geological Sciences Rutgers University, New Brunswick, New Jersey.

2. USACE, Philadelphia District. 1990. "New Jersey Shore Protection Study - Report of Limited Reconnaissance Study", Philadelphia, Pennsylvania, September 1990.

3. Farrell, S.C., Inglin, D., Venazi, P., and Leatherman, S. 1989. "A Summary Document for the Use and Interpretation of the Historical Shoreline Change Maps for the State of New Jersey," prepared for New Jersey Department of Environmental Protection, Coastal Research Center, Stockton State College, Pomona, NJ.

4. Weggel, Richard, Ph.D., P.E. 1995, "Coastal Processes Relevant to the Proposed Wildwood Convention Center Site, Wildwood, NJ."

5. USACE, Philadelphia District., "Townsends Inlet to Cape May Inlet Feasibility Report", Philadelphia, Pennsylvania, 1997.

6. Farrell, S. C., et al. 2003, "New Jersey Beach Profile Network, Report Covering 15 Years of Study on Shoreline Changes in New Jersey Coastal Reaches One Through Fifteen, Raritan Bay to Delaware Bay," prepared for New Jersey Department of Environmental Protection, Coastal Research Center, Stockton State College, Pomona, NJ.

7. Farrell, S. C. et al. A number of profile lines are monitored annually by Stockton State College for the State of NJ as part of the NJ Beach Profile Network. A series of reports by Farrell, et al. (1994, 1995, 1997, ….2006) analyzes this data for annual volumetric and morphologic changes.

2.7.1 Prior Shoreline Change Studies

The shoreline in the study area has been characterized as an unstable shoreline prior to the closing of Turtle Gut Inlet in the 1920s. Since the 1920s, the shoreline steadily accreted in Wildwood, Wildwood Crest and Lower Township. The shorelines in North Wildwood have been characterized as being unstable showing periods of erosion and accretion. This unstable behavior is typical of the northern ends of barrier islands in New Jersey that are adjacent to uncontrolled inlets and shoreline change is drastic at these areas because the shoreline moves frequently as spits and shoals associated with the inlet accrete and erode.

Sand bypassing at Hereford Inlet takes place continuously as sand is driven along the seaward side of the ebb tidal shoal by waves. Several reports have examined historic shoreline trends in this area as summarized in the following paragraphs.

Townsends Inlet to Cape May Inlet Feasibility Report, (1997). An analysis of historical shoreline behavior was done based upon maps of digitized aerial photographs and navigation charts by Dr. Steve Leatherman of the University of Maryland Laboratory for Coastal Research. Shoreline positions were extracted and shoreline change was calculated for various historical time periods dating back to 1839.

Between 1943 and 1977 it was calculated that accretion as high as 1,000' occurred at the ocean frontage just south of Hereford Inlet. It was concluded that the width of the beaches in this area depend on a non-interrupted supply of sand across Hereford Inlet. This sand supply is dependent upon the integrity of the ebb-tidal shoal extending from southern end of Stone Harbor to North Wildwood. When this supply line of sand gets breached, the natural long shore transport would take sand from North Wildwood and transport it to Wildwood and North Wildwood would be start to erode. A gradual accretion was calculated for Wildwood Crest and Lower Township from 1943 to 1977 and was due in part to the impoundment of sand at the northern jetty of Cape May Inlet.

Farrell et al. (2003). Onshore and near shore profile surveys conducted by the Coastal Research Center, Stockton State College under contract to NJDEP were collected annually, beginning in 1986. Four profiles have been collected within the study area as part of a general NJDEP program of monitoring the state's beaches. This profile was 1,060' wide in September 1989 and by December 2002 the shoreline retreated 740'. The amount of sand lost between September 1989 and December 2002 at 15th Ave. was reported to be 396 cubic yards per foot.

2.7.2 Historic Aerial Photography 1933-2012

Aerial photos from 1920, 1933, 1944, 1962, 1970, 2003, 2006 and 2012 are contained on the following pages (**Figure 62** through **69)** These photos illustrate the changes in beach shape after the closure of Turtle Gut Inlet in 1920 and the large "drumstick" barrier island shape of the shoreline in North Wildwood that appeared in 1970, potentially as a result of sediment bypassing across Hereford Inlet. The 1920, 1933, 1944, 1962 and 1970 photos were geo-referenced in Arcview using GIS layers including the 2005 Roads layer from the NJDEP and the study area navigation charts from NOAA.

Figure 62 Aerials 1920

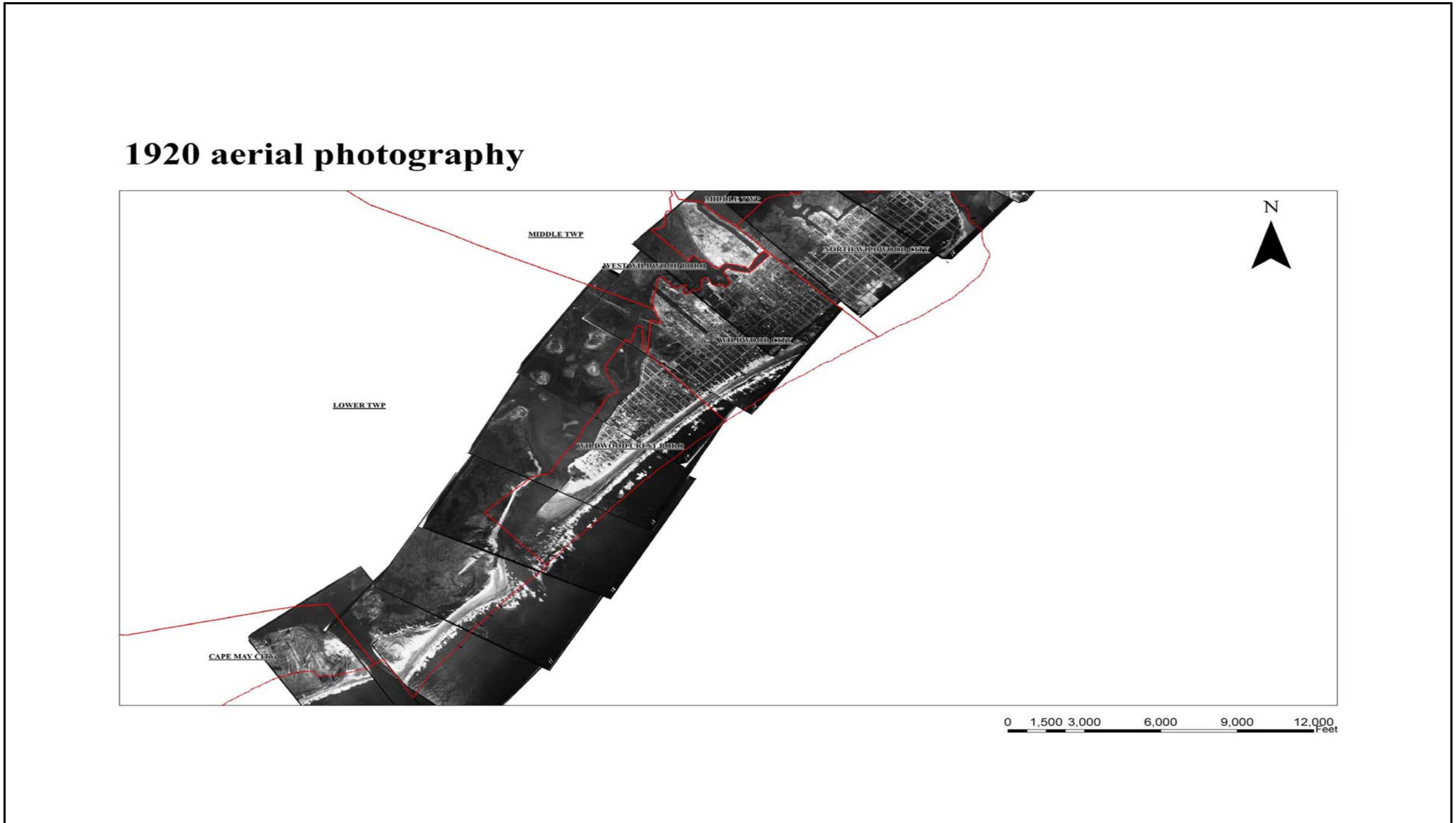


Figure 63 Aerials 1933

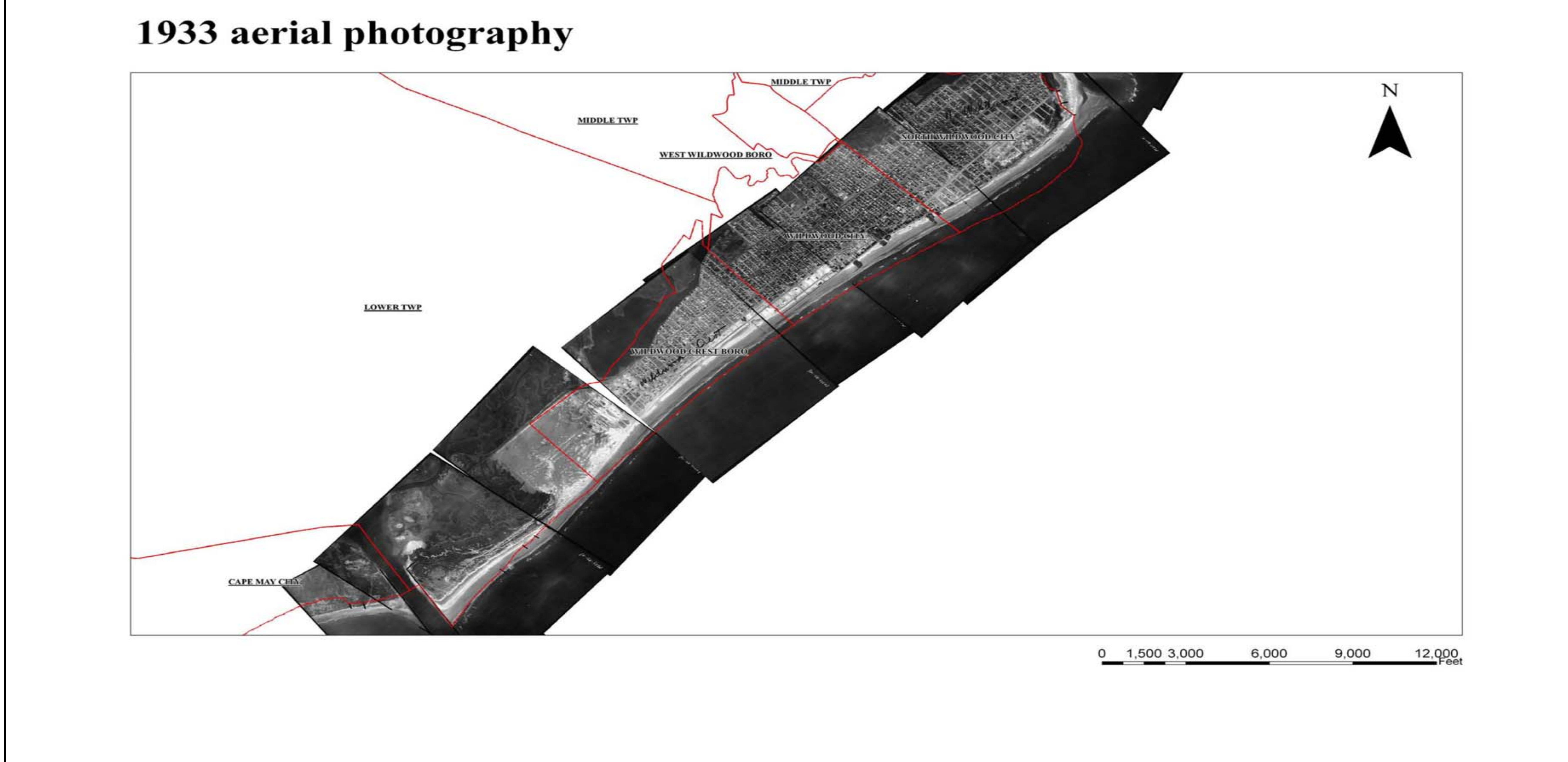


Figure 64 Aerial 1944

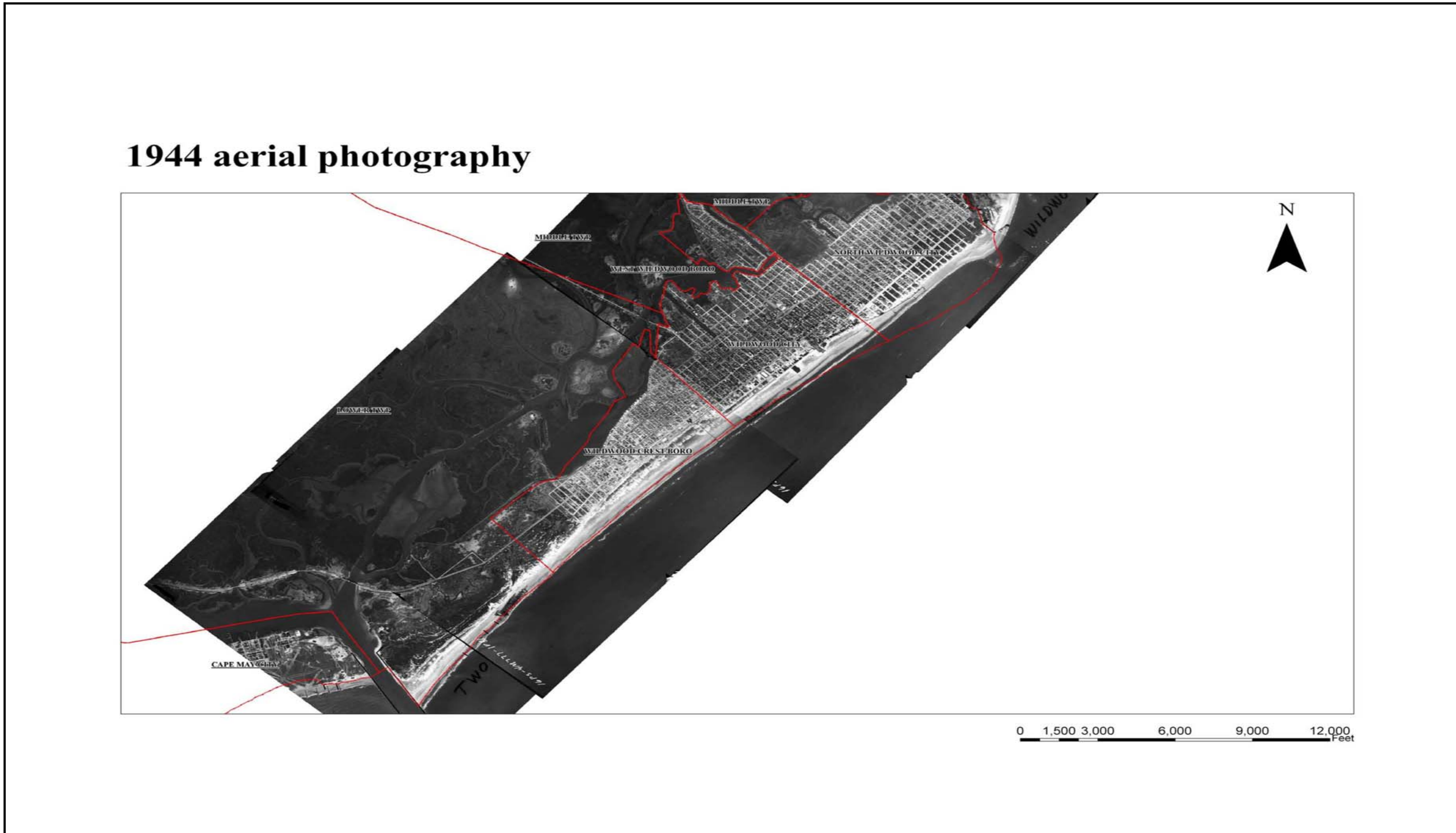


Figure 65 Aerials 1962

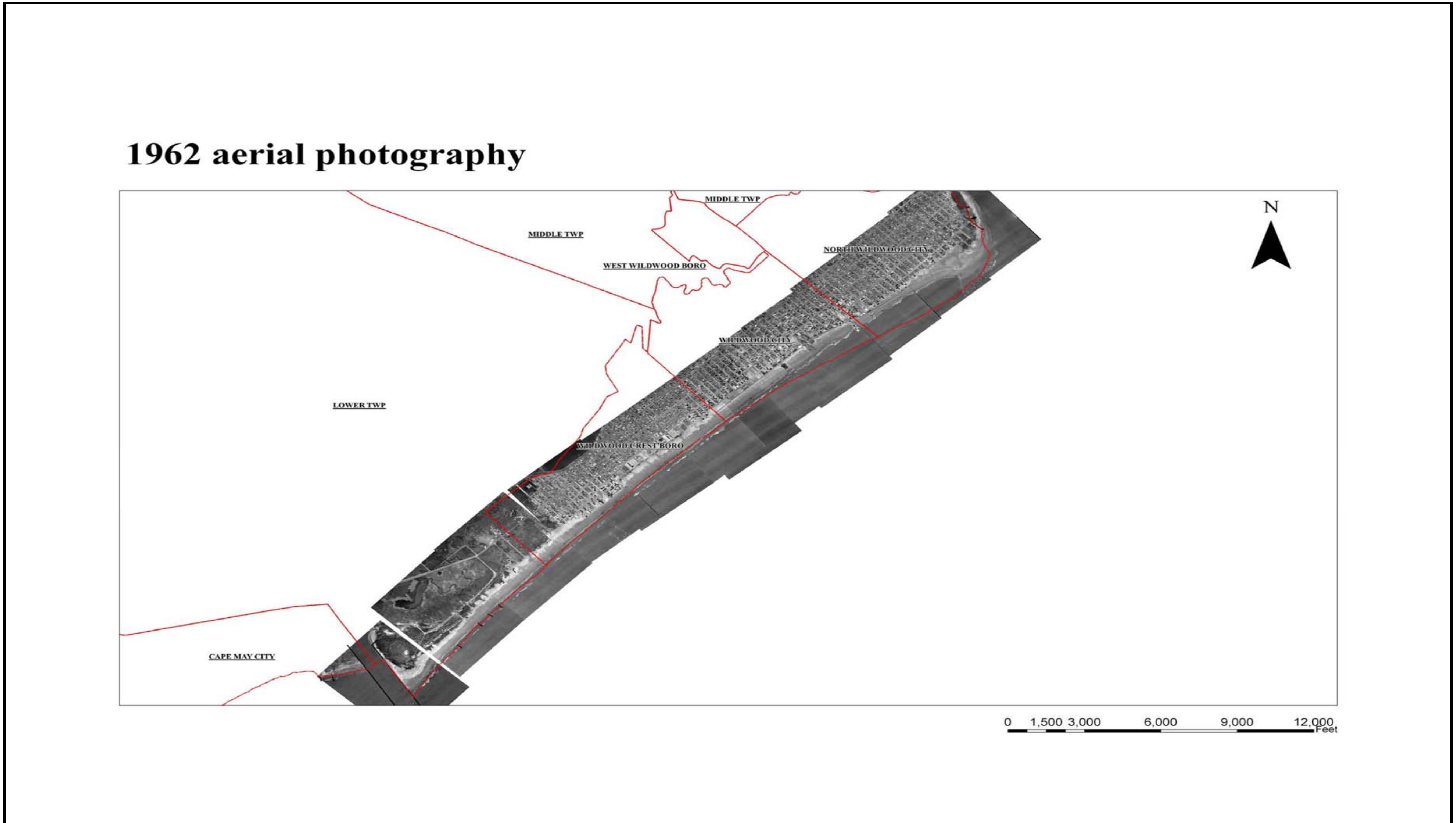


Figure 66 Aerials1970

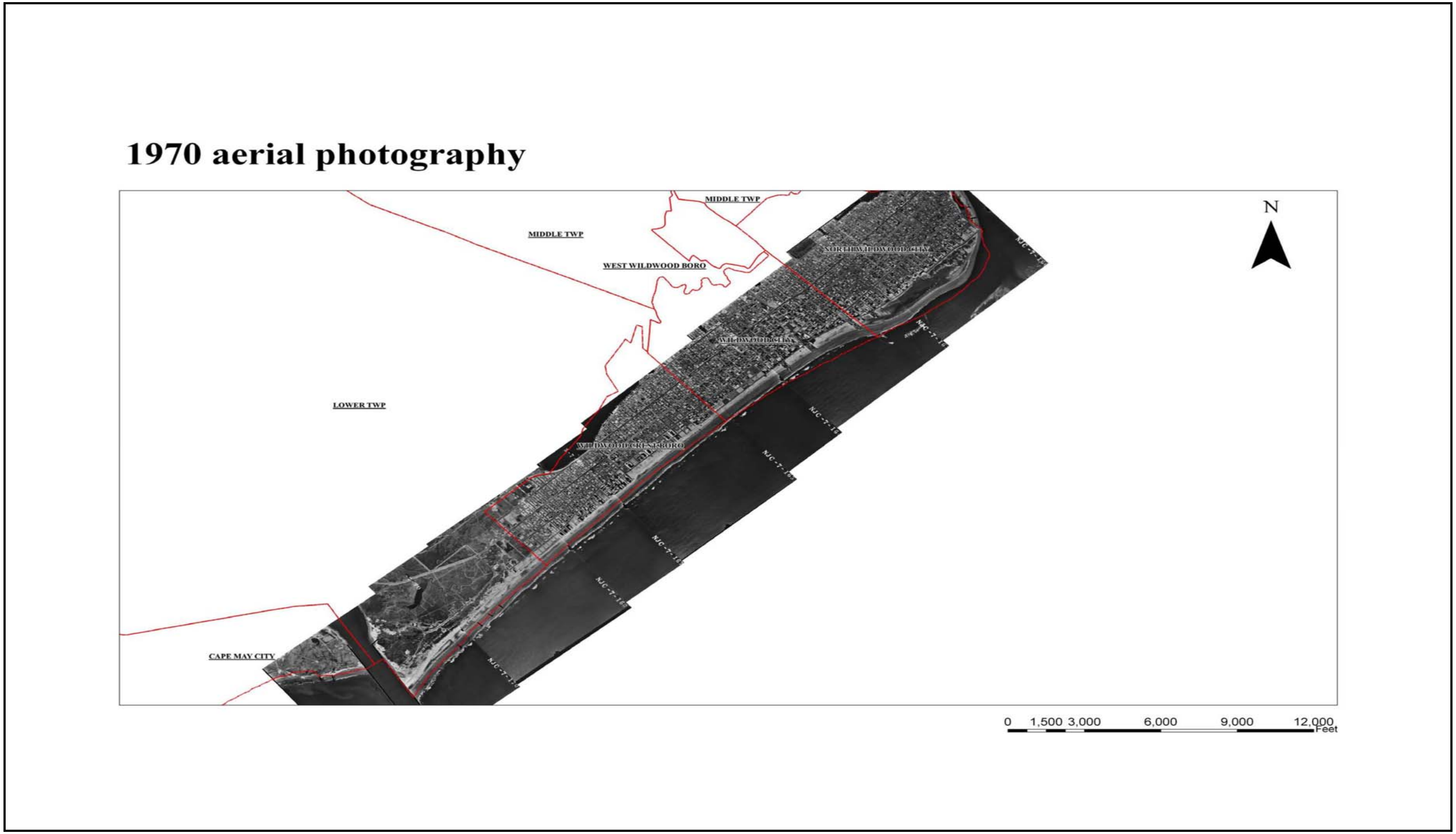


Figure 67 Aerials 2003

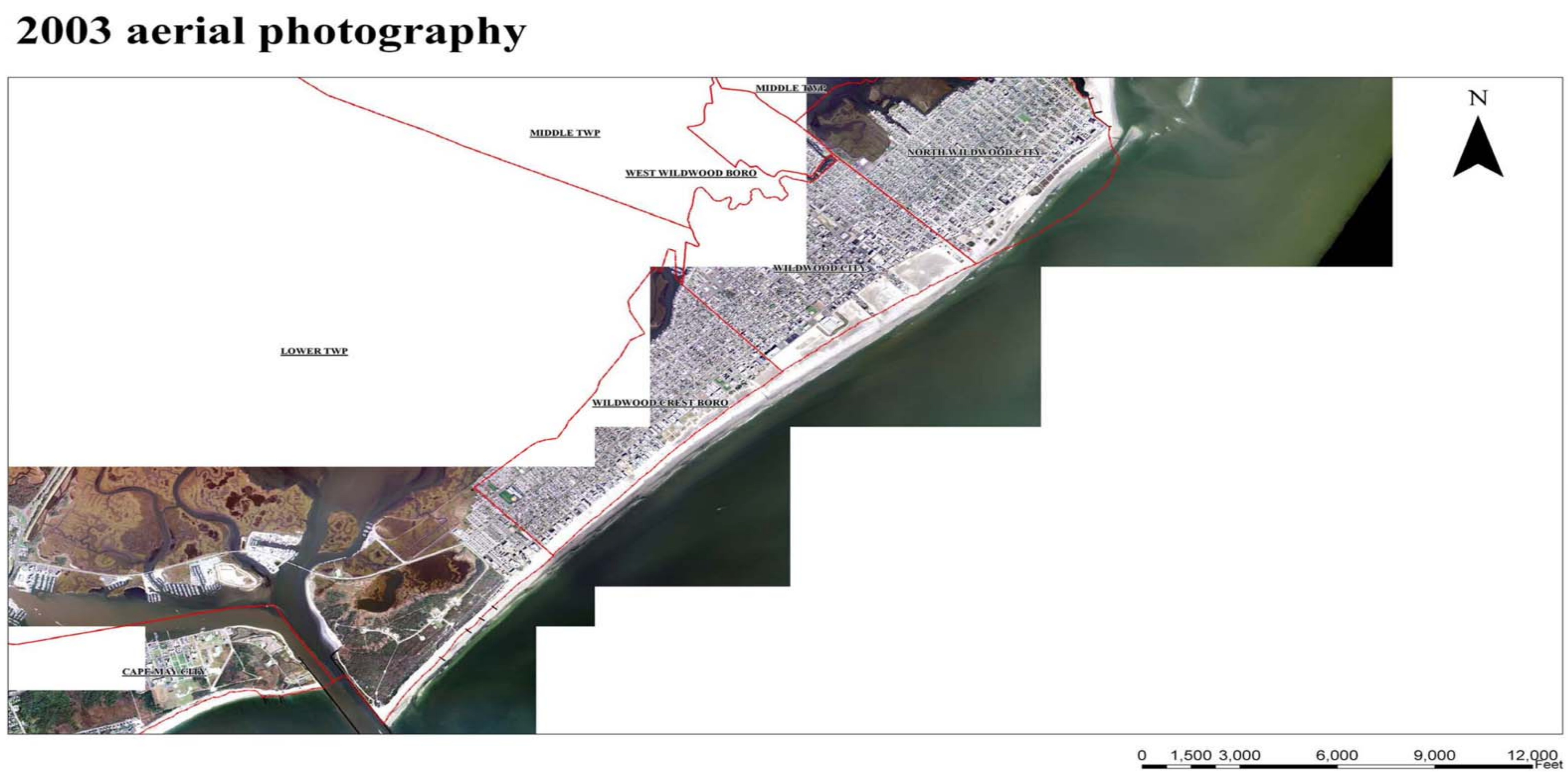


Figure 68 Aerials 2006

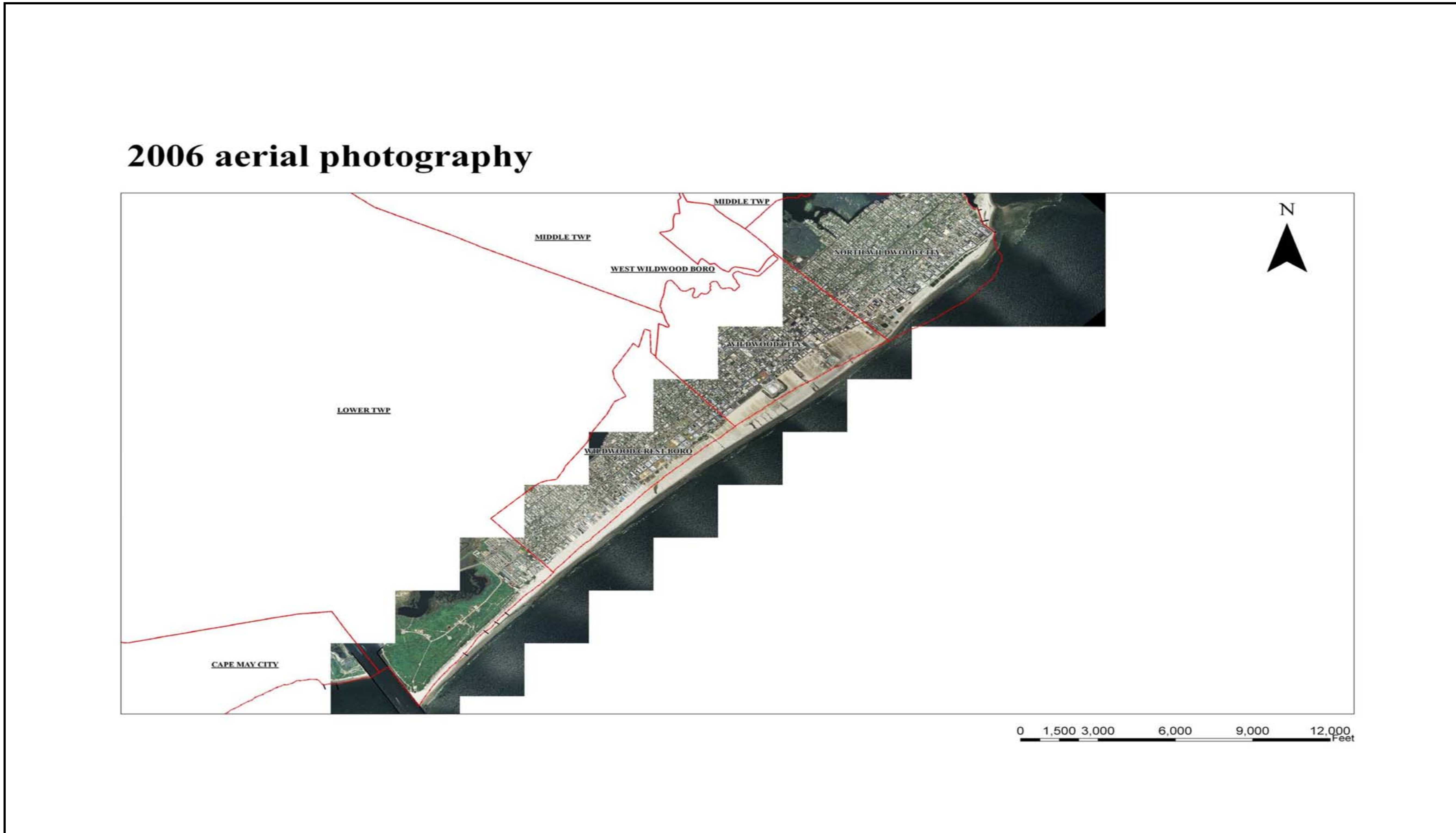


Figure 69 Aerials 2012

2.7.3 Analysis of Beach Profile Data, 1955-2003, 2012

Large quantities of sand have accumulated in the study area between the historic 1955 profiles to the present day. A historic profile comparison was initiated to determine the approximate amount of material that has arrived on the shoreline in the project area during this time frame. Three survey years were chosen for this comparison, 1955 and 2003 and 2012 (**Figure 70**).

The 1955 profiles were surveyed as part of the Beach Erosion Control Report on the Cooperative Study of the New Jersey Coast, Barnegat Inlet to the Delaware Bay entrance to the Cape May Canal, 30 December 1957 and directly correspond to the locations of the 2003 and 2012 surveys in the Wildwoods study area. The profile sheets from the 1957 report contained soundings from fathometer surveys in June of 1955 to a depth of approximately 30-35'. The 2003 and 2012 profiles were surveyed as part of the existing conditions analysis for this feasibility study, primarily occupying the same survey lines as 1955.

The measuring tool in Arcview was used to record a horizontal distance from the baseline to the 1955 sounding depth. This provided a distance (X) and depth (Y) value. These X,Y pairs were recorded for each 1955 profile and entered into a text file. A profile was created in BMAP (Beach Morphology Analysis Package) using the depth and distance pairs contained in the text file from the 1955 survey sheets **Figure 70**)

The project area gained approximately 12 million cubic yards of sand between 1955 and 2012 based on this analysis (**Table 38**). Currently, most of the sand sits in a relatively low, flat and wide beach. But this sand could be redistributed within the study area to maximize storm damage reduction benefits in the form of a comprehensive dune system designed to reduce impacts from coastal storms. It is though that the material arrived from Hereford Inlet through inlet sediment by-passing mechanisms explained in section **2.6.10**.

Figure 70 1955, 2003 and 2012 Profile comparison in Wildwood

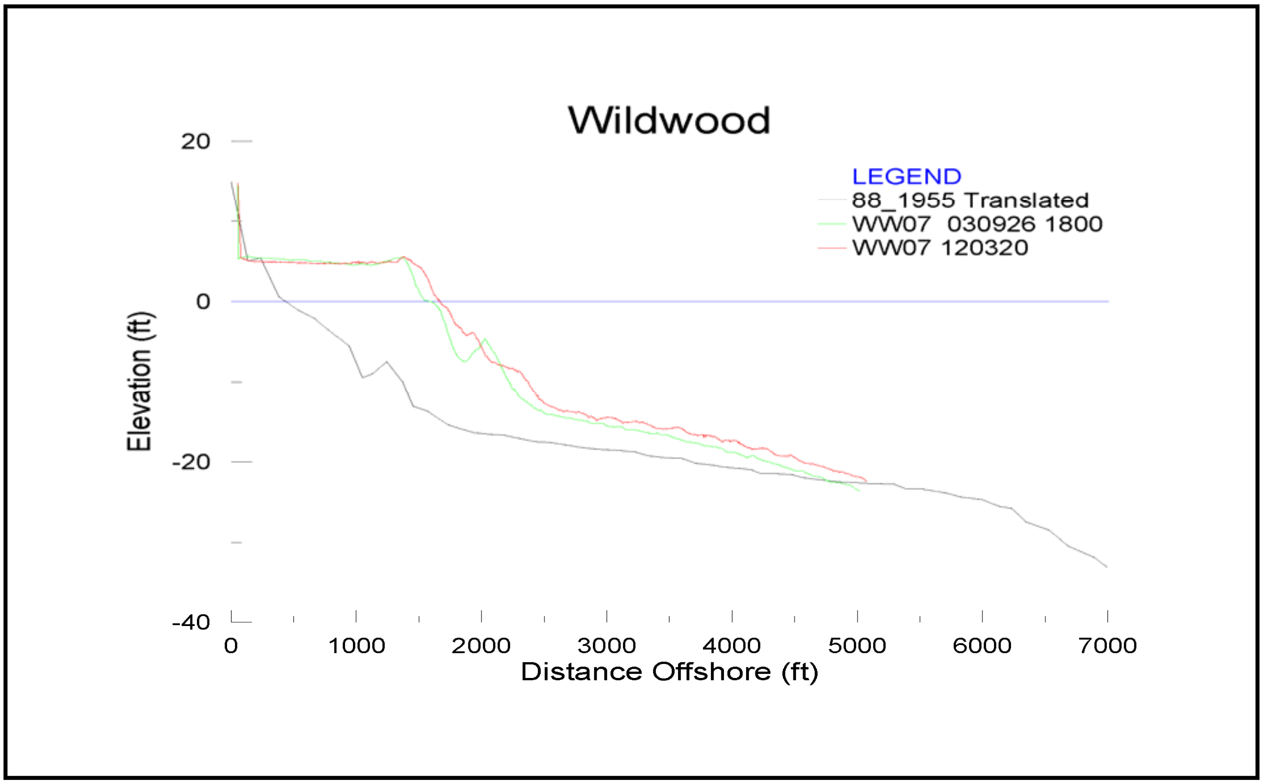


Table 38 1955, 2003, 2012 Volume Comparisons

Municipality	55 Profile	03, '12 Profile	Location	Shoreline '55	Shoreline 2012	Volume Change '55-'12
NWW	84-C	WW1	2nd Ave	656	124	-664
NWW	85	WW2	10th Ave	424	947	279
NWW	86	WW3	18th	41	942	632
NWW	87	WW4	26th Ave	443	1400	na
WW	88	WW7	Baker Ave	436	1661	1143
WWC	89	WW10	Crocus Ave	762	1568	659
WWC	90	WW12	Stanton rd	697	1400	na
LT	91	WW15	Seapoint Blvd	555	1219	495
LT	92	WW18	CG	1013	1414	339
LT	93	WW20	CG	867	1304	270
Average cu/yd/ft				**589.4**	**1197.9**	**394**
Avg. X 32000						**12,612,000**

2.8 Shoreline Change Analysis

An updated shoreline change analysis was done in order to incorporate shorelines from 1998 and 2003 by separating the study area into 4 shoreline segments. Digital shoreline change maps prepared for the State of New Jersey Historical Shoreline Map Series (Farrell et al. 1989) were reviewed to evaluate general shoreline trends. These maps include MHW shorelines from 1836-42, 1855, 1866-68, 1871-75, 1879-85, 1899, 1932-36, 1943, 1951-53, 1971, 1977, and 1986. Added to the analysis was a mean high water (MHW) shoreline digitized from an aerial photography flight taken September 1998 and an ATV survey done by USACE in November 2003. Several of the shorelines were missing, incomplete, or invalid for this area. All the shorelines from North Wildwood to Cape May Point used in the analysis can be seen in **Figure 71** through **Figure 76**. The shoreline change analysis involved rotating and translating each digital shoreline to a user-defined coordinate system grid. The grid ran alongshore for 31,650' from North Wildwood to Cape May Inlet and extended sufficiently seaward from the grid baseline to encompass all the historical shorelines. The grid for the study area was divided into four segments based upon the municipal boundaries of North Wildwood, Wildwood, Wildwood Crest, and Lower Township (**Table 39**). The segments were further divided into compartments that were no greater than 1000 ft. in length. A mean shoreline position was computed within each compartment by integrating the shoreline with respect to the coordinate system over the length of the compartment and dividing by the length of the compartment. A least squares fit of the mean shoreline positions versus date data was performed for each compartment to determine a shoreline change rate. Shoreline change rates were computed for the following periods: 1899-1932, 1932-1943, 1943-1977, 1977-1986, 1986-1998, and 1998-2003. Shoreline change rates were also computed for the time periods of: 1899-2003, 1932-2003, 1943-2003, and 1977-2003. summarizes the shoreline analysis grid.

Table 39 Historic Shoreline Analysis Segments

Analysis Segment	Avg Historical Shoreline Angle	Community	Segment Location	Segment Length (ft)
WW1	46.56	North Wildwood	2nd Ave to 26th Ave	6,840
WW2	52.4	Wildwood	26th Ave to Cresse Ave	6,830
WW3	46.16	Wildwood Crest	Cresse Ave to Jefferson Ave	9,630
WW4	42.3	Lower Township	Jefferson Ave to Cape May Inlet	8,350

The results of the analysis showed that the North Wildwood shoreline retreated significantly from 1986 to 2003 by a rate of 41'per year. Prior to 1986, the North Wildwood shoreline accreted for 43 years (1943-1986) at an average rate of 27' per year (**Table 40**). Prior to 1943, the North Wildwood shoreline experienced times of both minor accretion and retreat back to 1899.

Figure 71 North Wildwood Shoreline Positions 1899-2003

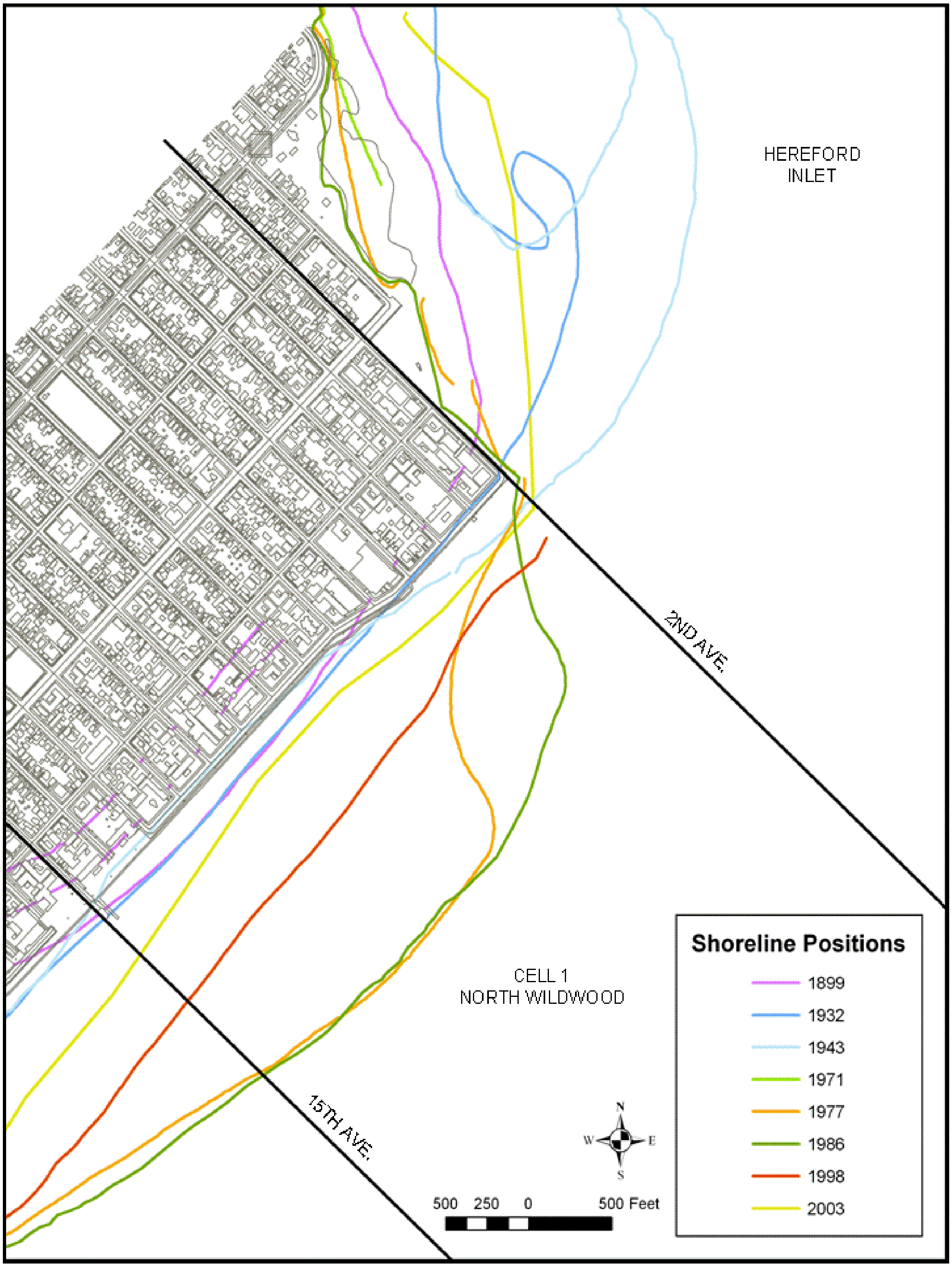


Figure 72 North Wildwood and Wildwood Shoreline Positions 1899-2003

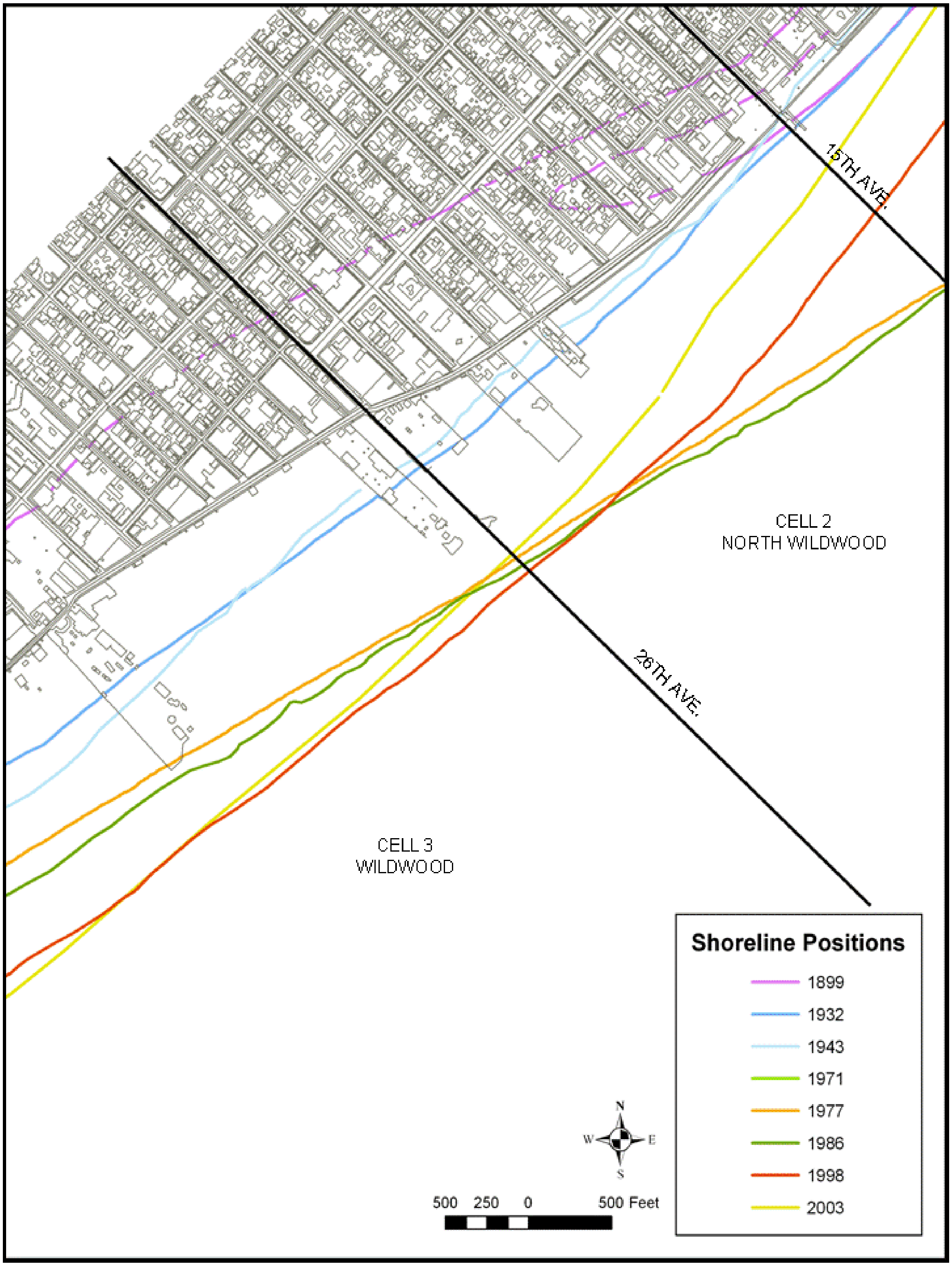


Figure 73 Wildwood and Wildwood Crest Shoreline Positions 1899-2003

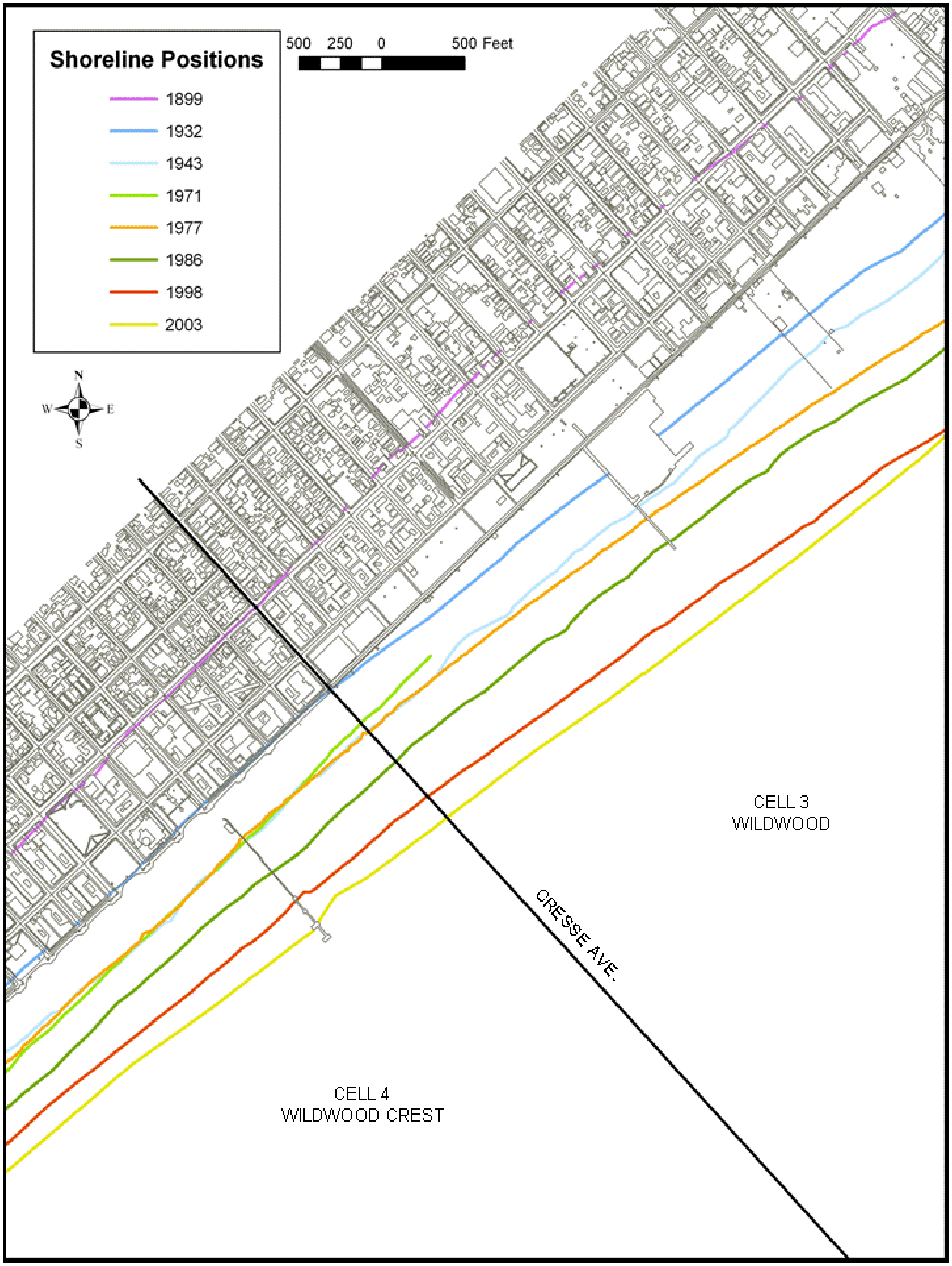


Figure 74 Wildwood Crest Shoreline Positions 1899-2003

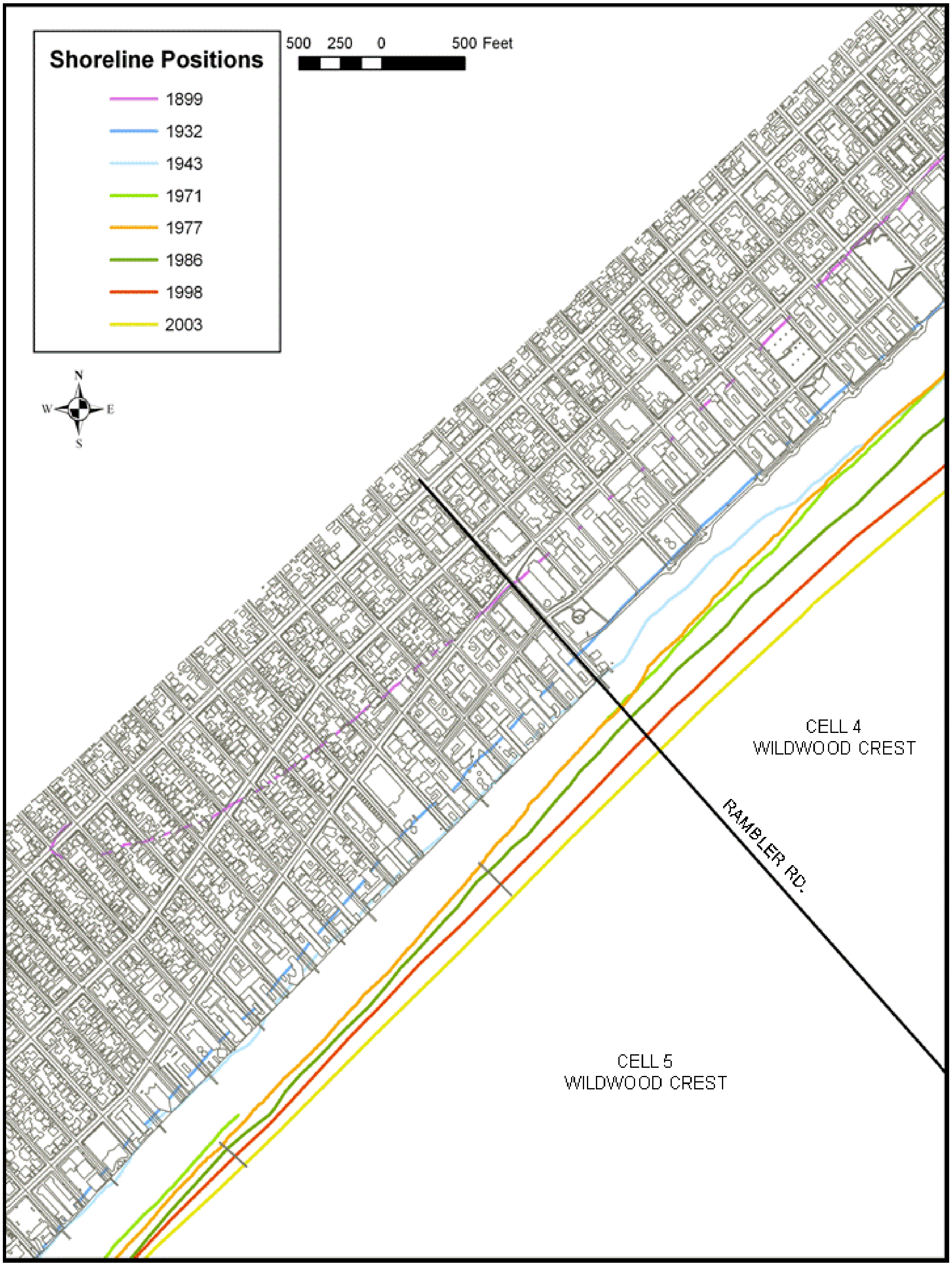


Figure 75 Wildwood Crest and Lower Township Shoreline Positions 1899-2003

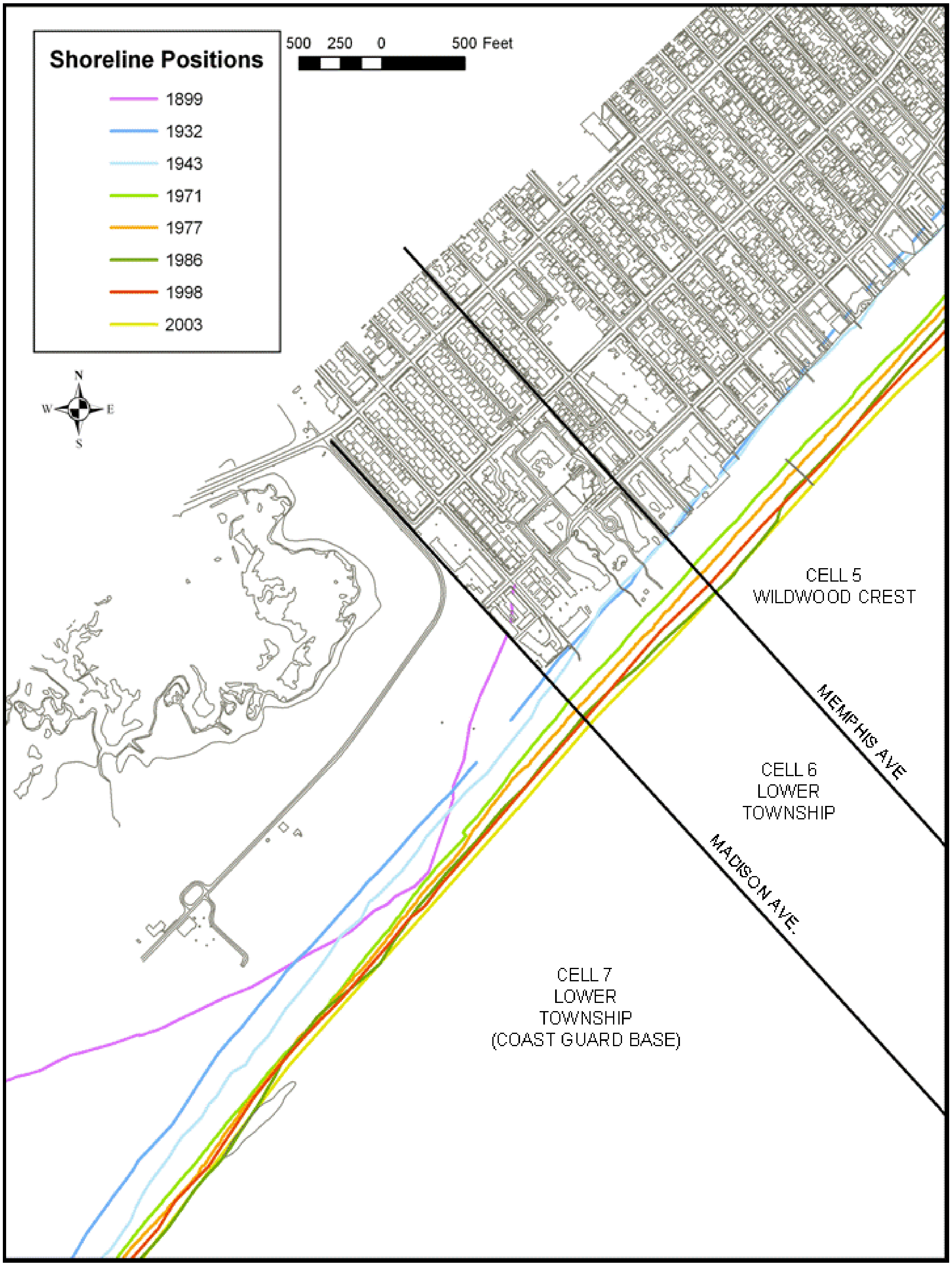
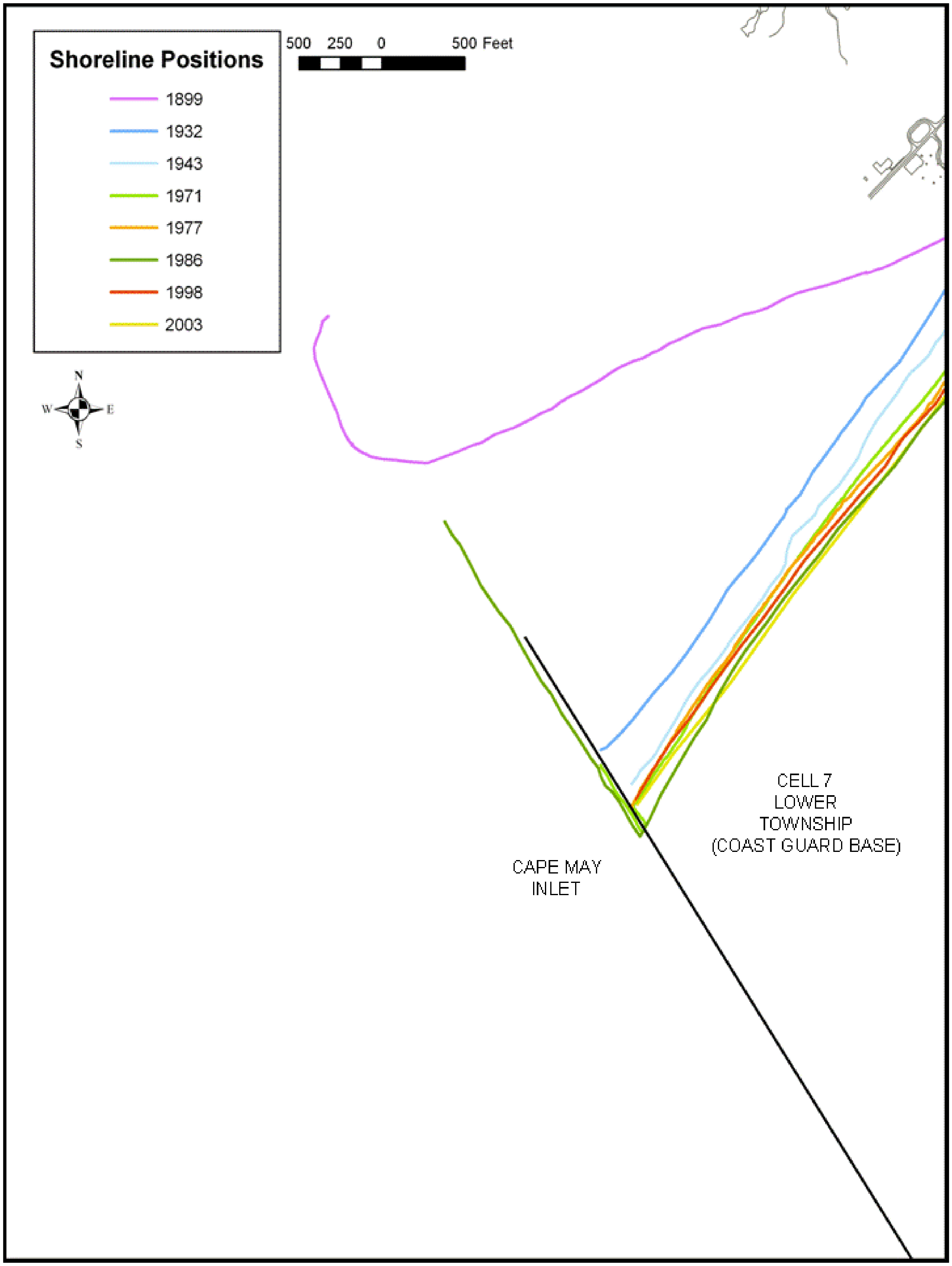


Figure 76 Lower Township Shoreline Position 1899-2003



Shoreline change in North Wildwood is heavily influenced by Hereford Inlet morphology. The link between Hereford Inlet morphology and the North Wildwood shoreline is complex and is related to the dynamics of Hereford Inlet. **Table 40** summarizes the shoreline change analysis for North Wildwood from Compartment 1 (at 2nd Ave.) to Compartment 9 (at 26th Ave.).

Table 40 Shoreline Change Rates, Segment 1

Adjacent Shoreline Dates (feet / year)							
Comp #	**Length (ft)**	**1899-1932**	**1932-1943**	**1943-1977**	**1977-1986**	**1986-1998**	**1998-2003**
1	800	4.47	17.96	3.59	48.52	-23.85	-30.57
2	700	2.82	-0.01	23.84	60.62	-67.15	-56.34
3	750	0.28	-11.29	46.19	-0.18	-68.96	-89.13
4	900	0.05	-16.85	47.07	-0.94	-64.32	-90.55
5	700	1.37	-10.71	41.09	4.27	-49.98	-79.23
6	750	7.61	-3.37	33.84	10.49	-33.83	-76.46
7	800	26.17	-9.39	30.84	9.00	-15.70	-58.43
8	600	35.78	-11.80	28.84	4.73	-2.74	-35.71
9	840	39.70	-11.71	25.25	5.58	4.70	-23.78
Avg		**13.14**	**-6.35**	**31.17**	**15.79**	**-35.76**	**-60.02**
Relative to 2003 Shoreline (feet / year)							
Comp #	**Length (ft)**	**1899-2003**	**1932-2003**	**1943-2003**	**1977-2003**	**1986-2003**	
1	800	6.26	5.92	3.83	-3.27	-25.45	
2	700	8.59	9.41	7.22	-27.52	-64.58	
3	750	9.31	10.77	7.75	-51.40	-73.75	
4	900	9.37	11.25	9.02	-49.25	-70.55	
5	700	10.09	11.92	10.01	-38.06	-56.93	
6	750	11.63	12.12	10.41	-26.80	-43.95	
7	800	16.11	13.08	13.10	-14.53	-25.85	
8	600	18.65	13.94	15.03	-5.29	-10.57	
9	840	19.17	13.64	15.25	0.84	-2.06	
Avg		**12.13**	**11.34**	**10.18**	**-23.92**	**-41.52**	

Care must be taken in utilizing the most recent shoreline changes along the study area in North Wildwood as shown in **Table 40** as an indicator of potential future trends. The most recent "snapshot" of volumetric changes is only for a 5 year time period of 1998 to 2003. Historically, the magnitude of erosion is far less than what they were in that 5 year time period. . The 1998-2003 time frame is not typical of how the study area shoreline has historical responded.

The existing conditions within and surrounding the study did not undergo any drastic "changes" that would lead someone to the conclusion that a continued accelerated rate of erosion would continue to happen post 2003. In fact, aerial photography collected since 2003 and profile data collected in 2012 associated with pre- and post Hurricane Sandy suggests that the rate of erosion has reduced significantly in North Wildwood; reverting back to historical values. More weight should be given to the longer time periods shown in **Table 40** when it comes to describing what the prevailing existing conditions within the study area; especially when in reference to comparing potential re-nourishment values against existing conditions.

In Wildwood the opposite is happening from North Wildwood. The Wildwood shoreline has been accreting significantly from 1986 to 2003 by a rate of 24' per year. From 1986 to 1998, the shoreline change rate was 26' per year while from 1998 to 2003 the accretion rate dropped slightly to 19' per year. In the long-term, the Wildwood shoreline has been accreting at a rate of 18' per year from 1899 to 2003. As previously discussed, the net long shore transport in the area is from the north to the south, and therefore much of the sand accumulating on the Wildwood beaches is coming from Hereford Inlet and North Wildwood. **Table 41** summarizes the shoreline change rates for Wildwood from 26th Ave. to Cresse Ave..

Table 41 Shoreline Change Rates for Wildwood Segment 2

Adjacent Shoreline Dates (feet / year)							
Comp #	**Length (ft)**	**1899-1932**	**1932-1943**	**1943-1977**	**1977-1986**	**1986-1998**	**1998-2003**
1	1000	38.66	-4.81	22.37	10.40	12.65	-11.75
2	900	35.97	5.60	16.48	12.58	21.56	1.16
3	600	33.35	14.33	11.15	11.81	28.88	10.59
4	700	31.67	18.08	8.50	17.00	31.74	14.61
5	1000	31.31	19.62	5.86	16.66	33.09	26.87
6	1000	29.54	23.69	2.74	20.88	30.56	33.37
7	1000	26.05	23.43	1.71	25.92	26.90	34.53
8	630	21.92	29.34	-0.08	25.07	24.84	39.76
Avg		**31.06**	**16.16**	**8.59**	**17.54**	**26.28**	**18.64**
Relative to 2003 Shoreline (feet / year)							
Comp #	**Length (ft)**	**1899-2003**	**1932-2003**	**1943-2003**	**1977-2003**	**1986-2003**	
1	1000	19.89	14.84	16.43	8.36	5.29	
2	900	19.55	15.04	16.13	15.93	16.71	
3	600	18.56	14.34	14.93	21.15	24.54	
4	700	18.94	15.27	13.80	24.86	27.67	
5	1000	17.72	13.84	14.39	27.29	31.61	
6	1000	16.74	12.95	13.11	28.08	31.23	
7	1000	15.60	12.51	12.66	27.72	28.71	
8	630	15.00	14.18	12.10	27.07	28.39	
Avg		**17.75**	**14.12**	**14.19**	**22.56**	**24.27**	

In Wildwood Crest the shoreline has been accreting at a greater rate than even the shoreline in Wildwood as **Table 42** shows. Since 1998, the shoreline in Wildwood Crest has accreted at an average rate 25.87' per year.

In Lower Township, which includes the Coast Guard Base, the shoreline has been fairly stable in the long-term since 1971. From 1998 to 2003, the shoreline has accreted at a rate of 11.5' per year. This rate is twice as large as the long-term (1932 – 2003) average of 5'per year. Prior to 1932, the shoreline accreted significantly due to Turtle Gut Inlet closing naturally in 1921**.** **Table 43** summarizes the shoreline change rates for Lower Township from Jefferson Ave to Cape May Inlet.

Table 42 Shoreline Change Rates for Wildwood Crest, Segment 3

Adjacent Shoreline Dates (feet / year)								
Comp #	**Length (ft)**	**1899-1932**	**1932-1943**	**1943-1971**	**1971-1977**	**1977-1986**	**1986-1998**	**1998-2003**
1	1000	19.15	30.26	-2.07	8.33	29.21	20.28	37.97
2	1000	18.01	30.48	-0.20	-0.63	23.32	19.45	34.15
3	1000	15.81	28.47	1.46	-4.68	23.60	14.81	33.88
4	1000	15.35	18.35	6.38	-7.08	18.68	12.46	35.55
5	1000	16.87	16.45	7.64	-2.50	12.14	11.57	26.63
6	1000	19.98	13.80	N/A	N/A	9.56	9.00	21.12
7	1000	25.09	11.04	N/A	N/A	5.74	5.96	23.37
8	700	37.00	8.25	N/A	N/A	5.90	4.66	18.25
9	1000	N/A	6.41	10.73	7.80	6.11	3.84	16.97
10	930	N/A	3.35	9.95	9.37	7.97	1.37	10.77
Avg		**20.91**	**16.69**	**4.84**	**1.52**	**14.22**	**10.34**	**25.87**
Relative to 2003 Shoreline (feet / year)								
Comp #	**Length (ft)**	**1899-2003**	**1932-2003**	**1943-2003**	**1971-2003**	**1977-2003**	**1986-2003**	
1	1000	13.68	11.69	10.90	23.32	25.51	24.49	
2	1000	12.57	10.65	10.08	19.69	22.73	22.94	
3	1000	11.68	10.08	9.36	17.15	20.19	19.34	
4	1000	11.33	10.03	9.88	14.43	17.66	17.94	
5	1000	11.33	9.47	9.11	11.59	13.92	15.14	
6	1000	11.89	9.31	8.97	N/A	10.92	11.88	
7	1000	13.15	9.44	9.18	N/A	8.42	10.10	
8	700	15.29	8.70	8.60	N/A	7.00	7.88	
9	1000	N/A	8.45	8.36	6.50	6.42	6.96	
10	930	N/A	7.59	7.69	5.50	4.70	3.60	
Avg		**12.62**	**9.54**	**9.21**	**14.03**	**13.75**	**14.03**	

Table 43 Shoreline Change Rates for Lower Township, Segment 4

Adjacent Shoreline Dates (feet / year)								
Comp #	**Length (ft)**	**1899-1932**	**1932-1943**	**1943-1971**	**1971-1977**	**1977-1986**	**1986-1998**	**1998-2003**
1	800	N/A	0.36	8.93	10.52	13.14	-2.91	11.83
2	800	N/A	-0.53	8.08	10.67	12.58	-4.07	16.04
3	1000	8.30	6.39	4.72	9.23	7.63	0.63	10.35
4	1000	-3.59	7.51	5.62	5.50	4.41	0.80	9.47
5	1000	-0.14	11.39	6.31	2.28	2.33	-0.18	12.07
6	1000	14.41	11.71	5.39	5.08	5.59	-3.45	10.77
7	1000	32.76	13.11	3.26	5.08	8.48	-3.02	9.06
8	750	46.07	16.55	1.49	-0.75	8.20	-2.87	13.33
9	500	56.31	16.05	2.40	-3.13	10.54	-5.96	13.64
10	500	N/A	22.53	2.68	-3.95	13.33	-9.51	8.54
Avg		**22.02**	**10.51**	**4.89**	**4.05**	**8.62**	**-3.05**	**11.51**
Relative to 2003 Shoreline (feet / year)								
Comp #	**Length (ft)**	**1899-2003**	**1932-2003**	**1943-2003**	**1971-2003**	**1977-2003**	**1986-2003**	
1	800	N/A	7.03	7.44	5.46	4.01	0.59	
2	800	N/A	6.45	6.95	5.25	3.80	0.71	
3	1000	6.07	5.32	5.16	5.00	4.13	2.94	
4	1000	3.16	5.00	4.53	3.49	3.13	2.86	
5	1000	4.20	5.04	3.99	2.27	2.34	2.73	
6	1000	7.46	4.83	3.73	2.04	1.30	-0.08	
7	1000	11.44	4.42	3.35	2.95	2.16	-0.15	
8	750	13.98	3.52	2.10	2.65	2.77	0.98	
9	500	16.39	3.50	1.99	1.73	1.80	-1.30	
10	500	N/A	3.87	1.50	0.35	-0.09	-5.22	
Avg		**8.96**	**4.90**	**4.07**	**3.12**	**2.54**	**0.41**	

2.8.1 Sediment Budget

The U.S. Army Corps of Engineers, Philadelphia District, as part of the New Jersey Alternative Long-Term Nourishment Study (NJALTN) study in 2006 developed a regional sediment budget from Cape May Point to Manasquan Inlet. The regional sediment budget was created with the software tool SBAS 2004, (Sediment Budget Analysis System) which was developed by the USACE Engineering Research and Development Center (ERDC). This regional sediment budget represents the latest budget for the study area. The following section describes the portion of the regional sediment budget from Hereford Inlet to Cape May Inlet that was developed in 2006.

A sediment budget represents an accounting of all sediment movement, both natural and mechanical, within a defined area over a specified time. The defined area is represented by a series of control volumes. Each control volume represents an area of similar geographical and littoral characteristics. Individually each control volume can be viewed as a complete self-contained sediment budget within its own boundaries. Sediment fluxes connect each control volume to one another and they represent either a sediment source or sink to the control volume. Sediment sources are such things as beach-fills, long shore transport, shoreline erosion, and inlet shoal growth. Sediment sinks are such things as long shore transport, shoreline accretion, dredging activities, and inlet shoal reduction. Sea-level rise can also be considered a sediment sink but it was not considered during the development of the sediment budget due to the fact that the period of analysis used was relatively short. A balanced sediment budget means that the sediment sources, sinks, and net change within each individual control volume equals zero. Also, a balanced sediment budget assumes that sediment cannot be created nor destroyed within each control volume.

A balanced sediment budget can be a useful tool in investigating observed coastal changes and estimating future changes and management measures. The sediment budget developed represented potential sediment movement. It was assumed for that an "unlimited" supply of sediment was available, and that obstructions such as groins, jetties, and breakwaters do not impact the sediment pathways in any way.

2.8.2 Analysis Procedures

Based on the availability of shoreline position and wave data, the specific period of analysis for the sediment budget was selected as 1986-2003. Shoreline position data was digitized from aerial photographs from 1986 and 2003 and used to determine shoreline erosion/accretion during this period. The wave data used was taken from the 1980 to 2000 updated WIS Hindcast of the Atlantic Ocean. Wave data was provided by the USACE, Field Research Facility and used for calculating potential long shore sediment transport. Additional input data used during the development of the sediment budget for the portion from Hereford Inlet to Cape May Inlet included: Dredging records from the coastal navigation project at Cape May Inlet. Quantities from Federal/State/Local beach fill projects compiled in a database developed by the District. Inlet bathymetry surveys conducted by the District and its Contractors.

One control volume was established for each inlet and each barrier island/land mass for the sediment budget. An additional control volume was delineated for North Wildwood because its shoreline is eroding compared to the accreting adjacent shoreline of Wildwood.

Once the control volumes were established, shoreline change was quantified using the 1986 and the 2003 digitized shorelines. The shoreline change rates were converted to volumes by utilizing representative berm heights and closure depths from available profile data. It was assumed that the "observed" shoreline change rate is applicable for the entire active profile height even though the change rate was based upon a digitized mean high water line shoreline. The "observed" shoreline change rate was converted to a volumetric change rate by multiplying the control volume's reach length with the active profile height and the computed shoreline change rate.

Another set of inputs that was calculated for the sediment budget was potential long shore transport rates due to waves. Wave-driven sediment transport potential was calculated using the CERC energy flux method with the computer program SEDTRAN as previously discussed in the Longshore Transport section of the report.

An analysis of available hydrographic surveys to quantify changes at inlet shoals was conducted for the inlet control volumes of the sediment budget. The computer program SMS was used to contour, compare, and quantify any changes between the surveys for Hereford and Cape May Inlets. Available hydrographic data that surveyed the entire inlet and not just navigation channels was sparse from 1986 to 2003 for these inlets. There were no inlets that had hydrographic surveys spanning the entire period of analysis from 1986 to 2003. The volumetric change during the time span where data was available had to be extrapolated to represent the entire period of analysis of 1986 to 2003.

The last set of inputs to go into the sediment budget was the compilation of borrow area and navigation channel dredging records. An average annual dredging rate was computed from the available records for Hereford and Cape May Inlets. The dredging records at Cape May Inlet were inspected to see if the dredged material was removed and placed outside the control volume or if the material was "relocated" within the same control volume. It was determined that at Cape May Inlet, the dredging that takes place does not remove sediment from the control volume but merely relocates it within the control volume. Also, Hereford Inlet has a beach fill borrow area for the federal beach fill project at Avalon and Stone Harbor within its control volume of the sediment budget. Dredging records at Hereford Inlet were compiled as well.

2.8.3 Sediment Budget Uncertainty

Uncertainty for each sediment budget input variable was considered and tracked using SBAS. Uncertainty provides a means of comparing cells within the budget and quantifying the reliability of the budget as a whole. The percent uncertainty for various inputs can be compared, revealing the degree to which various assumptions are known. A range representing reasonable values for each input was calculated and entered into SBAS. The range was based upon several factors, including: complexity of analysis, data availability, seasonal and yearly fluctuations, experience and CHL guidance. Final values for long shore transport and shoreline change within the sediment budget differ from the values previously shown in their respective sections in the report. The difference is based upon applying the uncertainty percentages to the values previously summarized for the study area from 1986 to 2003. **Table 44** summarizes the uncertainty percentages used during the development of the sediment budget.

Table 44 Sediment Budget Uncertainty

Sediment Budget Input	Uncertainty Percentage
Longshore Sediment Transport	60%
Longshore Sediment Transport to/from Inlets	75%
Shoreline Erosion/Accretion	40%
Dredging Quantities	20%
Offshore Losses	30%
Inlet Shoal Growth/Reduction	50%

2.8.4 Sediment Budget Balancing

The sediment budget was balanced on a control volume by control volume basis. The sediment budget inputs were adjusted within their computed uncertainty range in order to balance each control volume. Very often control volumes would not balance even when the known inputs were adjusted within their uncertainty ranges. When this happened it was often due to the fact that not all sediment sources/sinks were clearly identified for the control volume being balanced. Once the additional sources/sinks were entered, the control volume was able to be balanced. The Hereford and Cape May Inlet control volumes were balanced after balancing the control volumes for North Wildwood and Wildwood first. This had to be done in order to minimize the number of unknowns that often existed at the inlets due to lack of data. Common unknowns throughout the sediment budget that had to be solved for once everything else was examined were the transport rates to/from Hereford and Cape May Inlets to North Wildwood and Wildwood respectively. The high uncertainty percentage used for these values is a reflection of the fact that there is a lot of variability in these numbers since they are based upon other sediment sources and sinks and the complex hydrodynamics that exists at inlets.

2.8.5 Sediment Budget Results

The balanced regional sediment budget is shown graphically on **Figure 77** and **Figure 78** and summarized in **Table 45**. Various assumptions regarding long shore transport, offshore losses, shoal growth/reduction, and shoreline erosion/accretion quantities had to be made in order to solve for unknowns and balance the budget.

<u>Cape May Inlet</u>
The only sediment source considered was the 62,000 cubic yards per year of material entering the Inlet through the eastern jetty on the Wildwood side of the Inlet. The only sediment sink considered was 62,000 cubic yards per year of material bypassing the Inlet through the western jetty and entering the Cape May City control volume. Dredging of the inlet's navigation channel is done by a side casting dredge with no material "removed" from the control volume. The inlet is very stable with a negligible amount of sediment infilling the navigation channel that needs to be relocated using a side casting dredge.

Easterly sediment transport through the jetties from Cape May City and northerly sediment transport to the Wildwoods was assumed to be negligible. Assumed no sediment transported into the control volume from Cape May Harbor or any offshore losses of sediment beyond the seaward tips of the jetties. Therefore, it was assumed that 100% of the sediment entering the Inlet from Wildwood is bypassed to Cape May City.

<u>Wildwoods</u>
The sediment sources are 530,000 cubic yards per year of southerly long shore sediment transport from North Wildwood, and 6,000 cubic yards per year of beach fill. It was assumed that the sediment source of northerly long shore sediment transport from Cape May Inlet was negligible. The sediment sinks are 122,000 cubic yards per year of northerly long shore sediment transport to North Wildwood, 62,000 cubic yards per year of southerly long shore sediment transport to Cape May Inlet, 45,000 cubic yards per year of shoreline accretion, and an assumed offshore loss of 124,000 cubic yards per year. It was assumed that material from the

beach fills placed along with the material moved by southerly long shore sediment transport is accumulating offshore just northeast of Cape May Inlet. It was assumed that the east jetty for Cape May Inlet has effectively “blocked” sediment from entering the Inlet and deflected it offshore to this area which is commonly known as the Coast Guard Base Fillet. No hydrographic survey data was available to confirm this assumption, however profile data collected in 2001 and 2003 confirmed the growth of an offshore bar in the area.

North Wildwood

Since the littoral characteristics of Wildwood differ significantly from North Wildwood (an accreting shoreline for Wildwood versus an eroding shoreline for North Wildwood), a control volume representing just North Wildwood was created. The sediment sources are 320,000 cubic yards per year bypassing Hereford Inlet, 122,000 cubic yards per year of northerly long shore sediment transport from Wildwood, 11,000 cubic yards per year of beach fill, and 257,000 cubic yards per year of shoreline erosion. The sediment sinks are 178,000 cubic yards per year of northerly long shore sediment transport into Hereford Inlet, 530,000 cubic yards per year of southerly long shore sediment transport to Wildwood, and an assumed offshore loss of 20% or 2,000 cubic yards per year from the beach fills placed.

Hereford Inlet

The sediment sources are 450,000 cubic yards per year of southerly long shore sediment transport from Seven Mile Island, 178,000 cubic yards per year of northerly long shore sediment transport from North Wildwood, and 50,000 cubic yards per year of shoreline erosion from Stone Harbor Point which was assumed to be part of this control volume. The sediment sinks are 320,000 cubic yards per year of sand bypassing the Inlet to North Wildwood, 188,000 cubic yards per year of shoal growth which was measured using surveys from 1994 and 2002 with results extrapolated for the entire period of analysis, and 170,000 cubic yards per year of material removed from the Hereford Inlet borrow area. The borrow area for the Seven Mile Island Federal Beach fill Project lies within the control volume and was dredged in early 2003. Northern sediment transport from the Inlet to Seven Mile Island was assumed to be negligible. The Hereford Inlet control volume could not be balanced initially because the shoreline erosion from Stone Harbor Point was not a defined sediment source. Once it was added as a potential sediment source the control volume became easier to balance.

Figure 77 Sediment Budget

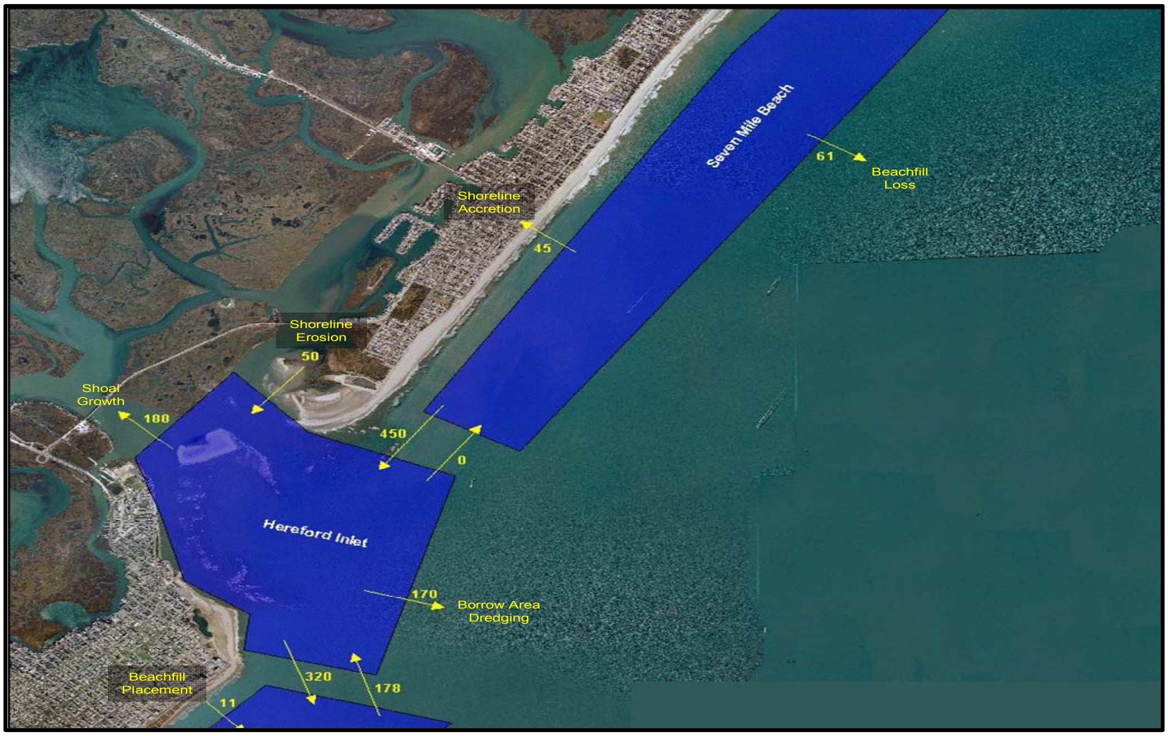


Figure 78 Sediment Budget

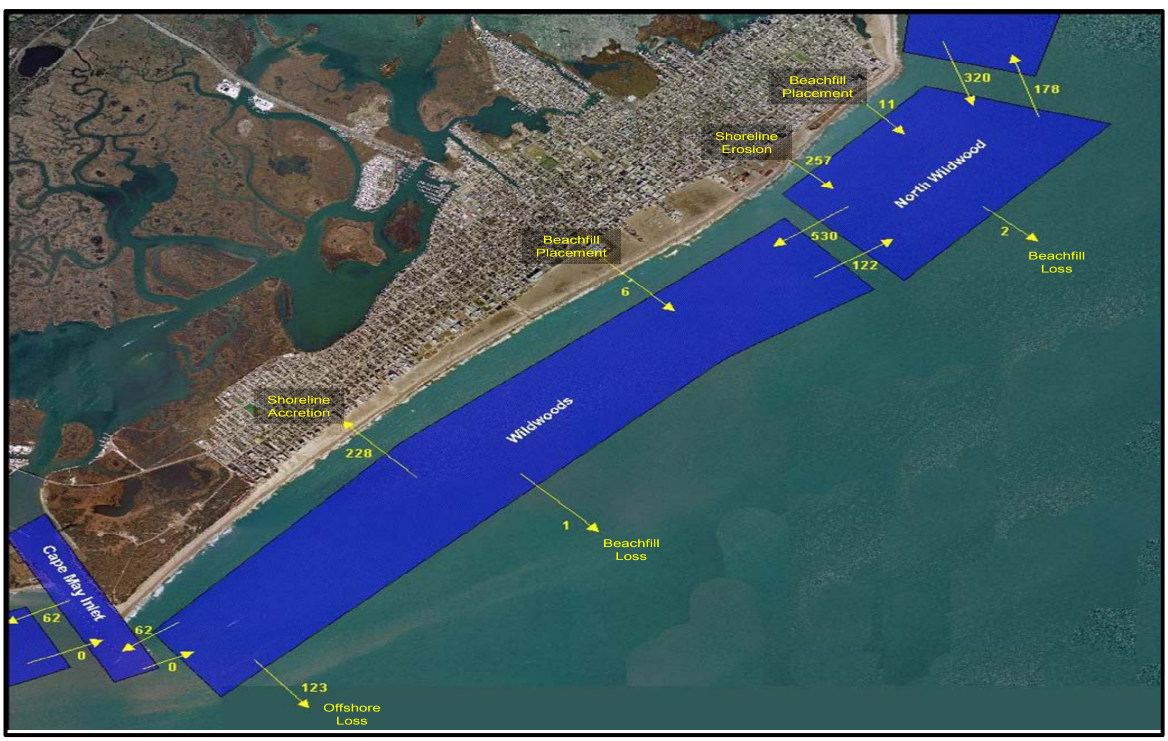


Table 45 Sediment Budget Results

Control Volume	Flux Value (cu yd/yr)	Source or Sink	To	From	Description
Cape May Inlet	0	Source	Cape May Inlet	Cape May City	Longshore Sediment Transport
	62,000	Sink	Cape May City	Cape May Inlet	Longshore Sediment Transport
	0	Sink	Wildwoods	Cape May Inlet	Longshore Sediment Transport
	62,000	Source	Cape May Inlet	Wildwoods	Longshore Sediment Transport
Wildwoods	0	Source	Wildwoods	Cape May Inlet	Longshore Sediment Transport
	62,000	Sink	Cape May Inlet	Wildwoods	Longshore Sediment Transport
	228,000	Sink	N/A	Wildwoods	Shoreline Accretion
	123,000	Sink	N/A	Wildwoods	Offshore Losses
	6,000	Source	Wildwoods	N/A	Beach fill
	1,000	Sink	N/A	Wildwoods	Offshore Beach fill Losses
	122,000	Sink	North Wildwood	Wildwoods	Longshore Sediment Transport
	530,000	Source	Wildwoods	North Wildwood	Longshore Sediment Transport
North Wildwood	122,000	Source	North Wildwood	Wildwoods	Longshore Sediment Transport
	530,000	Sink	Wildwoods	North Wildwood	Longshore Sediment Transport
	257,000	Source	North Wildwood	N/A	Shoreline Erosion
	11,000	Source	North Wildwood	N/A	Beach fill
	2,000	Sink	N/A	North Wildwood	Offshore Beach fill Losses
	178,000	Sink	Hereford Inlet	North Wildwood	Longshore Sediment Transport
	320,000	Source	North Wildwood	Hereford Inlet	Longshore Sediment Transport
Hereford Inlet	178,000	Source	Hereford Inlet	North Wildwood	Longshore Sediment Transport
	320,000	Sink	North Wildwood	Hereford Inlet	Longshore Sediment Transport
	50,000	Source	Hereford Inlet	N/A	Shoreline Erosion
	188,000	Sink	N/A	Hereford Inlet	Shoal Growth
	170,000	Sink	N/A	Hereford Inlet	Borrow Area Dredging
	0	Sink	Seven Mile Beach	Hereford Inlet	Longshore Sediment Transport
	450,000	Source	Hereford Inlet	Seven Mile Beach	Longshore Sediment Transport

3.0 Without Project Analysis

3.1 Hydraulic Analysis

3.1.1 Storm Erosion, Inundation and Wave Attack Analyses

Storm erosion, inundation and wave attack analyses were conducted for the communities to determine the potential for damage caused by waves and elevated water levels which accompany storms. Storm-induced erosion and coastal flooding is first evaluated for the without project condition, which is a projection of existing conditions in the base year. Similar analyses will then be conducted using selected measures for the with project conditions.

3.1.2 Factors Influencing Storm Effects

A brief summary of the mechanisms that result in erosion and inundation from coastal storms is provided in this section. Although wind, storm track, and precipitation are the primary meteorological factors affecting the damage potential of coastal storms, the major causes of damage and loss of life are storm surge, storm duration, and wave action.

Under storm conditions, there is typically a net increase in the ocean water level which is superimposed on the normal astronomic tide height fluctuations. The increase in water level caused by the storm is referred to as "storm surge." The effect of storm surge on the coast depends on the interaction between the normal astronomic tide and storm-produced water level rise. For example, if the time of normal high tide coincides with the maximum surge, the overall effect will be greater. If the surge occurs at low or falling tide, the impact will likely be lessened. The term "stage" as applied in this analysis pertains to the total water elevation, including both tide and storm surge components, relative to a reference datum (NAVD88, used herein). The term "surge" is defined as the difference between the observed stage and the stage that is predicted to occur due to normal tidal forces, and is thus a good indicator of the magnitude of storm intensity. Slowly moving "northeasters" may continue to build a surge that lasts through several high tides. Such a condition occurred during the devastating March 1962 storm that lasted for five high tides.

In addition to storm surge, a rise in water level in the near shore can occur due to wave setup. Although short period surface waves are responsible for minimal mass transport in the direction of wave propagation in open water, they cause significant transport near shore upon breaking. Water propelled landward due to breaking waves occurs rather rapidly, but water returned seaward under the influence of gravity is slower. This difference in transport rates in the onshore and offshore directions results in a pileup of water near shore referred to as wave setup. Wave setup was computed and included in this storm analysis.

There is typically also an increase in absolute wave height and wave steepness (the ratio of wave height to wave length). When these factors combine under storm conditions, the higher, waves and elevated ocean stage cause a seaward transport of material from the beach face. Net movement of material is from the foreshore seaward toward the surf zone. This offshore transport creates a wider, flatter near shore zone over which the incident waves break and dissipate energy.

Lastly, coastal structures can be exposed to the direct impact of waves and high velocity run-up in addition to stillwater flooding. This phenomenon will be considered the wave attack for the purpose of this analysis. Reducing wave attack with a proposed project such as a beach fill would reduce the severity of coastal storm damage and also improve the utility of bulkheads and seawalls during the storm.

Wave zones are the regions in which at least a 3 ft wave or a velocity flow that overtops the profile crest by 3 ft can be expected to exist. These zones are the areas in which greater structural damages are expected to occur. The remaining zones are susceptible to flooding by overtopping and waves less than the minimum of 3 ft. Total water level information for the study area was compiled, and the values used as input to the economic model that ultimately computes damages associated with all three storm related damage mechanisms.

3.1.3 Modeling Storm-induced Erosion

Storm erosion analyses require either a long period of record over which important storm parameters as well as resultant storm erosion are quantified, or a model which is capable of realistically simulating erosion effects of a particular set of storm parameters acting on a given beach configuration. There are very few locations for which the necessary period of prototype information is available to perform an empirical analysis of storm-induced erosion. This is primarily due to the difficulty of directly measuring many important beach geometry and storm parameters, before, during, and immediately after a storm. Thus, a systematic evaluation of erosion under a range of possible starting conditions requires that a numerical model approach be adopted for the study area.

The USACE has developed, released and adopted the numerical storm-erosion model SBEACH (Storm induced BEAch CHange) for use in field offices (Rosati, et al., 1993). SBEACH is available via a user interface for the personal computer or through the Coastal Modeling System (CMS) (Cialone *et al*., 1992). Comprehensive descriptions of development, testing, and application of the model are contained in Reports 1 and 2 of the SBEACH series (Larson and Kraus 1989; Larson, Kraus, and Byrnes 1990). SBEACH model runs comparing pre and post storm Hurricane Sandy profiles against the 20 year and 50 year event for the model outputs are included in this section.

3.1.4 Overview of SBEACH Methodology

SBEACH Version 3.2 (Windows version) was used in this analysis. SBEACH is a geomorphic - based two-dimensional model that simulates beach profile change, including the formation and movement of major morphologic features such as long shore bars, troughs, and berms, under varying storm waves and water levels (Rosati, et al. 1993). SBEACH has significant capabilities that make it useful for quantitative and qualitative investigation of short-term, beach profile response to storms. However, since SBEACH is based on cross-shore processes, there are shortcomings when used in areas having significant long shore transport.

Input parameters include varying water levels as produced by storm surge and tide, varying wave heights and periods, and grain size in the fine-to-medium sand range. The initial beach profile can be input as either an idealized dune and berm configuration or as a surveyed total profile configuration. SBEACH allows for variable cross-shore grid spacing, simulated water-level setup due to wind, advanced procedures for calculating the wave breaking index and breaker decay, and provides an estimation of dune overwash. Shoreward boundary conditions that may be specified include a vertical structure (that can fail due to either excessive scour or instability caused by wave action/water elevation) or a beach with a dune. Output results from SBEACH include calculated profiles, cross-shore parameters, and log and a report file.

3.1.5 SBEACH Calibration

Calibration refers to the procedure of reproducing with SBEACH the change in profile shape produced by an actual storm. Due to the empirical foundation of SBEACH and the natural variability that occurs along the beach during storms, the model should be calibrated using data from beach profiles surveyed before and after storms at the project coast or a similar coast. The calibration procedure involves iterative adjustments of controlling simulation parameters until agreement is obtained between measured and simulated profiles. The best profile data set for model calibration in the vicinity of the study area consisted of USACE profile surveys taken at Ocean City, NJ prior to and just after the December 1992 storm in **Figure 79** and **Figure 80**. Shoreline configuration, grain size, and coastal processes at Ocean City are similar to those for the study area; therefore, calibration using this well-documented pre- and post-storm data is considered sound. Additionally, a wave hindcast of the December 1992 storm (Andrews Miller, 1993) was prepared for the Philadelphia District, and water level data for the storm was recorded at the Atlantic City tide gage. Initial calibration simulations produced insufficient erosion when compared to the post-storm profile data. With CERC's assistance, minor modifications were made to the SBEACH program to allow for factors particular to the southern New Jersey coastline. Modifications included allowing the user to specify various controlling simulation parameters such as the empirical transport rate, transport rate coefficient for the slope dependent term, a decay coefficient multiplier, and the maximum profile slope prior to avalanching. These parameters were hardwired into the code previously. Final calibration using the Ocean City profile lines was satisfactorily completed and controlling simulation parameters were determined. Typical calibration plots are provided. Controlling simulation parameters determined from the calibration process are as follows:

$K = 2.5e^{-6}$ m/N
EPS = 0.005 m^2/sec
LAMM = 0.10
BMAX = 40 deg.
D_{50} = 0.24 mm

where K is the empirical transport rate coefficient, EPS is the transport rate coefficient for the slope dependent term, LAMM is the transport rate decay coefficient multiplier, BMAX is the maximum profile slope prior to avalanching, and D_{50} is the effective grain size.

An SBEACH simulation for Hurricane Sandy was performed that compared the estimated volumes lost above MHW from the pre- and post Sandy surveyed profiles versus predicted volume lost from a 20-50-yr storm taken from the existing analysis. It should be noted that not all the profiles collected pre- and post Sandy were evaluated within the project analysis. The profiles from the analysis were: WW02 (cell 1); WW03 (cell 2); WW07 (cell 3); WW10 (cell 4); WW13 (cell 5); and WW15 (cell 6). The pre- and post Sandy profiles that were collected were: WW01; WW02; WW04; WW07; and WW11. It should be noted that the pre- Sandy surveys were done in the previous Spring, 7 months prior to the hurricane and the post surveys were conducted 1 month afterwards. The volume lost between profiles was determined on a per linear foot basis by the average area end method. **Table 46** summarizes these loss rates as cubic yds per linear foot of shoreline:

Hurricane Sandy has been documented to be an event with a return period between 20- and 50-years along the NJ coast. This analysis verifies that the SBEACH model produced reasonable volumetric losses except for the extreme northern part of the project area where volumetric losses from Hurricane Sandy were at or exceeded the predicted losses from a 50-yr event. The total estimated sand lost is comparable to a 50-yr event.

Table 46 Hurricane Sandy vs. SBEACH Volume Loss Table

Profile	Distance btw Profiles (ft)	Hurricane Sandy Loss Rate (cy/lf)	Predicted Loss for a 20-yr Event (cy/lf)	Predicted Loss for a 50-yr Event (cy/lf)
WW01				
	2,137	16.8	N/A	N/A
WW02				
	2,172	26.12	13.94	26.30
WW03				
	2,232	26.12	8.34	16.12
WW04				
	4,103	11.8	8.34	16.12
WW07				
	4,203	11.73	7.75	12.77
WW10				
	2,057	11.73	8.51	13.26
WW11				
	3,935	12.64	8.51	13.26
WW13				
	1,916	12.64	8.63	12.95
WW14				
	1,726	N/A	8.63	12.95
WW15				
TOTALS	24,481			

Hurricane Sandy = 346,736 cy loss from WW01 to WW14 (22,755 ft) = 15.24 cy/ft average loss rate
Predicted 20-yr Event = 183,212 cy loss from WW02 to WW15 (22,344 ft) = 8.20 cy/ft average loss rate
Predicted 50-yr Event = 317,182 cy loss from WW02 to WW15 (22,344 ft) = 14.20 cy/ft average loss rate

Figure 79 Ocean City NJ 1992 SBEACH calibration Plots-138

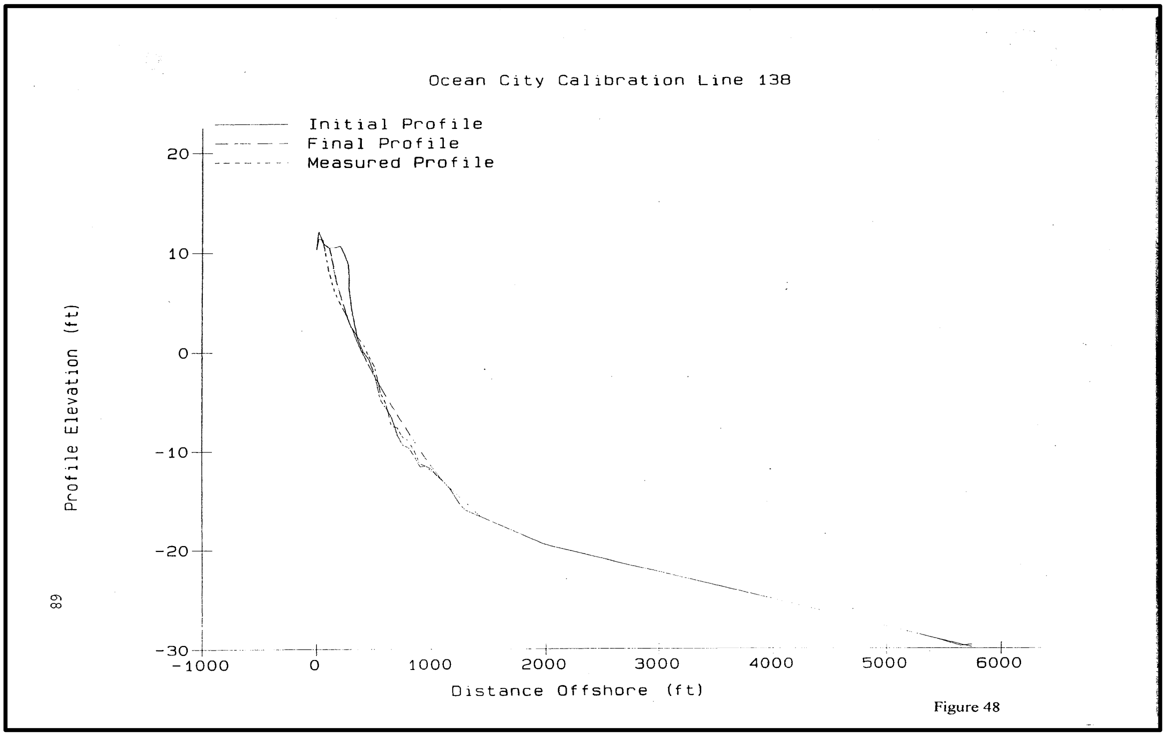
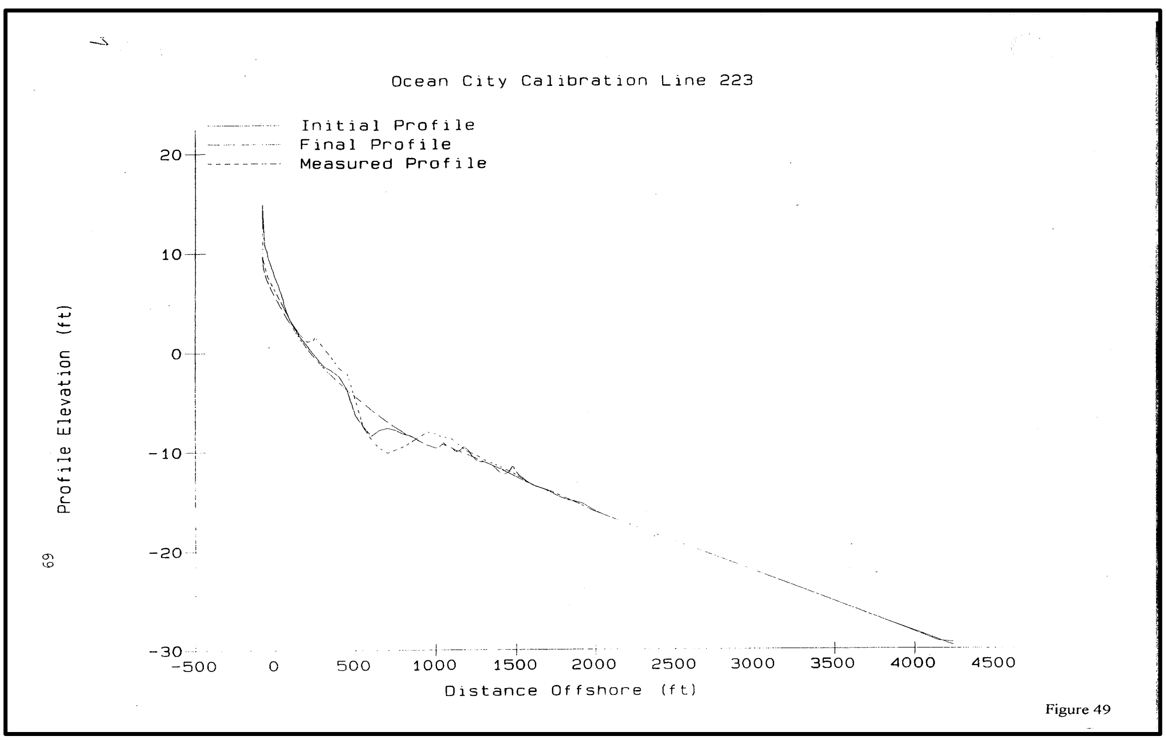


Figure 80 Ocean City, NJ 1992 SBEACH Calibration Plot-223



3.1.6 Development of Input Data for Storm Erosion Modeling

Transects were selected representing the "average" shoreline, structure, backshore configuration, and upland development conditions for various reaches in the study area. For each reach, storm erosion and inundation were computed and reported relative to a designated baseline. Input data was developed for each cell as follows.

3.1.7 Profile Data

The principal physical characterization of each cell is provided by the cross-sectional configuration of its beach and dune system (if present). In this investigation, the October 2003 survey profiles were selected to represent the onshore and near shore areas under the "without" ("W/O") project base year condition. Each profile extended from the seaward end of development to a sufficient distance seaward beyond the depth of closure. The original survey information was sufficient to perform beach/dune response modeling; however, economic damage assessment requires evaluation of damage potential landward of the first row of development. Therefore, the profiles were artificially extended in a landward direction several blocks. These extensions were based on general characteristics of the island's topography as determined by field investigations, USGS topographic sheets, and recent structure inventory surveys. Cross sections of representative beach profile lines can be seen in for each cell. **Figure 81** through **Figure 87.** The cell limits are listed in **Table 47** and shown in **Figure 88**.

Table 47 Profiles Used in Hydraulic Analysis

Cell	From	To	Cell Width feet	Representative Profile	Community
1	2nd St.	15th St.	3,549	WW 2	North Wildwood
2	15th St.	26th St.	2,959	WW 3	North Wildwood
3	26th St.	Cresse St.	6,965	WW 7	Wildwood
4	Cresse St.	Rambler Rd.	4,585	WW 10	Wildwood Crest
5	Rambler Rd.	Memphis Ave.	5,835	WW 13	Wildwood Crest
6	Memphis Ave.	Madison Ave.	1,090	WW 15	Lower Township
7	Madison Ave.	Cape May Inlet	6,267	WW 17	Coast Guard Base

Figure 81 Cell 1 Without Project Profile

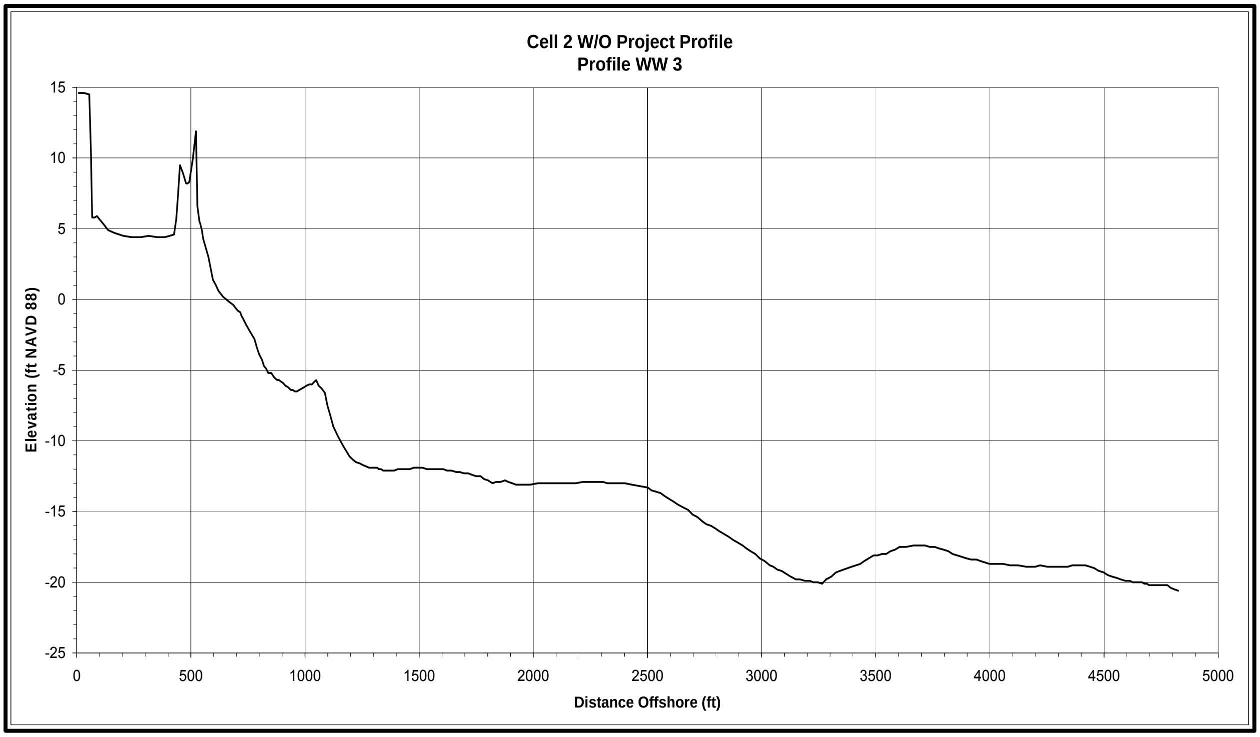


Figure 82 Cell 2 Without Project Profile

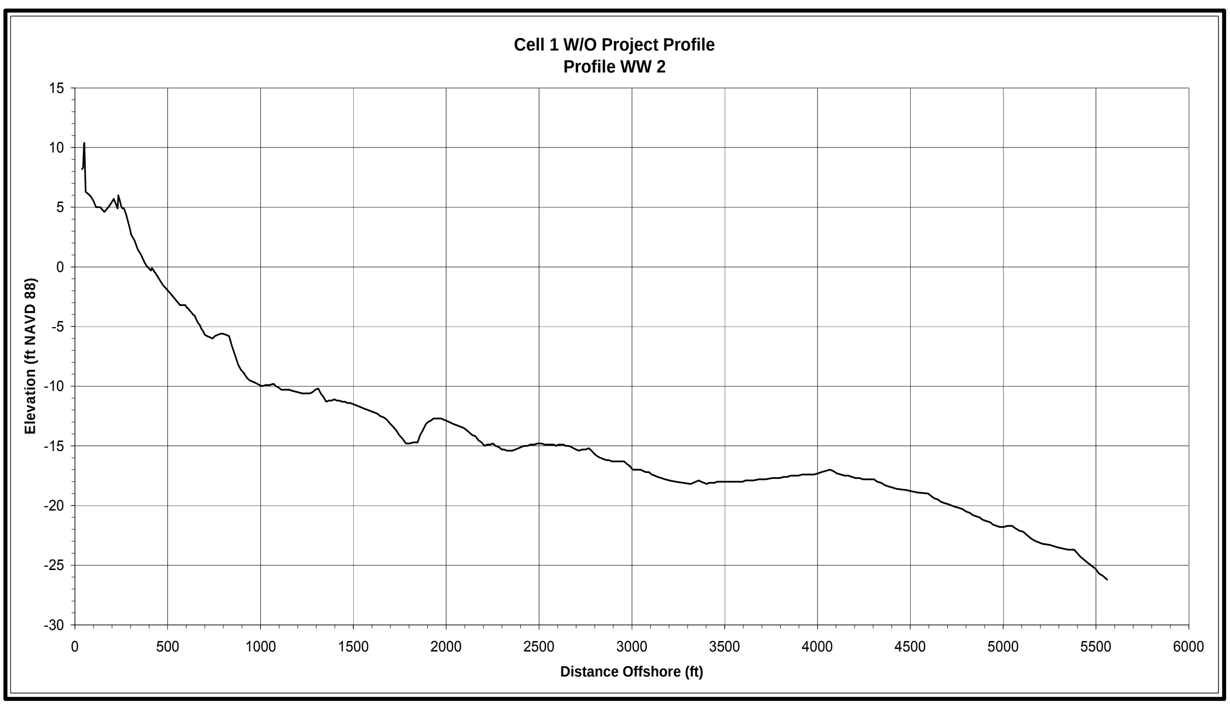


Figure 83 Cell 3 Without Project Profile

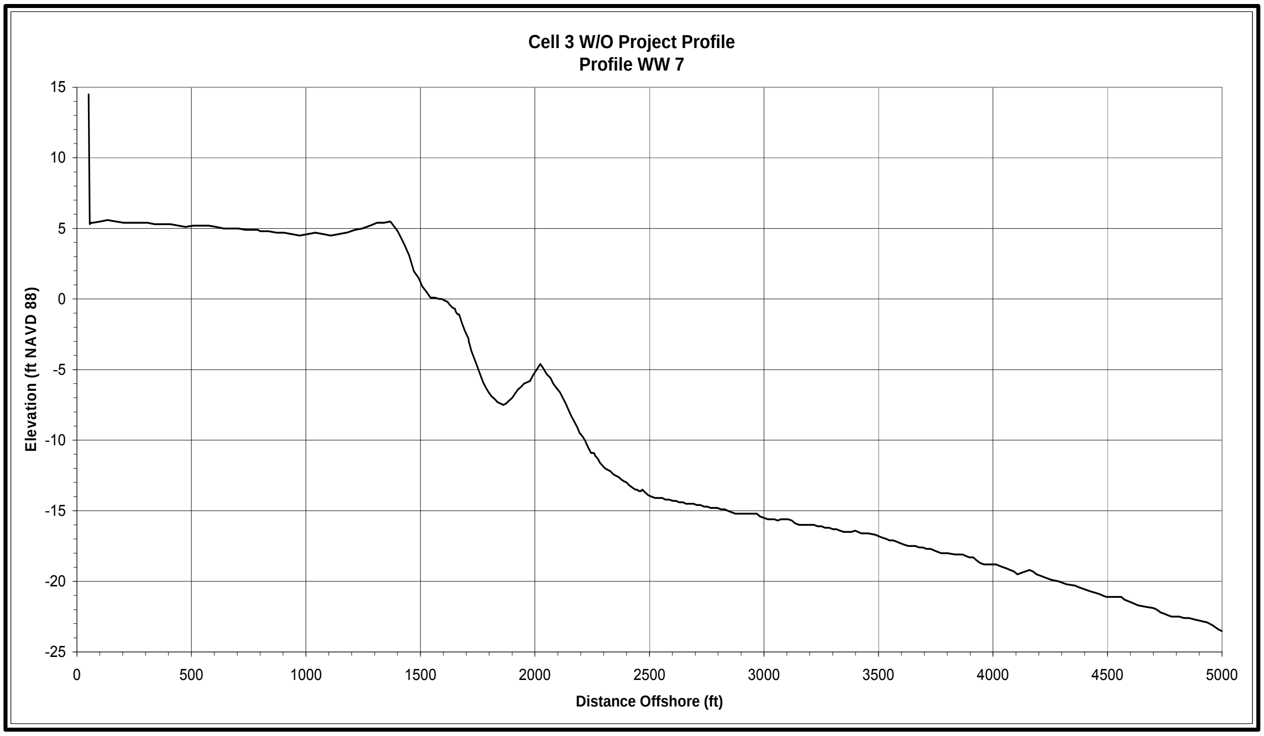


Figure 84 Cell 4 Without Project Profile

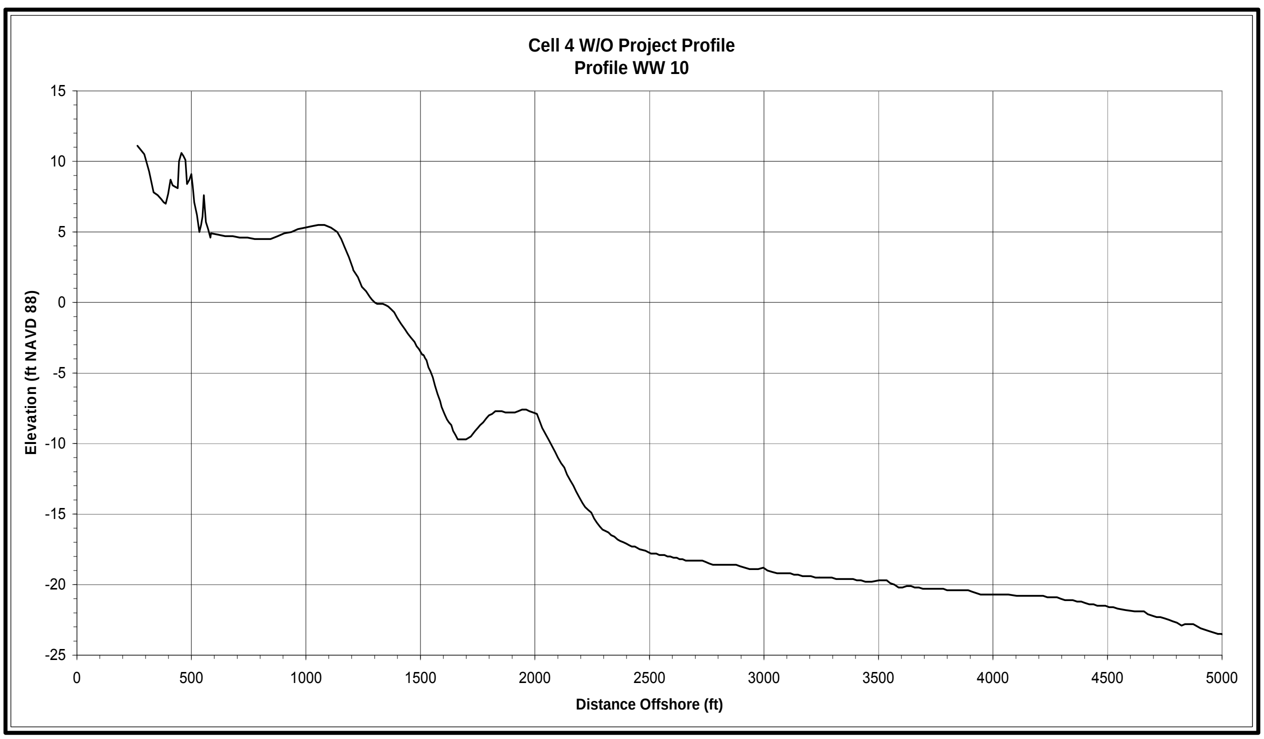


Figure 85 Cell 5 Without Project Profile

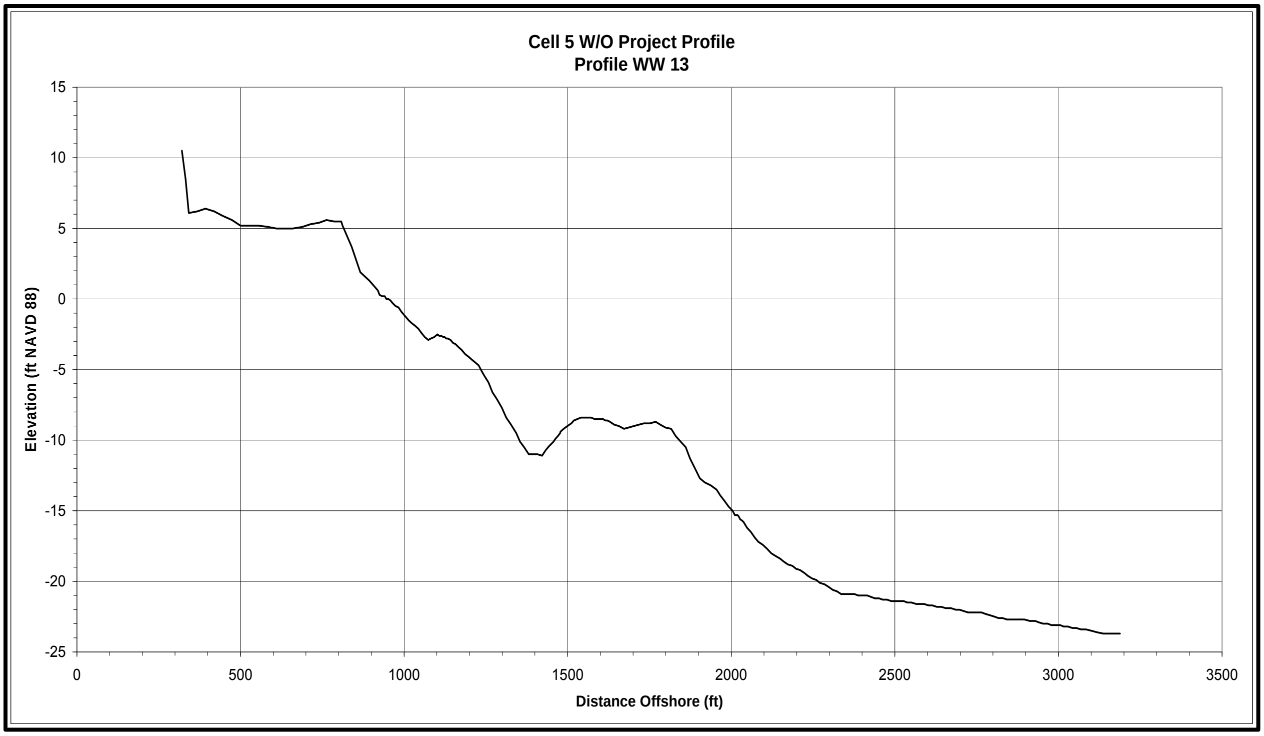


Figure 86 Cell 6 Without Project Profile

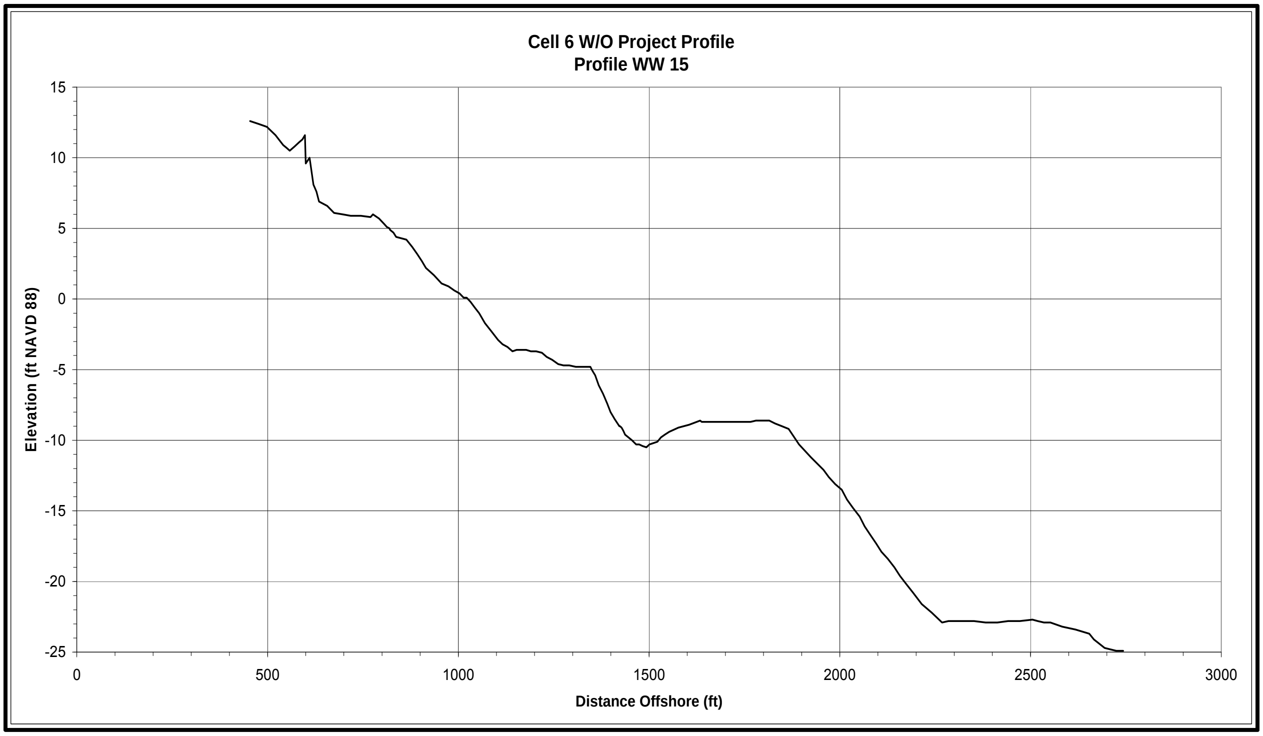


Figure 87 Cell 7 Without Project Profile

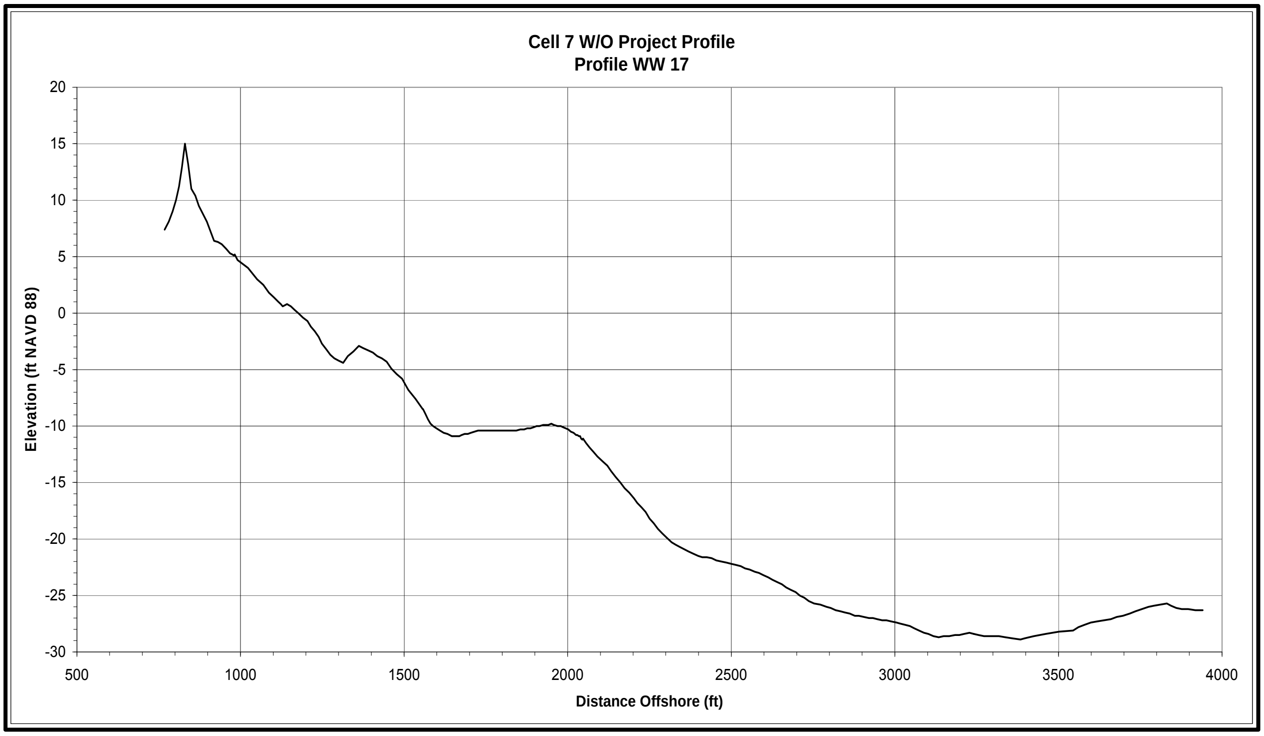
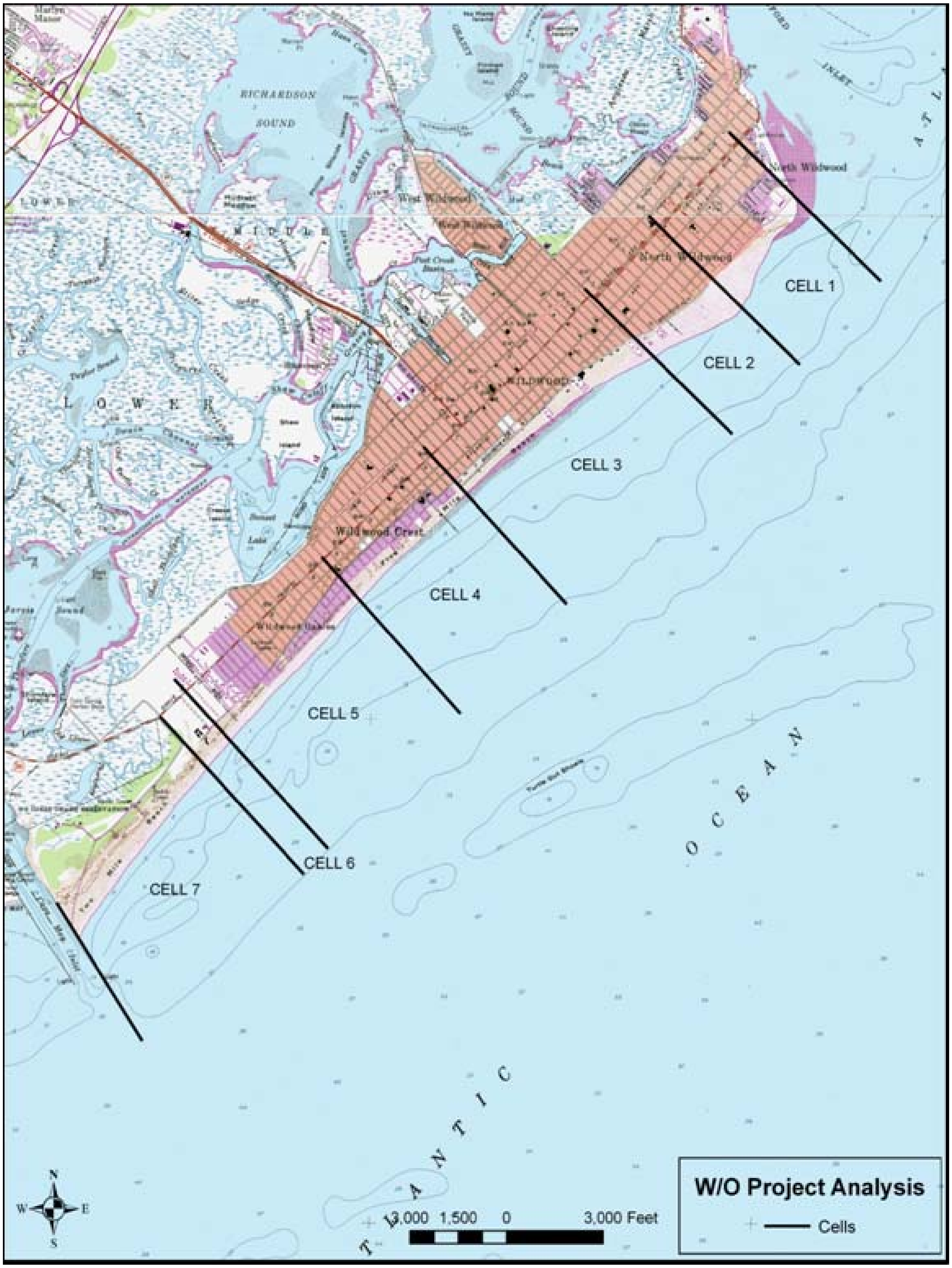


Figure 88 Cells 1-7 Layout



3.1.8 Model Parameters

Various model parameters required to run SBEACH are input into the reach and storm configuration files. The reach configuration parameters include grid data, profile characteristics, beach data (including grain size), sediment transport parameters, and seawall or bulkhead data. The storm configuration file includes information on wave angle, height and period, water elevation, wind speed and angle and other storm information.

In the reach configuration file, the location and failure criteria for a seawall or revetment can be entered. Unlike many other storm erosion models, SBEACH can account for the presence of a vertical structure such as a seawall or bulkhead. Cell 1 (North Wildwood) is fronted with an uniform timber bulkhead, and Cell 5 (Wildwood Crest) is fronted with various types of bulkheads. These structures were accounted for by inputting their locations along the profile along with appropriate failure criteria by waves, water levels, and profile scour.

3.1.9 Water Elevation

The water level is the most important or first-order forcing parameter controlling storm-induced beach profile change, normally exerting greater control over profile change during storms than either waves or wind. Water level consists of contributions from the tide, storm surge, wave- and wind-induced setup, and wave run-up; the latter three are computed within SBEACH. Input data in this case is tide and storm surge data. The combined time series of tide and surge is referred to as the hydrograph of total water level. The shape of the hydrograph is characterized by its duration (time when erosive wave conditions and higher than normal water elevation occur) and by its peak elevation were developed for the study area as part of the wave hindcast conducted by OCTI. The Gumbel distribution (Fisher-Tippett Type I) was used.

3.1.10 Wave Height, Period, and Angle

Elevated water levels accompanying storms allow waves to attack portions of the profile that are out of equilibrium with wave action because the area of the beach is not normally inundated. Wave height and period are combined in an empirical equation within SBEACH to determine if the beach will erode or accrete for a time step. In beach erosion modeling, a storm is defined neither by the water level, wave height or period alone, but by the combination of these parameters that produces offshore transport.

The SBEACH Version 3.2 allows for the input of random wave data, that is, waves with variable height, period, and direction or angle. Storm wave data for the seven representative events used in this analysis were generated in the OCTI wave hindcast described previously in the Existing Conditions Section *2.7 Coastal Processes*. Storm wave heights, as well as water levels (**Figure 89** to **Figure 95**), were developed by rescaling hindcasted actual storm time series.

3.1.11 Storm Parameters

A variety of data sources were used to characterize the storms used in this analysis. The ten highest ocean stages recorded at the Atlantic City tide gage between 1912 and 2006 were listed in the Existing Conditions Section *2.7 Coastal Processes.* For each stage, additional information on the storm type causing the water surface elevation and if possible the actual storm surge hydrograph were obtained. The duration of hurricanes along the New Jersey shore is generally less than 24 hours, while the average duration of northeasters is on the order of 40 hours, and in some cases (e.g., 5-7 March 1962) considerably longer. Though actual storm surge hydrographs are not available for all storm events, it was assumed that all hurricanes exhibit similar characteristics to one another. Northeasters demonstrate similar features; however, durations may vary significantly from storm to storm.

3.1.12 Storm Erosion Simulations

The SBEACH model was applied to predict storm-induced erosion for all cells within the study area. All representative storm events were run against the pre-storm profiles for the base year conditions. Model output for each simulation includes a post-storm profile plot and plots showing volume change and maximum wave and water level conditions. Simulation results from each particular combination of profile geometry and storm characteristics yield predicted profile retreat at three selected elevation contours. In this analysis, profile retreat for a given storm event was measured with respect to the proposed project baseline. Typical plots of input pre-storm profiles and the resultant post-storm (50-yr event) profiles based on SBEACH predicted retreat are provided in 96**Figure 96** through **Figure 102**.

Figure 89 Storm Conditions 5 year Event

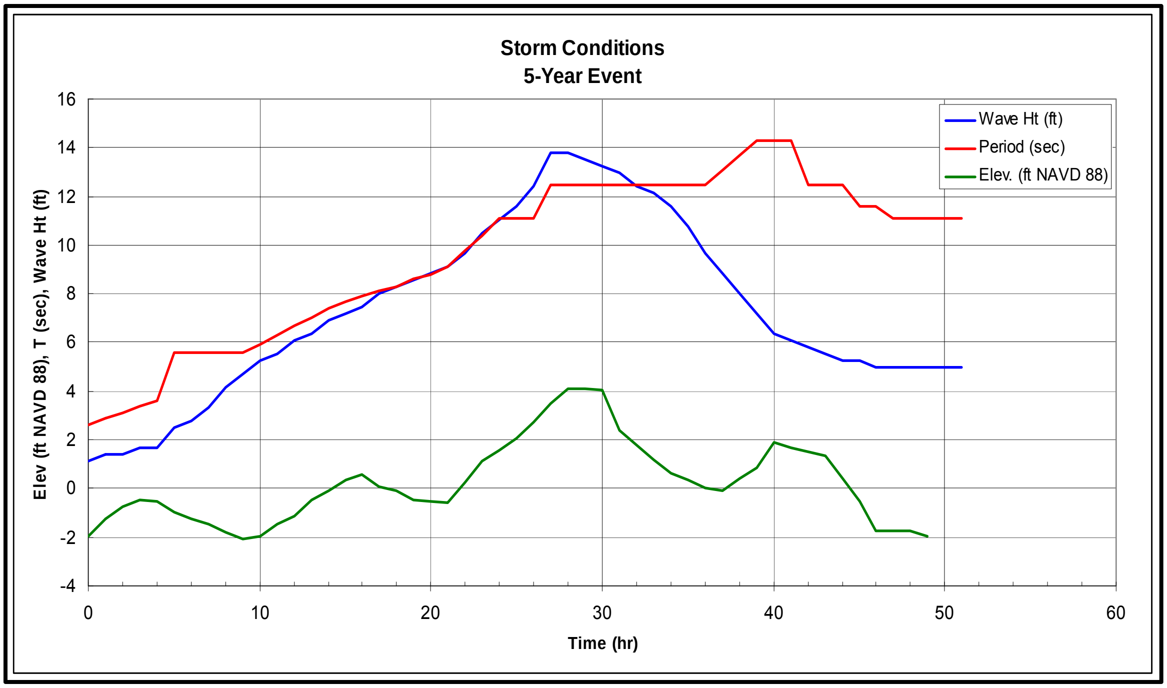


Figure 90 Storm Conditions 10 Year Event

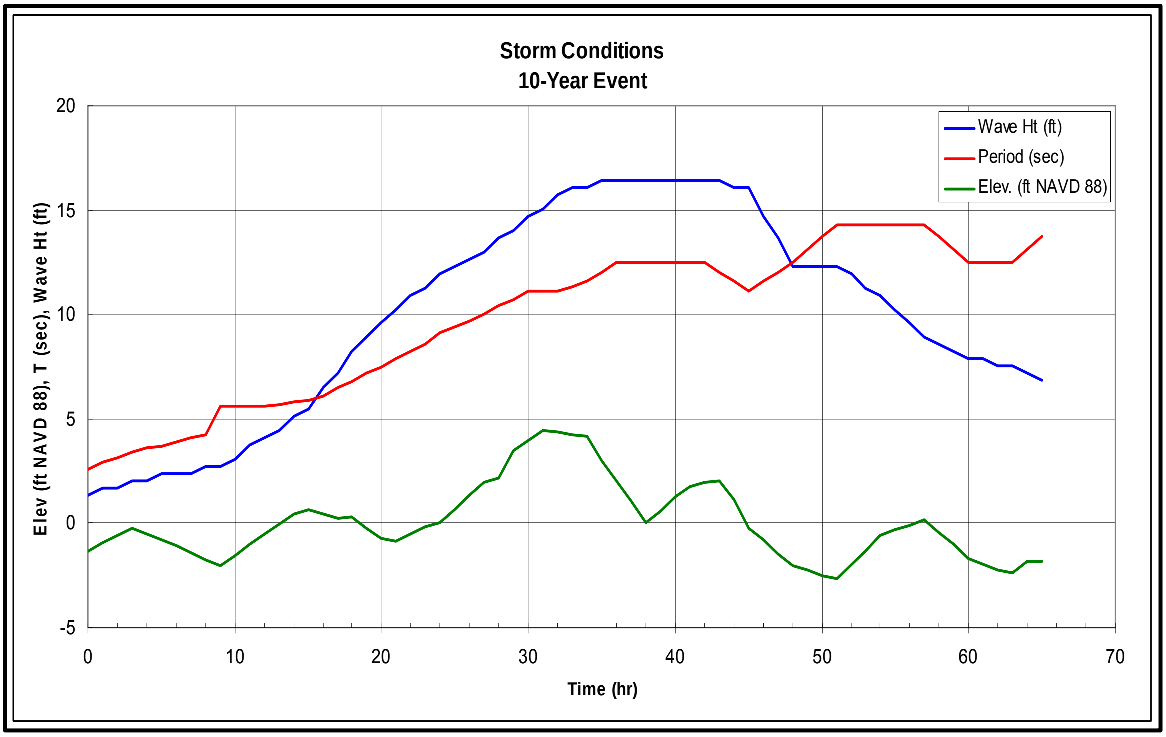


Figure 91 Storm Conditions 20 Year Event

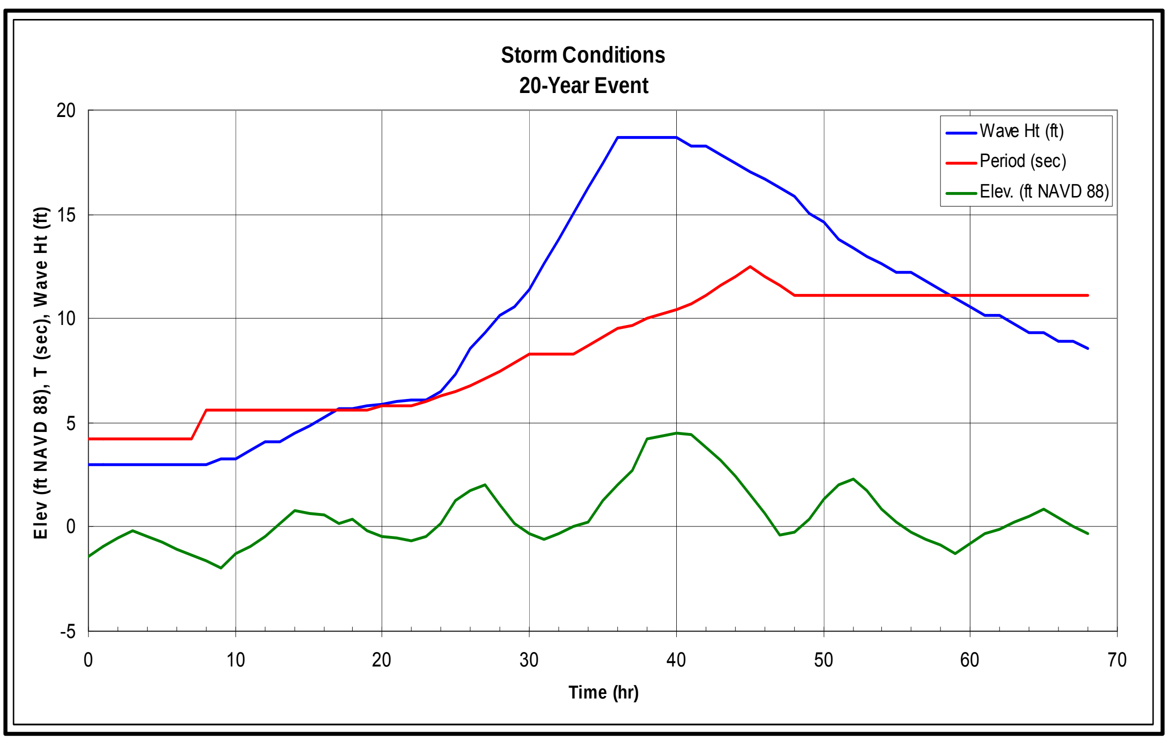


Figure 92 Storm Conditions 50 Year Event

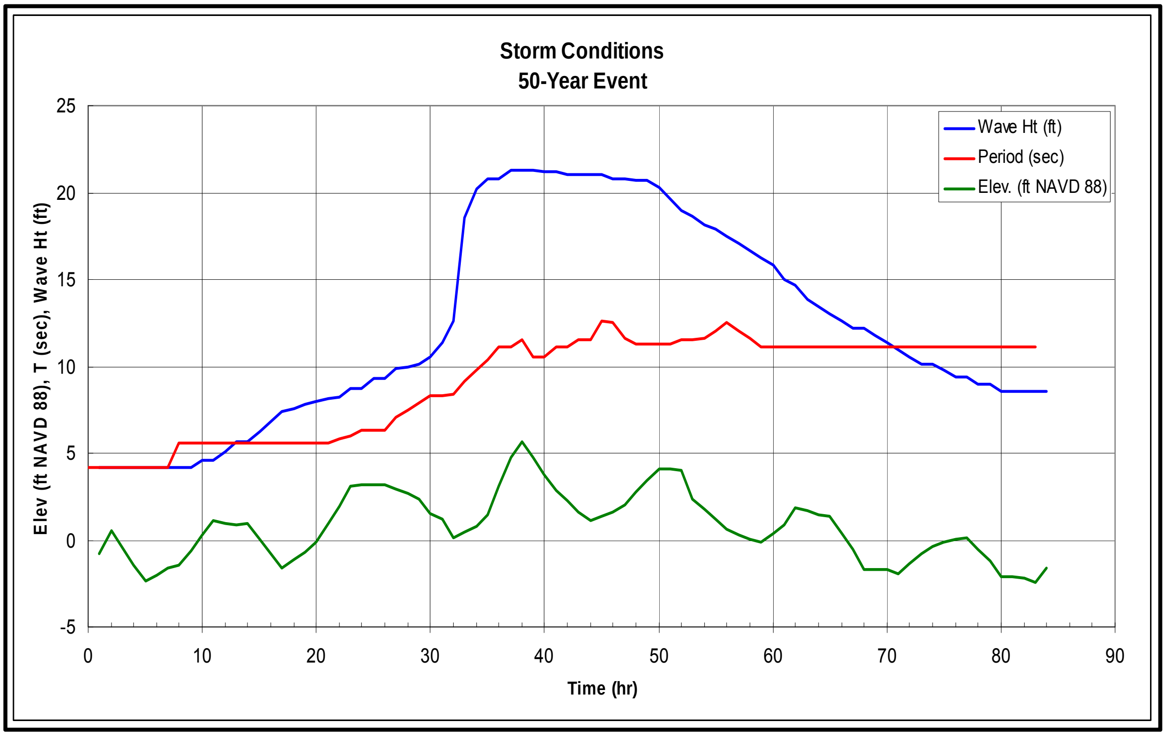


Figure 93 Storm Conditions 100 Year Event

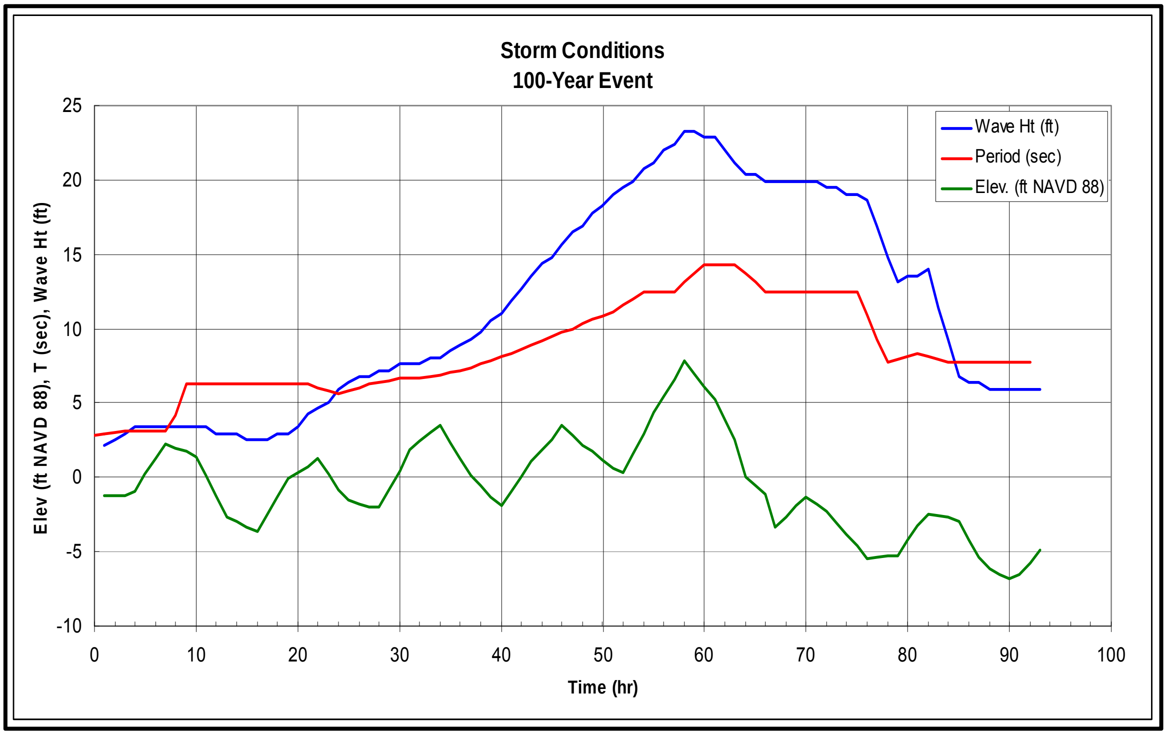


Figure 94 Storm Conditions 200 Year Event

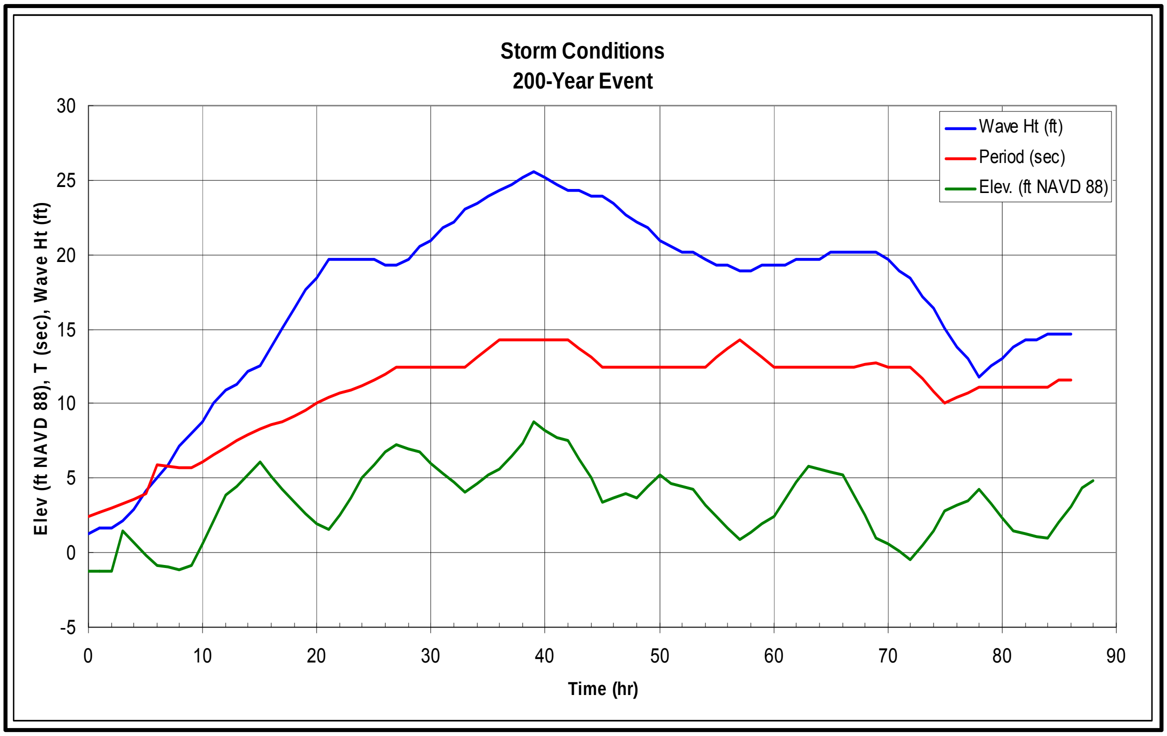


Figure 95 Storm Conditions 500 Year Event

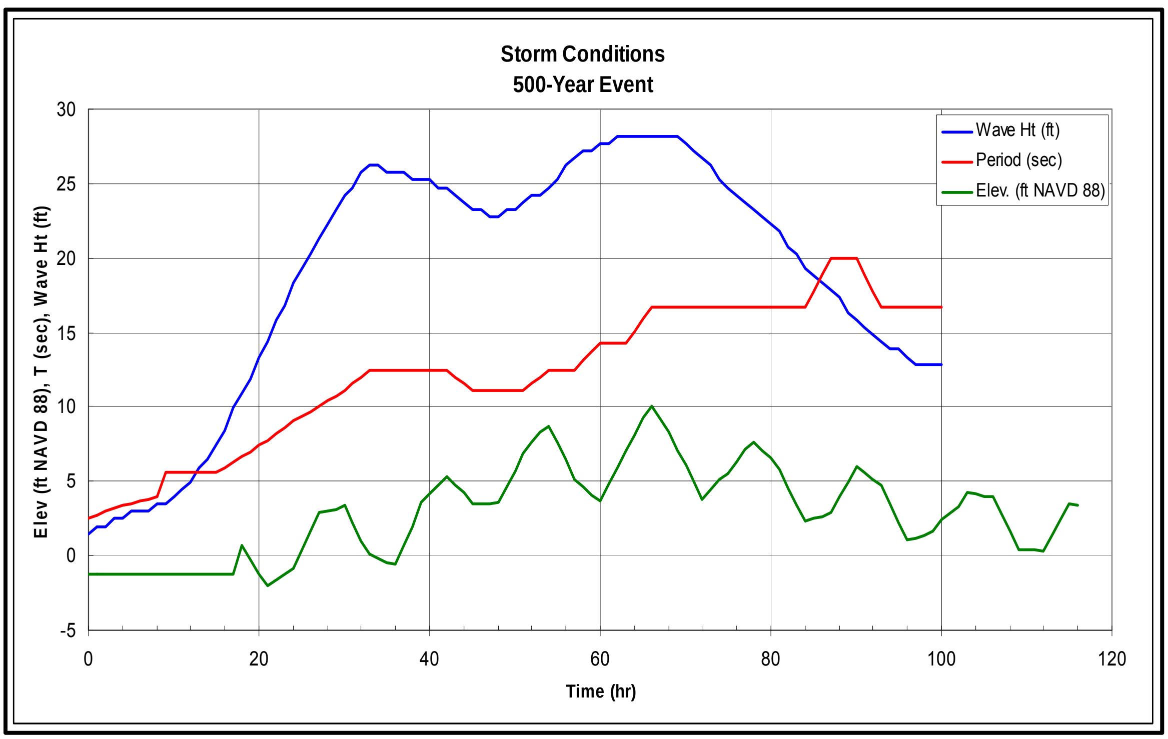


Figure 96 through **Figure 102** contain the results of the without project beach profile change from the fifty year event.

Figure 96 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 1

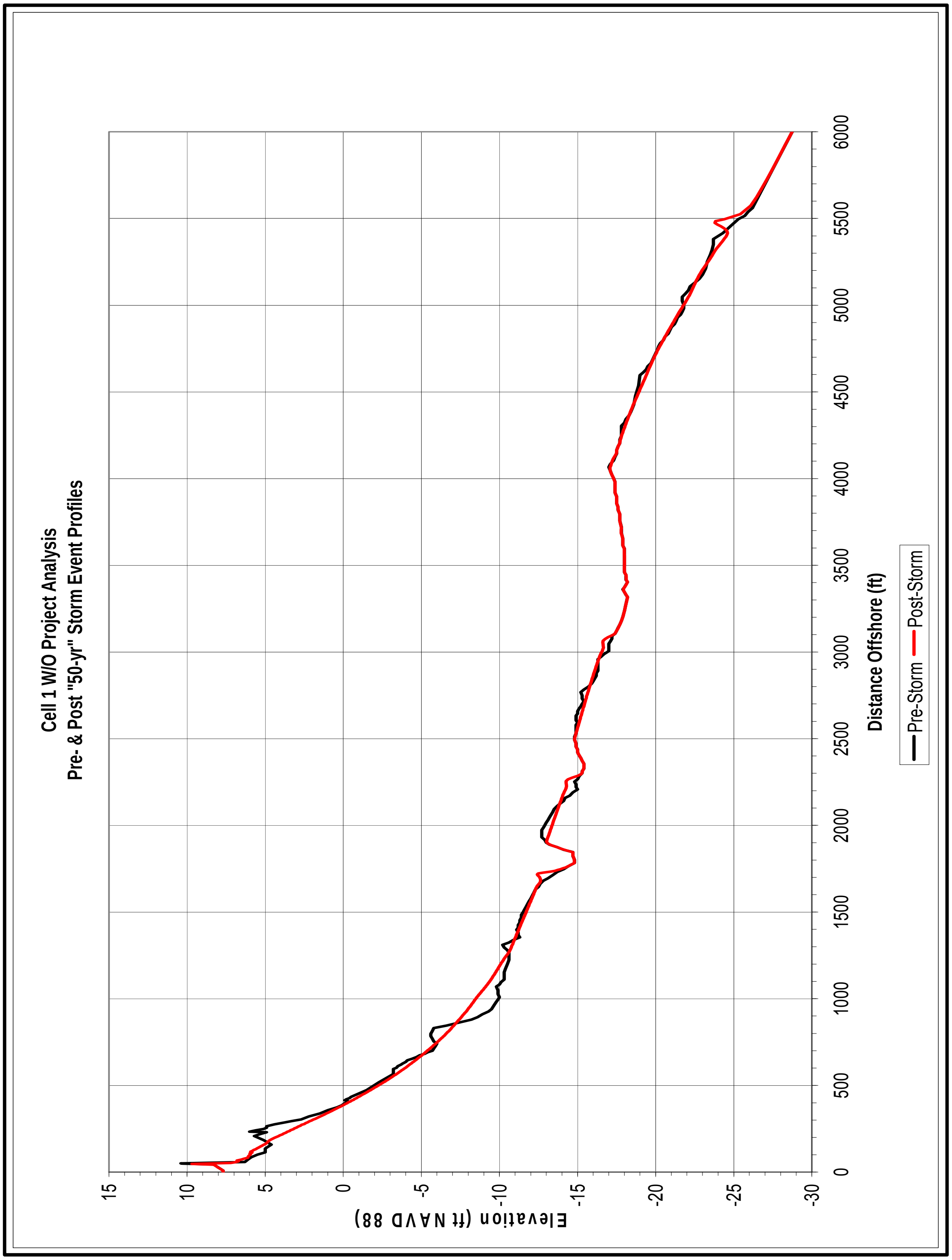


Figure 97 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 2

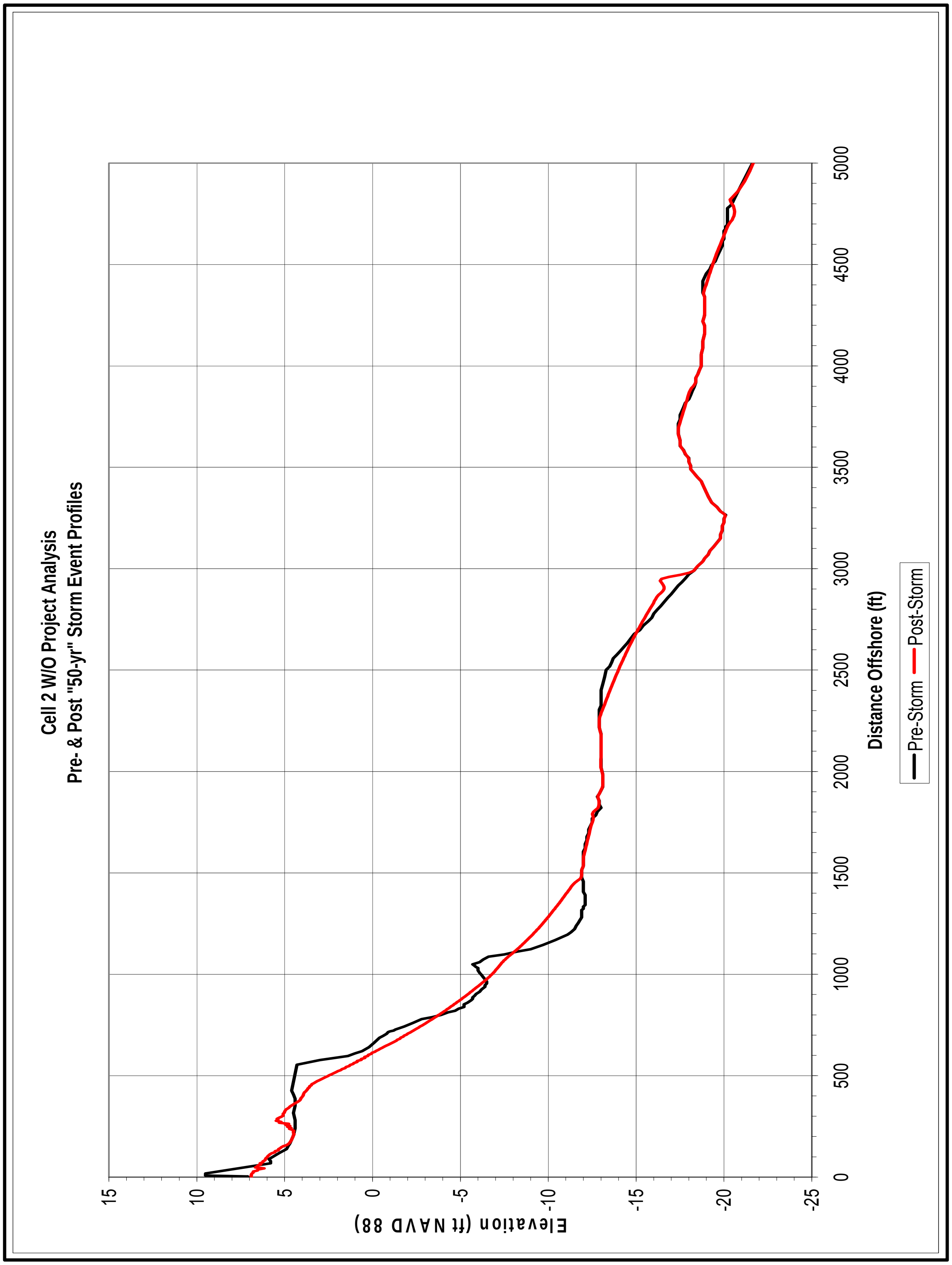


Figure 98 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 3

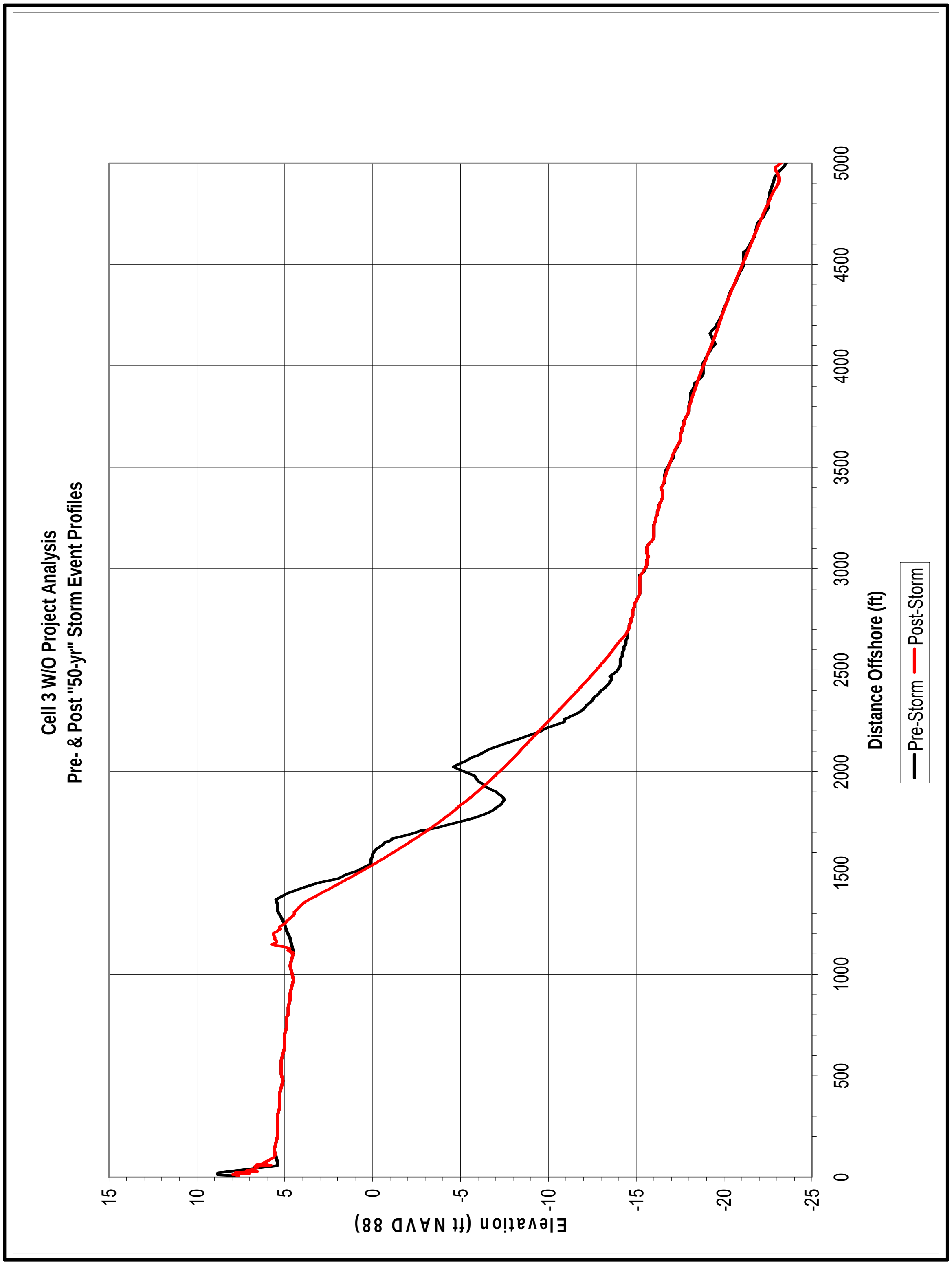


Figure 99 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 4

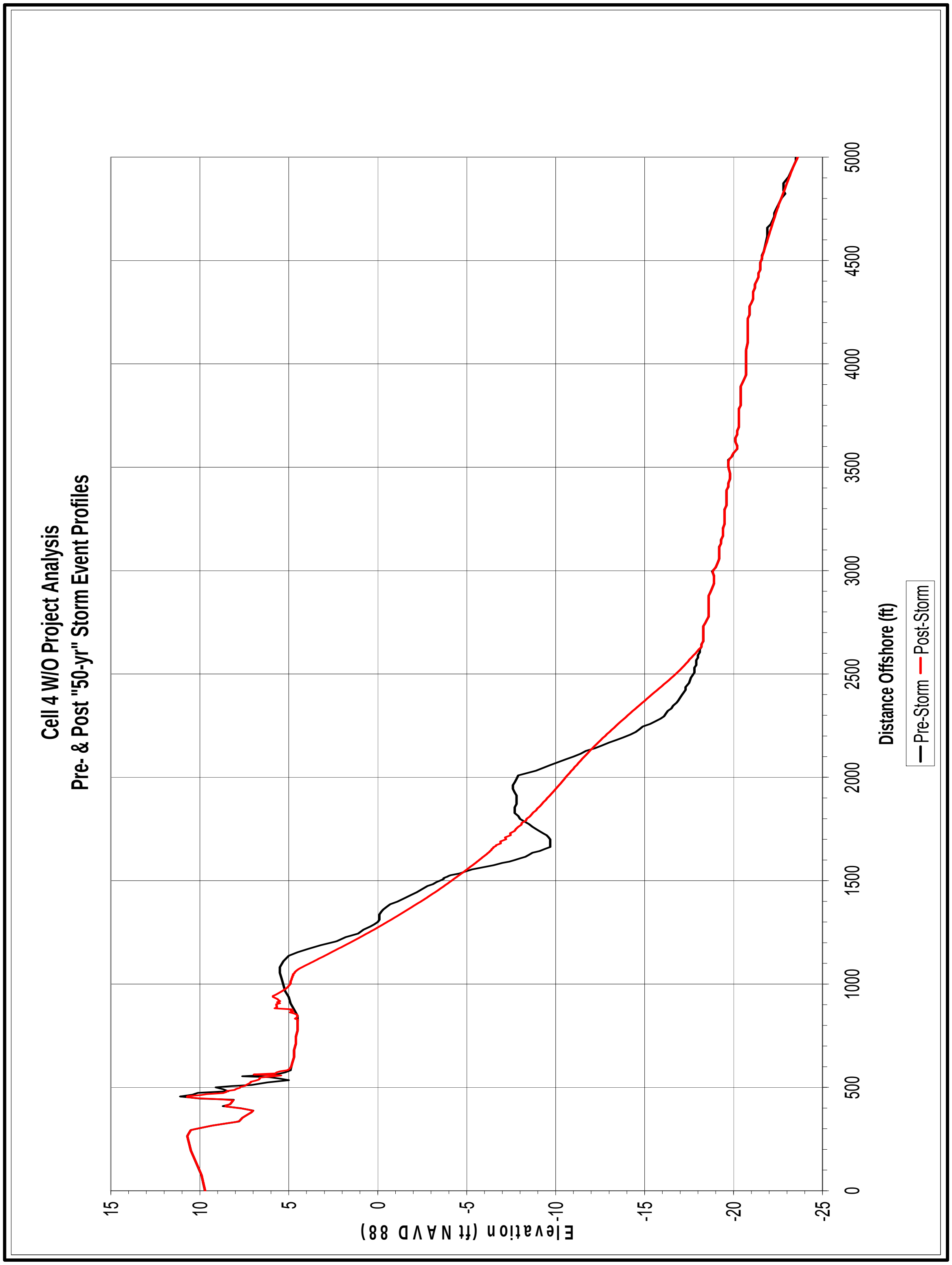


Figure 100 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 5

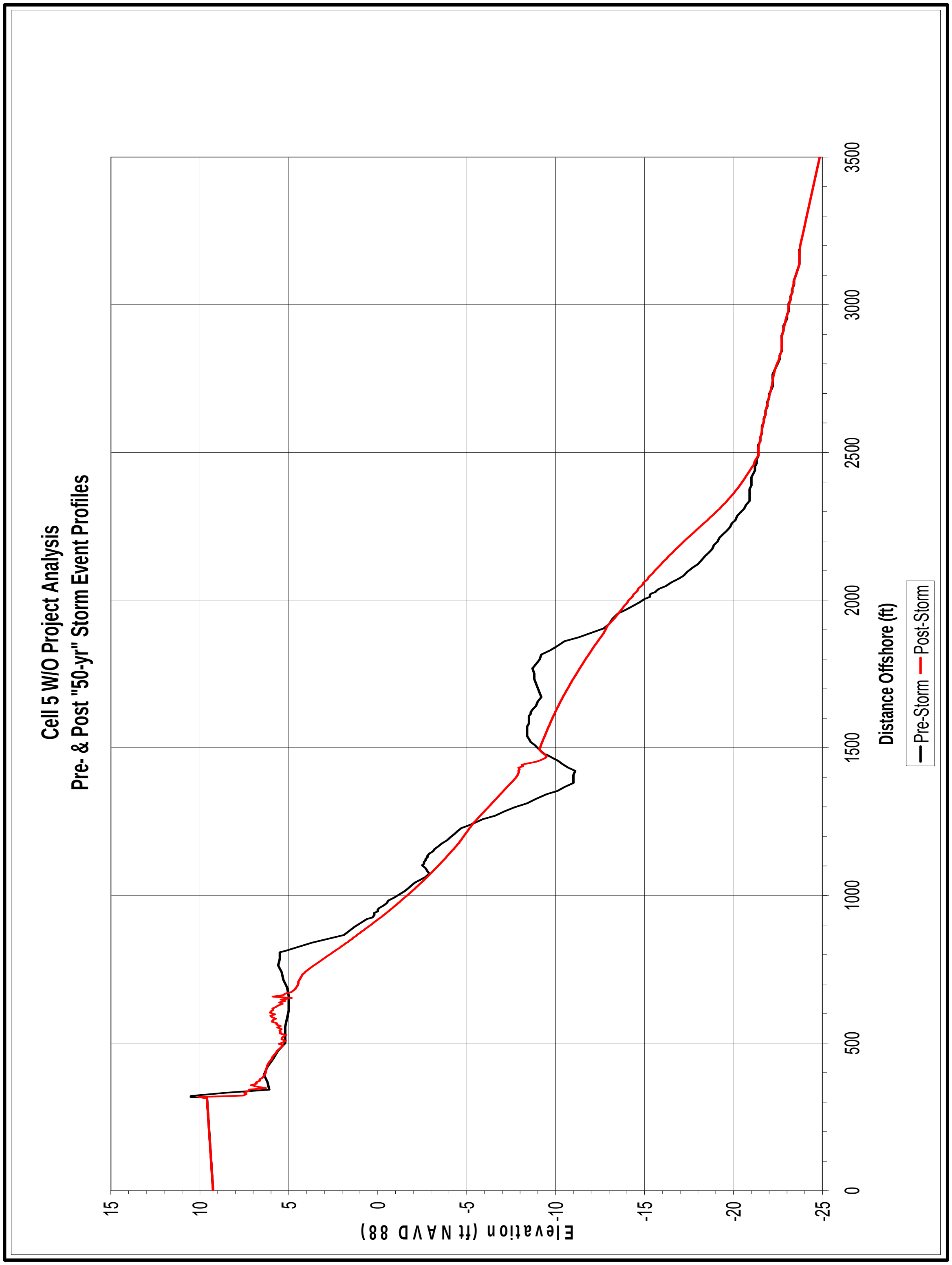


Figure 101 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 6

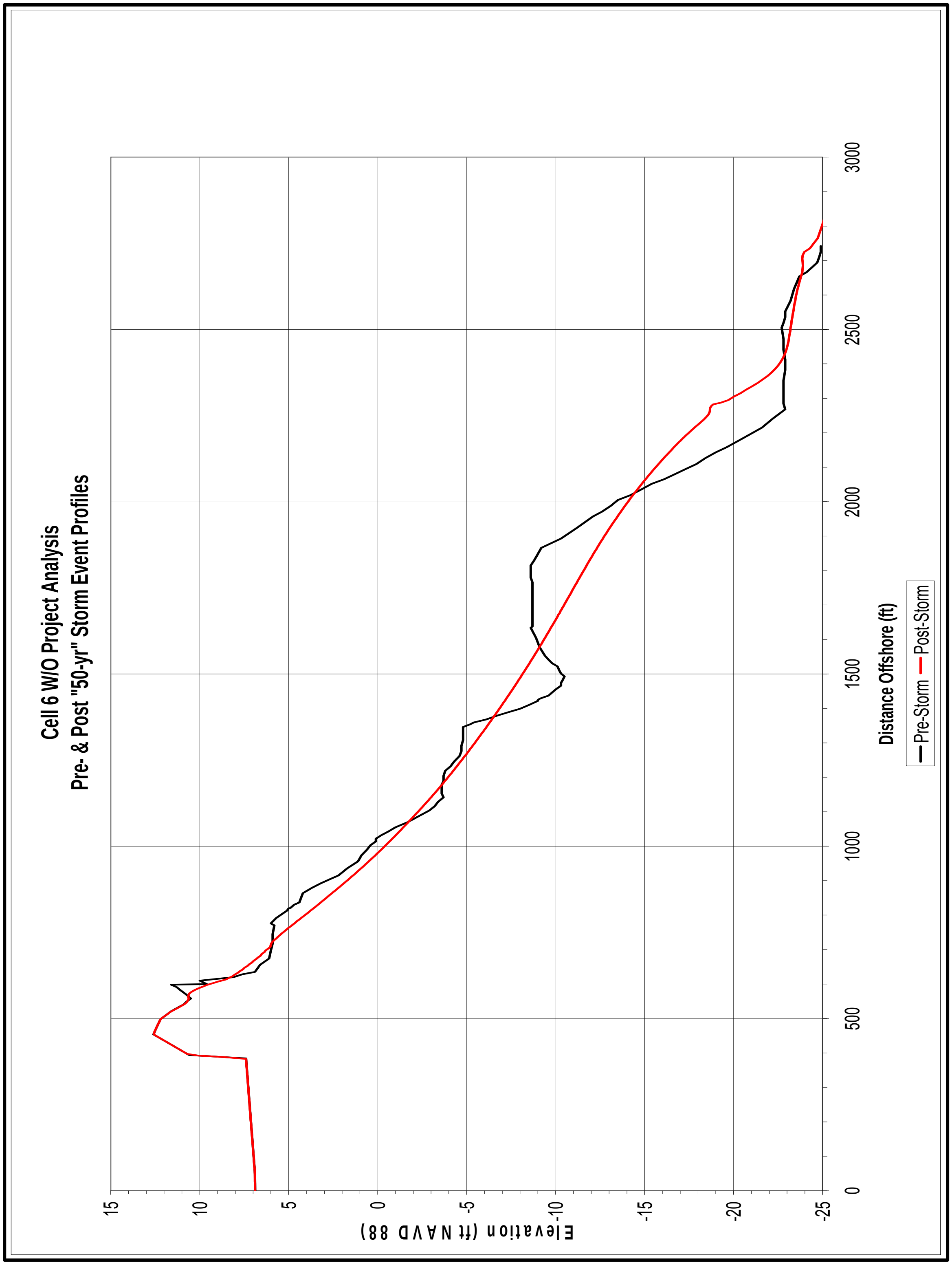
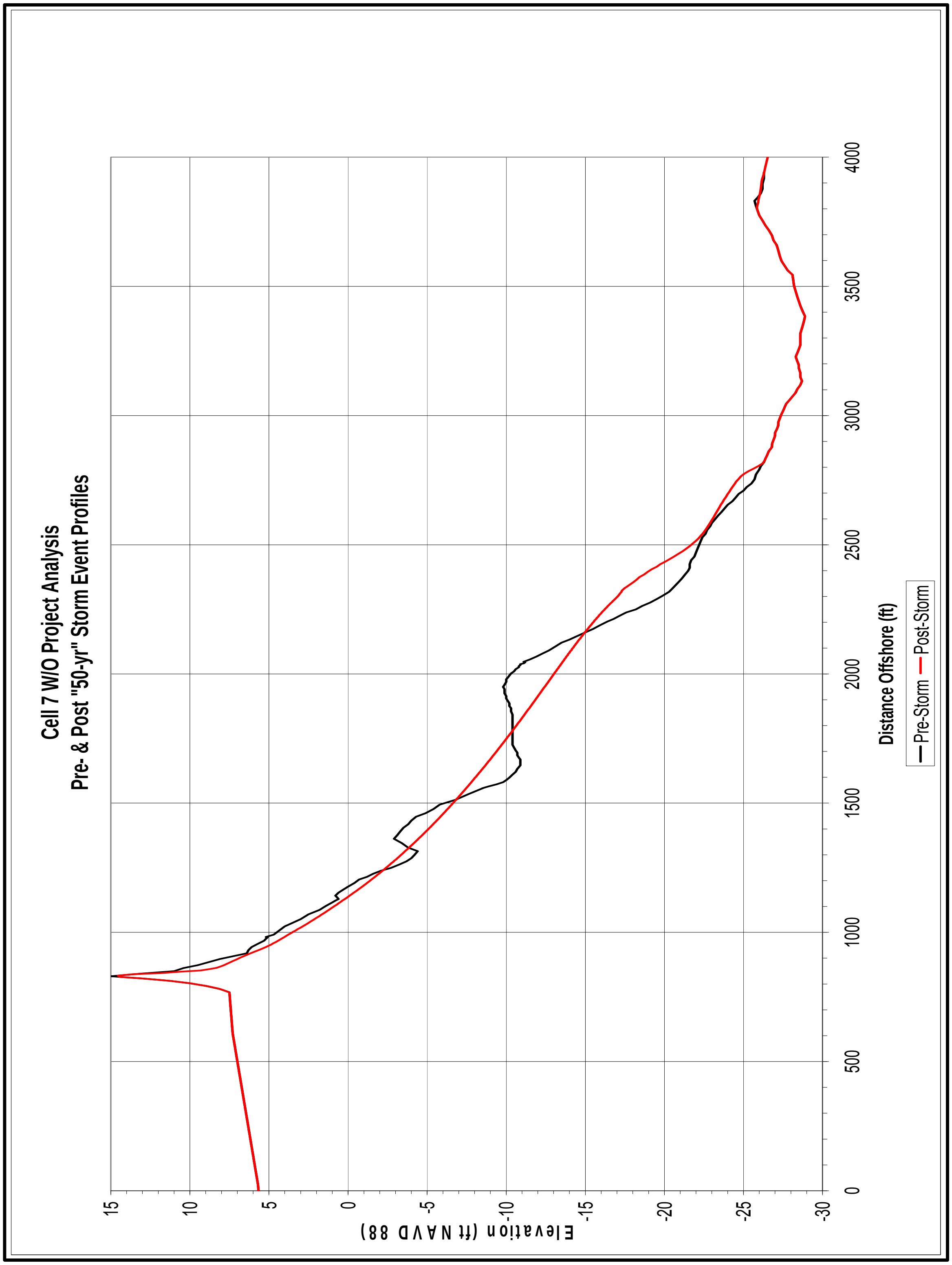


Figure 102 Pre and Post “50 yr” Storm Event Beach Profiles for Cell 7



The shorelines in Cell 1 and Cell 5 are structured with a bulkhead. In order for storm erosion to affect the community, the bulkhead must fail. SBEACH simulates failure through a number of mechanisms including storm-induced scour at the toe of the structure, direct wave attack, or inundation. There was insufficient data regarding the existing bulkheads in Cells 1 and 5, namely any construction and/or design details that specified such things as depth to toe. In lieu of having this data, engineering judgments of the failure criteria were used in the SBEACH analysis. The judgements were based upon the experience of conducting SBEACH analysis along the New Jersey coast along with field inspections of the bulkheads. The appropriate failure criteria were input to the SBEACH configuration file for each profile. Model simulations typically resulted in failure of the seawall by wave attack or toe scour at either the 100 or 200-year storms.

3.1.13 Analysis of Erosion Model Results

Two approaches can be taken to estimate storm-induced beach erosion: the "design-storm" and the "storm-ensemble" approach. For the storm-ensemble approach, erosion rates are calculated from a large number of historical storms and then ranked statistically to yield an erosion-frequency curve. In the design-storm approach, the modeled storm is either a hypothetical or historical event that produces a specific storm surge hydrograph and wave condition of the desired frequency. The design-storm approach was used in the storm erosion and inundation analyses for this study area.

Results of the without project storm erosion analysis are **Table 48,** in feet. Predicted shoreline erosion positions are reported relative to the design baseline. The baseline initially was placed at the seaward edge of boardwalks, bulkheads, and through the centerline of existing dunes, depending on the condition represented in each cell. In order to satisfy constraints in the economic analyses, an economic baseline was established that was 1350' seaward of the design baseline. This was done in order to ensure all structures were landward of the baseline. The pier mounted structures in North Wildwood and Wildwood governed the 1350 foot offset. These erosion values are used as input to the economic model that ultimately computes storm damages associated with storm-related erosion.

Table 48 Post Storm Erosion Distances

Storm Event	Cell 1 (ft.)	Cell 2 (ft.)	Cell 3 (ft.)	Cell 4 (ft.)	Cell 5 (ft.)	Cell 6 (ft.)	Cell 7 (ft.)
5-yr	270	310	1265	1025	695	825	1240
10-yr	170	250	1100	865	635	775	1135
20-yr	115	180	935	695	575	705	1040
50-yr	65	85	685	475	480	620	915
100-yr	5	20	475	305	75	520	815
200-yr	-100	-35	275	150	-50	380	665
500-yr	-185	-90	-25	-65	-125	205	425

3.1.14 Storm Inundation and Wave Attack Evaluation

The project area is subject to inundation from several sources including ocean waves overtopping the beach and/or protective structures as well as flooding from the back bay. The inundation can be analyzed as two separate categories: 1) Static flooding due to super elevation of the water surfaces surrounding the project area and 2) wave attack, the direct impact of waves and high energy run-up on coastal structures.

The model SBEACH calculates near shore wave characteristics, wave run-up, wave setup and elevation of the beach profile for each hindcasted event. The wave run-up and wave setup values are used, along with the eroded beach elevations, to determine inland water surface profiles, inland wave characteristics, and volumes of eroded material which in turn are used to assess economic damages. SBEACH output parameters are used to define the maximum water depth, run-up, and minimum dune crest elevation.

3.1.15 Inundation/Wave Attack Methodology

The inland wave attack and inundation methodology used in this project is based upon FEMA guidelines for coastal flooding analysis. The procedure divides possible storm conditions into four cases as follows:

- *Case I*: Entire storm-generated profile is inundated. For this case, the maximum water elevation including wave setup is maintained to the crest of the eroded dune. Landward of this point, the wave setup decays at 1 ft vertical drop per 1000 ft of horizontal distance until the bay flood level is met. A wave height of 0.78 times the water depth at the crest of the dune is maintained landward of the dune.

- *Case II*: The top of the dune is above the maximum water level, with wave run-up greater than (3 ft above the dune crest elevation. In this case, the run-up depth at the crest is limited to 3 ft, the water depth decays to 2 ft over first 50 ft landward of the crest, and stays at 2 ft until intersecting the bay water level. The wave height is limited to 0.78 times the water depth.

- *Case III* :The top of the dune is above the maximum water level, with wave run-up exceeding but still less than 3 ft above the dune crest elevation. In this case, the depth at the dune crest is the calculated run-up depth, which decays to 1 ft over the first 50 ft landward of the crest, and stays at 1 ft until it intersects the bay water level. The wave height is limited to 0.78 times the water depth.

- *Case IV*: The wave run-up does not overtop the dune. In this case, the wave height seaward of the dune is limited to 0.78 times the water depth.

The SBEACH results for the inundation analysis were used to determine for each frequency storm for each profile which one of the 4 cases was applicable. The case that was most applicable for each given simulation dictated the inundation profile used.

3.1.16 Back Bay Flooding

The project area is subject to flooding from back bay and adjacent waterways as well as direct ocean inundation. This elevated stage flooding is referred to as back bay stillwater flooding and is accounted for by subtracting the residual damages due to back bay flooding from the damages caused by ocean front inundation.

In order to quantify back bay water levels, the numerical model DYNLET (Amein and Cialone, 1994) was used. DYNLET is based on full one-dimensional shallow water equations employing an implicit finite-difference technique. The model simulates one-dimensional fluid flow through a tidal inlet and its tributaries. Flow conditions can be predicted in channels with varied cross section geometry and friction factors. Water surface elevation and average velocity can be computed at selected locations and times both across and along channels.

The model conducted for this study included Corson, Townsends, and Hereford Inlets. A total of 84 cross-sections or nodes were input to describe the system. Depth soundings for each cross section were interpolated from the National Oceanic Atmospheric Administration (NOAA) Nautical Chart for Little Egg Harbor to Cape May. The model was calibrated to predicted tides for Corson Inlet to the north and various other locations within the system including Hereford Inlet. Predicted stages for 5 through 500-year storms were then used to drive the model. Model results indicated differences on the order of 0.3 ft. between ocean and back bay stages for each storm. Therefore, it is assumed that water levels along the back bay shorelines are not damped and are in-phase with the ocean water levels and the bay stage-frequency curve used in the inland inundation analysis is the same as the ocean stage-frequency curve.

3.1.17 Other Parameters

The output from the SBEACH modeling at each of the profile lines and 8 storm events was used to compute inland wave attack and inundation for each case. Inland island ground elevations for each shoreline cell were taken from quad sheets and recent surveys. Bay elevations were used as specified above. The bulkheads located in cells 1 and 5 reduced the direct impact from wave attack and erosion damage. For all but the most extreme events, failure of the protective structures is required for significant wave attack to occur. However, extreme waves on certain profiles can plunge over the fixed barriers and attack the adjacent structures causing significant damage. The recurrence interval in which the protective structure will fail was determined previously in conjunction with the erosion analysis.

3.1.18 Without Project Inundation and Wave Attack Results

The *Engineering Technical Appendix Section 2* and *Economics Technical Appendix* contain detailed results of the inundation and wave attack analyses for base and future conditions. Inundation curves and wave attack limits are provided in modified COSTDAM model format for each of the cells and respective storm conditions.

3.2 Economic Analysis

The study area was delineated based on physical setting, hydraulic characteristics, and economic factors. The oceanfront communities of *The Wildwoods* were analyzed by community from the representative beach profiles. Overall, the study area is less than 6 miles in length. The U.S. Coast Guard base is buffered by hundreds of feet of beach and the surrounding vegetation of the Cape May National Wildlife Refuge. It was, therefore, not further considered in the damage analysis. Damages and benefits in subsequent project formulation tables prior to determination of the tentatively selected plan (TSP) combination are based on a June 2007 price level for comparison to costs which were provided in a June 2007 price level.

3.2.1 Recent Storms

The shoreline has been characterized by severe erosion near Hereford Inlet in North Wildwood in the northeastern portion of the island and generous accretion toward the south of the island in Wildwood and Wildwood Crest. This accretion in the south from the down drift transport of sand has resulted in nontraditional damages such as clogged and damaged outfall pipes, subsequent standing water on the beach, and internal drainage problems of water overflow into local streets. Meanwhile, residents at the northeastern end of the island have endured loss of land and dune encroachment. Several damage causing storms occurred in the late 1980s, early 1990s, 2011, and most recently in 2012. Hurricane Sandy made landfall on the New Jersey shore in late October in 2012 causing millions of dollars of damage to residential, commercial and public property in coastal communities, debris and sand dispersal, and extensive damage and disruption to utilities and transportation systems. Superstorm Sandy, as it has been called, registered the second highest observed stage at the Atlantic City tidal station in the 100 years from 1912 to 2012. Shore communities north of the storm's landfall received the most devastating damage during this event. Although the Wildwoods fared better than barrier island towns up the coast, beach erosion and coastal structure damage were inevitably realized.

North Wildwood: Local officials were contacted to determine the extent of historical damage. **Table 49** displays an example of the most damaging events for which information was available. In general, the beach in North Wildwood has eroded significantly over the years while the beach in the middle and southern end of the island has accreted. According to emergency management officials in North Wildwood much of the beach loss has occurred on the oceanfront between 2nd Avenue and 19th Avenue. No recent structural or content damage to buildings has been recorded from ocean wave or inundation infiltration. A damaging storm occurred in February 2003 in which concrete walkways on Allen Drive at the Anglesea Beach Colony collapsed. One or two houses on Ocean Avenue received some water in the ground floor/basement from the bay (8-foot tide) during this same event. Street flooding from the bay is common in North Wildwood. In 2008, the Mother's Day northeaster from May 12 through 13 caused minor flooding when the ocean extended beyond the beach, below the boardwalk, and over the streets. An amusement pier bulkhead was severely damaged during this storm event. Erosion in front of Surfside Pier was so severe that the pier owner constructed a bulkhead to protect against continued storm damage. In October 2012, the borough experienced beach erosion and damage to shoreline structures such as bulkheads and boardwalks from Superstorm Sandy. Repairs to oceanfront protective structures and replacement of sand and required walkovers are estimated to be more than $3 million.

Wildwood: Damage in Wildwood has been relatively minor and mostly affected infrastructure. Outfall pipe damage creates street flooding and vehicle damage. A large beach has been the only problem area from the oceanfront causing outfalls to back up into the community. Some commercial structures have received minimal damage. Amusement piers and rides that are on the beach, and unprotected may be vulnerable to oceanfront damage. The west side of town floods from the bay similarly to North Wildwood. The difference between historical observations and modeled results for the high probability events could be caused by a combination of factors. Officials and business owners implement mitigation measures such as sandbag placement and constructing building closures. When there has been no time to deploy protective measures damage has occurred in Wildwood. Businesses experienced with frequent potentially damaging storm events also may have employed storm proofing and modifications to property to reduce the impacts of flooding. Natural landscaping may also act as a barrier to infiltration of water into buildings. These variables are not included in model parameters. The magnitude of Hurricane Sandy (~ 30 year event) affected the entire region including the City of Wildwood. According to published reports, 400 residences were damaged and almost 800 businesses were impacted. Nevertheless, the wide beaches provided a critical buffer to mitigate some of the damage to the oceanfront structures.

Table 49 North Wildwood Storm Damages

Date	Event	Major Damage Category	Dollar Loss
Oct. 1991	20-year	Sewage system	$150,000
Dec. 1992	25-year	Debris removal	$130,000
Feb. 1998	5-year	Drainage system	$232,000
May 2008	3-year	Pier bulkhead	$726,000
Oct. 2012	~ 30-year	Bulkheads and boardwalk	$2.6 million

**Dollar loss in September 2007 dollars*

Wildwood Crest: The southern portion of the island has wide beaches and has experienced inconvenience and expenses associated with having a wide beach. The beach grows at about 80 – 100’ per year. Wildwood Crest has had to extend its outfall pipes. Outfalls were extended several years ago at a cost of approximately $400,000. The town has sought permits to extend the outfalls again. The municipality has also built walkways for the convenience of recreational users with gear who must walk many yards to reach the water’s edge. The municipality experienced erosion as the result of a severe storm more than five years ago. Superstorm Sandy caused damage to sand fences, walkways, and access ramps on the oceanfront in addition to bay front bulkhead and railing damage. Also, it was reported that property damage was sustained by nearly 100 residences and approximately 250 businesses.

Superstorm Sandy*:* The storm left millions of dollars of damage to east coast communities from the Mid-Atlantic to New England when it made landfall north of Atlantic City in late October 2012. The nature of the storm destroyed property in the shore counties north and northeast of the landfall zone and, to a lesser extent, in the counties south and southwest. In New Jersey from north to south, nine counties were impacted by the hurricane: Bergen, Essex, Hudson, Union, Middlesex, Monmouth, Ocean, Atlantic, and Cape May. Atlantic, Ocean, Monmouth, and Hudson Counties were hardest hit by Superstorm Sandy. Published reports assert that about 1% of the approximately 300,000 residential structures damaged by this significant storm will require elevating.

The study area of the *Wildwoods* is in Cape May County and located approximately 60 miles south of the storm's landfall. Beach erosion and back-bay inundation were the major damage mechanisms experienced on Hereford Island. Overall, the protective berm, dune, and bulkhead took the brunt of storm waves and erosion and buffered oceanfront structures in the erosion-susceptible northern section of the study area. The deepest flooding occurred from the bay (Grassy Sound) to New Jersey and 15th Avenues. According to local officials, no ocean-block structures were washed away, and demolition of structures was not required as a result of Hurricane Sandy. This confirmation along with review of post-Sandy aerial photography indicates that structures in the potential benefits pool remain in the analysis.

3.2.2 Structure Inventory

A structure database was compiled containing information pertinent to the calculation of hurricane and storm damage for the study area. Initially, the inventory focused on North Wildwood, the erosion prone portion of the study area, because field conditions established that the beaches in Wildwood and Wildwood Crest were extremely wide, in excess of 1,500 and 1,100', respectively. The inventory was later expanded to include structures in Wildwood and Wildwood Crest to evaluate the extent of potential damage to reaches without dunes and assess the impact of sand backpassing.

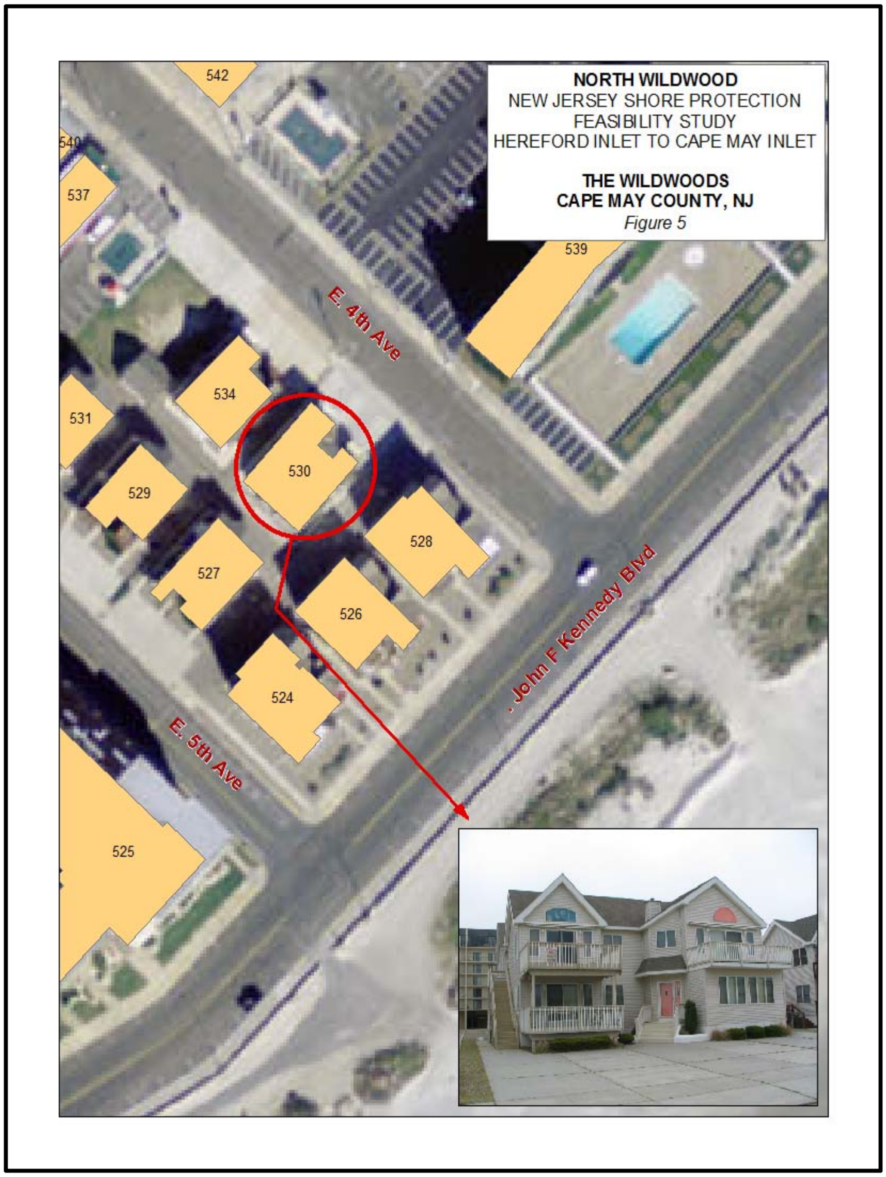
Available digital aerial photos, street centerlines, and footprints of structures derived from a geographic information system were reviewed, and unique identification numbers were assigned to each structure. Data collected in the field included address, quality and construction type, number of stories, and occupancy type. A handheld computer with a digital map of the study area was used to code structure characteristics on electronic forms. Photographs of each inventoried structure were taken for in-office verification. **Figure 103** displays an example of a map and photo. Additional data such as first floor elevations, ground elevations, footprint area, and foundation type (pile or slab) were also obtained for each inventoried structure. Professional surveyors conducted the elevation survey on a structure by structure basis.

The construction characteristics of each building were entered into the Marshall & Swift Valuation Service software to calculate depreciated replacement cost value. **Table 50** displays total and mean residential and non-residential structure values by foundation type for the study area. The inventory consists of approximately 60% commercial and 40% residential structures. The associated content value of each residential structure is assumed to be 25% of the structural replacement cost. This assumption is based on previous studies that established content value to be about 40% of structural value in primary homes and 15 to 20% of structural value in secondary/vacation homes. The study area consists of a combination of rental or vacation homes, and year round residential homes. However, nearly 70% of the residential structures are vacation and rental homes, and typically the contents of structures with these types of occupancies are insured at a much lower percent, therefore, a conservative weighted content-to-structure value of 25% was adopted. Field observations and site-specific interviews with local residents during the conduct of the Townsends Inlet to Cape May Inlet Feasibility Study, which included a portion of the Wildwoods, substantiate that the ratio is suitable. Also, information from a local insurer confirmed that personal property in secondary homes is typically insured at a lower percentage than that of primary residences. Typically applied in urban areas, affluence is an inundation reduction benefit defined as an increase in residential content-to-structure value ratio in relation to future increases in residential income. The benefit is based on the prevention of damages to potentially increased content values of residential structures in the future. Affluence is a minor potential benefit which has not been claimed by the District in any coastal studies.

Table 50 Summary of Depreciated Replacement Cost Values

Type (North Wildwood)	Structures	Value ($000)	Mean
Pile			
Residential	99	$43,179	$436
Commercial	63	$108,965	$1,730
Subtotal	*162*	*$152,144*	
Slab			
Residential	18	$22,403	$1,245
Commercial	13	$22,993	$1,769
Subtotal	*31*	*$45,396*	
Total	*193*	*$197,540*	
Type (Wildwood)	**Structures**	**Value ($000)**	**Mean**
Pile			
Residential	0	$0	$0
Commercial	11	$28,034	$2,549
Subtotal	*11*	*$28,034*	
Slab			
Residential	28	$5,594	$200
Commercial	97	$37,115	$383
Subtotal	*125*	*$42,709*	
Total	*136*	*$70,743*	
Type (Wildwood Crest)	**Structures**	**Value ($000)**	**Mean**
Pile			
Residential	0	$0	$0
Commercial	24	$186,917	$7,788
Subtotal	*24*	*$186,917*	
Slab			
Residential	46	$32,223	$700
Commercial	59	$201,155	$3,409
Subtotal	*105*	*$233,378*	
Total	*129*	*$420,295*	

Figure 103 Map and Photo of Structure Inventory



3.2.3 Storm Damage Methodology

Damages (for without and with project conditions) were calculated for seven frequency storm events (5, 10, 20, 50, 100, 200, and 500 year events) for erosion, wave and inundation damage to structures, infrastructure and improved property. The calculations were performed using COSTDAM. COSTDAM reads an ASCII 'Control' file which contains the storm frequency parameters for each cell and an ASCII 'Structure' file which contains the information database of each structure and EAD. COSTDAM checks if a structure has been damaged by wave attack, based on the relationship between a structure's first floor elevation and the total water elevation that sustains a wave. Then COSTDAM checks for erosion damage at a structure. Finally, COSTDAM calculates inundation damages if the water elevation is higher than the first floor elevation based on FIA depth-damage curves adjusted for increased salt-water damageability.

To avoid double counting, if damage occurs by more than one mechanism, COSTDAM takes the maximum damage of any given mechanism (wave, erosion, or inundation) and drops the rest of the damages from the structure's total damages.

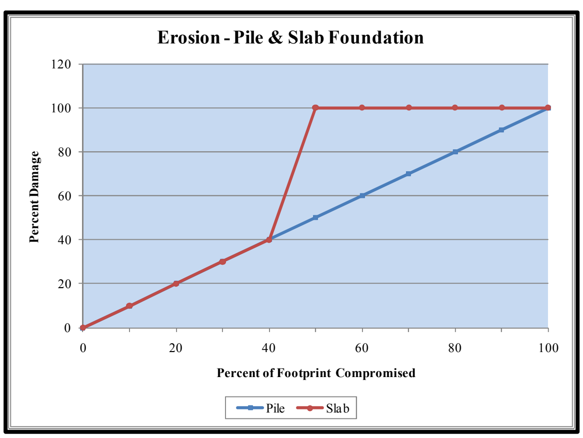
COSTDAM (COastal STorm Damage Assessment Model) was used to estimate erosion, wave, and inundation damage to the structures in the database. The economic model incorporates pertinent structure characteristics such as location, ground and first floor elevations, structure and content values and foundation type along with coastal storm parameters such as wave zone, erosion zone, and water level by distance from the shore/reference line. The COSTDAM model and methodologies have been applied and approved for the other studies in the series of studies conducted along the coast of New Jersey. A description of the program's damage estimation methodology is provided in the following paragraphs.

3.2.4 Erosion Damages

The distance between the reference (profile) line and the oceanfront and back walls were measured in ArcGIS using geo-referenced mapping of the study area. This technique reduces the amount of human error and photographic distortion. For the structure damage/failure analysis, it was assumed that a structure is destroyed at the point that the land below the structure is eroded halfway through the structure's footprint if the structure is not on a pile foundation. If the structure is on piles, the land below the structure must have eroded through the entire footprint of the structure before total damage is claimed. Prior to this, for both foundation types, the percent damage claimed is equal to the linear proportion of erosion under the structure's footprint relative to the total damage point.

Figure 104 depicts the relationship between percent damage and percent of footprint compromised. The damage relationship was developed during the initial assessment of storm erosion damage susceptibility on the Delaware and New Jersey coasts, has been applied regionally, and is considered a reasonable method to estimate aggregate erosion damages to the structure types represented in this coastal environment.

Figure 104 Pile and Slab Foundation Erosion



The communities' participation in the National Flood Insurance Program (NFIP) ensures that requirements are met to build structures with first floors beyond the base flood elevation. NFIP effective dates are in 1979 for North Wildwood and in 1980 for both Wildwood, and Wildwood Crest. It is likely that structures closest to the oceanfront are newer and elevated. According to local officials, piling depth requirements are contingent upon several factors, vary for each property, and pile depth data on a structure by structure basis was not available at the time of study commencement. Furthermore, if the data were available it could be addressed qualitatively only because structure pile depth is not a variable in the modeled calculation of hurricane and

storm damage reduction benefits.
In addition to erosion damage to structures, damage to the land the structures are on or improved property was calculated. The improved property value was determined by comparing market value of the near shore land to the cost of filling in the eroded land for reutilization and using the more conservative estimate. The cost of filling/restoring the improved property is based on the different depths, widths and cubic yards of erosion produced by each storm event. The cost of filling/restoring eroded improved property was determined to be less expensive. The cost was prorated for the width of each cell to estimate total land erosion damage.

Erosion damage to infrastructure was also calculated. An erosion damage curve was developed for damage to infrastructure within the erosion limits. Values for roads, sidewalks, storm drains, electrical lines, and other utilities were estimated using standard engineering criteria. The judgment was made that all infrastructure damaged in *the Wildwoods* would be replaced in-kind. The replacement cost does not necessarily relate to the number of structures in the area. Road and utilities replacement costs consisted of fixed and variable costs based on ranges of feet of replacement/repair. In general, the replacement unit cost of roads decreased with greater quantities eroded reflecting economies of scale. Distance from the reference line and feet of erosion per event for each road and associated utilities were used to determine damage susceptibility. Once damages were calculated for infrastructure for the storm events they were placed into EAD to calculate the Expected Annual Damages.

3.2.5 Wave-Inundation Damages

A structure is considered damaged by a wave when there is sufficient force in the total water elevation to completely destroy a structure. Partial wave damages are not calculated; instead the structure is subjected to inundation damages. Large masonry structures like high-rise condominiums are not expected to experience failure by wave damage. The wave attack damage relationship developed by Wilmington District for Atlantic coast studies was adopted for use in the New Jersey coast hurricane and storm damage reduction analyses of seven projects. Since waves cause similar types of damage as inundation, assessing damage prior to full wave impact on a structure would, in essence, duplicate the inundation damage estimate. Percentages of total depreciated replacement cost used to calculate damage by the depth-damage function curves for inundation damage reflect various characteristics of a structure. The depth-damage curves display the percent damaged at various stages relative to the first floor. The curves used to estimate inundation damage to structures were derived from well-established FIA (Federal Insurance Administration) depth-damage curves and previous studies of saltwater areas are applicable for this study. The distinguishing characteristics are construction type and the number of stories in a structure. The FIA curves were developed by sampling the various types of structures and contents at New Jersey seashore communities in Cape May and Atlantic counties. Curve percentages were compared to survey data of the additional damage that corrosive saltwater would cause. An example of the frequency at which damage begins and the damage mechanism for the project area is shown below in **Table 51.**
.

Table 51 Beginning Damage Event

		With Out Project Damage Start	
Community	**Cell**	**Frequency**	**Type**
North Wildwood	1	**50**	Flooding
North Wildwood	2	**5**	Flooding
Wildwood	3	**5**	Flooding
Wildwood Crest	4	**100**	Erosion/Flooding
Wildwood Crest/LT	5	**50**	Flooding
Lower Township (LT)	6	**50**	Flooding

3.2.6 Emergency Clean-Up Information

Clean-up costs for individual structures are based on the time for clean-up and additional meal and travel costs. Travel and meal costs are conservatively included as opposed to evacuation costs because most residential structures and many commercial structures are occupied only on a seasonal basis, and oftentimes, not by the structure's owner. Clean-up costs are applied to those structures affected by a particular storm event.

Emergency and clean-up costs were calculated for North Wildwood. The cost of emergency public services during or immediately after storm events was analyzed using information provided by the municipality. As a point of reference, the municipality reported damages for the December 1992 event with associated elevations that correspond to a 25-year event. Damage frequency curves were developed and extrapolated for major flood events consistent with the damage frequency distribution for buildings, and historic data.

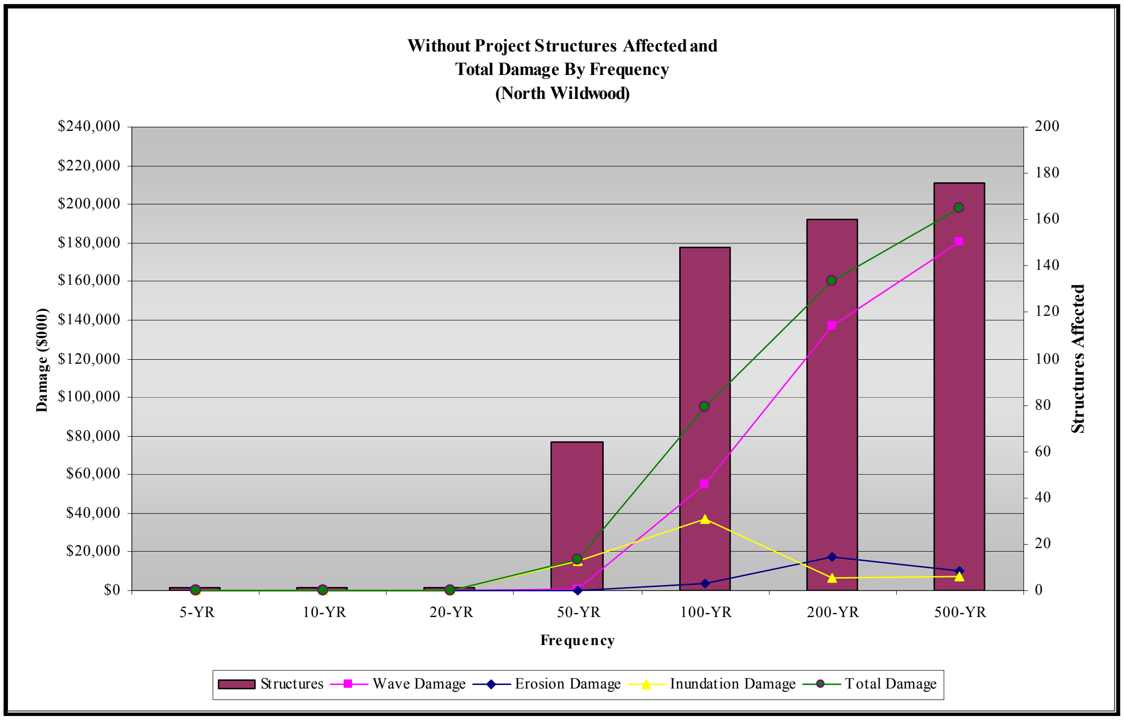
3.2.7 Damage Zone Structures

The number of structures affected and total damages by damage zone or damage frequency for structures is presented in (**Table 52**). Damage from the different mechanisms (wave, erosion, or inundation) decreases between storm events because structures may be susceptible to more damage from a different mechanism at different storm frequencies. However, overall damage from all damage mechanisms increases with higher intensity storms. Structural damage below the 5-year event is negligible. Storms equivalent to a 2-year event have occurred in which no structural damages were reported.

Table 52 Without Project Damages by Frequency (In $000, June 2007 p.l.)

North Wildwood	5-yr	10-yr	20-yr	50-yr	100-yr	200-yr	500-yr
Structures	1	1	1	64	148	160	176
Wave Damage	0	0	0	$485	$54,954	$136,861	$180,796
Erosion Damage	0	0	0	0	$3,395	$17,167	$10,175
Inundation Damage	$140	$152	$165	$15,349	$36,774	$6,418	$7,263
NWW-Total Damage	$140	$152	$165	$15,834	$95,123	$160,446	$198,234
Wildwood	**5-yr**	**10-yr**	**20-yr**	**50-yr**	**100-yr**	**200-yr**	**500-yr**
Structures	32	47	54	63	115	125	131
Wave Damage	0	0	0	0	0	$48,306	$51,036
Erosion Damage	0	0	0	0	0	$70	$1,603
Inundation Damage	$1,797	$3,650	$5,543	$9,298	$29,236	$3,933	$3,578
WW-Total Damage	$1,797	$3,650	$5,543	$9,298	$29,236	$52,309	$56,217
Wildwood Crest	**5-yr**	**10-yr**	**20-yr**	**50-yr**	**100-yr**	**200-yr**	**500-yr**
Structures	0	0	0	19	81	100	105
Wave Damage	0	0	0	0	$1,406	$20,881	$41,371
Erosion Damage	0	0	0	0	$29,497	$22,301	$6,071
Inundation Damage	0	0	0	$5,598	$17,299	$53,059	$111,406
WWC -Total Damage	$0	$0	$0	$5,598	$48,202	$96,241	$158,848
Lower Township	**5-yr**	**10-yr**	**20-yr**	**50-yr**	**100-yr**	**200-yr**	**500-yr**
Structures	0	0	0	1	2	5	11
Wave Damage	0	0	0	0	0	$12,605	$12,605
Erosion Damage	0	0	0	0	0	$4,566	$12,318
Inundation Damage	0	0	0	$2,153	$3,826	$15,675	$62,169
LT -Total Damage	$0	$0	$0	$2,153	$3,826	$32,846	$87,092

Figure 105 Without Project Structures and Total Damage in North Wildwood



3.2.8 Structure Damages

Expected average annual damages by cell for structures in *the Wildwoods* are presented in **Table 53**.

Table 53 North Wildwood Average Annual Structural (Dollars in thousands)

Location	Cell	Erosion	Wave	Inundation	Average Annual Damage
North Wildwood	1	$23	$919	$269	$1,211
North Wildwood	2	$97	$502	$401	$1,000
Total		$ 120	$1,421	$ 670	$2,211

3.2.9 Infrastructure and Improved Property Damages

Total infrastructure damages by frequency are shown in **Table 54** and **Table 55**. This includes without project average annual damages (AAD) for the infrastructure such as roads, storm drains, the boardwalk, piers, bulkheads, and improved property.

Table 54 North Wildwood Without Project Conditions Infrastructure Damages
(Dollars in thousands)

Category	5-YR	10-YR	20-YR	50-YR	100-YR	200-YR	500-YR
Infrastructure	$1,440	$3,350	$3,418	$3,852	$15,089	$18,173	$22,124
Boardwalk	0	0	0	0	5,540	5,540	5,540
Bulkhead	0	0	0	0	1,239	1,239	1,239
Total	$1,440	$3,350	$3,418	$3,852	$21,868	$24,952	$28,903

Table 55 North Wildwood Without Project Average Annual Infrastructure and Improved Property Damages (Dollars in thousands)

Category	*Total*
Infrastructure	$226
Boardwalk	83
Bulkhead	19
Improved Property	28
Total	$ 356

3.2.10 Summary of Damages

Total estimated average annual damages in North Wildwood by location/cell and damage mechanism are $3,070,000 as shown in Table 56 Average Annual Damages **Table 56.** Average annual damages to structures only are estimated to be $2,211,000.

Table 56 Average Annual Damages (Dollars in thousands)

Location	Cell	Structure	Infrastructure	Improved Property	Average Annual Damage
North Wildwood	1	$1,211	$185	$24	$1,420
North Wildwood	2	$1,000	$646	$4	$1,650
Total		$2,211	$ 831	$ 28	$3,070

3.2.11 Emergency/Clean-Up Costs

The number of structures affected and the estimated costs for each storm event are presented in Table 57 for North Wildwood. Average annual emergency and clean-up costs for all affected individuals and public entities are $103,000, combined. Total expected average annual damage under without project conditions including emergency costs is $3,173,000.

Table 57 North Wildwood Without Project Damages, Emergency Cleanup Costs
(Dollars in thousands)

North Wildwood	5-YR	10-YR	20-YR	50-YR	100-YR	200-YR	500-YR
Structures	1	1	1	64	148	160	176
Individual Clean-up Costs	$1	$1	$3	$65	$351	$812	$1,786
Municipal Emergency Costs	$11	$92	$141	$826	$2,410	$4,122	$6,005

3.2.12 Back Bay Flooding

Storm damage resulting from infiltration of waves, beach erosion, and inundation from the ocean shoreline was the focus of the study. Many barrier islands, including the Wildwoods, are traditionally subject to the impacts of bay flooding from any combination of storm events and high tides. This phenomenon was not evaluated as part of this study. As an example, the model was run for the stages associated with the back-bay (stillwater) inundation. The result represents inundation damages specific only to the oceanfront/nearshore structures in the database that would not be eliminated by a project on the oceanfront of North Wildwood. These back-bay residual damages for these structures total $153,000 in average annual damages.

3.2.13 Wildwood, Wildwood Crest and Lower Township

The study area at *The Wildwoods* is a dynamic system, characterized by the movement of sand down-shore from North Wildwood to the beaches in Wildwood and Wildwood Crest. This redistribution of sand from North Wildwood has created an on-shore borrow area of built-up accreted sand in Wildwood and Wildwood Crest which has caused water to pond at clogged outfalls, and increased costs for beach maintenance and outfall pipe extension. At the beginning of the study, initial review of field conditions in Wildwood and Wildwood Crest indicated that beach width were in excess of 1,500' and 1,100', respectively. Therefore, the study focused on the highly eroded oceanfront of North Wildwood.

In addition to the down drift structures south of North Wildwood, property located on the piers seaward of the proposed project may be susceptible to damage from hurricanes and storms. Three piers in North Wildwood and Wildwood were constructed with extensions sloping down near beach level and not uniformly elevated on tall piles as in other shore communities like Atlantic City. Structures located in these areas were reviewed to determine potential damages and the impact of extending various plan measures around the piers.

3.2.14 Accreted Area Damage Summary

Expected average annual damages by location/cell and damage mechanism for structures in the communities within the potential backpass area are presented in **Table 58**. Average annual damages to structures only are an estimated $3,081,000 of the $5,124,000.

Table 58 Wildwood, Wildwood Crest Lower Township Without Project Average Annual Damages (Dollars in thousands)

Location	Cell	Erosion	Wave	Inundation	Infrastructure	Improved Property	Structure Subtotal	Average Annual Damage
Wildwood	3	$4	$298	$1,192	$1,306	$0	$1,494	$2,800
Wildwood Crest	4	$15	$5	$198	$498	$4	$ 218	$ 720
Wildwood Crest	5	$288	$178	$482	$212	$11	$ 948	$1,171
Lower Township	6	$49	$82	$290	$12	$0	$ 421	$ 433
Total		$ 356	$ 563	$2,162	$2,028	$ 15	$3,081	$5,124

3.2.15 Amusement Piers Damages

A major attraction of *the Wildwoods* are the amusement piers which offer an assortment of mild to high thrill rides, kids' rides, game booths, and concessions, as well as water parks. The unique nature of analyzing damage to the amusement piers required a separate database for the pier structures. Amusement pier ride replacement cost values were provided by the pier operator and depreciated using an amusement ride depreciation schedule. Specialized depth damage curves from similar activities were used in the inundation analysis. Estimated average annual damage to the amusement pier rides is $122,000. **Table 59** presents a breakdown of the damage estimate by community/pier and damage category.

Table 59 North Wildwood & Wildwood Pier Damages (Dollars in thousands)

Location	Pier	Erosion	Wave	Inundation	*Average Annual Damage*
North Wildwood	Surfside	$27	$7	$0	$34
Wildwood	Mariner's Landing	$44	$1	$0	$45
Wildwood	Adventure	$3	$12	$28	$43
Total		*$74*	*$20*	*$28*	*$122*

3.2.16 Estimated Total Damages

Total estimated without project average annual damage for all categories in North Wildwood, the eroding portion of the study area, and Wildwood and Wildwood Crest, the down-drift accreting area, is $8,194,000. **Table 60** presents a breakdown of the damage estimate by community.

Table 60 Without Project Average Annual Damages, Total (Dollars in thousands)

Community	Total
North Wildwood	$3,070
Wildwood	2,800
Wildwood Crest/ Lower Township	2,324
Total	$8,194

3.2.17 Beach Maintenance

The 4 municipalities within the island all have different approaches to their outfall problems. North Wildwood only has 2 outfalls and they are in need of repair, but exposed so no excavation of sand is necessary to allow proper drainage from the street. Wildwood City excavates the outfalls on a daily basis and incurs a small yearly fee associated with paying its workers to do so. They also commissioned a report in 2003 to quantify the costs associated with extending the outfalls and building a pump system to alleviate the drainage problem. Wildwood Crest extended their outfalls from 1999-2007, and extended them again in 2008, Lower Township and Diamond Beach both excavate their outfalls. The costs outlined below are included as Local Costs Forgone in the With Project section of this report.

North Wildwood

North Wildwood has not extended its outfalls, nor do they perform daily excavations. The outfalls are exposed and draining the interior sections of the island without incident, to date. The NJDEP currently has a beach nourishment project it is planning to construct in the fall of 2009 in North Wildwood at a cost of $9,750,000.

Wildwood City

Wildwood has a persistent outfall maintenance problem due to the large influx of sand to the area. In order to economically quantify the effort to maintain outfall flow for the 9 outfalls in Wildwood the District contacted the Wildwood City Public Works Department regarding their outfall maintenance schedules. The District also discussed flooding issues associated with the clogged outfalls. The Public Works Department characterized the depth of water levels from flooding when the outfalls are clogged as approximately 4-8" inches along Atlantic, Ocean and Pacific Avenues in Wildwood. He said outfall maintenance was done daily and workers were on call for rain events that occurred outside normal work hours. These workers were paid time and a half for what they estimated to be 15 events a year in which two workers had to be called in to deal with the problem.

The Public Works Department also purchased a new excavator in 2006 for approximately $35,000. Maintenance costs on the old machine were approaching the cost of a new one at $34,552 over a 3 year period. Wildwood estimated the cost of fencing and warning signs around clogged outfalls to be approximately $500/yr. Yearly outfall excavation cost estimates based on daily excavation (regular man hours) and excavation during rain events (overtime), for 2 municipal workers, for 3 1/2 hours, with 1 backhoe, and fencing repairs , was approximately $115,000 per year.

In 2003 Wildwood City also commissioned a report by Remington & Vernick to estimate the cost of extending their municipal outfalls to deal with the clogged outfall problem. Multiple scenarios were considered for solving the problem including; a pump station with outfall extension, extending outfalls, two pump stations and beach grading. The costs associated with these 4 plans is in **Table 61**.

Table 61 Drainage Issue Options

Option	2003	2007
Pump Station 25 year storm	$7,818,900	$9,428,600
Extend Outfalls	$7,867,800	$9,487,500
Two Pump Stations	$9,698,100	$11,694,700
Beach grading/Dune Building	$8,184,000	$9,868,800

Wildwood Crest

Wildwood Crest has been dealing with their clogged outfall issue by extending their outfalls to accommodate the influx of sand. They extended their outfalls in 2001, 2004 and again in 2009-2010. Costs for these extensions are outlined below and total $1,612,000. (**Table 62**)

Table 62 Wildwood Crest Outfall Extensions

Location (Street)	2001 (lf)	2004 (lf)	2009-2010 (lf)	Total (lf)
Washington	0	363	306	669
Hollywood	0	357	279	636
Miami	340	109	171	620
Atlanta	0	450	297	747
Fern	480	162	207	849
Heather	680	108	234	1022
Total Length (lf)	1500	1549	1494	4,543.00
Costs	**$ 340,000**	**$405,000**	**$ 867,000**	**$1,612,000**

Local Costs Forgone categories for North Wildwood, Wildwood, and Wildwood Crest were annualized and included as a project benefit in the economic analysis section of this report.

3.3 Future Without Project Conditions

Gathering information about potential future conditions requires forecasts, which should be made for selected years over the period of analysis to indicate how changes in economic, social environmental and other conditions are likely to impact problems and opportunities. Other categories such as Local Costs Forgone, study area maintenance, future average annual damages, level of future development were also included in the assessment of Future Without conditions.

Future without project conditions in the project area have the potential to be impacted by a variety of conditions including; beach geomorphology, sea level rise (SLR), economic factors, future development and new rules and regulations as a result of impacts from Hurricane Sandy. Future economic factors, beach geomorphology and SLR scenarios were evaluated in the risk and uncertainty analysis contained in this report. Rules and regulations imposed as a result of Hurricane Sandy, and modifications to existing floodplain management practices also have the potential to impact the study area through updates the Flood Insurance Rate Maps (FIRM), new building code regulations and development restrictions.

The Federal Emergency Management Administration (FEMA) recently undertook an effort to update their FIRMs based on analyses that were underway prior to the impact of Hurricane Sandy. The District considered damage values from FEMA's New Jersey Comprehensive Damage Assessment in North Wildwood, Wildwood and Wildwood Crest as indicators of how the structure database would be impacted by new floodplain management rules. This indicates that North Wildwood has potential to see the greatest change in the structure database as a result of improved floodplain measures since it had the highest level of FEMA assistance on the island, followed by Wildwood Crest and Wildwood. Lower Township was excluded since a large portion is on the mainland, and the data does not separate the claims based on location within the Township. It is important to note that the North Wildwood damages are based on the entire island, and represent areas subject to back-bay flooding outside the ocean front structure database for the project.

Changes to structure database as a result Hurricane Sandy will be evaluated as the flood plain maps are updated and the Hazard Mitigation Program grants (HMP) and Increased Cost of Compliance (ICC) grants are awarded to homeowners. The initial analysis indicates that 60% of the structure database is below the current Advisory Base Flood Elevation (ABFE), but these structures will not need to comply with stricter floodplain management regulations since the properties were not significantly damaged during the storm. ICC and HMP grants are for buildings that are "substantially damaged", or subject to "repetitive losses".

Recent discussions with floodplain officials after the Corps of Engineers In Progress Review (IPR) meeting in July indicate that most damages in North Wildwood were caused by elevated water levels on the bayside during Hurricane Sandy. These damages were experienced outside of our structure database, and indications are that no structures within the economic database will need to be excluded due to their removal from the community due to recent storm activity from Hurricane Sandy, buyouts or relocations out of the flooded areas.

3.3.1 Future Without Project Hydraulic Conditions

Previous shore protection studies the Philadelphia District have calculated the future without project conditions to account for the effects on damages from a steady erosion rate applied to the representative profiles.

This forecasted erosion rate was applied until the erosion reached a point in which local municipalities would intervene with a beach-fill or shore protection measure of their own. An average annual damage calculation was performed based on the new adjusted profile in the Risk and Uncertainty analysis in Section 5.0. For this study the potential future damages were evaluated for cells where long-term erosion may result in profile conditions significantly different from those simulated in the base year. Sufficient long-term erosion warranted modification of profiles for cells 1 and 2 (North Wildwood), with the remaining cells within the study area being historically accretional. Long term erosion was incorporated by translating the profile landward a distance equal to the long-term erosion rate adopted for each cell times the number of years projected into the future. The long term erosion rates adopted for Cell 1 and Cell 2 were 33'/year and 17'/year, respectively. These values were taken from averaging compartment values for each cell respectively from the 1977-2003 epoch in Section 2.8, Shoreline Change Analysis.

It was assumed the locals would intervene in the future for Cell 1 when the beach profile eroded back to the existing bulkhead. It was also assumed at that time that any Local or State beach fill needed for Cell 1 would also be applicable for Cell 2 in North Wildwood. The time required for the existing beach profile used in the without project conditions for Cell 1 to erode back to the bulkhead was calculated to be 5 years based upon an annual erosion rate of 33' per year. Based upon this calculation, the future without project condition eroded beach profiles for Cells 1 and 2 would be applicable starting in year 6. In Cell 2, it was assumed that the future without project beach profile would be translated 85' landward (17' per year * 5 years) from its base condition.

This eroded beach condition and other key Hydraulic and Hydrologic (H&H) parameters were varied for potential Future Without Project conditions in the Risk and Uncertainty Analysis in **Section 5.0**. Variation in water levels and the six SBEACH parameters had a large impact on future damages levels in the project area. Sea Level Rise was calculated and applied to the storm damage analysis. The higher SLR scenarios had a larger impact on project benefits and damages than variation in the economic parameters for this study.

The municipality of North Wildwood initiated a beachfill in response to the sand lost during Hurricane Sandy. A contract was awarded in the Spring of 2013 for 150,000 cubic yards of sand for North Wildwood. Our pre and post storm surveys indicate that 350,000 cubic yards was eroded above the mean high water line during sandy, island wide. Therefore, we do not feel the spring re-nourishment will impact future without project conditions. A table of all recent local nourishment activity is contained in **Table 21**.

3.3.2 Future Without Project Economic Conditions

Property development within the study area will be limited since the availability of undeveloped property is low. The communities in the study area are well established with limited area for new development beyond replacing older structures. The standard procedure for the District's coastal studies has been to expect the baseline structure inventory to remain stable over the period of analysis. In addition, any new development must comply with guidelines that the first floor of new buildings be at least one foot above the base flood elevation. Therefore, any future without project damage reduction from the proposed plans most likely would be limited. Most of the new development in the study area has been rehabilitations or replacement of older structures, not new construction on undeveloped land. The existing conditions section of the report shows Proposed Residential Development Site Plans for the study area. This table shows 1,775 new developments in 2005 but quickly declines to 10 new developments in 2010. The Wildwoods have a relatively limited area for new development and most of the site plans were for renovation and rehabilitation. Economic factors including future discount rates, structure to content percentage, depreciated replacement cost value, and stage damage function were varied based on potential future scenarios in the Risk and Uncertainty analysis in **Section 5.0**. These key economic inputs had marginal impacts to benefits and damages for the selected plan.

3.3.2.1 Additional Study Efforts as a Result of Hurricane Sandy

After Hurricane Sandy and the passage of PL 113-2, the Disaster Relief Appropriations Act of 2013 instructed the Corps to compile four reports designed to expedite and complete ongoing flood and storm damage reduction studies in areas that were impacted by Hurricane Sandy within North Atlantic Division. These four reports included; 1) A Comprehensive study to address the flood risk of vulnerable coastal populations in the areas impacted by Hurricane Sandy within the North Atlantic Division of The Army Corps of Engineers (The Comprehensive Study), 2) an interim report with an assessment of authorized Corps projects for reducing flooding and storm risks in the affected area that have been constructed or are under construction (The First Interim Report), 3) an interim report identifying any previously authorized but unconstructed projects, and any project under study by the Corps for reducing flooding and storm damage risks , that are, or would be consistent with the Comprehensive Study (The Second Interim Report), 4) and an evaluation of the performance of existing projects constructed by the Corps and impacted by Hurricane Sandy for the purpose of determining their effectiveness and making recommendations for improvements (The Performance Evaluation Study).

The Hereford to Cape May feasibility study falls into the category of a “previously authorized but unconstructed project, or any project under study” since it is currently in the General Investigations phase of the Corps Civil Works program and was included in the Second Interim Report delivered to Congress on 30 May 2013. The primary goal of the Second Interim Report was to identify the projects in the Corps of Engineers flood risk management portfolio that were authorized for construction but not yet constructed and to identify existing projects under study that addressed coastal populations at risk within the North Atlantic Division. These projects and studies were given Federal priority for completion by being funded at a 100% Federal cost based on the funds remaining to complete the study as of the date of the signature of the Disaster Relief Bill, on 29 January 2013.

The Disaster Relief Appropriations Act describes the purpose of the second interim report as;

"*Provided further, that an interim report identifying any previously authorized but unconstructed Corps project and any project under study by the Corps for reducing flooding and storm damage risks in the affected area, including updated construction cost estimates, that are, or would be, consistent with the comprehensive study shall be submitted to the appropriate congressional committees by May 1, 2013*"

The Second Interim Report was sent to Congress in the spring of 2013 and it listed the Hereford Inlet to Cape May Inlet project as a study area with a population at risk that was impacted by Hurricane Sandy. As a result of this inclusion the study costs are 100% Federal, and additional management measures may need to be evaluated in order to be in compliance with the federal objectives of coastal resilience and risk reduction in a "post Sandy" paradigm. Additional management measures that were previously screened out of the plan formulation phase, and any measures that may result in the development of improved floodplain management decisions and coastal resiliency may need to be included in the implementation of the selected plan, or further evaluated in the Planning Engineering and Design phase.

3.3.2.2 FEMA, the Community Rating System, and the Hazard Mitigation Program

The Federal Emergency Management Administration (FEMA) has issued grants and increased costs of compliance funding to property owners that need to raise or flood proof their homes in order to reduce their coastal flooding risk. They have also revised their flood mapping with the Advisory Base Flood Elevations (ABFE) and are currently in the process of revising the Preliminary Working Maps and the Flood Insurance Rate Maps (FIRM) for the entire region in order to more accurately assess flood risk. The ABFE was published (draft), but the preliminary working maps, and the FIRM were not published as of the date of this publication . These maps are designed to show the 100 and 500 year flood plain and will impact insurance rates, building codes and coastal development. Changes to this flood map, and the subsequent modifications to the structures within the newly designated floodplain may impact the study areas benefits and costs as properties are raised and or relocated.

3.3.2.3 Community Rating System (CRS)

FEMA administers a program to help communities with flood prone areas minimize flood impacts and reduce their resident flood insurance costs called the Community Rating System (CRS). This program has the potential to reduce flood insurance premiums community wide by up to 45%. There are 4 categories within the CRS to reduce flood premiums; Public Information, Mapping and Regulations, Flood Damage Reduction and Flood Preparedness. Specific activities within these categories include maintaining FEMA elevation certificates, providing flood protection and flood insurance information in the local library, etc.. Currently, three of the four communities on the island are registered with the CRS, and none receive the full 45% reduction in flood premiums that FEMA offers as a result of improved floodplain management. Most of the communities on the island receive between 10-15% reduction in premiums. Part of the recommendation for this project should be increased participation in the CRS for the communities on the island and maximization of the potential reduction of their flood insurance premiums. Flood insurance premiums are likely to increase after Sandy, and all of the municipalities on the island should evaluate ways to reduce both their flood premiums, and flood risk. Participation in this program would achieve both of these goals.

3.3.2.4 The Hazard Mitigation Program (HMP)

The Hazard Mitigation Program (HMP) is administered through FEMA and authorized by Section 404 of the Robert T. Stafford Disaster Relief and Emergency Assistance Act, as amended (the Stafford Act), Title 42, U.S. Code (U.S.C.) 5170c. The key purpose of HMGP is to ensure that the opportunity to take critical mitigation measures to reduce the risk of loss of life and property from future disasters is not lost during the reconstruction process following a disaster. HMGP is available, when authorized under a Presidential major disaster declaration, in the areas of the State requested by the Governor. There are three types of improvements that qualify for assistance in the Hazard Mitigation Projects, Mitigation, Hazard Mitigation Planning and Management Costs. There are three categories of the HMP grant;. 1.Mitigation Projects (acquisition, demolition, relocation, elevation), 2.- Hazard Mitigation Planning (Hazard identification and risk assessment and 3.Management Costs (Expenses that are reasonably incurred by a Grantee or sub-grantee in administering a grant or subgrant award).

3.3.2.5 Increased Cost of Compliance Grant

Changes to the Flood Insurance Rate Maps may force homeowners to comply with different rules regarding floodplain development. National Flood Insurance Program (NFIP) policyholders may receive up to $30,000 of Increased Cost of Compliance (ICC) coverage to help pay the costs to bring their building into compliance with their community's floodplain ordinance. Eligibility to file a claim for your ICC coverage is based on two criteria;1-When your community determines that your building is "substantially damaged", wherein the cost to repair or improve the structure exceeds its market value by a threshold amount adopted by law or ordinance. Community building officials are responsible for the issuance of substantial damage declarations 2- When your community has a "repetitive loss" provision in its floodplain management ordinance and determines that your building was damaged by a flood two times in the past 10 years, where the cost of repairing the flood damage, on average, equaled or exceeded 25 percent of its market value at the time of each flood. There are four options to pursue to comply with the community's new floodplain management; Flood Proofing, Relocation, Elevation, Demolition, referred to with the acronym (F.R.E.D.).

3.3.2.6 Impacts of FEMA grants and Floodplain Maps on Structure Database

Changes to the areas structure database as a result of applications to the HMP, ICC or better floodplain management through the CRS may reduce project damages within the area as homes are elevated, flood proofed or acquired and relocated/demolished or as better decisions are made within the floodplain. If implemented, these improvements will likely reduce impacts from future floods. Revised flood plain maps were not available at the time of this writing. Revisions to flood plain maps go through a multi-stage review and may not be available for a year or two. The District considered proxy values for potential impacts to the structure database from FEMA's New Jersey Comprehensive Damage Assessment. These values were obtained by assessing the impacts from Sandy on the project area in North Wildwood, Wildwood and Wildwood Crest. These values may indicate the level of changes to the structure database as a result of new floodplain guidance. Areas that were impacted the greatest would have the most flood claims for individual assistance and Small Business Administration (SBA) loans. These areas would also be leading candidates for improved floodplain management policies, buy outs and structure elevating. **Table 63** indicates that North Wildwood has the potential to see the greatest change in the structure database as a result of improved floodplain measures since it had the highest level of NFIP and SBA assistance on the island, followed by Wildwood Crest and Wildwood. But most of these structures were likely not in the project database used for the economic evaluation since this table also includes back bay properties. Lower Township data was excluded since a large portion of Lower Township is on the mainland, and the data does not separate the claims based on location within the Township.

Table 63 NFIP and SBA claims after Hurricane Sandy

Community	NFIP claims	NFIP total $	SBA	SBA total ($)
North Wildwood	682	$14,403,876	22	$948,000
Wildwood	0	0	28	$1,379,000
Wildwood Crest	113	$1,497,292	3	$291,000
Total	**795**	**$15,901,168**	**53**	**$2,618,000**

3.3.2.7 Executive Order (EO) 11988

Executive Order 11988 requires federal agencies avoid, to the extent possible, the long and short-term adverse impacts associated with the occupancy and modification of flood plains and to avoid direct and indirect support of floodplain development wherever there is a practicable alternative. In accomplishing this objective, "each agency shall provide leadership and shall take action to reduce the risk of flood loss, to minimize the impact of floods on human safety, health, and welfare, and to restore and preserve the natural and beneficial values served by flood plains in carrying out its responsibilities."

The Water Resources Council Floodplain Management Guidelines for implementation of EO 11988, as referenced in USACE ER 1165-2-26, requires an eight-step process that agencies should carry out as part of their decision-making on projects that have potential impacts to, or are within the floodplain. The eight steps and project-specific responses to them are summarized below.

1. Determine if a proposed action is in the base floodplain (that area which has a one percent or greater chance of flooding in any given year).

The proposed action is within the base floodplain. However, the project is designed to reduce damages to existing infrastructure located landward of the proposed project.

2. If the action is in the base flood plain, identify and evaluate practicable alternatives to the action or to location of the action in the base flood plain.

Chapter 4 of this document presents an analysis of potential alternatives. Practicable measures and alternatives were formulated and evaluated against the Corps of Engineers guidance, including non-structural measures such as retreat, demolition and land acquisition.

3. If the action must be in the flood plain, advise the general public in the affected area and obtain their views and comments.

A Public Notice and a draft of this report were sent to pertinent Federal, State and local agencies in December of 2013. A public hearing was held in North Wildwood and multiple meetings were held with the local municipalities during the public review period from 20 December 2013 to 10 March 2014 for the Draft Feasibility Report and Integrated Environmental Assessment. The electronic versions of the report were also made available on compact disc and online.

4. Identify beneficial and adverse impacts due to the action and any expected losses of natural and beneficial flood plain values. Where actions proposed to be located outside the base flood plain will affect the base flood plain, impacts resulting from these actions should also be identified.

The anticipated impacts associated with the Selected Plan are summarized in Chapters 5 and 6 of this report. The project would not alter or impact the natural or beneficial flood plain values.

5. If the action is likely to induce development in the base flood plain, determine if a practicable non-flood plain alternative for the development exists.

The project will not encourage development in the floodplain since the project area frontage is 95% developed with 5% of the ocean front parcels that are not developed being owned by the municipality and managed as public space. The project provides benefits solely for existing development.

6. As part of the planning process under the Principles and Guidelines, determine viable methods to minimize any adverse impacts of the action including any likely induced development for which there is no practicable alternative and methods to restore and preserve the natural and beneficial flood plain values. This should include reevaluation of the "no action" alternative.

There is no mitigation to be expected for the Selected Plan. The project would not induce development in the flood plain and the project will not impact the natural or beneficial flood plain values. Chapter 4 of this report summarizes the alternative identification, screening and selection process. The "no action" alternative was included in the plan formulation phase.

7. If the final determination is made that no practicable alternative exists to locating the action in the flood plain, advise the general public in the affected area of the findings.

The Draft Feasibility Report and Integrated Environmental Assessment were provided for public review and a public hearing was held during the public review period. The comments that were received are provided in Volume 3, Appendix G. of the report titled Pertinent Correspondence.

8. Recommend the plan most responsive to the planning objectives established by the study and consistent with the requirements of the Executive Order.

The Recommended Plan is the most responsive to all of the study objectives and the most consistent with the executive order.

4.0 With Project Analysis

4.1 General

This section contains the plan formulation for the Hereford Inlet to Cape May Inlet Feasibility study. Plan formulation is used to identify a list of potential plans in order to reduce impacts from coastal storms, and eventually recommend a selected plan. This analysis involved the establishment of plan formulation rationale, identification and screening of potential measures, and evaluation of detailed plans to address the study objectives outlined in the Corps of Engineers Planning Guidance Notebook, (1105-2-100) and the Corps Planning Manual.

The purpose of the formulation was to identify plans which are acceptable, implementable, and feasible from an environmental, engineering, economic and social standpoint. The plan formulation process was undertaken in three cycles:

Cycle 1 - Initial Screening of Measures
Cycle 2 - Secondary Screening of Measures
Cycle 3 - Final Screening and Optimization

Plan formulation included input from the New Jersey Department of Environmental Protection (NJDEP), the U.S. Fish and Wildlife Service (USFWS) and the Project Development Team as well as the local municipalities. Information from the following Philadelphia District feasibility reports was also used since these studies addressed similar hurricane and storm damage problems along the Atlantic Coast of New Jersey:

New Jersey Shore Protection Study, Barnegat Inlet to Little Egg Inlet, Final Feasibility Report, September 1999

New Jersey Shore Protection Study, Manasquan Inlet to Barnegat Inlet, Final Feasibility Report, June 2002

4.2 Planning Objectives

The Federal objective of water resource planning is to contribute to National Economic Development (NED) in a way that is consistent with protecting the nation's environment pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements contained in Engineering Regulation 1105-2-100. This objective was established by the U.S Water Resources Council's *Economic and Environmental Principles and Guidelines for Water and related Land Resources Implementation Studies* on 10 March 1983.

The objective of the Hereford Inlet to Cape May Inlet study is to formulate solutions to the problems within the study area. These solutions must be acceptable to the study sponsor. Plans were developed to address the following study objectives:

- Reduce erosion, inundation and wave damages and maximize benefits over a fifty year period of time within the study area.

- Apply Regional Sediment Management to the study area in order to maximize the use of sand as a resource.
- Limit environmental and cultural impacts to borrow areas.
- Provide a plan that satisfies the needs of the study sponsors and the local communities within the study area to the fullest extent possible.

4.3 Constraints

Constraints are items that limit the planning process and are unique to each planning study. They include Planning, Technical, Economic, Environmental, Institutional, Regional and Social Constraints.

4.3.1 Planning Constraints

Planning constraints are restrictions that are considered when attempting to meet the identified planning objectives. The formulation of all measures was conducted in accordance with Federal laws and guidelines established for water resources planning in order to avoid constraints and meet the study's objectives.

4.3.2 Technical Constraints

These constraints include physical or operational limitations. The following criteria were used in plan formulation:

- Federal participation in the cost of restoration of beaches should be limited so that the proposed beach will not extend seaward of the historical shoreline of record.

- Natural berm elevations, widths, and foreshore beach slopes should be used as a preliminary basis for the restoration of beach profiles.

- Plans must represent sound, safe, acceptable engineering solutions.

- Plans must comply with USACE regulations.

- Analyses are based on the best information available using accepted methodology.

4.3.3 Economic Constraints

The following items constitute the economic constraints that may impact analysis of the plans considered in this study.

- Analyses of project benefits and costs are conducted in accordance with Corps of Engineers' guidelines and must assure that any plan is complete within itself, efficient and safe and economically feasible in terms of current prices.

- To be recommended for project implementation, benefits must exceed project costs. Measurement shall be based on the NED benefit/cost ratio being greater than one.
- The benefits and costs are expressed in comparable quantitative economic terms to the

maximum practicable extent.

4.3.4 Environmental Constraints

Appropriate measures must be taken to ensure that any resulting project is consistent with local, regional and state plans, and that the necessary permits and approvals are likely to be issued by the regulatory agencies. Further environmental constraints relate to the types of flora and fauna which are indigenous and beneficial to the ecosystem. The following environmental and social well-being criteria were considered in the formulation of alternative plans. Consideration should be given to public health, safety and social well-being, including possible loss of life.

- Avoid detrimental environmental and social effects, specifically eliminating or minimizing the following where applicable:

  air, noise and water pollution;
  destruction or disruption of manmade and natural resources (including endangered or threatened wildlife species), aesthetic and cultural values, community cohesion and the availability of public facilities and services;
  adverse effects upon employment as well as the tax base and property values;
  displacement of people, businesses and livelihoods; and
  disruption of normal and anticipated community and regional growth.

- Maintain, preserve and, where possible and applicable, enhance the following in the study area:

  water quality;
  the beach and dune system together with its attendant fauna and flora;
  wetlands, if any;
  sand as a geological resource;
  commercially important aquatic species and their habitats; and
  nesting sites for colonial birds.

4.3.5 Institutional Constraints

The formulation of alternative plans was conducted in accordance with all Federal laws and guidelines established for water resources planning. According to the Planning Guidance Notebook (ER 1105-2-100), Section IV--Shore Protection, "Current shore protection law provides for Federal participation in restoring and protecting publicly owned shores available for use by the general public." Typically, beaches must be either public or private with public easements/access to allow Federal involvement in providing shoreline protection measures. Private property can be included only if the, "protection and restoration is incidental to protection of publicly owned shores or if such protection would result in public benefits." Items which can affect the designation of beaches being classified as public, include the following:

- A user fee may be charged to aid in offsetting the local share of project costs, but it must be applied equally to all.

- Sufficient parking must be available within a reasonable walking distance on free or reasonable terms. Public transportation may substitute for, or complement, local parking and street parking may only be used if it will accommodate existing and anticipated demands.

- Reasonable public access, defined as every one half mile or less, must be furnished to comply with the planned recreational use of the area.

- Private beaches owned by beach clubs and hotels cannot be included in Federal shore protection activities if the beaches are limited to use by members or paying guests.
- Publicly owned beaches which are limited to use by residents of the community are not considered to be open to the general public and cannot be considered for Federal involvement

4.3.6 Regional and Social Constraints

- The needs of other surrounding regions must be considered and one area cannot be favored to the unacceptable detriment of another
- Consideration should be given to public health, safety and social well-being, including possible loss of life
- Plans should minimize the displacement of people, businesses and livelihoods of residents in the project area
- Plans should minimize the disruption of normal and anticipated community and regional growth.

4.4 Problems Within the Study Area

The following problems were identified based on the existing conditions of the study area based on the problem statement below.

Problem Statement-Erosion in North Wildwood is leaving the municipality vulnerable to storm damage while sand accumulation in Wildwood and Wildwood Crest is clogging municipal storm water systems, degrading beach habitat, causing health issues and leaving the municipalities vulnerable to storm damage. Problems are explicitly identified in **Table 64**.

Table 64 Problems, Opportunities and Objectives Within the Study Area

Problems Within Study Area			Opportunities	Objectives
	Problem	*Explanation*		
1	Erosion, flood and wave damages.	Narrow beaches in North Wildwood and wide, low dune less beaches in Wildwood and Wildwood Crest make the area susceptible to storm damages.	Protect homes and infrastructure from storm damage.	Restore the beaches in North Wildwood with a berm and dune that will reduce future damages and restore beaches in Wildwood and Wildwood Crest with a dune to reduce damages.
2	Impacts from clogged outfalls and decreased recreation experience due to excessive beach width.	The outfalls have stagnant water at their terminus, causing health, safety and flooding issues and municipal fishing piers fall short of waterline.	Restore natural storm-water flow, reduce health and safety issues, maintain recreation and Wildwood Crest fishing pier activity.	Reduce the size of the beach in Wildwood and Wildwood Crest to eliminate storm water ponds.
3	Maintenance costs to keep outfalls open.	The outfalls within the study area have to be excavated daily and money has been expended to extend them in the past.	Mitigate for monetary damages caused by excessive beach growth.	Us the excess sand in Wildwood and Wildwood Crest as a source of beach nourishment material for North Wildwood, Wildwood and Wildwood Crest

Although the closure of Turtle Gut Inlet in the 1920's likely added a significant amount of sand to the beaches in the study area from the onshore welding of the ebb shoal, re-opening that inlet to reduce the accumulation of sand and un-clog municipal outfalls would prove to be problematic from an economic, real estate and environmental perspective. Acquisition costs of purchasing properties, paying for relocations and utility relocations would exceed project benefits and re-opening of the inlet might have un-intended consequences on down drift beaches, which are protected and maintained by the US Fish and Wildlife Service. Consideration of this alternative was raised during the review process and the District felt that the re-opening of the inlet would not address the problems, opportunities and objectives to a level that it should be considered further in the plan formulations phase.

4.5 Cycle 1 - Initial Screening of Solutions

In Cycle 1, measures were identified and evaluated on the basis of their suitability, applicability, merit in meeting the study objectives, engineering criteria and potential to solve the indentified problems listed above. The goal of the Cycle 1 analysis was to screen out those measures that do not fulfill the needs of the study area based on technical appropriateness and economic feasibility. Judgments were made about each alternative based on knowledge gained from past reports and the experience of study team members. In addition, all measures were measured for their completeness, effectiveness, efficiency and against the study's objectives.

The initial screening addressed both non-structural and structural measures. Non-structural measures control or regulate the use of land such that damages may be reduced or eliminated. When implementing non-structural measures, no attempt is made to reduce, divert or otherwise control coastal processes or storm damage mechanisms. Typically, specific non-structural solutions include: regulation of any future development (setback limits, building elevation restrictions etc.), and permanent evacuation of the study area. These options are typically not feasible due to the level of development of a region.

Structural measures protect property by modifying the existing coastal processes and/or by providing a buffer to reduce potential storm damage. Typical structural measures include seawalls, bulkheads, revetments, breakwaters, groins and beach fill. The list of measures that was identified to solve the water resource problems are contained below

Non –Structural Measures

- No action
- Regulation of future development
- Permanent evacuation

Structural Measures

- Berm & Dune Restoration using Backpass Technology
- Berm & Dune Restoration from an Inlet Source
- Groins
- Excavate Sand from in Front of Outfalls
- Extend Outfalls
- Combine Outfalls
- Bulkhead around Piers
- Seawall
- Elevate Amusements
- Remove Amusements
- Hereford Inlet Channel Maintenance
- Geotextile tubes

These plans were measured against the projects objectives, the four planning criteria and the five evaluation tasks from the Planning Manual in the following Cycle -1 screening. A description of each plan is provided below.

Non Structural Measures

No Action. This measure would involve leaving the island to erode naturally at the north end in North Wildwood and allow Wildwood and Wildwood Crest to continue to accumulate sand. This will require significant expenditures by both municipalities as detailed later in this section in the form of local beach fills and municipal outfall extensions and beach maintenance. This measure does not meet any of the stated objectives. In the absence of Federal involvement, the potential without-project damages discussed in section 3 of this report would be realized.

Regulation of Future Development. The with project condition for this measures involves land use controls enacted through codes, ordinances, or other regulations to minimize future development and damages on presently undeveloped lands. Such regulations are traditionally the responsibility of state and local governments. Regulations are currently in place to control future development and reduce susceptibility to damage such as the Coastal Area Facility

Review Act (CAFRA) and FEMA guidelines. The State of New Jersey restricts building at the shore to landward of existing dune or bulkhead lines. Regulation of future development lends itself more to relatively large, continuous, undeveloped areas rather than heavily developed areas. Comparison of the with and without project condition for this measures are extremely similar since it is unlikely that any regulation of future development would reduce the susceptibility of this area due to the current level of development. There is only once section within the project area that is undeveloped, the USFW property at Cape May Inlet. No beach nourishment activities are being considered there. Therefore additional regulation to prevent new development would have little to no impact on the study area.

Permanent Evacuation. Permanent evacuation involves retreat from and abandonment of coastal areas experiencing ongoing erosion and subject to future storm damage. This would require acquisition of lands and structures either by purchase or through the exercise of powers of eminent domain, if necessary. Following this action, all commercial and residential property in the acquired areas would either be demolished or relocated to another site. The level of development within the study area would make this measure cost prohibitive.

Structural Measures

Berm and Dune Restoration Using Backpass Technology. This would involve excavating the entire beach in front of the outfalls and shaping the sand into a dune and berm for storm damage reduction benefits. This measure would protect North Wildwood, Wildwood, Wildwood Crest and Lower Township from storm damages and require less maintenance than excavating the sand from in front of the outfalls. This measure would be better than the without project measure since it provides storm damage reduction to the area and relieves the maintenance burden from Wildwood and Wildwood Crest of excavating sand from in front of the outfalls. This measure meets all three of the project primary objectives listed in **Table 64**.

Berm and Dune Restoration Using Inlet Dredge Source. Berm and dune restoration can provide a high level of storm protection, merges favorably with the existing environment, and has been shown in recent Philadelphia District studies to be the most effective and cost efficient measure in terms of providing protection from storms. Of all measures considered, a combined berm and dune system most closely replicates conditions typically found along natural undisturbed barrier island shorelines. This measure would protect North Wildwood, Wildwood, Wildwood Crest and Lower Township from storm damages, but it would exacerbate the impact of excess sand on the beaches in Wildwood and Wildwood Crest by adding more sand to the system. This measure satisfies only 1 objective from **Table 64**.

Groins. Groins are coastal structures built perpendicular to the shoreline. They extend from the upper beach face into the surf zone and are designed to trap littoral drift and retain sand on the beach. Properly designed groins can stabilize an eroding shoreline, reduce periodic nourishment requirements and consequently prevent sand from moving into adjacent beaches. Since the sediment imbalance in the study area is resulting in erosion in North Wildwood and sand accretion in Wildwood City, a groin or groin field may help balance the sediment in the area. But groins provide no protection from storm surge, and must be combined with a dune or other structure that is designed to provide storm wave and flood damage reduction. Groins would only solve 2 of the problems in the study area identified in **Table 64** by temporarily reducing the migration of sand into Wildwood and Wildwood Crest.

Excavate Sand in Front of Outfalls. Trenching sand from directly in front of the outfalls in Wildwood and Wildwood Crest would temporarily alleviate their clogged storm water outfall problem. This is currently done by the Public Works Departments on a daily basis. The employees use a backhoe to dig a 5' by 5' trench approximately 300' from the terminus of the outfall to the ocean. This is a temporary solution to the problem whose costs have been outlined in the Existing Conditions section of this report. This measure would not solve the storm damage problem in the project area. This would only solve objectives 2 and 3 in **Table 64**.

Extend Outfalls The City of Wildwood commissioned an Engineering Report to be written by Remington and Vernick that outlined costs of extending their beachfront outfalls. The costs associated with that option were excessive when compared to the daily maintenance cost of excavation. This report identified a cost of extending the outfalls between 9-11 million dollars. **Table 64**. This measure would not satisfy the objective of providing storm damage reduction benefits.

Combine Outfalls The report written for the City of Wildwood by Remington & Vernick recommended combining the storm water outfalls into a single manifold system and extending one outfall on the beach and re-routing all the urban run-off through that pipe. Costs associated with this option may be prohibitive considering the cost of daily excavation and maintenance. This measure would not satisfy the objective of providing storm damage reduction benefits. This report identified a cost of extending the outfalls between 9-11 million dollars. **Table 64**.

Bulkheads around Piers. Bulkheads are shore-parallel structures usually built at or above the mean high water line to prevent wave, inundation, and/or erosion damages. The crest elevation is the primary design parameter controlling the effectiveness in reducing wave and flooding damages. Under normal conditions, bulkheads have no impact on littoral drift. However, if the beach erodes to the point where waves are frequently impacting the bulkhead, erosion may be accelerated due to scour at the base. This may lead to permanent loss of dry beach in the absence of sand nourishment. Berm placement and periodic nourishment in front of the structure can prevent such failures, but the combined costs may be prohibitive. Bulkheads are costly, but can be effective in preventing wave and flood damages at the end of the piers located on the beach. This measure was expanded to include the potential for dunes around the piers, not just bulkheads. This measure would only solve a small portion of providing storm damage reduction benefits to the piers, not the rest of the communities that are identified in **Table 64**.

Seawalls. Seawalls are large shore-parallel structures usually built above the mean high water line to prevent wave, inundation, and/or erosion damages. They are typically wider structures with a stone face intended to reduce wave damage and prevent overtopping and flooding. Crest elevation is the primary design parameter controlling the effectiveness in reducing wave and flooding damages. Seawalls are costly, but can be very effective in preventing wave and flood damages. This measure would protect North Wildwood, Wildwood, Wildwood Crest and Lower Township from storm damages, but it would be very costly across 7 miles of beach, locally it might not be acceptable, and it may increase erosion potential of the beach in the long term.

Elevate Pier Amusements . The project area has 4 piers on the beach that have outer sections that are not traditional piers. The seaward ends of the piers are built at the beach level, making them susceptible to storm damage. Elevating the seaward end of the piers is one way to avoid damage from coastal storms, but these structures represent a very small portion of the study area and formulating a repair to protect them would only accomplish a fraction of the project's objectives of storm damage reduction.

Remove Pier Amusements. The project area has 4 piers on the beach that have outer sections that are not traditional piers. The seaward ends of the piers are built at the beach level, making them susceptible to storm damage. Removing the seaward end of the piers is one way to avoid damage from coastal storms, but these structures represent a very large portion of the study areas economy and could have detrimental impacts to the municipalities they are within.

Hereford Inlet Channel Maintenance. The position of the Hereford Inlet channel could aggravate the erosion problem in North Wildwood. As the inlet channel migrates between the northern and southern portion of the inlet it cuts a channel in the sand in order to fill and drain the back bay during rising and falling tides. When this channel reaches a southern position in Hereford Inlet it is thought to cause erosion in North Wildwood. Maintaining the Hereford inlet channel in a central or northerly position might reduce erosion of the beach in North Wildwood. Analysis of this inlet process is out of the scope of this study due to the modeling requirements.

Geotextile Tubes . This measure consists of the use of sand-filled geotextile tubes (geotubes) as a structural core of a sand dune. Depending on placement, the geotubes may provide greater protection than a traditional sand dune since they are more resistant to erosion. The bottom of the geotube core needs to be placed at or below the base of the dune to prevent scour, undercutting, and slumping failure of the geotube. Geotubes should remain covered under non-storm conditions to prevent failure due to puncture and ultraviolet light degradation. Once the geotube is fully exposed during a storm, stability against direct wave attack and overtopping is questionable. Therefore, a geotube core may be effective in reducing erosion damages, but is not expected to provide significant wave and inundation damage reduction. Cost effectiveness of a geotube core would require that potential benefits of decreased erosion damage exceed the added costs of constructing and maintaining the geotube core within the dune. This measure would protect North Wildwood, Wildwood, Wildwood Crest and Lower Township from storm damages, but it would be very costly across an entire 7 miles of beach, locally it might not be acceptable, and it may increase erosion potential of the beach in the long term.

The Cycle -1 analysis was accomplished in a three part screening process using the recommendations from the Planning Guidance Notebook (1105-2-100) and the Corps Planning Manual. The first part was to measure the measures against the four planning criteria for Completeness, Effectiveness, Efficiency and Acceptability (**Table 65)**. The second part of the screening was to compare the measures to the study's objectives (**Table 66)**. The third part combined the Corps Five Part Evaluation Phase, from the IWR Planning Manual, (Chapter 9 page 147) with the results of the four planning criteria screening, and the objectives screening (**Table 67)**. If the management measure satisfied one of the screening criteria, or a study objective, it received a "1". All the scores that the management measure received for each part of the screening process were totaled at the right side of the table. Those scores were then carried over to the Five Part Evaluation phase table for the final Cycle -1 screening. Study objectives and planning criteria were all weighted equally.

Table 65 Study Measures Measured Against the Four Planning Criteria

	Measure	Complete	Effective	Efficient	Acceptable	Score
Non -Structural	**No Action**	Not Complete.	Not effective. since the outfalls re clogged.	Efficient.	Not Acceptable.	**1**
	Regulation of Future Development	Not complete. Would not solve the storm outfall clogging problem.	Entire Island from Hereford Inlet o Cape May Inlet is almost 100% built upon, no positive impacts from regulation	Efficient from a cost perspective, not likely to impact anything.	Not Acceptable.	**1**
	Permanent Evacuation	Complete. No erosion, damages or clogging issues would arise if the island were empty.	Effective.	Very costly. Likely to be costly t remove and relocate tens of thousands of property owners. Buyouts and relocation would far exceed the cost of placing sand.	Not Acceptable.	**2**
Structural	**Berm and Dune Restoration/Backpass**	The most complete option of all measures. Will alleviate the outfall clogging issues and the lack of sand in North Wildwood.	Extremely effective. This is a proven method to alleviate sediment imbalances.	Likely to have positive BCR, NED benefits	Acceptable to NFS and to the Corps, the local sponsors will require more analysis on potential impacts.	**4**
	Berm and Dune Restoration/Inlet	Not Complete. Would not solve the problem of sediment surplus, clogged outfalls in Wildwood and Wildwood Crest.	Effective at adding sand to North Wildwood, but not effective at reducing outfall maintenance costs in Wildwood and Wildwood Crest.	Not as efficient in using sand resources	Acceptable to North Wildwood since they don't have as much of a maintenance issue with outfalls, but downbeach communities would incur costs for removing	**3**
	Groins	Not Complete. The additional of groins would not solve primary problems wave/inundation damages	May be Effective at reducing sediment surplus in Wildwood and Wildwood Crest over time.	Not Efficient, Costs of groins is high relative to their benefits	Acceptable.	**2**
	Excavate Sand From in Front of Outfalls	Not Complete. Would not resolve issues at North Wildwood with erosion, storm damage.	Not effective. Current practice in Wildwood. Needs to be done on a daily basis and cannot be done during storm events which cause interior sections to flood since the outfalls re clogged.	Efficient. Cheap labor costs to excavate the sand.	Local sponsors do not see this as acceptable, and are looking for measures.	**1**
	Extend Outfalls	Not Complete. Extending the outfalls would alleviate the clogging problem, but would not fix the erosion problem at North Wildwood.	Effective for stopping clogging of the outfalls.	Extending the outfalls is cheaper than excavating the sand using backpass technology, but not cheaper than excavating the outfalls daily.	Likely Acceptable. Wildwood Crest has performed this twice in the past 10-15 years.	**3**
	Combine Outfalls	Not Complete. Would not resolve issues at North Wildwood with erosion, storm damage.	Effective for stopping clogging of the outfalls.	Very costly. Combining the outfalls into a single manifold system would likely cost more than backpassing sand,	Not acceptable due to costs.	**1**
	Bulkhead Around Piers	Not Complete. Would leave other portions of the area vulnerable to other damages.	Effective only at pier.	Costly compared to beach fill, but damage potential may be high.	Acceptable.	**3**
	Seawall	Not Complete, would not solve outfall problem or erosion problem, would likely increase erosion rates in North Wildwood.	Effective at reducing damages in North Wildwood.	Very Costly, likely exceeds benefits.	Not Acceptable.	**1**
	Elevate Amusements	Amusements are built at low elevations but elevating them would only reduce a portion of potential damages.	Effective in a small area.	Very costly.	Not Acceptable.	**1**
	Remove Amusements	Amusements are built at low elevations but elevating them would only reduce a portion of potential damages.	Effective in a small area.	Very costly.	Not Acceptable.	**1**
	Hereford Inlet Channel Maintenance	Would potentially reduce erosion at North Wildwood, which may reduce dowdrift sediment transport.	May be effective.	Not as costly as other measures.	Likely Acceptable, but determining the impacts of maintenance may prove difficult, may	**1**
	Geotextile Tubes	Not Complete. Would not solve the issue of too much sand in Wildwood and Wildwood Crest unless tubes were filled with sand from those areas.	Effective at preventing damages where tubes are in place. May have issues with tearing, exposure, vandalism.	No, slightly costlier than regular beach fill since labor costs and material costs for tubes have to be included.	Acceptable.	**2**

After the initial screening against the four planning criteria it became apparent that the berm and dune restoration using backpass technology was the only measure that met each criteria for being complete, efficient, effective and acceptable. Berm and dune restoration using an inlet source extending outfalls, and a bulkhead around piers was tied for the second highest score against the four planning criteria.

The screening of the measures against the study objectives is contained in **Table 66.** The management measure that scored the highest against all the projects objectives was Berm and Dune Restoration Using Backpass Technology. Groins finished second and Berm and Dune restoration using an inlet borrow source was third.

Table 66 Study Measures Measured Against the Objectives

	Project Objectives (7)							
Measures	**Erosion Protection**	**Inundation Protection**	**Wave Protection**	**Reduce Outfall Costs**	**Low Env./Cult Impacts**	**RSM Benefits**	**Customer Satisfaction**	**Total**
No action	N	N	N	N	Y	N	N	**1**
Regulation of future development	N	N	N	N	Y	N	N	**1**
Permanent Evacuation	N	N	N	N	Y	N	N	**1**
Berm & Dune Restoration /Backpass	Y	Y	Y	Y	Y	Y	Y	**7**
Berm & Dune Restoration/Inlet Source	Y	Y	Y	N	N	N	Y	**4**
Groins	Y	Y	N	Y	Y	N	Y	**5**
Excavate Sand from in Front of Outfalls	N	N	N	N	N	N	N	**0**
Extend Outfalls	N	N	N	N	Y	N	Y	**2**
Combine Outfalls	N	N	N	N	Y	N	Y	**2**
Bulkhead around Piers	Y	Y	Y	N	Y	N	Y	**5**
Seawall	Y	Y	Y	N	N	N	N	**3**
Elevate Amusements	N	Y	Y	N	Y	N	N	**3**
Remove Amusements	Y	Y	Y	N	N	N	N	**3**
Modify Hereford Inlet	Y	N	N	N	N	N	N	**1**
Geotextile Tubes	Y	Y	Y	N	N	N	Y	**4**

Scoring for the four planning criteria was combined with the scoring against the study's objectives and the Five Part Evaluation Phase in **Table 67.**

Table 67 Combined Five Part Evaluation with the 4 Planning Criteria and Objectives Scoring

Measures	Forecast With Project	With vs. Without	Differences	Appraisal	Objectives	Criteria	Criteria + Objectives
No Action	Result in continued erosion and beach accretion	No change	No change	Nothing to appraise, continues erosion, accretion	1	1	**2**
Regulation of Future Development	Not likely to have impact due to level of development	No change, project area fully built out	Change in public laws, building codes, development patterns	Not likely, project area built out almost completely. May work in sparsely developed areas of the island, which are very few	1	1	**2**
Permanent Evacuation	Expensive, not likely to be politically feasible	Permanent evacuation would involve removing full time and part time residence while the without project condition would allow them to stay	Change in housing inventory, offshore development would increase, mass removal of property, infrastructure, roads, etc…	Not favorable, high costs, probably not feasible	1	2	**3**
Berm and Dune Restoration/Backpass	Favorable, likely to result in storm damage reduction	The with project condition would involve hydraulically backpassing sand from Wildwood and Wildwood Crest to North Wildwood to achieve a specific design template and the Without condition would be no action, continued erosion at the north end of the island and accumulation of sand in the middle of the island	Improve HSDR, improved drainage	Favorable, could solve two problems in the study area of excess sand and sand deficits, meet projects objectives, regionally manage sediment, and reduce impacts to Hereford Inlet which is already being used as a source of material for other projects	7	4	**11**
Berm and Dune Restoration/Inlet	Favorable, likely to improve storm damage reduction, but not excess sand in Wildwood and Wildwood Crest, may exacerbate ponding and clogged outfall issues, would decrease recreation at fishing pier	The with project condition would involve dredging sand from Hereford Inlet and placing it in a specific design temple while the Without condition would be no action, continued erosion at the north end of the island and accumulation of sand in the middle of the island	Improved HSDR, deteriorated interior drainage	Slightly less favorable than backpass option, but will provide storm damage reduction benefits	4	3	**7**
Groins	Likely to enhance other plans and reduce longshore transport, but not a standalone project	The with project condition would involve constructing groins to reduce sediment transport and trap sand in a fillet area, the without project condition would involve allowing the sand to move throughout the project area. These groins would be placed in the middle of the island in a series to reduce transport into the beach sections currently receiving excess sand. They would be stone and possibly timber.	Sand impoundment in fillet, improved drainage below fillet	Favorable, but costly, don't provide storm damage reduction benefits, but may help manage littoral transport and sand impacts downbeach	5	2	**7**
Excavate Sand From in Front of Outfalls	Currently being performed by locals	Currently being performed by locals, with vs. without condition are same	Daily excavation of small amounts of sand is the same as the without project condition.	Current practice by Wildwood, less favorable than other options, would continue under No Action plan	0	1	**1**
Extend Outfalls	Current practice in Wildwood and Wildwood Crest	Currently being preformed every few years by locals, with vs. without condition are same	Capital improvement costs increase for Wildwood and Wildwood Crest significantly as the cost for pipe and construction materials for extended outfall systems.	Current practice by Wildwood, less favorable than other options, would continue under No Action plan	2	3	**5**
Combine Outfalls	No Corps Authority, expensive	Would involve the construction of a manifold system to pump stormwater into central drainage basin, then offshore. Without project condition would involve the continued accumulation of material in from of the outfalls	Manifold construction, pump house construction, impacts to beach and recreation experience with infrastructure on the beach, increase in storm damages to new infrastructure.	Costly, technically possible but might be out of reach of local municipalities	2	1	**3**
Bulkhead Around Piers	Costly, but likely to prevent damages to piers by shielding them with steel sheetpile bulkheads driven below surface.	Construction at the seaward end of the piers would reduce storm damage, without project condition would be to allow the damage elements to remain vulnerable	Bulkheads and or dunes built around the seaward end of the piers, may increase erosion in front of piers if a bulkhead, if a dune, they may not withstand storm and erosion events due to the location	This option has already been constructed at one pier in North Wildwood to reduce damages, and is performing well. But a dune was also placed in front of this pier by the NJDEP, but this dune did not last and placing a dune in this location would probably not last on future projects	5	3	**8**
Seawall	Costly, involve the transportation of large amounts of stone to project area, may be difficult to construct at the study area	Construction of a seawall from Hereford Inlet to Cape May Inlet, the without project condition would allow continued inundation from storms and waves from the ocean side to reach the interior of the island	Rock wall 10-14 feet in height, would protect the area from storm damages but may impact nearshore environment, dunes and habitat.	This would be costly and the damages in the project area might not support it, high impacts, possible erosion impacts at the beach	3	1	**4**
Elevate Amusements	Elevate damage elements seaward of the boardwalk. Never attempted before, retro-fitting amusement rides would be extremely difficult, dangerous and likely impossible	The difference between with and without is that the with project would elevate the damage elements and the without would keep them in place	Building up piers and the foundation of the amusements and rides to reduce their storm damages	Not possible, should be removed from screening, protection is better option	3	1	**4**
Remove Amusements	Removal of all damage elements seaward of the boardwalk.	The difference between with and without is that the with would elevate the damage elements and the without would keep them in place	Remove piers and the foundation of the amusements and rides to reduce their storm damages	Not possible, should be removed from screening, protection is better option, similar to permanent evacuation	3	1	**4**
Hereford Inlet Channel Maintenance	May or may not have desired effect on project area, difficult to predict. Would require extensive modeling.	The difference between the with and without is the dredging of Hereford Inlet vs. not dredging it	Dredging to reduce erosion impacts at North Wildwood	Not impossible, somewhat likely, but impacts of adjacent shoreline are unknown without more analysis, results may take years to develop, riskier than placing material	1	1	**2**
Geotextile tubes	Favorable, likely to improve storm damage reduction	Geotextile tubes would be placed from Hereford Inlet to Cape May Inlet vs. not placed, the placement of these geotubes would reduce storm damages	Geotextile fabric filled with sand to mimic dunes to reduce damages instead of regular sand dunes	Similar to dunes, but may increase erosion after exposed, geotextile has a tendency to rip if exposed, likely to with stand overwash better than a dune in extreme conditions	4	2	**6**

Planning Criteria Scoring

Measures that scored well against the 4 Planning Criteria were; Berm and Dune Restoration Using Backpass Technology (4), Berm and Dune Restoration Using an Inlet Borrow Source (3), Bulkhead Around Piers (3), Groins (2), Extend Outfalls (2) and Permanent Evacuation (2), Geotextile Tubes (2).

Measures that did not score well against the four criteria were No Action (1), Regulation of Future Development (1), Excavation of Sand in Front of the Outfalls (1), Combining Outfalls (1), Seawall (1), Elevate Amusements (1), Remove Amusements (1), and Hereford Inlet Channel Maintenance (1)

Objectives Scoring

Measures that scored well against the planning objectives are; Berm and Dune Restoration using Backpass Technology (7), Bulkhead Around the Piers (5) Berm and Dune Restoration using an Inlet Borrow Source (4), Groins (4).

Measures that did not score well against the study's objectives are; Excavating Sand from in Front of the Outfalls (0), No Action (1), Regulation of Future Development (1), Permanent Evacuation (2) Extend Outfalls (2), Combine Outfalls (2), Seawall, (3) Elevation of Amusements (3) and Remove Amusements (3).

The combined ranking of the management measures against; 1- The Four Planning Criteria, 2- The Projects Objectives and 3- the appraisal section of the Five Point Evaluation is summarized below.   Tie scores in the Cycle- 1 screening process were settled by qualitative evaluation from the Corps Five Part Evaluation table.

1. Berm and dune restoration using backpass system
2. Bulkhead around the piers
3. Berm and dune restoration using inlet source
4. Groins
5. Geotextile tubes
6. Extend outfalls
7. Seawall
8. Elevate amusements
9. Remove amusements
10. Combine outfalls
11. Permanent evacuation
12. Hereford Inlet channel maintenance
13. Regulation of future development
14. No Action
15. Excavate Sand From in front of outfalls

Measures that were excluded from further analysis are listed here. Extending the Outfalls was excluded since this is not within the authority of the Army Corps of Engineers. Constructing a Seawall was excluded due to costs, and the potential erosion impacts it may cause. Elevating and Removing the Amusements was excluded since it is not likely feasible at this stage of development and likely not possible. Combining the outfalls into a single pump house and flushing the material offshore was excluded since it would not solve the issue of erosion and storm damage across the study area and it also appeared cost prohibitive ($9-$11 million dollars 2007 P.L., **Table 61**). Permanent Evacuation was excluded since it is not likely to be feasible at the current level of development on the island. Hereford Inlet Channel Maintenance was excluded since the direct impacts are not clear on the study's objectives, and maintaining a different channel position may or may not reduce erosion in North Wildwood and the different channel configurations would also need to be modeled beyond the scope of this study. Regulation of Future Development was excluded since the study area is almost 100% built out, the No Action Plan was also excluded from further analysis.

4.6 Cycle-2

In accordance with the Planning Manual and the Planning Guidance Notebook (1105-2-100) the array of measures after Cycle 1 were evaluated against a System of Accounts (**Table 68)** which included; National Economic Development (cost effectiveness, federal tax revenues) , Regional Economic Development (jobs, income, taxbase) , Environmental Quality (air quality, topography, groundwater, hydrodynamics, water quality, terrestrial ecology, wetlands, benthic resources, shellfish, finfish, endangered species) and Other Social Effects (cultural resources, aesthetics) for the Cycle 2 analysis. The five remaining management measures for the System of Accounts are:

1. Berm and dune restoration using backpass system
2. Bulkhead around the piers
3. Berm and dune restoration using inlet source
4. Groins
5. Geotextile tubes

Table 68 System of Accounts

Resource Categories	berm and dune restoration/backpass	berm and dune restoration/inlet source	Bulkhead/dune around piers	groin field	geotubes
1-National Economic Development					
Cost effectiveness	Sand backpassing would most likely be the 2nd most cost effective method for re-nourishment.	Inlet dredging would most likely be the most cost effective method for re-nourishment.	The construction and building material may render this not cost effective.	The construction and building material may render this not cost effective.	May be cost effective but performance has been an issue in the past.
Federal tax revenues	NJ travel and tourism generated $3,088,000 in Federal tax revenue. (1)	NJ travel and tourism generated $3,088,000 in Federal tax revenue. (1)	Not likely to have impact.	Not likely to have impact.	Not likely to have impact.
2-Environmental Quality					
air quality	Emissions discharges from dredge and construction equipment would be minor, temporary.	Emissions discharges from dredge and construction equipment would be minor and temporary.	Emissions discharges from dredge and construction equipment would be minor, temporary.	Emissions discharges from dredge and construction equipment would be minor, temporary.	Emissions discharges from dredge and construction equipment would be minor, temporary.
topography and soils	Beach/Nearshore: Impacts on beach topography would be beneficial by providing a consistent stable beach profile during the project life. Beach berm elevation would be raised by a few feet over existing profile. Sand fill would be compatible with existing beach sand and used as nourishment material in North Wildwood. Offshore, no effect.	Beach/Nearshore: Impacts on beach topography would be beneficial by providing a consistent stable beach profile during the project life. Beach berm elevation would be raised by a few feet over existing profile. Sand fill would be compatible with existing beach sand and used as nourishment material in North Wildwood. Offshore, change in borrow area depth	Beach/Nearshore: Without nourishment, long term effects may involve loss of beach profile due to continued erosion, resulting in an abrupt break in the profile at the revetment interface with intertidal or subtidal areas. Offshore: No effect.	Beach/Nearshore: small footprint of the beach taken up by rock. Offshore: same as in the nearshore.	Beach/Nearshore: tubes would represent the core of a dune. Topographic changes would result in areas that have no existing dune raising a dune several feet higher than the beach. With no nourishment, the geotextile tube dune would be subject to undercutting and exposure. Offshore: Material to fill geotextile tubes and dune would most likely be obtained from an offshore source, which would induce changes in depth in the borrow site. However, the impacted area would be significantly less than berm and berm and dune restoration because less material would be required.

groundwater	Not likely to have impact.	Not likely to have impact.	Not likely to have impact.	Not likely to have impact.	Not likely to have impact.
Resource Categories	**grade and re-shape entire beach/backpass**	**berm and dune restoration/inlet source**	**bulkhead**	**groin field**	**geotubes**
hydrodynamics	Beach/Nearshore: Only negligible effects are expected on nearshore transport and beach run up. Intertidal zone would be displaced landward in borrow areas and seaward in placement area. Offshore: Only negligible effects are expected on wave climate.	Beach/Nearshore: Only negligible effects are expected on nearshore transport and beach run up. Intertidal zone would be displaced seaward. Potential impacts to wave environment in Hereford Inlet and adjacent shorelines. Offshore: Negligible effects are expected on wave climate.	Beach/Nearshore: It is generally believed that hardened structures such as revetments without beach nourishment could exacerbate erosion to adjacent unprotected areas. Sand nourishment could mitigate this effect. Offshore: No effect.	Beach/Nearshore: Groins would alter alongshore transport by trapping sand in the compartments. If not constructed properly, groins have potential to starve downdrift beaches of littoral drift sand. Offshore: Same as berm restoration.	Geotube construction may have small impact on hydrodynamics as reflected waves travel back to the nearshore and cause erosion of the beachface
water quality	Beach/Nearshore: Backpassing sand from Wildwood to North Wildwood would allow the flow of water through municipal stormwater system and reduce ponded areas on the beach, Material is mainly sands, however, resuspension of materials during fill placement would have temporary, minor adverse impacts on water quality. Offshore: Material is mainly sands, however, resuspension of materials during dredging would have temporary minor adverse impacts on water quality.	Beach/Nearshore: Negative impact on water quality by increasing the probability of ponded water at outfall terminus and the creation of stagnant water ponds, material is mainly sands, however, resuspension of materials during fill placement would have temporary, minor adverse impacts on water quality. Offshore: Material is mainly sands, however, resuspension of materials during dredging would have temporary minor adverse impacts on water quality.	Temporary During Construction	Temporary During Construction.	Temporary During Construction.

terrestrial ecology	Beach/Nearshore: Beachfill placement would initially displace mobile organisms and smother non-mobile organisms during construction, however, a wider berm would provide a wider more stable beach habitat.	Beach/Nearshore: Beachfill placement would initially displace mobile organisms and smother non-mobile organisms during construction, however, a wider berm would provide a wider more stable beach habitat.	Beach/Nearshore: revetment or seawall may reduce terrestrial habitat diversity for the upper beach and dune area.	Not likely to have impact.	Beach/Nearshore: A dune system w/ a geotextile tube core would provide greater terrestrial habitat diversity on the upper beach flora and fauna.
	Offshore: Not applicable	Offshore: Not applicable	Offshore: Not applicable		Offshore: Not applicable
wetlands	Beach/Nearshore: NA. Offshore: Not applicable.	Beach/Nearshore: NA. Offshore: Not applicable.	Beach/Nearshore: NA. Offshore: Not applicable.	Not likely to have impact.	Beach/Nearshore: NA. Offshore: Not applicable.
Resource Categories	**grade and re-shape entire beach/backpass**	**berm and dune restoration/inlet source**	**bulkhead**	**groin field**	**geotubes**
benthic organisms	Beach/Nearshore: Benthos of the intertidal and nearshore zones would initially be impacted, however, recovery is expected to be rapid due to adaptive capabilities of benthic organisms in these highly dynamic environments.	Beach/Nearshore: Benthos of the intertidal and nearshore zones would initially be buried, however, recovery is expected to be rapid due to adaptive capabilities of benthic organisms in these highly dynamic environments.	Beach/Nearshore: Impacts would be minimal since most of the construction would occur on the upper beach.	Beach/Nearshore: Same as berm and dune restoration, except that groins would permanently convert soft-sandy bottom into hard rock bottom within each groin footprint. This would result in a different type of benthic community, which would most likely include mussels, barnacles, starfish, and amphipods.	Beach/Nearshore: Impacts would be minimal since most of the construction would occur on the upper beach.

	Offshore: no effects on offshore benthos.	Offshore: Benthos within portion of borrow area being utilized would be destroyed during dredging. Borrow area impacted may take up to 2 years for benthic recovery assuming that similar environmental conditions to the pre-dredge locations exist in the post-dredge locations.	Offshore: No Effect.	Offshore: No Effect.	Offshore: No Effect.
shellfish and essential fish habitat	Beach/Nearshore: temporary Impact to prey resources. Recruitment and recolonization is expected shortly after construction is completed. Offshore: No temporary loss of commercial surf clams and other shellfish and reproductive stocks within the offshore borrow site since the material would be taken from an upland borrow site.	Beach/Nearshore: temporary Impact to prey resources. Recruitment and recolonization is expected shortly after construction is completed. Offshore: Temporary loss of commercial surf clams and other shellfish and reproductive stocks within offshore borrow site. Areas would be left for recolonization/recruitment after dredging ceases.	Beach/Nearshore: No Impacts since most of the construction would occur on the upper beach.	Beach/Nearshore: Impacts would be minimal since most of the fill placement and construction would occur on the upper beach. May Create Shellfish Habitat.	Beach/Nearshore: No Impacts since most of the fill placement and construction would occur on the upper beach.

			Offshore: No Effect.	Offshore: No Effect..	Offshore: Same as berm and dune restoration, but on a smaller scale.
Resource Categories	**grade and re-shape entire beach/backpass**	**berm and dune restoration/inlet source**	**bulkhead**	**groin field**	**geotubes**
finfish and essential fish habitat	Beach/Nearshore: Most highly mobile finfish would be able to avoid beachfill placement area during construction. Turbidity generated could clog gills and inhibit respiration and adversely affect sight feeders. Burial of benthic community may temporarily disrupt food chain in impacted area. Offshore: Finfish would not be effected since the dredging would take place onshore/upland.	Beach/Nearshore: Most highly mobile finfish would be able to avoid beachfill placement area during construction. Turbidity generated could clog gills and inhibit respiration and adversely affect sight feeders. Burial of benthic community may temporarily disrupt food chain in impacted area. Offshore: Most highly mobile finfish would be able to avoid the dredging intake during dredging. Turbidity generated could clog gills and inhibit respiration and adversely affect sight feeders. Loss of benthic community may temporarily disrupt food chain in impacted area.	Beach/Nearshore: Impacts would be minimal since most of the fill placement and construction would occur on the upper beach.	Beach/Nearshore: Impacts would be minimal since most of the fill placement and construction would occur on the upper beach.	Beach/Nearshore: Impacts would be minimal since most of the fill placement and construction would occur on the upper beach.

			Offshore: No Effect.	Offshore: No Effect.	Offshore: Same as berm restoration
endangered species	Beach/Nearshore: Potential impacts to threatened and endangered nesting shorebirds: piping plover, least tern and black skimmer. Timing restrictions and avoidance of nests should be observed during construction. Wider beach may become more attractive to these birds, which is considered adverse if it is a heavily urbanized beach subject to frequent human/animal disturbance. Offshore: No impacts to offshore endangered species.	Beach/Nearshore: Potential impacts to threatened and endangered nesting shorebirds: piping plover, least tern and black skimmer. Timing restrictions and avoidance of nests should be observed during construction. Wider beach may become more attractive to these birds, which is considered adverse if it is a heavily urbanized beach subject to frequent human/animal disturbance. Offshore: Use of hopper dredge from 6/15 – 11/15 could potentially impact Federally listed threatened and endangered sea turtles and marine mammals.	Beach/Nearshore: Potential impacts to threatened and endangered nesting shorebirds: piping plover, least tern and black skimmer. Timing restrictions and avoidance of nests should be observed during construction. Wider beach may become more attractive to these birds, which is considered adverse if it is a heavily urbanized beach subject to frequent human/animal disturbance. Offshore: No Effect.	Beach/Nearshore: Same as berm and dune restoration. Offshore: No effect.	Beach/Nearshore: Same as berm restoration. Offshore: Same as berm restoration

3-Other Social Effects					
Resource Categories	**grade and re-shape entire beach/backpass**	**berm and dune restoration/inlet source**	**bulkhead**	**groin field**	**geotubes**
cultural resources	N Beach/Nearshore: Zero Potential to cover shipwreck sites with beachfill. Offshore: Not likely to have impact.	Beach/Nearshore: Zero Potential to cover shipwreck sites with beachfill. Offshore: Potential to impact offshore shipwreck sites in Hereford Inlet . Sites would be avoided based on remote sensing investigations	Not likely to have impact.	Beach/Nearshore: Same as berm and dune restoration. Offshore: Same as berm restoration	Not likely to have impact.
aesthetics	Beach/Nearshore: Temporary adverse impacts on sight and smell due to construction activities (equipment, earth moving, initial color of sand, sulfide gas) would disappear upon cessation of construction. A wider, more stable beach in the impact area may have long-term beneficial impacts on aesthetics in maintaining the integrity of the area. Offshore: No effects	Beach/Nearshore: Temporary adverse impacts on sight and smell due to construction activities (equipment, earth moving, initial color of sand, sulfide gas) would disappear upon cessation of construction. A wider, more stable beach in the impact area may have long-term beneficial impacts on aesthetics in maintaining the integrity of the area. Offshore: Dredge equipment working offshore may appear unsightly during construction and periodic nourishment	Beach/Nearshore: A bulkhead may inhibit ocean views of some properties may be considered unsightly.	Beach/Nearshore: Same as berm and dune restoration, except that an artificial rocky groin would modify the natural shoreline appearance. This would appear unsightly to some while it may be attractive to others looking for diversity in the shoreline, however, groins are already present within project area.	Possible negative effect if the geotubes become exposed

			Offshore: Same as berm restoration.	Offshore: Same as berm restoration.	
4-Regional Economic Development (1)					
Resource Categories	**grade and re-shape entire beach/backpass**	**berm and dune restoration/inlet source**	**bulkhead**	**groin field**	**geotubes**
jobs	In New Jersey 466,442 jobs were created in travel and tourism activity in 2007, most tourism takes place in the coastal Atlantic Counties.	In New Jersey 466,442 jobs were created in travel and tourism activity in 2007, most tourism takes place in the coastal Atlantic Counties.	This option would most likely have a local impact on jobs at the piers.	Not likely to have impact.	Not likely to have impact.
income	27 billion dollars annually generated from NJ travel and tourism, a 60% of which is spent in Atlantic, Cape May and Ocean County and $16 billion was generated in wages and salaries was created in 2007.	27 billion dollars annually generated from NJ travel and tourism, a 60% of which is spent in Atlantic, Cape May and Ocean County and $16 billion was generated in wages and salaries was created in 2007.	Localized incomes may increase from this option as a result of business being able to stay open during and after storm events.	Not likely to have impact.	Not likely to have impact.
taxbase	Tourism from coastal communities generates $1,892,000 in local tax revenue from hotel and property taxes and $2,332,000 in State tax revenues.	Tourism from coastal communities generates $1,892,000 in local tax revenue from hotel and property taxes and $2,332,000 in State tax revenues.	Not likely to have impact.	Not likely to have impact.	Not likely to have impact.
further consideration	**YES**	**NO**	**YES**	**YES**	**NO**

After the Systems of Accounts screening it was determined that three measures would be eliminated from the five remaining. The three measures that were removed from the analysis were a Groin Field, Geotextile Tubes, and Berm and Dune Restoration using an Inlet Borrow Source.

The Groin Field was excluded due to the impacts it may have on costs and net benefits and Corps guidance in ER 1165-2-130. While a Groin Field would reduce the longshore transport back into the accumulated areas around the outfalls, and subsequently keep material in place in North Wildwood, it might have only marginal impacts on project benefits while having a very large impacts on costs . A Rough Order of Magnitude (R.O.M.) cost estimate was developed using parametric cost data from a previous project where groins were rehabilitated and repaired to retain sand in a highly erosive beach area. The estimate was done using 2012 bid results for groin repair from the Brigantine Inlet to Great Egg Inlet, Absecon Island project and design parameters from Engineering Manual (EM) 1110-1617.

Groin lengths were determined from the existing beach widths and consultation with EM 1110-2-1617. These estimates were based on 3 groins extending from the bulkhead line to the surf zone in Wildwood in order to keep the sand from migrating downdrift and impacting clogged the outfalls. The potential lengths of series of three groins may be necessary to slow the down drift erosion of sand from the northern portion of the study area into the southern portions while avoiding a large groin offset on the northern side that is common with a single groin system. The length of the beaches in the area necessitates a long groin to traverse the entire beach width from the bulkhead to beyond the mean low water line. It was assumed that approximately three groins totaling 4,500 feet in length would be needed to reduce longshore transport and transition the beach at a gradual angle from north to south in order to eliminate the large beach offsets of the beach fillet area (**Table 69).**

Table 69 Cost Estimates for a Groin field

Absecon Island Feature	Length (feet)	Elev. (NAVD)	Contractor 1	Contractor 2	Contractor 3	Contractor 4	Avg. Cost	Avg. Cost/Ft	Length 2,000'	Length 1,455'	Length 1,059'	Total
Mass - Rehab	152	2.59	$1,009,478	$1,289,550	$1,849,500	$1,921,000	$1,517,382	$9,983	$19,965,553	$14,527,693	$10,570,899	**$45,064,145**
Mass - Extension	63	2.59	$1,142,160	$1,221,000	$1,814,000	$1,615,500	$1,448,165	$22,987	$45,973,492	$33,452,055	$24,340,982	**$103,766,529**
Vermont - Rehab	142	4.56	$892,000	$897,925	$1,417,850	$1,444,000	$1,162,944	$8,190	$16,379,489	$11,918,337	$8,672,234	**$36,970,060**
Vermont - Extension	32	4.56	$867,510	$925,125	$1,959,000	$1,209,200	$1,240,209	$38,757	$77,513,047	$56,401,430	$41,039,817	**$174,954,294**
Low Timber	600	7.75	$1,680,000	$1,200,000	$660,000	$960,000	$1,125,000	$1,875	$3,750,000	$2,728,642	$1,985,463	**$8,464,105**

Cost estimates were based on construction bids for a similar project. The project that the bids were based on was the Absecon Island beachfill in Atlantic City, New Jersey and the estimate was based on the bids for groin rehabilitation and groin extension for two existing groins in Atlantic City at Massachusetts Avenue and Vermont Avenue. Four contractors bid on the Atlantic City project for the New Jersey Department of Environmental Protection. Each contractor bid on five elements including a 1- Massachusetts Avenue groin rehabilitation, 2- Massachusetts Ave groin extension, 3- Vermont Avenue groin rehabilitation, 4- Vermont Avenue groin extension and 5- low profile timber groin. The bids for each feature were averaged, and the total length of each feature was then used to determine the cost per linear foot of each feature. The range of potential costs vs. savings for a stone groin field would be cost prohibitive based on this estimate.

The Philadelphia District also preformed a groin analysis as part of the Absecon Island Feasibility Study in 1996. The analysis examined whether the construction costs was offset by the savings due to reduction in re-nourishment. Four groins were analyzed for possible placement south of Atlantic City, NJ. The four groins were each extended several hundred feet seaward of MHW. The beach widths there are smaller than the Wildwoods, but the overall coastal processes and setting is very similar. It was determined that 20,000 cy of sand was saved for a 6-yr re-nourishment interval. This savings varied and increased slightly as the re-nourishment interval got longer. Below a 5-yr cycle, there was no savings. The groins reduced re-nourishment from 540,000 cy to 520,000 cy every 6 yrs.

A groin(s) separating North Wildwood from Wildwood was in place a reduced the 4-year nourishment quantity by 50% from 305,000 cy down to 152,500 cy. Sand costs between $8.00 -$10.00 per cubic yard. The cost savings by reducing nourishment would therefore be $1,220,000 every four years or annually at $305,000. The annualized cost to construct a jetty/groin system at North Wildwood would be significantly higher than this cost savings based on the reduced nourishment requirements based on the length of groins required to span the large beach at the North Wildwood and Wildwood border.

Groins are also not recommended for projects advocating periodic nourishment as part of the project's construction based on Corps of Engineers guidance. Engineering Regulation 1165-2-130 indicates that "periodic nourishment by placement of suitable material on a beach at appropriate intervals of time, is considered "construction" for cost-sharing purposes when, in the opinion of the Chief of Engineers, such periodic nourishment would be a more economical erosion protection measure than retaining structures such as groins. Thus, projects recommending periodic nourishment should not include structures which materially reduce littoral drift from reaching downdrift shores".

Groin placement will not be considered further since the Hereford to Cape May project will be recommending periodic nourishment of the selected plan, and a groins costs will likely exceeded its benefits.

Geotextile tubes were excluded due to their performance issues and costs vs. a natural dune. An Inlet Borrow Source was excluded since it would not meet the planning objectives of reducing sand maintenance issues at the outfalls, reduce environmental impacts to inlet borrow sources, take advantage of RSM opportunities, or provide customer satisfaction for municipalities dealing with excess sand (Wildwood/Wildwood Crest).

Three measures were considered for detailed cost and benefit estimating in Cycle-3. Bulkhead Construction around the Piers was expanded to also consider Dune Construction around the piers in the Cycle 3 analysis.

4.7 Cycle-3

Measures recommended for further consideration in Cycle 3 are listed below.

1. Berm and Dune restoration using Backpass Technology
2. Bulkhead Construction around the Piers
3. Dune Construction around the Piers

These 3 remaining measures were evaluated based on an analysis of storm damage reduction benefits versus costs. Designs were formulated and optimized to develop the NED plan for the study area. A 50-year period of analysis was used with a June 2007 price level, and a 4.625% discount rate.

The selected plan is determined by comparing expected benefits and estimated costs for a matrix of design measures. The selected plan is that which maximizes the amount of net benefits (benefits minus costs). Plan selection is not accomplished with the goal of providing a specific level of storm protection (e.g., 500 year frequency event). Rather, the selected plan is determined based on analysis of damage reduction benefits in response to events over a range of frequencies (5-year event through 500-year event).

4.7.1 Beachfill Design Parameters

In Cycle 3, the beach nourishment measure required optimization of the design parameters. In developing these parameters the Shore Protection Manual, Coastal Engineering Tech Notes (CETN), the existing conditions in the study area and accepted coastal engineering practices were reviewed. Listed below are the boundary conditions utilized to construct a logical methodology to efficiently identify the optimum plan. The necessary design parameters for beach fill include beach slope; berm elevation and width; and dune width, height and slope. The beach slope, berm elevation, dune top width, and dune slope are affected by the prevailing natural processes and were based on the study area existing beach conditions. Berm width and dune elevation were varied to achieve project optimization.

Beach Slope. Beach slopes are the result of on-site wave climate and the characteristics of the beach material. Both are similar throughout the study area. Existing beach slopes for North Wildwood are comparable to other Atlantic ocean shorelines in the mid-Atlantic region. An average near shore beach slope throughout the study area of 1 V:30 H was adopted for all measures.

Berm Elevation. Tides, waves, and beach slope determine the natural berm elevation. If the nourished berm is too high, scarping may occur, if too low; ponding of water and temporary flooding may occur when a ridge forms at the seaward edge. Design berm heights for each measure have an elevation set at the natural berm crest elevation as determined by historical profiles. The profile surveys conducted by the Coastal Research Center, Stockton State College under contract to NJDEP were used to examine historical berm elevations. The existing berm elevation for NJ Profile No. CM 111 in North Wildwood, varied between + 5.4 ft NAVD and + 8.0 ft NAVD between 1986 and 2006 with the average berm elevation being 6.8 ft NAVD. It was determined that a constructible template which closely matches the prevailing natural berm height in the study area would be set at + 6.5 ft. NAVD. This elevation was used for all designs.

Berm Width & Dry Beach Width. Four berm widths were modeled with varying dry beach widths seaward of the dune. For the purposes of this study, berms widths were defined as the distance from the landward toe of dune to the beach slope, and dry beach widths were defined as the distance from the seaward toe of dune to the beach slope. An interval between the four successive berm widths was chosen for modeling purposes. This interval is set wide enough to discern significant differences in costs and benefits between measures but not so great that the NED plan cannot be accurately determined. Additionally, due to the capability of the storm modeling methodology and effectiveness of the existing condition parameters, a 25-ft. interval achieved the desired accuracy. The largest dry beach width per berm considered was 160 ft. The smallest width was determined in a similar manner, by analyzing benefits captured with minimum dimensions along with the minimum dry beach width required to maintain a constructible beach fill given the footprint requirements of varying dune heights and toe protection for dune stability. The smallest dry beach width was determined to be 75 ft based on research on the minimum dry beach necessary to protect the existing dune from damages based on historic surveys by the District and the New Jersey Beach Profile Network at Richard Stockton College. Dune height and the corresponding dune footprint determined the dry beach width for each berm. Larger dune footprints resulted in shorter dry beach widths. As dune heights increased by 2'; the resultant dry beach width decreased by 20'.

Dune Position. Following available Corps guidance, dunes were placed as landward as possible in North Wildwood, Wildwood, Wildwood Crest and Lower Township. This takes into account the location of existing isolated dunes , piers, boardwalks, vehicular rights of way and pedestrian access The design layouts tie new dunes into the existing dunes wherever possible.

Dune Slope. Majority of the existing dunes within the project area have seaward slopes averaging 1V:5H. Side slopes for all measures were set at 1V:5H, which was determined to be the optimum condition based on native sand grain size and the grain size of sand to be obtained from potential borrow areas.

Dune Top Width. Dune top width for all measures was set at 25'. That width is considered a standard Caldwell width that is common among most dune widths in coastal engineering dunes in NJ and Delaware.

Dune Elevation. The dune heights we evaluated were sufficiently above the height of the berm and existing protective structures in order to provide for additional storm damage protection. The minimal dune height the study evaluated was 12 ft. Additionally, dune heights of 14 ft, 16 ft, 18 ft, and 20 ft were considered for North Wildwood. Dune heights that ranged from +12'to + 16' NAVD 88 were considered in Wildwood and Wildwood Crest.

Dune heights under the amusement piers that run perpendicular to the boardwalk are limited above 14.75' NAVD 88 due to the maximum elevation under the piers. Dune elevations above that height will not be able to be constructed to their full height under the piers because the pier elevation (14.75 NAVD 88) is below the top of the dune elevation. Past practices involved constructed dunes to the full elevations on the sides of the piers and at lower elevations under the piers, while increasing the dunes width on its landward and seaward side under the pier in order to accommodate the decrease in elevation and achieve the same storm damage reduction potential. Lower dune elevations may create a situation where structures immediately behind the lower dune sections are more vulnerable than at the fully constructed dune, and therefore at a greater risk of damage. There are six piers that will restrict the dune elevation above 14', these piers are approximately 200' wide and approximately 1,276' of beachfront property across 25,000' (5.1%) of the total length of the project may be at residual storm damage risk behind the piers. Our storm damage modeling did not account for a 200' wide lowered dune section or pilings and storage under the pier, so the results of the model represent a dune profile at its full height, even though any height over +14.75 NAVD 88 is not possible at these locations. Therefore, the model may overestimate the storm damage protection capability of a dune above +14.75 NAVD 88 behind these six pier sections.

Bulkhead Design. The bulkhead that was selected for cost analysis was steel sheeting bulkhead 30 feet in length with 20 feet below grade and 10 feet above grade. The estimate considered protecting the entire pier section with a bulkhead front, including the boardwalk sections that separate the piers, in order to create a continuous system of protection.

Summary**.** Based on the design parameters discussed above, 14 combinations of dry beach widths and dune heights were generated for North Wildwood Cells 1 and 2 as shown in **Table 71**. Initially, nine measures (alternatives A – I) were generated but results of the COSTDAM economic analysis suggested that measures with larger dunes should also be examined (alternatives J – N). These additional measures were examined from an economic perspective in order to make sure that the matrix of measures adequately captured the point where incremental increases in beach fill material (costs) exceeded the incremental increases in net benefits. **Figure 106** and **Figure 107** show the beach fill measures for Cells 1 and 2 in North Wildwood. The berm widths for the measures in Cell 2 are shorter and higher than the existing berm width used for the w/o project analysis. Existing berm widths in Cell 2 vary from 200 ft. near the northern boundary with Cell 1 to 1,000 ft. at the southern boundary with Cell 3. The location of the representative profile used for Cell 2 has a berm width of 550 ft. which is approximately the average berm width for the cell. Only 400 to 500 ft. of the northern portion of Cell 2 has a berm width less than the measures examined. In addition to the 14 alternatives for Cells 1 and 2, three different dune height alternatives were examined for Cells 3 – 6 in Wildwood, Wildwood Crest and Lower Township. Dune position, side slopes, and top widths were kept consistent with the dune alternatives examined for Cells 1 and 2. The three dune elevations were 12-, 14-, and 16-ft. respectively and were evaluated in the same way as cells 1 and 2, with a 75' berm added to the design template.

4.7.2 Berm and Dune Heights for Previously Authorized Federal Projects

The District examined the Federally authorized beach nourishment projects in New Jersey **Table 70**, as well as local beach nourishment activity by the municipality of North Wildwood in order to determine the range of berm and dune dimensions for this project**.** This provided a starting point for bracketing dune heights. Most of the dunes in the Cape May County area range from 12-16' NGVD, with an 18' NGVD dune at Lower Cape May Meadows Cape May Point. Based on this information the dune and berm combinations for the study were developed.

Table 70 Previously Authorized Project Dimensions

Project	Dune Ht	Dune Crest Width	Berm Ht	Berm Width
Manasquan-Barnegat - main section	22 NAVD88	25	8.5	75
Manasquan-Barnegat - Seaside, Pt Pl Bch	18 NAVD88	25	11.5	100
LBI	22 NAVD88	25	8	125
Brigantine	10 NAVD88	25	6	100
Absecon (AC/Ventnor)	16/14 NGVD~15/13 NAVD	25	8.5	200/100
Ocean City *	16 NGVD~15 NAVD		10	100
Gt Egg/Townsends - Ocean City	12.8 NAVD88	25	7	100
Gt Egg/Townsends – O.C., Sea Isle, Strathmere	14.8 NAVD88	25	6	50
Townsends-Cape May	16 NGVD~15 NAVD	25	8.5	150
Cape May Inlet to Lower Township*	12-16 NGVD~11-15 NAVD		8.5	25-180
LCMM - CM Pt	18 NGVD~17 NAVD	25	8	20

Some project elevations above are shown in NGVD and NAVD. Projects containing references to both datums were originally authorized in NGVD, and the NAVD value is a conversion. The projects containing only NAVD were originally authorized at NAVD88
Berm widths are measured from seaward toe of dune to berm slope.

The City of North Wildwood has been participating in beach nourishment activity with the State of New Jersey and FEMA since 2009. The dune height for this beachfill was +14.75 NAVD 88 and the berm elevation was +6.75 NAVD 88. A listing of the nourishment activity, general location of the placement of the fill and fill volumes are contained in **Table 71**. These beach fills were impacted by coastal storms after their construction and had to be supplemented by additional fill after the initial placement. Areas of acute erosion correlate to cell 1 in North Wildwood, the area in front of the amusement piers in North Wildwood and Wildwood and the transition area into Wildwood City**.**

A large portion of the material placed by North Wildwood was lost as a result of Hurricane Sandy. District pre-storm and post storm estimates placed these losses at approximately 348,000 cubic yards of sand lost from the MHW line to the landward most portion of the beach profile. These estimates, along with pre storm and post storm profiles from Hurricane Sandy are contained in **Section 2.6.5**.

Table 71 Dune and Berm Configurations

Measure	Dune Height, ft NAVD	Dry Beach Width, ft
A	12	115
B	14	95
C	16	75
D	12	140
E	14	120
F	16	100
G	12	165
H	14	145
I	16	125
J	18	80
K	18	105
L	20	85
M	20	110
N	20	160

Figure 106 Cell 1 in North Wildwood

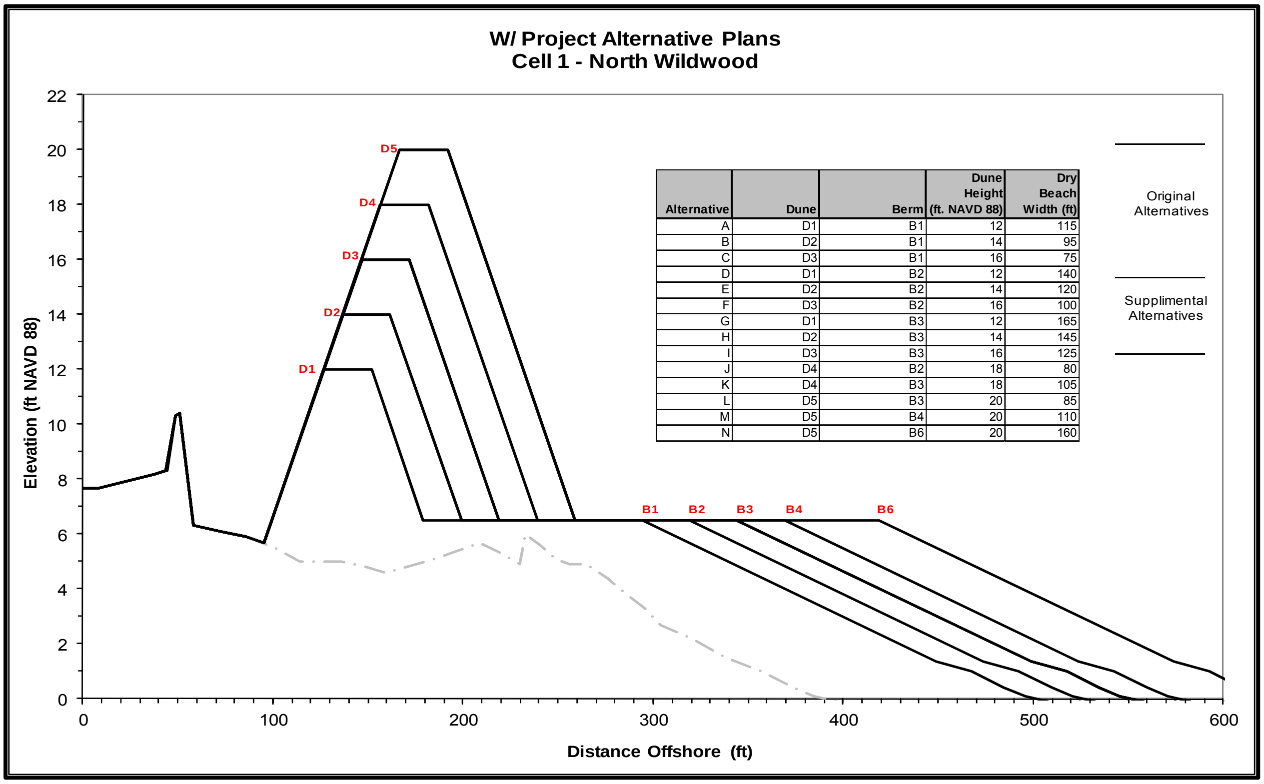
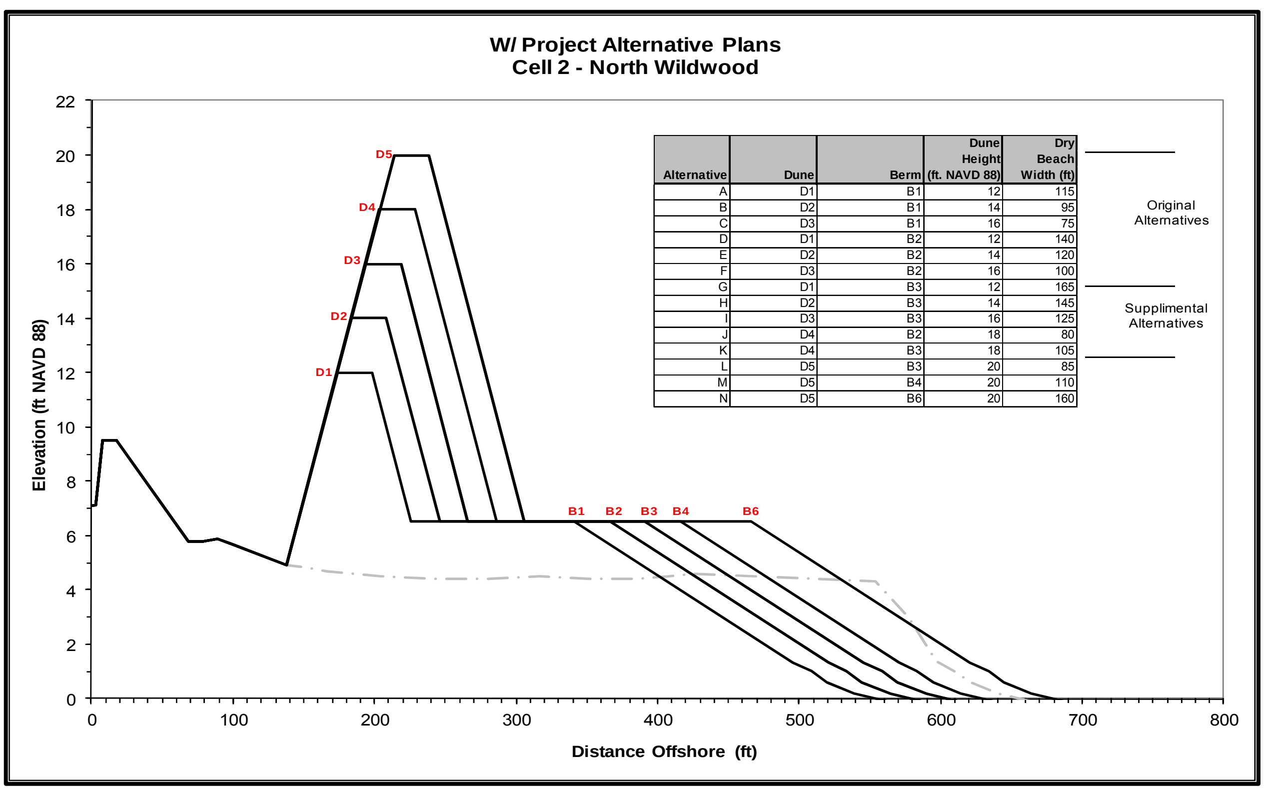


Figure 107 Cell 2 in North Wildwood



Initial Design Quantities. Required beach fill volumes (excluding renourishment) were computed for each measure in the Cycle 3 analysis. Volumes were separated into "dune" and "berm" to account for the irregularities in shoreline positions found in the study area. “Dune” volumes were computed using the difference between the design measure and existing conditions and multiplying the unit volume by the appropriate reach length. “Berm” volumes were computed by comparing the existing shoreline position in plan view in each cell to a proposed MHW line that was representative for each measure. Total “berm” volumes were computed by multiplying the differences in shoreline positions by an active profile depth (the average berm elevation to the depth of closure).

The plans were analyzed for erosion, wave attack and inundation damage reductions compared to the without project conditions. Initial model results showed that inundation was sensitive to dune height and erosion was sensitive to berm width. To a small degree, berm width affected the total storm stage due to the berm’s ability to break the waves further offshore. Both dune and berm affected wave attack.

The results of the initial model runs indicated measures with larger dunes should also be examined (Plan J – Plan N). These additional measures were examined in order to make sure that the matrix of measures adequately captured the point where incremental increases in beach fill material (costs) exceeded the incremental increases in net benefits. Berm widths in excess of 165’ resulted in exceptionally higher quantities without a commensurate increase in the performance of reducing the storm impacts. A similar conclusion was reached with dune heights in excess of + 20’ NAVD. For this reason, measures which included wider berms and higher dunes were not modeled.

As more measures were modeled and net benefits calculated, performance trends became evident. These trends helped to identify which measures would produce the highest net benefits and thereby, optimize the design.

Table 72 Initial Formulation Quantities

Cell	Length		Dune Volume	Berm Volume	Volume
1	3,549	A	38,000	435,000	473,000
		B	61,000	435,000	496,000
		C	90,000	435,000	525,000
		D	38,000	520,000	558,000
		E	61,000	520,000	581,000
		F	90,000	520,000	610,000
		G	38,000	610,000	648,000
		H	61,000	610,000	671,000
		I	90,000	610,000	700,000
		J	125,000	520,000	645,000
		K	125,000	610,000	735,000
		L	164,000	610,000	774,000
		M	164,000	703,000	867,000
		N	164,000	901,000	1,065,000
2	2,959	A	31,000	9,000	40,000
		B	51,000	9,000	60,000
		C	75,000	9,000	84,000
		D	31,000	16,000	47,000
		E	51,000	16,000	67,000
		F	75,000	16,000	91,000
		G	31,000	25,000	56,000
		H	51,000	25,000	76,000
		I	75,000	25,000	100,000
		J	104,000	16,000	120,000
		K	104,000	25,000	129,000
		L	137,000	25,000	162,000
		M	137,000	35,000	172,000
		N	137,000	47,000	184,000
3	6,965	AA	96,000	26,000	122,000
		BB	148,000	26,000	174,000
		CC	210,000	26,000	236,000
4	4,585	AA	20,000	18,000	38,000
		BB	39,000	18,000	57,000
		CC	69,000	18,000	87,000
5	5,835	AA	68,000	28,000	96,000
		BB	110,000	28,000	138,000
		CC	163,000	28,000	191,000
6	1,090	AA	0	0	0
		BB	0	0	0
		CC	6,000	0	6,000

4.7.3 Pier Protection Measures

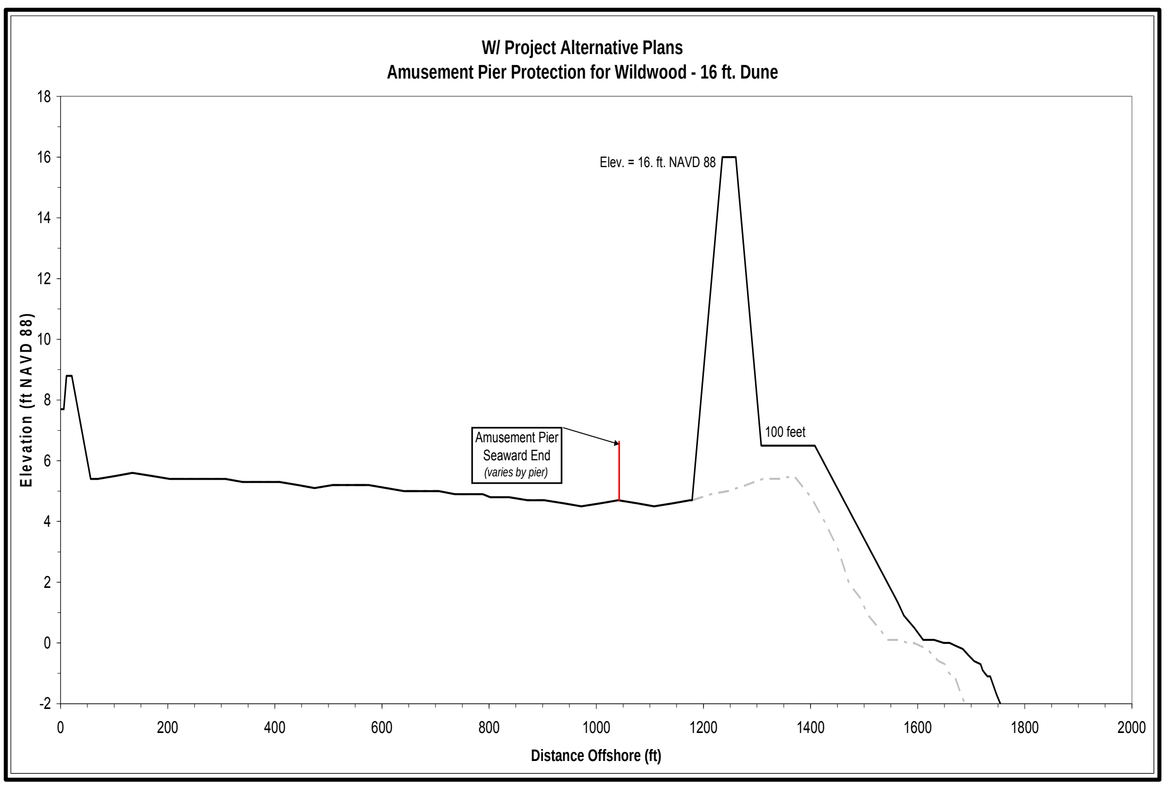
In addition to analyzing beach fill measures for Cells 1 and 2 in North Wildwood, beach fill measures were also examined to protect the amusement piers in North Wildwood and Wildwood against storm damages (**Figure 108** and **Figure 109**). Historic efforts to protect these piers with a dune by the NJDEP were not successful. Two piers are located in North Wildwood at 23rd Ave. and 25th Ave. respectively, and the other three piers are in Wildwood at Juniper Ave, Cedar Ave. and Spencer Ave, respectively. The two North Wildwood piers along with the Wildwood pier at Juniper Ave. were considered together in one analysis group, and the other two Wildwood piers were considered together in another analysis group. As with the beach fill design measures for Cell 1 and Cell 2, the beach nourishment measure for the amusement piers required optimization of the design parameters. The analysis incorporated the fact that the beach fill parameters would be more susceptible to the prevailing natural processes due to the fact that the location is adjacent to the natural mean high water line. The beach fill parameters of beach slope, berm elevation, dune width, dune height and dune side slopes were kept consistent from the analysis of Cell 1 and Cell 2 in North Wildwood. A single dry beach width of 100' seaward of the piers was analyzed. The 100' was determined to be the minimum dry beach width necessary in order to protect the dune footprint from being compromised seaward of the amusement piers against the natural processes. This represented an increase of 25' from the minimum dry beach width requirement utilized in Cell 1 and Cell 2. Due to the location of the design berm seaward of the amusement piers, quantities of sand required to construct and maintain the berm increased significantly as berm widths increased. Wider berm widths seaward of the amusement piers were considered but were determined not be feasible because the incremental increases in beach fill material (costs) exceeded the incremental increases in net benefits.

In order to protect the piers from being "flanked", and causing damages to the infrastructure beneath them (gas, water, electric) a continuous dune alignment was considered from 23rd Ave. in North Wildwood to the dune system at the Wildwood Convention Center as shown in **Figure 108.** The dune heights we evaluated were sufficiently above the height of the berm and top of the amusement piers' decking in order to provide for additional storm damage protection, principally reducing inundation damages. As with the analysis done for Cell 1 and Cell 2, the minimal dune height evaluated was 12 ft. Additionally, dune heights of 14 ft and 16 ft were considered. The additional storm damage protection in Cell 3 from the continuous dune alignment adjacent to the boardwalk was minimal due to the low "without project" damages calculated for Cell 3.

Three dune measures were generated for the amusement pier analysis (three dune heights per berm for each grouping) **Figure 108** and **Figure 109** show the 16 foot dune beach fill measures for the North group which includes the two North Wildwood piers and the Juniper Ave. pier in Wildwood and the South group which includes the other two piers in Wildwood. One steel sheet pile bulkheads surrounding the piers was also considered.

Figure 108 Pier Protection Plan View

Figure 109 Pier Protection Cross Section



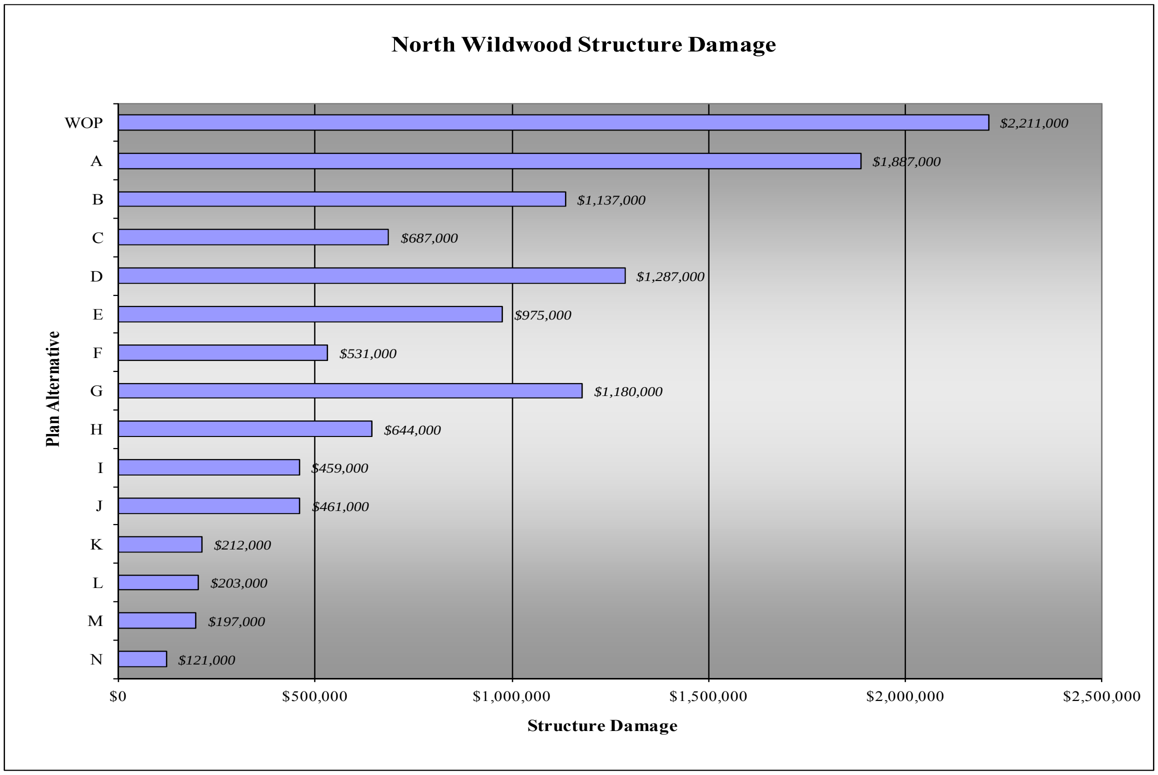
4.7.4 Storm Damage Reduction Benefits

Expected damages for several different project measures were calculated using the same methodologies and databases as previously detailed in the without project conditions. The benefits from the project measures were estimated by evaluating damage to structures under with and without project conditions. Potential damage reduction to infrastructure, improved property, and other auxiliary categories is expected to parallel reduced damage to structures and, therefore, was not calculated for the matrix of measures. The eroded shoreline in North Wildwood was analyzed first. Plan measures A-N are aligned with the current beach profile landward of the amusement pier structures and, therefore, would not protect those structures from storm damage. **Table 73** and **Figure 110** display the results of the storm damage reduction analysis.

Table 73 North Wildwood Storm Damage Reduction Benefits by Measure

Plan	Project Type	Without Project Storm Damages†	With Project Storm Damages	Storm Damage Reduction Benefits	Percent Reduced
A	12’ Dune, 115’ Berm	$2,211,000	$1,887,000	$324,000	15%
B	14’ Dune, 95’ Berm	$2,211,000	$1,137,000	$1,074,000	49%
C	16’ Dune, 75’ Berm	$2,211,000	$687,000	$1,524,000	69%
D	12’ Dune, 140’ Berm	$2,211,000	$1,287,000	$924,000	42%
E	14’ Dune, 120’ Berm	$2,211,000	$975,000	$1,236,000	56%
F	16’ Dune, 100’ Berm	$2,211,000	$531,000	$1,680,000	76%
G	12’ Dune, 165’ Berm	$2,211,000	$1,180,000	$1,031,000	47%
H	14’ Dune, 145’ Berm	$2,211,000	$644,000	$1,567,000	71%
I	16’ Dune, 125’ Berm	$2,211,000	$459,000	$1,752,000	79%
J	18’ Dune, 80’ Berm	$2,211,000	$461,000	$1,750,000	79%
K	18’ Dune, 105’ Berm	$2,211,000	$212,000	$1,999,000	90%
L	20’ Dune, 85’ Berm	$2,211,000	$203,000	$2,008,000	91%
M	20’ Dune, 110’ Berm	$2,211,000	$197,000	$2,014,000	91%
N	20’ Dune, 160’ Berm	$2,211,000	$121,000	$2,090,000	95%

Figure 110 North Wildwood Structure Damage



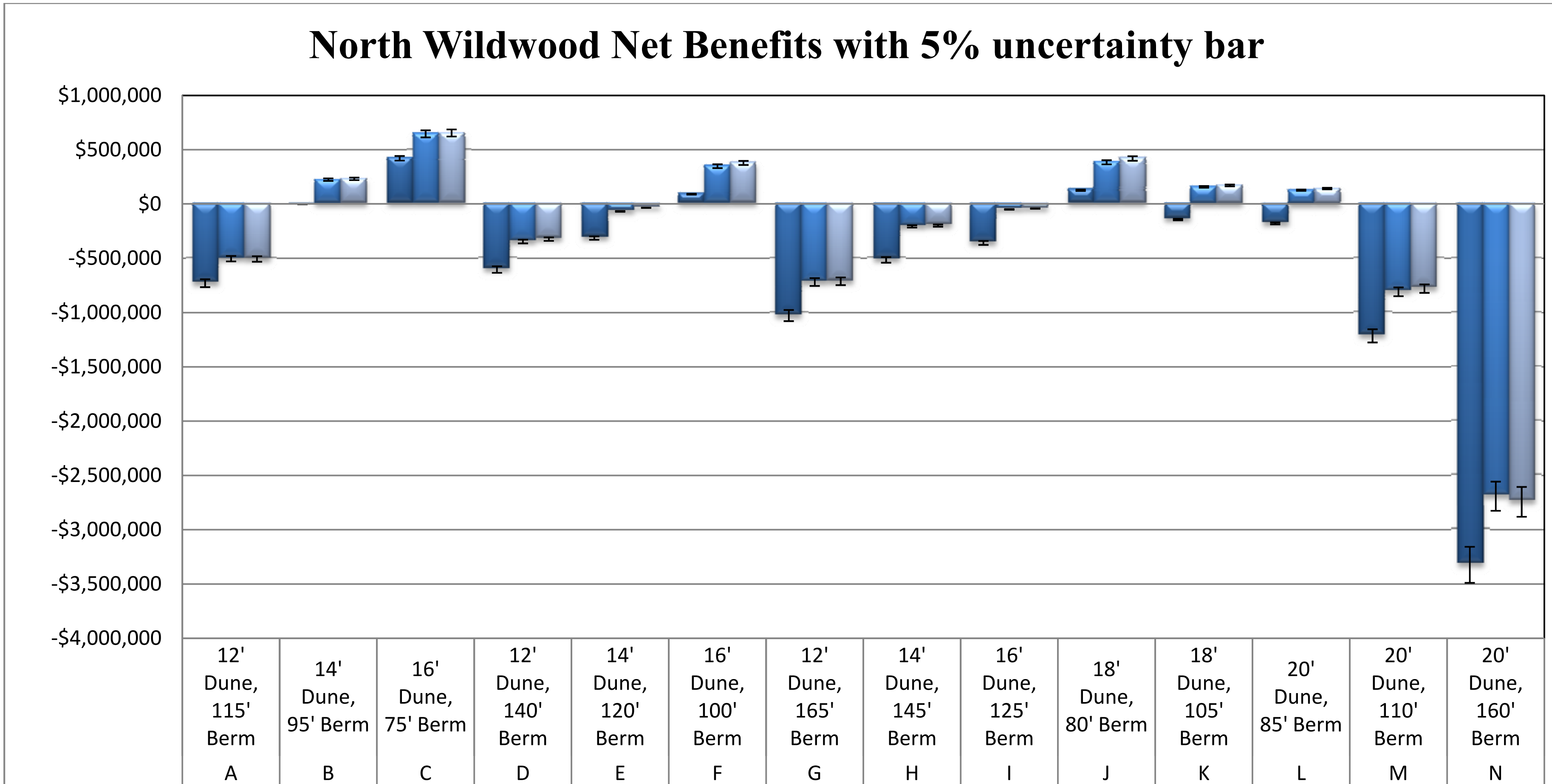
4.7.5 Optimization

Optimization of the measures is based on maximizing storm damage reduction to structures, which is the priority benefit category. This was accomplished by evaluating a combination of dune and berm combinations costs against the projects benefits. The optimization for North Wildwood can be seen in **Table 74**. A graphic that better illustrates the net benefits is provided in **Figure 111**. Project induced benefits from backpassing operations and sediment removal were accounted for during optimization. Storm damage reduction to infrastructure and improved property, and recreation were not used in the optimization process. Benefits which will accrue for those categories will be evaluated for the selected plan alternative only. Initial and nourishment costs for the various project measures are annualized for comparison to the average annual benefits for each project alternative. Initial construction and periodic nourishment costs are annualized over a 50-year period of analysis at an FY14 discount rate of 3-½%. Monitoring, major rehabilitation, and real estate costs will be included for the selected plan alternative. The average annual costs are subtracted from and compared to average annual benefits to calculate net benefits and the benefit-cost ratio and select the optimal plan, which maximizes net benefits The average annual benefits and costs, net benefits and benefit-cost ratio for storm damage reduction are included in below**.**

Table 74 AAB/AAC/Net Benefits for Backpass Alternative

Plan	Project Type	AAB	AAB w/LCF	AAC	Net Benefits	BCR
3-YR Nourishment Cycle						
A	12' Dune, 115' Berm	$324,000	$1,278,000	$2,007,000	($729,000)	0.64
B	14' Dune, 95' Berm	$1,074,000	$2,028,000	$2,030,000	($2,000)	1.00
C	16' Dune, 75' Berm	$1,524,000	$2,478,000	$2,056,000	$422,000	1.21
D	12' Dune, 140' Berm	$924,000	$1,878,000	$2,481,000	($603,000)	0.76
E	14' Dune, 120' Berm	$1,236,000	$2,190,000	$2,503,000	($313,000)	0.87
F	16' Dune, 100' Berm	$1,680,000	$2,634,000	$2,543,000	$91,000	1.04
G	12' Dune, 165' Berm	$1,031,000	$1,985,000	$3,012,000	($1,027,000)	0.66
H	14' Dune, 145' Berm	$1,567,000	$2,521,000	$3,035,000	($514,000)	0.83
I	16' Dune, 125' Berm	$1,752,000	$2,706,000	$3,064,000	($358,000)	0.88
J	18' Dune, 80' Berm	$1,750,000	$2,704,000	$2,577,000	$127,000	1.05
K	18' Dune, 105' Berm	$1,999,000	$2,953,000	$3,095,000	($142,000)	0.95
L	20' Dune, 85' Berm	$2,008,000	$2,962,000	$3,140,000	($178,000)	0.94
M	20' Dune, 110' Berm	$2,014,000	$2,968,000	$4,182,000	($1,214,000)	0.71
N	20' Dune, 160' Berm	$2,090,000	$3,044,000	$6,367,000	($3,323,000)	0.48
4-YR Nourishment Cycle						
A	12' Dune, 115' Berm	$324,000	$1,278,000	$1,781,000	($503,000)	0.72
B	14' Dune, 95' Berm	$1,074,000	$2,028,000	$1,803,000	$225,000	1.12
C	16' Dune, 75' Berm	$1,524,000	$2,478,000	$1,831,000	$647,000	1.35
D	12' Dune, 140' Berm	$924,000	$1,878,000	$2,223,000	($345,000)	0.84
E	14' Dune, 120' Berm	$1,236,000	$2,190,000	$2,257,000	($67,000)	0.97
F	16' Dune, 100' Berm	$1,680,000	$2,634,000	$2,285,000	$349,000	1.15
G	12' Dune, 165' Berm	$1,031,000	$1,985,000	$2,703,000	($718,000)	0.73
H	14' Dune, 145' Berm	$1,567,000	$2,521,000	$2,727,000	($206,000)	0.92
I	16' Dune, 125' Berm	$1,752,000	$2,706,000	$2,755,000	($49,000)	0.98
J	18' Dune, 80' Berm	$1,750,000	$2,704,000	$2,319,000	$385,000	1.17
K	18' Dune, 105' Berm	$1,999,000	$2,953,000	$2,794,000	$159,000	1.06
L	20' Dune, 85' Berm	$2,008,000	$2,962,000	$2,834,000	$128,000	1.05
M	20' Dune, 110' Berm	$2,014,000	$2,968,000	$3,776,000	($808,000)	0.79
N	20' Dune, 160' Berm	$2,090,000	$3,044,000	$5,735,000	($2,691,000)	0.53
5-YR Nourishment Cycle						
A	12' Dune, 115' Berm	$324,000	$1,278,000	$1,784,000	($506,000)	0.72
B	14' Dune, 95' Berm	$1,074,000	$2,028,000	$1,796,000	$232,000	1.13
C	16' Dune, 75' Berm	$1,524,000	$2,478,000	$1,823,000	$655,000	1.36
D	12' Dune, 140' Berm	$924,000	$1,878,000	$2,201,000	($323,000)	0.85
E	14' Dune, 120' Berm	$1,236,000	$2,190,000	$2,224,000	($34,000)	0.98
F	16' Dune, 100' Berm	$1,680,000	$2,634,000	$2,255,000	$379,000	1.17
G	12' Dune, 165' Berm	$1,031,000	$1,985,000	$2,696,000	($711,000)	0.74
H	14' Dune, 145' Berm	$1,567,000	$2,521,000	$2,719,000	($198,000)	0.93
I	16' Dune, 125' Berm	$1,752,000	$2,706,000	$2,747,000	($41,000)	0.99
J	18' Dune, 80' Berm	$1,750,000	$2,704,000	$2,284,000	$420,000	1.18
K	18' Dune, 105' Berm	$1,999,000	$2,953,000	$2,781,000	$172,000	1.06
L	20' Dune, 85' Berm	$2,008,000	$2,962,000	$2,819,000	$143,000	1.05
M	20' Dune, 110' Berm	$2,014,000	$2,968,000	$3,747,000	($779,000)	0.79
N	20' Dune, 160' Berm	$2,090,000	$3,044,000	$5,787,000	($2,743,000)	0.53

Figure 111 Benefits Optimization for North Wildwood



	12' Dune, 115' Berm A	14' Dune, 95' Berm B	16' Dune, 75' Berm C	12' Dune, 140' Berm D	14' Dune, 120' Berm E	16' Dune, 100' Berm F	12' Dune, 165' Berm G	14' Dune, 145' Berm H	16' Dune, 125' Berm I	18' Dune, 80' Berm J	18' Dune, 105' Berm K	20' Dune, 85' Berm L	20' Dune, 110' Berm M	20' Dune, 160' Berm N
3 year cycle	($729,00	($2,000)	$422,000	($603,00	($313,00	$91,000	($1,027,	($514,00	($358,00	$127,000	($142,00	($178,00	($1,214,	($3,323,
4 year cycle	($503,00	$225,000	$647,000	($345,00	($67,000	$349,000	($718,00	($206,00	($49,000	$385,000	$159,000	$128,000	($808,00	($2,691,
5 year cycle	($506,00	$232,000	$655,000	($323,00	($34,000	$379,000	($711,00	($198,00	($41,000	$420,000	$172,000	$143,000	($779,00	($2,743,

3 year cycle 4 year cycle 5 year cycle

Figure 111 indicates that the plan that reasonably maximizes the project net benefits is Plan C with a 4, or a 5 year nourishment cycle. Only $8,000 separates the two cycles but this analysis does not yet account for annual Local Costs Forgone benefits associated with outfall maintenance from sand clogging. These maintenance costs exceed the $8,000 that separates the 4 year cycle from the 5 year cycle above, and any situation that triggers one year of outfall maintenance activities detailed in this report would negate any gains from choosing the 5 year cycle over the 4 year cycle due to storm damage reduction benefits alone. In a systems context, the 4 year cycle will have greater net benefits than the 5 year cycle since it would reduce the occurrence of outfall maintenance costs which are detailed to be on the order of $75,000 per year in Wildwood and $148,00 per year in Wildwood Crest.

Only the first two cells in North Wildwood were evaluated for storm damage analysis when the study began. After this analysis the results showed residual damages in Wildwood, Wildwood Crest and Lower Township. Therefore, a plan was evaluated for these areas. **Table 75** shows the results of the benefit cost analysis for protecting Wildwood, Wildwood Crest and Lower Township with a dune and berm. Dune heights above +16’ NAVD 88 were not evaluated since the results in North Wildwood indicated that +16 NAVD 88 dune was the optimal plan. Berm widths were selected to be 75’ as the minimum width necessary to protect the dune and appurtenances since the smallest berm width was optimized for North Wildwood.

Table 75 Wildwood and Wildwood Crest and Lower Township AAB, AAC, Net Benefits

Plan	Project Type	Berm	AAB	AAC	Net Benefits	BCR
AA	12’ Dune	75'	$1,574,000	$112,000	$1,462,000	14.05
BB	14’ Dune	75'	$1,986,000	$173,000	$1,813,000	11.48
CC	16’ Dune	75'	$2,231,000	$245,000	$1,986,000	9.11

Three simulations for Wildwood and Wildwood Crest were done using the same methodology (SBEACH/COSTDAM work flow) as described for the dune/berm template combinations done for North Wildwood. In addition, the same H&H/Econ workflow using SBEACH & COSTDAM was done for Wildwood and Wildwood Crest using a representative post-construction beach profile that took into account removal of sand from the borrow area with the selected plan dune height.

Plan C with a 16-foot dune and a 75-foot berm was used as a base plan to evaluate extending protection to the low-lying amusement piers in the study area. Plans C1, C2, and C3 were developed to determine whether additional beach fill to protect the piers would be incrementally justified. **Table 76** shows the resulting incremental average annual costs to expand protection around the ends of the piers. The benefits include the maximum potential storm damage reduction benefits to pier infrastructure. A steel sheet pile barrier around the piers was also evaluated and is presented. These options were eliminated from the analysis due to the limited benefit potential and prohibitively high cost.

Table 76 North Wildwood and Wildwood Piers AAB, AAC, Net Benefits & BCR by Plan

Plan	Project Type	AAB	AAC	Net Benefits	BCR
DUNE					
C1	12' Dune, 100' Berm	$400,000	$857,000	($457,000)	0.47
C2	14' Dune, 100' Berm	$401,000	$1,135,000	($734,000)	0.35
C3	16' Dune, 100' Berm	$497,000	$1,410,000	($913,000)	0.35
STEEL SHEET PILE					
S1	Steel Sheeting	$497,000	$1,658,000	($1,161,000)	0.30

The Cycle 3 analysis shows that the optimum dune and berm combination was Plan C, the 16 dune 75 berm in North Wildwood across all nourishment cycles (3,4, and 5). This was one of only five berm and dune configurations to show positive net benefits across 14 scenarios over the three nourishment cycles. The other scenarios with positive net benefits were Plan B, F, J, K, and L. The benefits for these options were less than Plan C. The plan alternative selected to alleviate the severe erosion in North Wildwood includes the construction of a dune with a height of 16' (NAVD) and a berm with a width of 75'. The backpass option was reviewed and selected in an effort to maximize benefits and employ a systems approach to combine protecting property and infrastructure at the northern end of the island with improving beach conditions in Wildwood and Wildwood Crest/Lower Township. The presence of a wide feeder beach provides adequate sand to form protective dunes in the cells of the study area that lack this additional height buffer.

Dune scenarios within Wildwood, Wildwood Crest and Lower Township showed positive benefits across all three scenarios with the 16' dune having the greatest net benefits. A 75' berm will also be placed in front of the dune for protection of the dune toe from scour, protection of the appurtenances and in case of PL 84-99, FCCE emergencies and the entire beaches needs replacement. The dune volume in this area was determined to be minimal, will have a small impact on costs and would likely maximize at the 75' length similar to North Wildwood.

Protecting the piers with a dune or bulkhead was not feasible for two reasons; 1-the dune at the seaward end of the amusement pier eroded rapidly after a locally constructed project was placed in 2009 and 2- bulkhead and dune construction around the piers had negative net benefits.

4.8 Summary of Optimized Plan

The Project Development Team (PDT) employed a systems based, incremental analysis and life-cycle approach to the quantification of benefits, costs and uncertainties consistent with E.R. 1105-2-100 to optimize the selected plan and determine the National Economic Development (NED) benefits for the Hereford to Cape May Inlet study area. Optimal plans are those plans that maximize net NED benefits without violating the pre-established planning criteria and study objectives.

For North Wildwood, the PDT analyzed various dune elevations and berm configurations between + 12 NAVD 88 and + 20 NAVD 88 (75-foot minimum berm width) to determine the optimum net benefits. This included fourteen different configurations for three nourishment cycles for a total of 51 separate scenarios. **Table 74** shows the results of this analysis and demonstrates that a 16-foot dune with a 75-foot berm produced the maximum net benefits. This is the optimal plan for North Wildwood.

The physical features, wave climate and tidal range of Wildwood, Wildwood Crest and Lower Township are similar enough to North Wildwood to use the later as a starting point for the storm damage analysis in the remaining towns. Therefore, the team applied engineering judgment and S.M.A.R.T. planning principles to the optimization process based on the results of the North Wildwood analysis. The project team analyzed dune heights at + 12 NAVD 88, + 14 NAVD 88, and + 16 NAVD 88 and a berm width at 75 feet for Wildwood, Wildwood Crest and Lower Township based on the results of the North Wildwood optimization and applied a risk-based decision process to evaluate the maximum allowable residual risk acceptable to the non-Federal sponsor and to provide for a systems based approach along the study area. This analysis resulted in a + 16 NAVD 88 dune with a 75-foot berm for Wildwood, Wildwood Crest and Lower Township as the optimum plan, which is consistent with the plan for North Wildwood.

The plan with the highest net benefits while meeting the study's objectives is Plan C in North Wildwood and Plan CC in Wildwood, Wildwood Crest and Lower Township. Plans C1 through C3 and S1 that were designed to protect the piers had negative net benefits and benefit cost ratios less than one. Detailed designs, cost estimates and environmental assessments will be evaluated for implementation of Plan C and Plan CC in Section 5, Selected Plan.

The dune system along the boardwalk will not channel flood waters to the amusement piers during storm events. During large storm events, the dune will erode under the direct impact of wave forcing due to elevated storm surge levels and wave processes. Dunes do not increase water depths associated with coastal storms and water levels seaward of the dune are the same for "without project" and "with project" conditions. No induced damages are anticipated at the piers due to the presence of the dune system.

4.9 Resiliency, Risk Reduction and Sustainability

4.9.1 Resiliency

Resiliency can be measured by post storm engineering resilience, ecological resilience and community resilience. Given the absence of an explicit definition of the term we evaluated the definition of “resilience” presented in the February 2013 USACE-NOAA white paper “Infrastructure Systems Rebuilding Principles.

“Resilience. Ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies”.

A comparable definition of “resilience” is presented in “Disaster Resilience: A National Imperative” by the National Academies Press (2012):

“. . . the ability to prepare and plan for, absorb, recover from, and more successfully adapt to adverse events”. [Definition 2]

Shore protection projects are engineered beaches that are designed, constructed, and periodically nourished to reduce the risk of economic losses arising from coastal storms, primarily along communities with high-value public and private infrastructure immediately landward of the beach. Most shore protection projects have been authorized for and constructed in communities with a history of at least five decades and in some cases more than a century of intensive human influence, development, and investment. Shore protection projects are generally constructed to replicate the function of beaches in areas that were once part of natural, undeveloped systems that have subsequently experienced significant human development and utilization.

Storms reduce the degree of protection provided by the beach fill project; elevated water levels and larger-than-normal waves displace sand from the berm and dune portions of the engineered beach profile and transport it principally in the offshore direction. After the storm, normal tide and wave conditions return, typically resulting in onshore-directed sand transport that rebuilds at least a portion of the berm (i.e., beach). This natural recovery of the beach berm occurs over a period that may range from days to months. Natural rebuilding of the dune is a process that requires years to decades, given its dependence on wind transport and an adequate sand supply on the beach.

In the period between the storm and the partial natural recovery, an increased level of storm damage risk exists due to the eroded condition of the project berm and dune relative to the level of risk associated with a constructed, fully maintained project. Consequently, repair of an engineered beach to its design dimensions is usually accomplished as a planned renourishment, which is included in the authorized period of analysis cycle, or as an emergency activity under the USACE Flood Control and Coastal Emergencies authority (PL 84-99), to restore the storm damage risk reduction function for which the project was authorized. This post-storm repair is necessary because the engineered beach may not otherwise fully recover to its authorized dimensions naturally, or at least not in a time frame that would minimize risks due to the deteriorated condition.

In this regard, it is apparent that shore protection projects involving beach replenishment possess intrinsic “resilience”, in light of the large volume of sediment that remains within the system after a major disturbance and the associated repair or replenishment that is included to restore the protective features to the project design dimensions.

Community Resilience. Although shore protection projects including beachfill are sacrificial by nature with the degree of resiliency described above, they *do* provide storm damage risk reduction that contributes significantly to the "resilience" of the community in which the project is located. Beach fill projects reduce coastal storm damages, as was amply demonstrated in October 2012 during Sandy at constructed projects (see USACE "Project Performance Evaluation Study" dated 6 November 2013). Engineered beaches prevent damages that would have occurred in the absence of the project. In doing so, they significantly contribute to the larger notion of "community resilience". That is, by reducing damages from coastal storms they provide the community with the "*ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies*" (per Definition 1 above).

With a project in place, storm damages are less severe than would have been the case in the absence of the project. With a project in place, fewer homes, businesses, and public infrastructure elements are damaged and destroyed, and fewer lives are disrupted or lost. Transportation and critical health and public safety assets return to full function after a storm more quickly. All of these considerations lessen the duration and reduce the costs of the recovery period, and consequently make the community more resilient than would have been the case without the project in place.

4.9.2 Risk Analysis

ER 1105-2-101, "Risk Analysis for Flood Damage Reduction Studies" (3 January 2006) provides guidance on the framework to be used in Corps of Engineers flood damage reduction studies in order to incorporate risk and uncertainty into project planning and design. This ER updates and expands on guidance in EM 1110-2-1619, "Risk-based Analysis for Flood Damage Reduction Studies" (1 August 1996).

The 2006 publication recommends varying certain input parameters that could have an impact on study conclusions. This analysis was included as part of the risk and uncertainty analysis in **Section 5** of this report. Key economic and hydrologic parameters were varied to produce a range of potential benefits and costs of the selected plan. The greatest contributor to deviations from the selected plan's benefits was from the extreme high sea level rise calculation and a future without project projected erosion rate on the projects profile. These factors contributed to a dramatic increase in project benefits and BCR.

4.9.3 Risk Reduction

This project contributes to long term risk reduction over the fifty year period of analysis by reducing the impacts from coastal storms. Storm damages without a project in place will be more frequent and with greater impact than with a project in place. The study are will see less damages with a berm and dune in place, indicating a risk reduction from the without project condition. **Table 77** indicates that storm damages are reduced significantly island wide with the implementation of the selected plan.

Table 77 Risk Reduction for Without Project and With Project by Cell

		Without Project Damage Initiation		With Project Damage Initiation	
Community	**Cell**	**Probability of Occurrence**	**Type**	**Probability of Occurrence**	**Type**
North Wildwood	1	2%	Flooding	0.50%	Flooding
North Wildwood	2	20%	Flooding	5%	Flooding
Wildwood	3	20%	Flooding	0.20%	Wave/Flooding
Wildwood Crest	4	1%	Erosion/Flooding	0.20%	All
Wildwood Crest/LT	5	2%	Flooding	0.50%	Flooding
Lower Township (LT)	6	2%	Flooding	2%	Flooding

This project will not completely eliminate damages within the study area. Even with the project in place the study area still has the risk of residual damages. These are damages that we cannot prevent with the project in place. These damages occur from overtopping of the dune and berm as a result of a storm that exceeds the identified NED plan and back bay flooding. Damages will also occur in areas of the project that could not be protected like the amusement piers. The with project condition will still have damages from coastal storms for the communities on the island.

4.9.4 Sustainability

There are multiple definitions of the word sustainable and several definitions of the term sustainability are presented below, along with references to their source.

Definition 1.- *Sustainability refers to the capacity to endure and remain productive over time, which is very well aligned with the concept of adaptation, which is "Adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects*." (USACE CLIMATE CHANGE ADAPTATION PLAN AND REPORT 2011).

Definition 2- *Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations. Sustainability is important to making sure that we have and will continue to have, the water, materials, and resources to protect human health and our environment.* (Environmental Protection Agency)

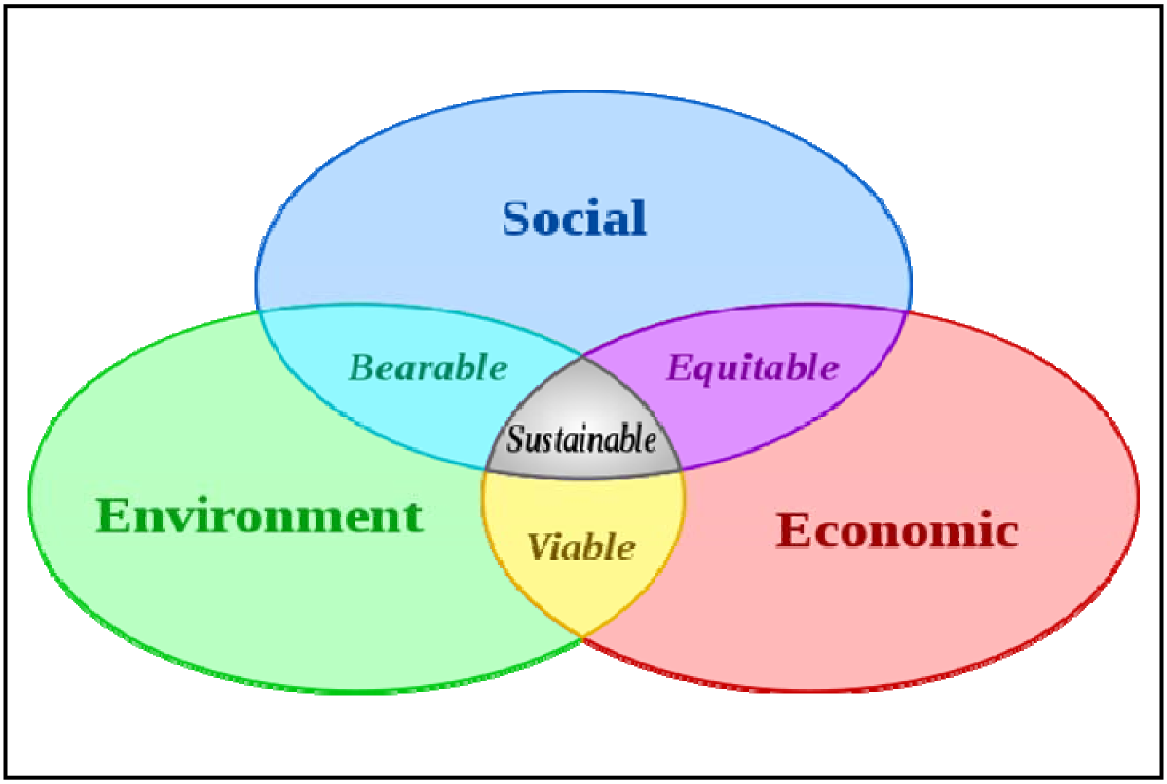
Definition 3- *Relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged* (Merriam Webster)

A common thread to these definitions is the need to promote productivity and well being over time, the need to promote the coexistence of humanity and nature, and the need to minimize negative effects on the environment so it will be available for future generations. At the 2005

World Summit on Social Development it was noted that sustainability requires the reconciliation of environmental, social and economic demands . This view has been expressed as an illustration using three overlapping ellipses indicating that the three pillars of sustainability are not mutually exclusive and can be mutually reinforcing.

The Hereford Inlet to Cape May Inlet project meets sustainability goals across multiple definitions of the term since it is required to incorporate these three pillars of sustainability in a feasibility analysis for the fifty year length of the project. Environmental concerns are evaluated in the Environmental Assessment and through coordination and review by the resource agencies including the Environmental Protection Agency, the US Fish and Wildlife Service and the New Jersey Department of Environmental Protection as part of the feasibility process. Economic principals are used in benefit calculations, plan formulation ranking, and project justification by their contributions to the National Economic Development account. Social accounts are intrinsic in beach nourishment projects since they maintain habitat for beach patrons. The nexus of these three pillars indicates that a project is sustainable.

Figure 112 The Three Pillars of Sustainability, World Summit on Social Development



5.0 Selected Plan

5.1 Identification of the Selected Plan

The Planning Guidance Notebook (1105-2-100) recommends "*selecting the alternative plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment*". This criteria was used to select a plan for implementation. Design parameters for the selected plan can be seen in section 4.7.1 of this report.

5.1.1 Description of the Selected Plan

The selected plan is a dune and berm constructed using sand obtained from an onshore borrow source located a the southern end of Five Mile Island **Table 79**. The plan extends approximately 4.5 miles from Hereford Inlet to Cape May Inlet and will encompass the towns of North Wildwood, Wildwood, Wildwood Crest and Lower Township. The southernmost beach section, which contains US Fish and Wildlife Property, is not included in the selected plan. The project will include a +16' NAVD 88 dune, with a 25' crest on a 75' berm that is + 6.5' NAVD88 in elevation in North Wildwood, Wildwood, Wildwood Crest and Lower Township. Side slopes for the dune will be 1V:5H. The plan includes approximately 64 acres of dune grass, 28,000 linear feet of sand fence, 44 extended crossovers, 7 new pedestrian crossovers, 7 extended handicap crossovers, 6 new handicap crossovers, 8 existing vehicle crossover extensions and 5 new vehicular crossovers. The dune appurtenances requirements were based on existing pedestrian pathways, existing vehicular pathways and the inclusion of Americans with Disabilities Act complaint crossover structures to accommodate the fact that based on the existing profile, the beach is almost 100% ADA compliant. Without the proposed ADA access the dune would not be ADA compliant. The sand for the dune and berm will be pumped from the southern borrow area using mobile backpassing technology to hydraulically pump the sand from the Wildwood and Wildwood Crest borrow source to the placement area on a four year nourishment cycle. The initial sand quantity is estimated at 1,527,250 cubic yards, which includes a design quantity of 1,136,000 and advanced nourishment of 391,000 yards.

The backpass option will be less costly than the offshore dredging option based on lower sand unit costs, lower mobilization costs and higher Local Costs Forgone benefits associated with sand backpassing. A recent comparison to 3 dredging projects in New Jersey based on 2014 Limited Reevaluation Reports indicates that pumping sand from NJ offshore dredging sites ranges in costs from $9.32 cyd to $15.18 cyd depending on location and pumping distance, while the current backpass estimate is $3.61- $6.05cyd (2014 P.L.). Mobilization costs for Hereford backpassing operations are $1,284,000 (2014 P.L.) for the current Hereford estimate, while mobilization costs for an inlet/offshore dredging job is averaging approximately $2,500,000 (2014 P.L.). Local Costs Forgone benefits will also decrease under an offshore dredging scenario since local benefits such as elimination of outfall clearing ($75,000 per year in Wildwood) and reduced outfall extensions ($148,000 per year in Wildwood Crest) (**Section 5.4.4**) will not be achievable under an offshore dredging operation.

Impacts to recreation in Wildwood City were raised by the Mayor of Wildwood during the Public Comment period. The selected plan proposes to shorten the beach with sediment backpassing and elevate the berm and construct dune to create a storm damage reduction feature, which may reduce the opportunities the mayor has for recently developed recreation plans. The mayor of Wildwood had planned a Recreational Vehicle (RV) park on the beach, had held a summer concert series in 2013, and has other existing recreation events on the beach including sporting and youth events. With the project in place - the recreational area of the berm will still range from 300-1,100 ft depending on location, and the Corps believes that a storm damage reduction feature and recreation opportunities can co-exist in the study area. We will work with the Mayor to make every effort to have zero impact to his plans.

5.1.2 Periodic Nourishment Requirements

In order to maintain the integrity of the design beachfill alternatives, beachfill nourishment must be included in the project design. If periodic nourishment was not performed throughout the life of the project, longshore and cross shore sediment transport mechanisms, separate from storm induced erosion, would act to erode the design beach. A four year nourishment cycle was chosen as the cycle interval over the five year plan even though the 5 year cycle had annual net benefits that were $8,000 greater. The basis for this decision was in the application of Local Costs Forgone benefits of the backpassing operation was annualized at $75,000 per year in Wildwood and $148,000 per year in Wildwood Crest (**Section 5.4.4**). Longshore transport direction indicates that material would arrive in the study area through natural processes and eventually build the shoreline seaward, eventually clogging the outfalls. Once the outfalls are clogged the municipalities would have to expend funds to remove the excess sediment equal to the amount outlined in the Local Costs Forgone estimate, which exceeds the annualized $8,000 difference between the 4 year and 5 year nourishment cycles. The decision to recommend the 4 year cycle over the 5 year cycle is therefore policy compliant since the application of the annualized Local Costs Forgone benefits in a systems context would elevate the 4 year cycle benefits over the 5 year cycle benefits by reducing outfall maintenance costs.

The nourishment parameters were developed by considering background erosion losses using shoreline recession rates developed in the historic shoreline change analysis, losses due to the predicted rate of sea level rise, and "spreading out" losses due to diffusion of the beachfill through longshore transport gradients.

The first step in the calculation of nourishment rates was to compute representative wave characteristics and potential net longshore transport rates based upon the OCTI wave hindcast. A WIS phase III transformation was done to transform the deepwater waves from the OCTI hindcast described in Section 2.6.1 to shallower water. The program SEDTRAN was then used as discussed in Section 2.6.7 along with representative shoreline angles for each community on the barrier island to calculate potential net transport rates for each community along with representative wave characteristics along the barrier island. The representative wave characteristics computed by SEDTRAN included: effective wave height, mean wave period and wave angle.

A planform evolution model (**Table 78**) was then developed that required the following inputs: The effective wave height, period, angle, and longshore transport rates from the SEDTRAN simulations, a representative shoreline angle, and an equivalent beachfill width representing the size of the berm of the proposed beachfill. Beachfill percent remaining after any given year was output from the planform evolution model. Inputs to the planform evolution model are summarized below .

Table 78 Planform Evolution Model Inputs

Parameter	Value
Effective Wave Height	2.8 ft.
Mean Period	4.7 sec.
Wave Angle	133 deg. wrt North
Representative Shoreline Angle	47 deg. wrt North
Background Transport Rate	420,000 cy / yr
Nourished Beach Width	75 ft.

The background transport rate of 420,000 cy/yr is consistent with the value reported previously in **Table 34** for North Wildwood. The planform evolution model is a grid based model, and to account for end losses and diffusion of the beachfill, the grid was extended to the south. A zero nourished beach width was simulated in this grid extension. The grid was not extended to the north due to the presence of Hereford Inlet. The planform evolution model did not consider the down drift borrow area at Wildwood and Wildwood Crest. It was assumed that the borrow area would have minimal impact on the fill area given the distance between the northern most outfall as shown in **Figure 117** and end of the fill area as shown in **Figure 118** (Magnolia Drive). These plan sheets do show that the fill and borrow areas are adjacent to each other. However, it should be noted that emphasis when it comes time to take sand within the borrow area will be at outfall locations, and it should also be noted that the constructed berm as shown on the plans that is adjacent to the borrow area is relatively small compared to the larger berm that is required at the northern end of the project. This smaller constructed berm was assumed to have a negligible impact on the borrow area especially since the outfall where most likely material will be taken from is a significant distance away from Magnolia Ave. (approx. 2200 ft).

Output from the planform evolution model includes percent of original beachfill remaining after a given year. Experience gained by District personnel from ongoing monitoring of similar beachfills for neighboring northern parts of barrier islands in New Jersey suggest that approximately 70% of a beachfill remains after 4-years. Output from the model suggested that the percent of the original fill remaining after 4-years should be approximately 64% for the selected plan. To be conservative, the study team lowered the beachfill remaining percentage slightly to 60% in order to account for the location of the beachfill in relation to Hereford Inlet.

The 60% was applied to the initial quantity used in the model which resulted in a 4-year nourishment rate of approximately of 305,000 cy (no overfill factor applied) for Cells 1 and 2 combined with the majority of it being for Cell 1. Since the borrow area is the beach itself in front of Wildwood and Wildwood Crest and that the sand characteristics are similar along the entire barrier island, a 1:1 overfill factor was assumed for future nourishment cycles.

It should be noted that the 305,000 cy every 4-years may appear to be low and inconstant when compared to the potential net transport rate of 420,000 cy every year and the most recent erosion rates quantified in the shoreline change analysis for North Wildwood presented in the **Table 40** as 60 ft/yr. However, the value can be considered to be reasonable based upon a couple of factors:

1. A comparison was done of computed nourishment quantities against other projects the District has done in New Jersey. For this study the computed nourishment rate was calculated to be 19 cy per foot per year. This value was based upon a 4,000 foot beachfill length that covers Cells 1 and a small part of Cell 2. This value of 19 cy per foot per yr is slightly higher than other rates computed for the District's New Jersey's constructed projects which ranged from 7 to 15 cy per foot per yr and New Jersey's authorized but unconstructed projects which ranged from 3 to 13 cy per foot per yr. It is reasonable to assume that re-nourishment for North Wildwood be higher than other projects within the District; however to assume a significantly higher rate is most likely erroneous because as the long-term history has shown, the shoreline of North Wildwood has experienced periods of natural accretion in the past.

2. The reported net transport value of 420,000 cy/yr for North Wildwood is based upon several assumptions as the report suggests in Section 2.6.7. Namely that the rate assumes an "endless" supply of sand, free from influences of adjacent inlets or structures. As it is stated in Section 2.6.7, the actual sediment transport rate for North Wildwood could be less when considering the impact of Hereford Inlet. It should also be noted that the calculated transport rate was based upon wave characteristics and shore alignment for the years of 1986 – 1998. Long-term history suggests that transport rates could be smaller based upon the other longer time periods relative to 2003 that are shown in **Table 40**.

3. The reported erosion rate of 60 ft/yr for North Wildwood between the years of 1998-2003 as shown in **Table 40** is relative to a small time period of accelerated erosion that is not typical of the long-term trends of the shoreline in North Wildwood. For example in **Table 40**, the longer time period of 1977-2003 suggest that the erosion in North Wildwood was around 24 ft/yr (longer time periods relative to 2003 even suggest shoreline accretion). This value of 24 ft/yr is less than half of the more recent accelerated rate of 60 ft/yr. To disregard the erosion trends over the longer time periods and to focus solely on the most recent shorter trend of accelerated erosion could lead to the conclusion that nourishment should be higher. Only further data collection and monitoring efforts will indicate if the recent accelerated shoreline erosion rates in North Wildwood are a trend or an anomaly.

Table 79 Description of the Selected Plan

Design Component	Dimension/Quantity	Remarks
Berm Elevation	+6.5 NAVD 88	North Wildwood, Wildwood, Wildwood Crest and Lower Township
Berm Width	75 feet	Berm width measured from seaward base of dune to berm crest
Seaward Berm Slope	1:30	Same as average existing condition
Dune Elevation	+ 16 feet NAVD 88	Similar to surrounding regional beaches
Dune Width at Crest	25 feet	Standard Caldwell section
Dune Side Slopes	1:5	Standard Caldwell section
Dune Offset for Maintenance of Existing Structures	30 feet	Required dune offsets are reflected in selected plan layout
Length of Project	25,000 feet	Project extends from North Wildwood to southern tip of Diamond Beach
Initial Sand Quantity	1,527,250	Includes advanced nourishment with overfill
Periodic Nourishment Quantity	391,000	Includes overfill
Major Replacement Quantity	544,250	Includes periodic nourishment with overfill; same dune grass and sand fence quantities as initial fill
Taper Section	Northern taper -200 feet.,	The project will taper into Hereford Inlet and terminate at the USFWS property
Borrow Source Location	Beach in Wildwood Crest, Wildwood and Lower Township.	Overfill factor of 1.5 for borrow material
Dune Grass	64 acres	18” spacing
Sand Fence	28,000 feet	Along base of dune and at crossovers
Handicap Crossovers	7 existing, 6 new	
Pedestrian Dune Crossovers	44 existing, 7 new	Includes handicap access ramps
Vehicle Dune Crossovers	8 existing, 5 new	

5.1.3 Borrow Area Infilling Analysis

An analysis to determine potential longshore sediment transport was done in order to ascertain possible infilling rates post dredging of the borrow area along the beaches of Wildwood and Wildwood Crest (**Table 80**). Longshore or littoral transport can both supply and remove sand from coastal areas. In order to determine the balance of sediment losses and gains for an area such as the borrow area, net, rather than gross, transport rates are required. Net longshore transport refers to the difference between volume of material moving in one direction along the coast and that moving in the opposite direction. The design of the selected plan is consistent with accepted coastal engineering practice and Corps criteria described in the Coastal Engineering Manual. Implementation of the selected plan may cause temporary steep drop offs and small depressions along the beach during the initial construction. All construction areas are roped off and secure during construction, and the design profile is a smooth beach profile that mimics the existing slope. Beach conditions that could temporarily be hazardous to the community will be avoided by creating a profile that mimics the natural topography as planned in this document and designed in the project specifications. Safety zones will also be established around active construction areas.

The time period analyzed based upon available data was from 1986 to 1998. As part of the investigation, potential longshore transport rates due to waves were computed. The resulting longshore transport rates are shown in the table below.

Table 80 Potential Longshore Transport Rates

Analysis Segment	Shoreline Angle	Community	Left Directed (to the North) (cu. yds / yr)	Right Directed (to the South) (cu. yds / yr)	Net (to the South) (cu. yds / yr)	Gross (cu. yds / yr)
WW1	47	North Wildwood	-300,000	720,000	420,000	1,020,000
WW2	52	Wildwood	-300,000	670,000	370,000	970,000
WW3	46	Wildwood Crest	-300,000	720,000	420,000	1,020,000
WW4	42	Lower Township	-300,000	750,000	440,000	1,050,000

The values in the table indicate that generally, there is a net southward transport which may vary from 370,000 to 440,000 cubic yards per year within the study area. The trends in the estimates for the net longshore transport show southward transport to be almost doubled of northward transport. The rates computed can be used as a potential infilling rate for the borrow area along the beaches of Wildwood and Wildwood Crest.

The values in the table should be viewed as representative of potential average conditions over a span of 12 years from 1986 to 1998 It can be expected, however, that changes in longshore sediment transport could happen in a seasonal timeframe and could contribute significantly to both the short- and long-term infilling rates of the borrow area. It would be anticipated that shortly after removing any sand from the borrow area that there would be a short-term accelerated infilling rate of sand coming from the north followed by a period of time that is more representative of the long-term average infilling rate. It is recommended that any removal of sand from the borrow area be done over as wide of an area as possible within the borrow area as oppose to removing sand in a small concentrated area. This would help maintain the natural coastal processes in the area.

A periodic nourishment quantity of 305,000 cu yds (minus overfill) was estimated by modeling the selected plan layout as a single domain using the *Planform Evolution Model*, a numerical tool that calculates background erosion and alongshore spreading losses associated with beach fill construction. Advanced and periodic nourishment quantities include an overfill factor of 1.25 based on the use of sand from the selected borrow areas.

5.1.4 Project Construction Template

The constructed beach fill template typically varies from the design template because of working limitations of equipment used to place and shape the fill. After placement, sorting of the fill by waves and currents will naturally shape the constructed fill profile to an equilibrium form consistent with the design template. To account for these factors, the construction template is developed based on the “overbuilding method.”The overbuilding method involves placing the required design quantity at the proposed berm elevation, but with a berm width greater than the design width. The seaward slope of the construction berm is generally equal to or steeper then the natural existing equilibrium slope. The constructed berm is “overbuilt” in the sense that it is wider than the intended design berm. Coastal processes readjust the profile to a natural equilibrium state. In this case much of the overbuilt berm sand moves offshore to form the intended design profile. The proposed construction and design templates for the selected plan are shown in **Figure 116** through(**Figure 121)**. In these figures the part of the design template labeled “Design Offshore Volume” is the quantity that is placed up on the beach as a part of the overbuilt berm, labeled “Design Offshore Volume Placed Onshore”. The advanced nourishment quantity is also included in the overbuilt construction berm template. Beach fill construction using the overbuilding method often leaves the impression that much of the project sand has been lost soon after construction due to rapid readjustment of the construction profile. However, rather than being “lost,” this offshore movement of sand is an indication that the construction profile is functioning as intended to naturally form the design template. During the review a commenter pointed out that there was a concern with regards to the stability of the proposed berm where it connects to the existing berm which surrounds the convention center dune. Without sufficient design information to evaluate with regards to the existing berm, a hard 90 degree berm connection to existing berm can be a weak point and may fail during a large storm event. During the PED phase the design section at the junction of the existing dune and the new dune will be refined to show a larger than 90 degree radius turn at that junction.

Figure 113 North Wildwood Cross Section

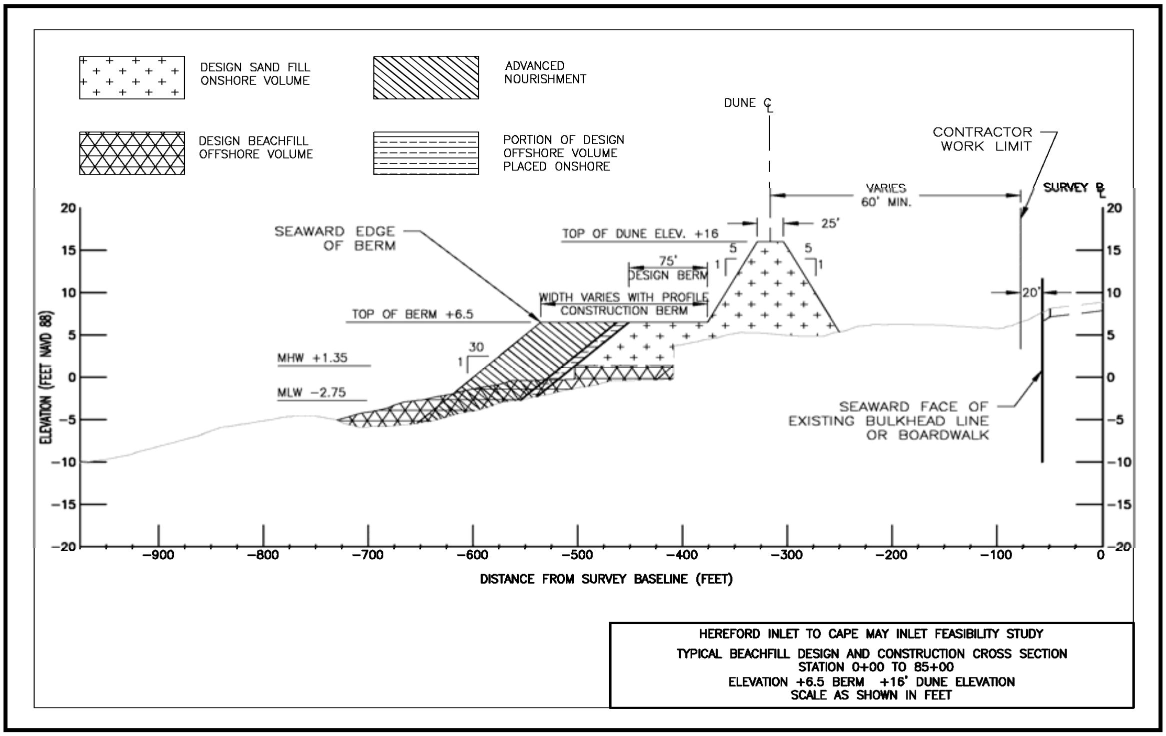


Figure 114 Wildwood and Wildwood Crest Cross Section

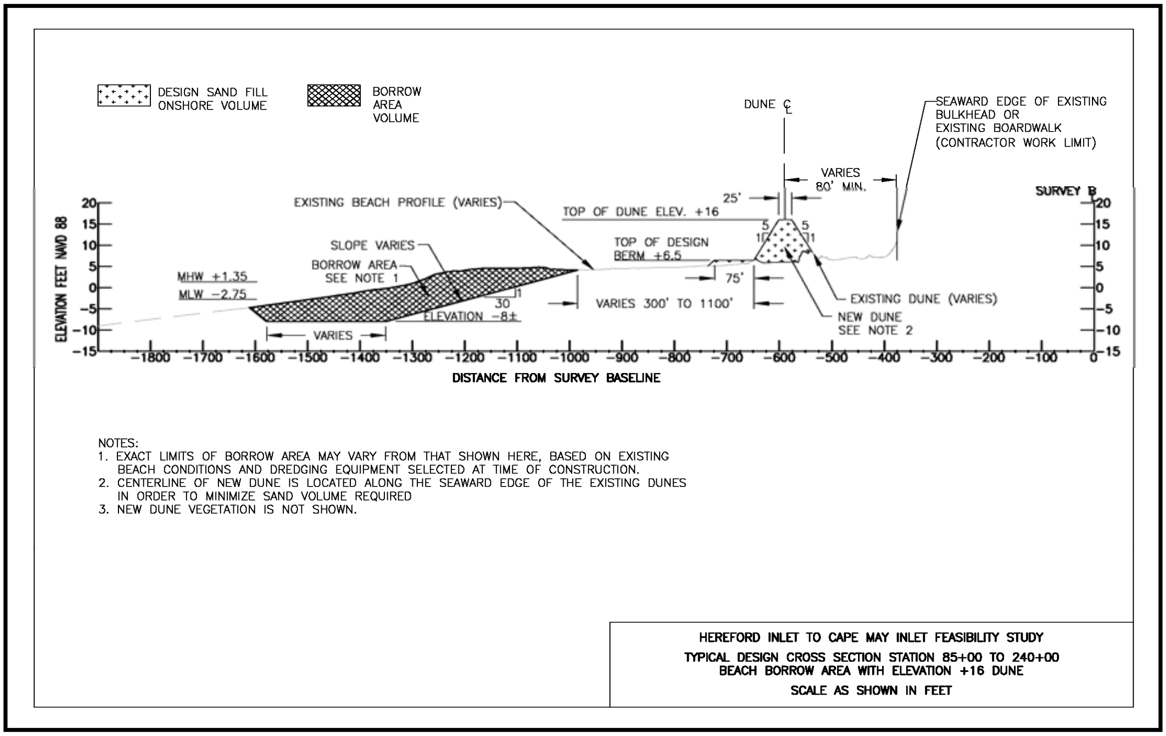


Figure 115 Lower Township Cross Section

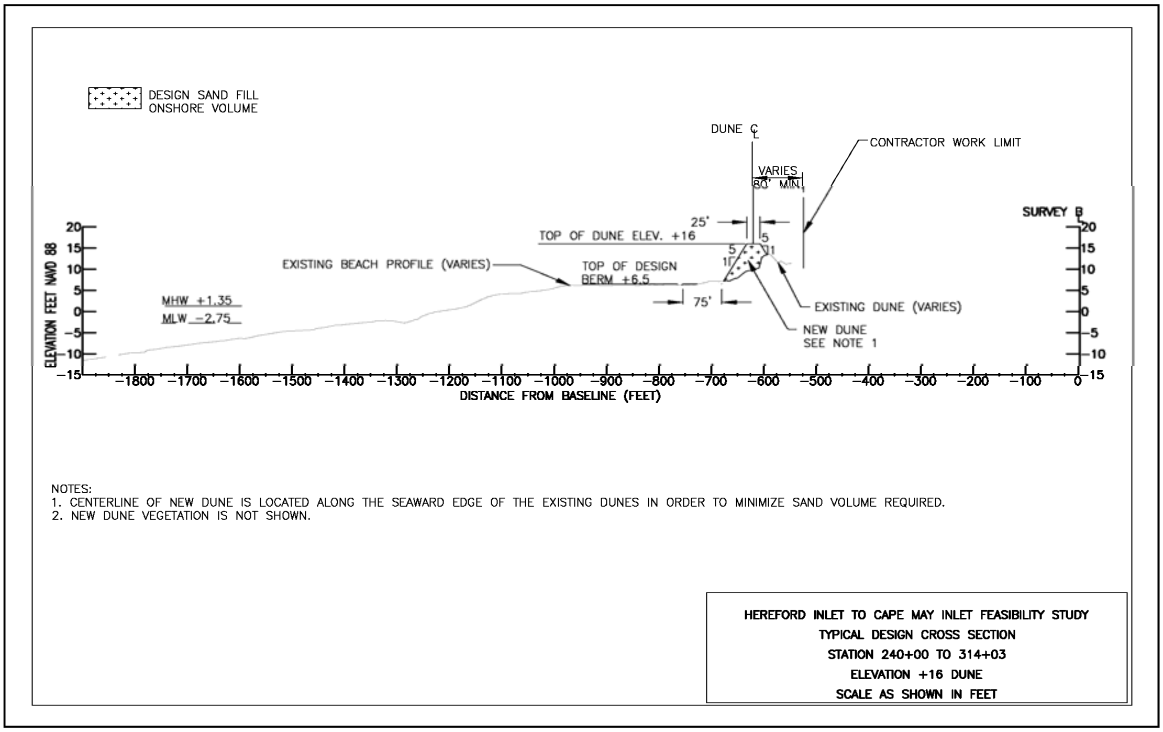


Figure 116 North Wildwood Plan View

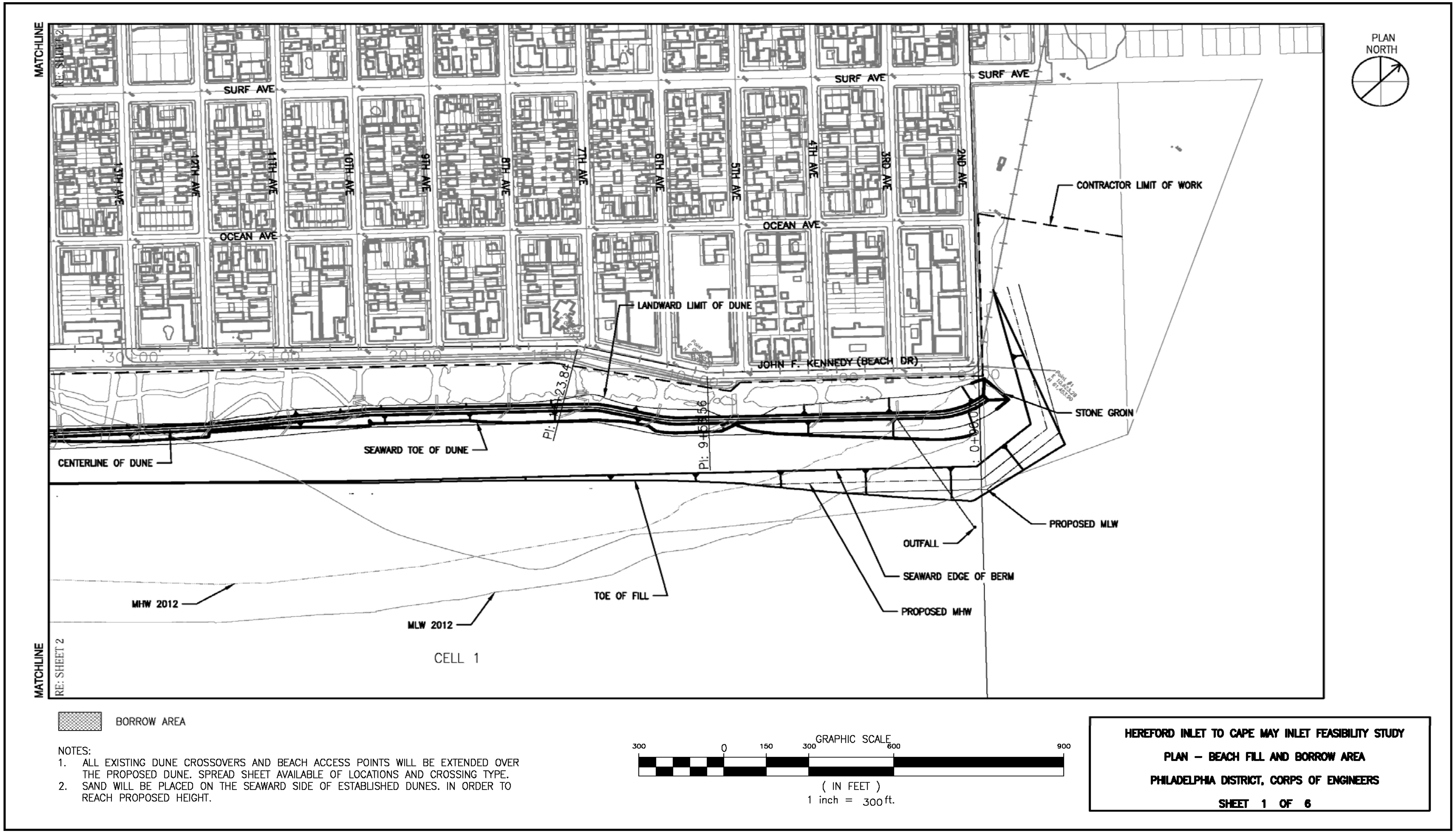


Figure 117 North Wildwood/Wildwood Plan View

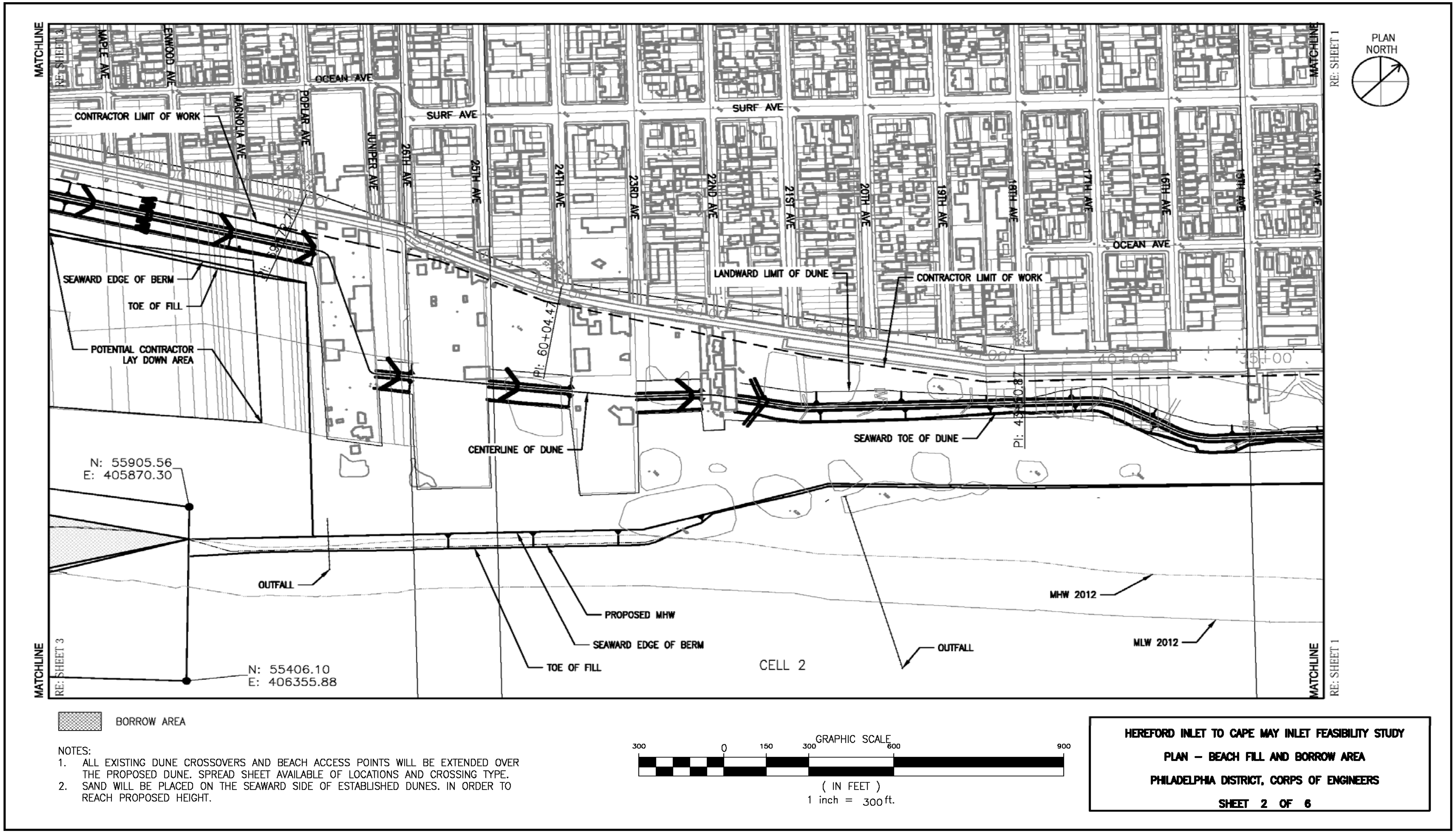


Figure 118 Wildwood Plan View

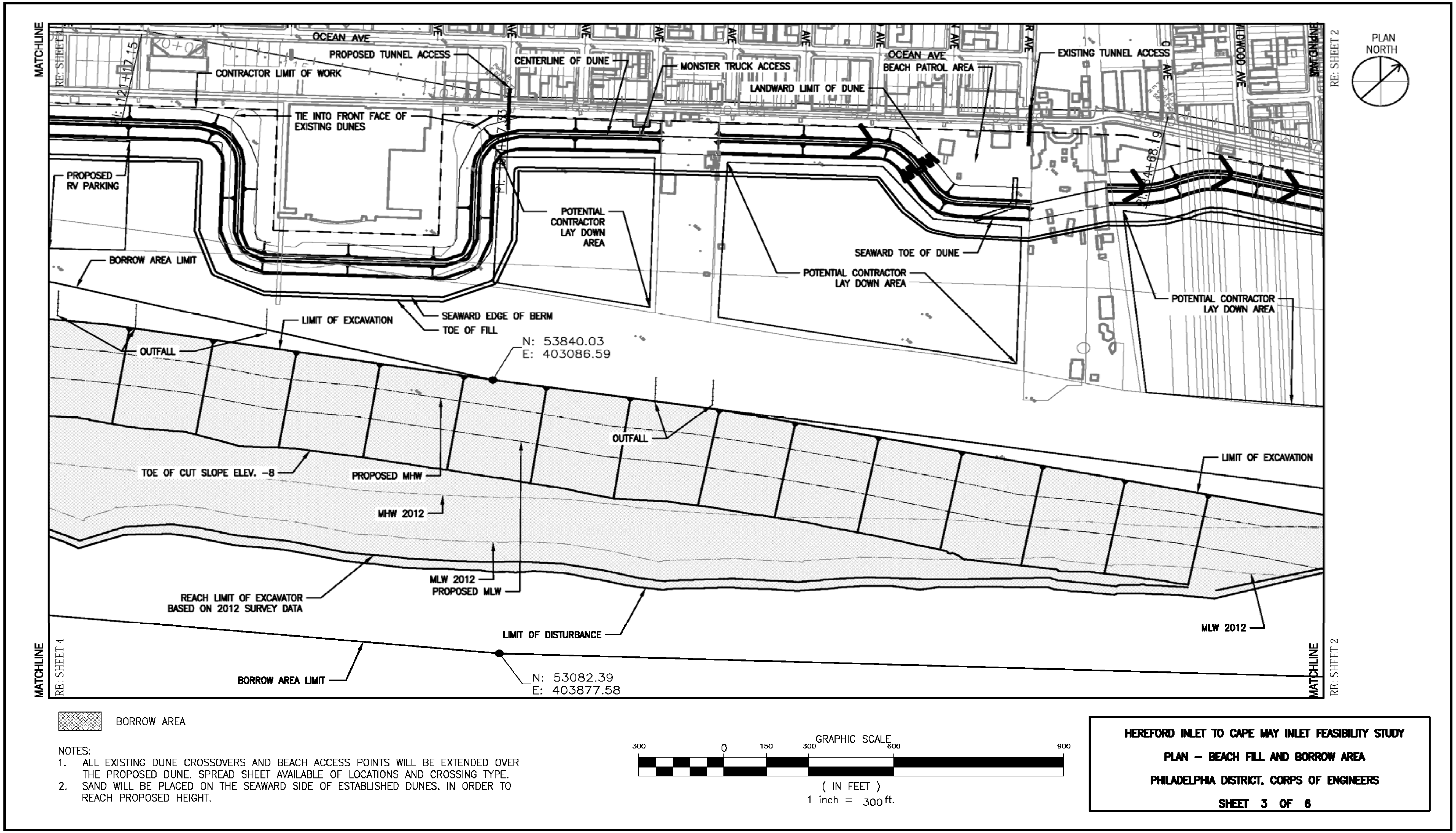


Figure 119 Wildwood Crest Plan View (2)

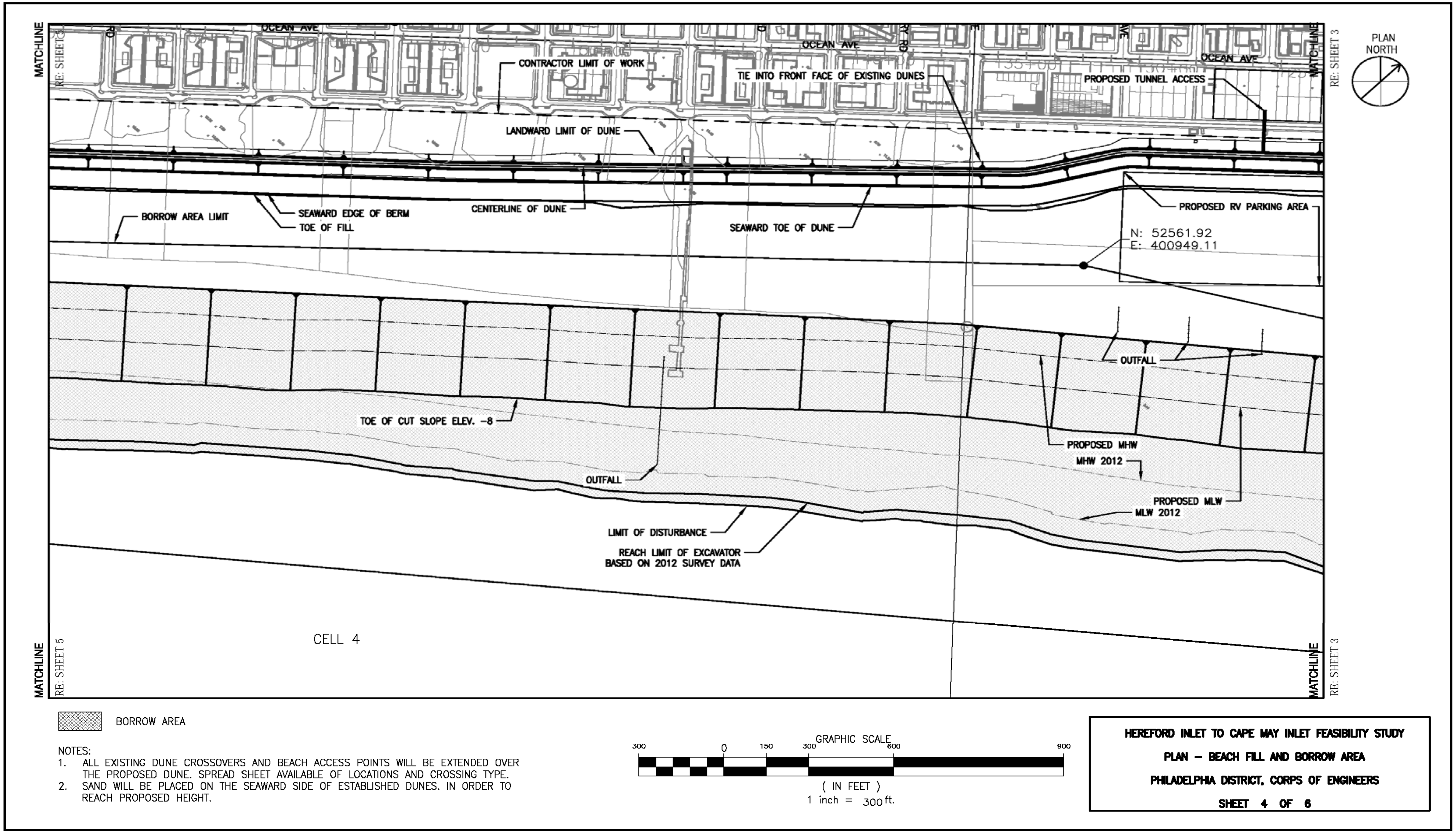


Figure 120 Wildwood Crest Plan View

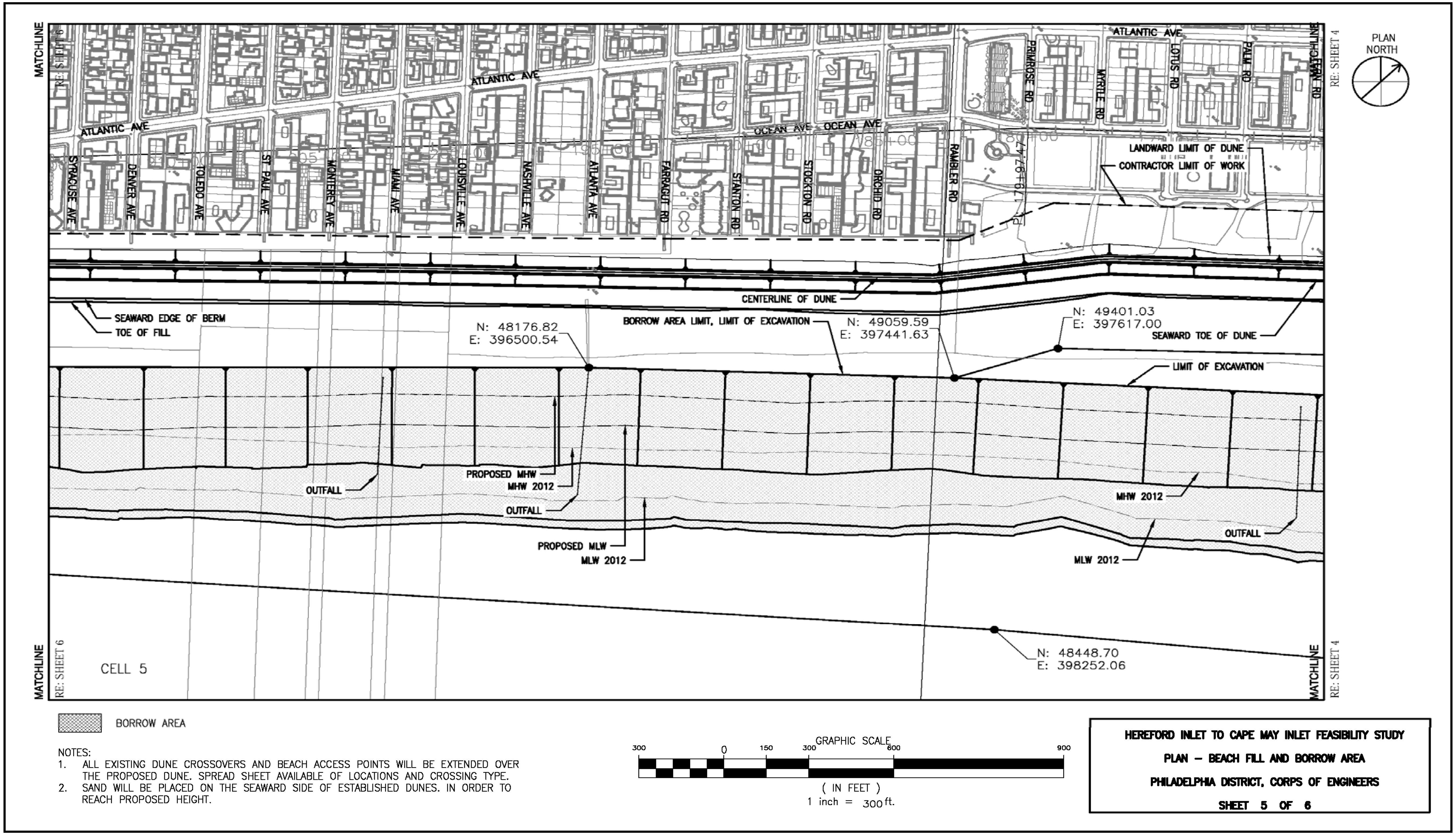
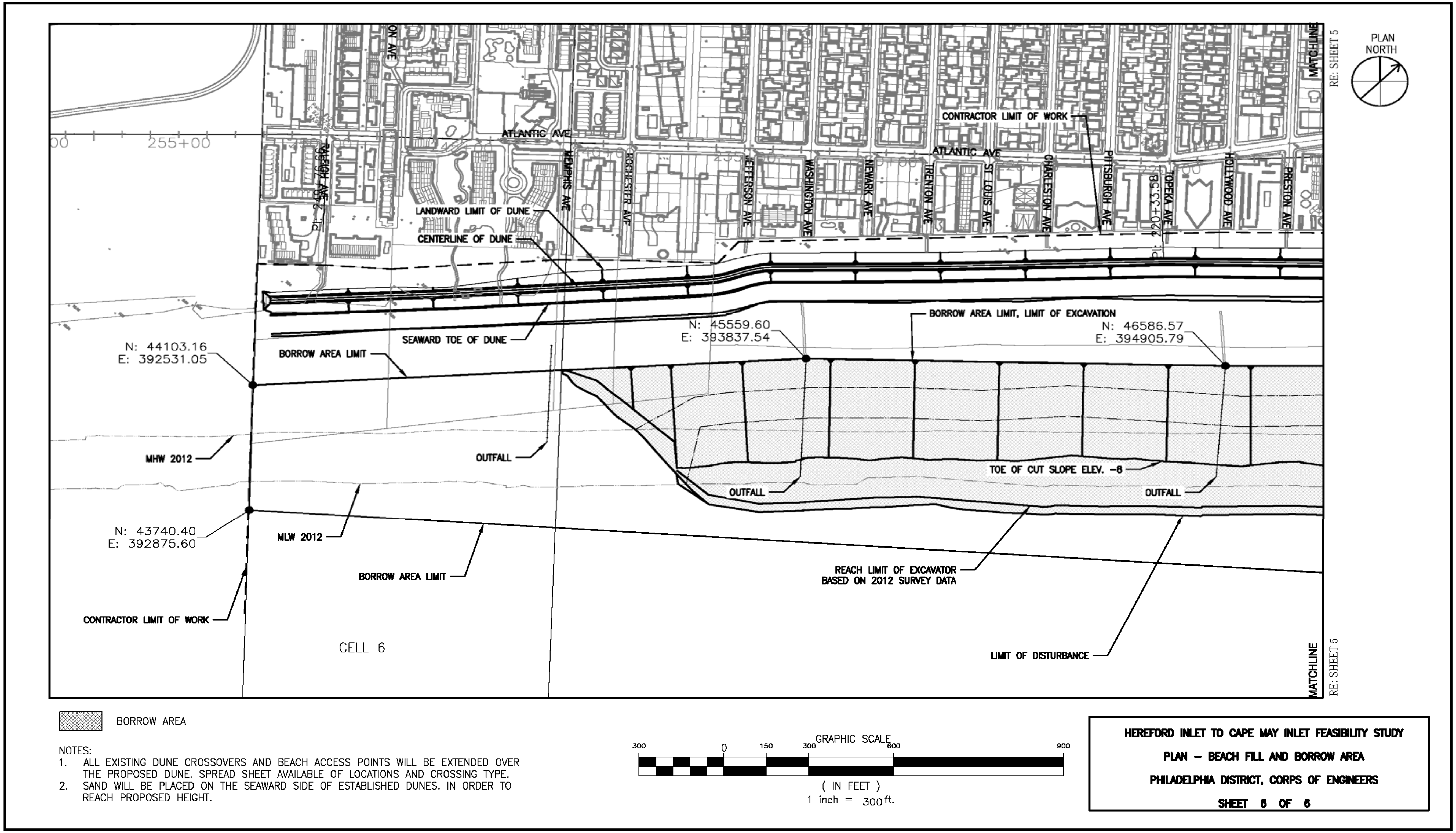


Figure 121 Wildwood Crest and Lower Township Plan View



5.1.5 Backpass Methodology

Sediment backpassing involves the removal of sand from an area in a sand surplus to an area in a sand deficit, usually in the opposite direction of long-shore transport. Longshore sediment transport is dominant in the southerly direction in this area, and we propose backpassing sediment from the south to the north, in the opposite direction of natural transport. This can be accomplished with scraping and truck hauling the material to the deposition site or with mobile hydraulic backpassing techniques. The latter is being recommended for the Hereford Inlet to Cape May Inlet project. Mobile hydraulic sediment backpassing will involve the use of 1 to 2 crawler cranes deploying a submersible or centrifugal pump in the surf zone to remove sediment from a source area, pump it through an 12 inch pipeline to a the placement area, and shape the sand into a dune and berm**.**

5.1.6 Existing Backpass Systems

The Worldwide Systems Data Report by PK Bosswood and RJ Murray, 1997 indicated that as of 1997 there were 53 sediment backpass, and by-pass systems worldwide. These systems remove material from areas of surplus sand to deficit areas in order to manage the resource more efficiently. Locally, two systems are employing backpass methodology successfully, The Indian River Inlet, Delaware project and a project recently constructed by the National Park Service at Sandy Hook, NJ. Sandy Hook, the northernmost 7 miles of beach along New Jersey's coast, has a long history of persistent shoreline erosion and change. After considering many options and measures, all parties agreed that the best plan would be a sand recycling arrangement based on pumping a sand slurry from a point of surplus at Gunnison Beach to the critical eroding zone. Gunnison Beach, in the northern area of Sandy Hook, has been increasing in sediment budget by the same amount of sand being lost in the critical eroding zone. The Gunnison Beach shoreline also has access to large migrating shoals, which makes it an ideal source of sand.

The Indian River Inlet project was authorized in the Flood Control Act of 1968 and the Water Resources Development Act of 1986 (P.L. 99-662). The plan of improvement consists of constructing a sand bypassing plant and operation of the plant for the periodic nourishment of approximately 100,000 cubic yards of sand annually to nourish approximately 3,500’ of shoreline on the north side of the inlet and protect the Delaware Route 1 highway. The Indian River Inlet project is authorized for nourishment until September 2021.

5.1.7 Sediment Backpassing Technology

Design decisions for the backpass system were assisted with a letter report by the Corps James Clausner P.E., and Time Welp of the U.S. Army Engineer Research and Development Center (ERDC), in Vicksburg Miss., as well as Engineering Instruction Report HL-81-1 (**Appendix 16, Volume 2**). The ERDC letter report compiled data on dredging rates, pumping technology, the industry’s ability to complete the work based on similar projects, the conceptual layout and the design. The report assisted in the details of the design including pump size, booster spacing requirements based on distance and grain size of the native material and pipeline diameter.

A conceptual layout of a sediment backpass system for the Hereford Inlet to Cape May Inlet project is contained in **Figure 122** and **Figure 123.** The system would involve a crawler crane mounted with a pump on a 100' boom that would excavate material from the beach and nearshore in Wildwood and Wildwood Crest. This crane and pump system would be attached to an 8" High Density Polyethylene Pipe (HDPE) with a series of boosters that would transport the material to the design locations.

Figure 122 Schematic of Hydraulic Backpassing System courtesy of ERDC

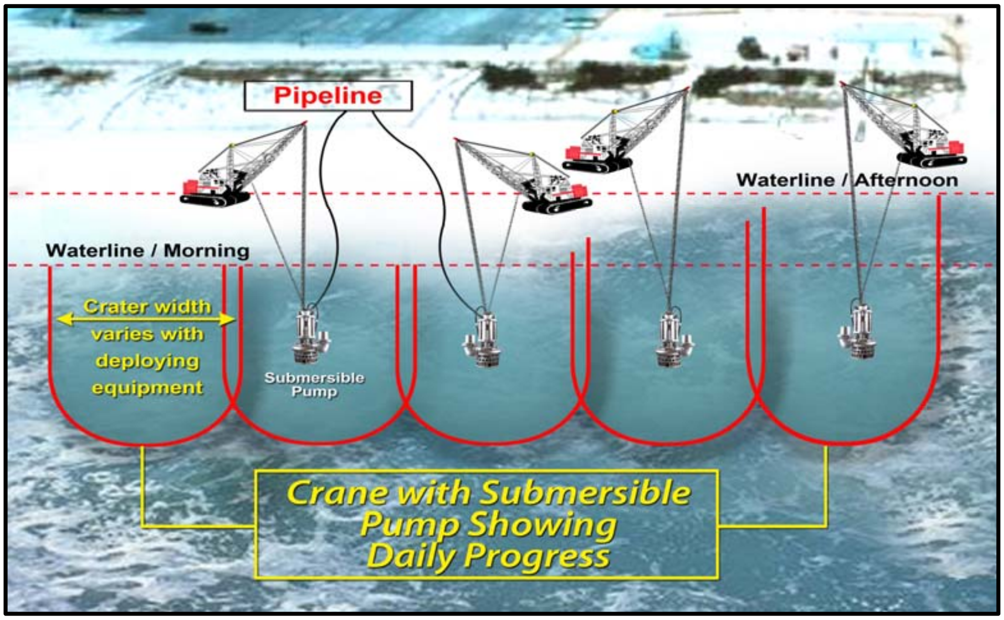
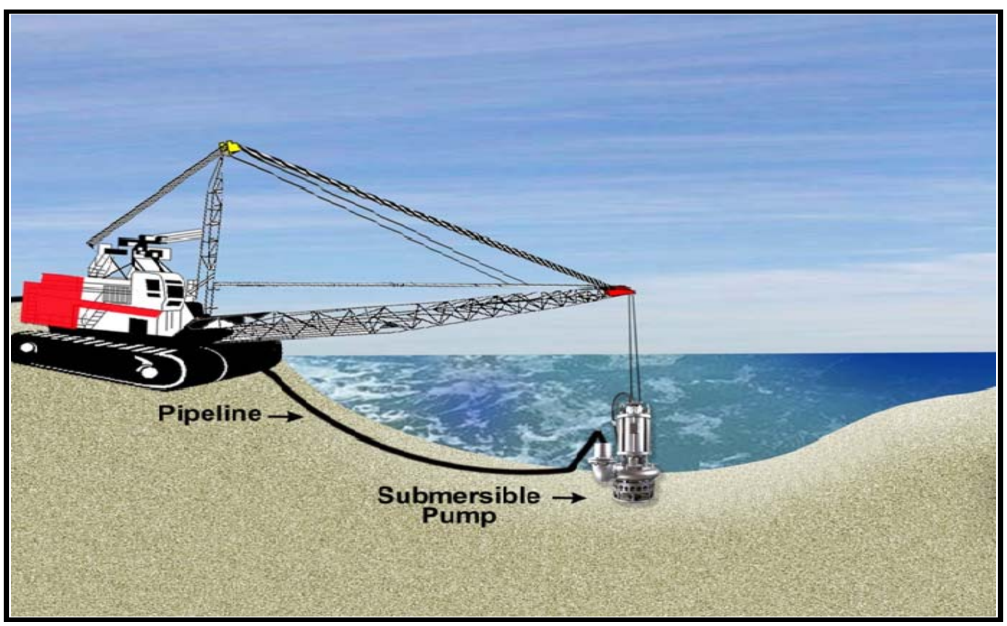


Figure 123 Side View of Crawler Crane and Crater



The crater size generated by the pump is shown in the figure above and equal to three times the depth of the crater. Dredging rates and volumes in cubic yards per hour are contained the in the Dredging Technology Appendix provided by Clausner and Welp of the Corps of Engineers, Engineering Research and Design Center. Tables from that report are contained on the following page (**Table 81** and **Table 82**).

5.1.8 Pumps

There are two types of pumps used for most sediment backpassing and by-passing operations; centrifugal and eductor. Centrifugal pumps operate with a combination of an agitator with spinning blades or high pressure water injected into the sand in combination with a spinning blade within a chamber that causes negative pressure in the chamber and entrainment of a sand/water mixture. Centrifugal pumps do not require a 100% clear water mixture and have a high discharge capability compared to eductor pumps. Eductor, or jet pumps, use the acceleration of water through a restrictor nozzle to entrain and transport sand. Clear, 100% sediment free water enters the eductor pump through the supply line and is forced through a restrictor nozzle. This restrictor nozzle increases the water velocity, and this increase in velocity over a bed of unconsolidated material will entrain the sand/water mixture into the pump, through the suction tube, through the mixing chamber and eventually through the discharge pipeline. Jet pumps require a 100% clean water supply to operate, and have a lower cubic yards per hour discharge rate than centrifugal pumps. Eductor pumps are employed at Indian River Inlet, DE for the sand by-passing project across Indian River Inlet.

The Corps Engineering and Research Design Center (ERDC) evaluated 88 different scenarios for transporting between 100,000- 1,000,000 cubic yards of sand based on production rates, working days and pumping hours .

For the initial construction cost estimate and design, the District is estimating two crawler cranes, each with a 100’ boom suspending a centrifugal pump that is capable of pumping approximately 400 cubic yards an hour (cyh). The initial construction is estimated to be approximately 8 months. These cranes will work in the intertidal zone, and move in and out with the tides in order to reach the outer limits of the near shore borrow area. The excavated material will be shaped into a dune and berm in North Wildwood, Wildwood, Wildwood Crest and a portion of Lower Township.

Table 81 Sediment Backpassing Production, 300 cyh

Scenario	Volume	Average production	Working hours	Avg Daily	Working days	Avg Weekly	Job Duration
1	1,000,000	300	8	2,400	5	12,000	18.9
2	1,000,000	300	9	2,700	5	13,500	16.8
3	1,000,000	300	10	3,000	5	15,000	15.2
4	1,000,000	300	12	3,600	5	18,000	12.6
5	1,000,000	300	16	4,800	5	24,000	9.5
6	1,000,000	300	8	2,400	6	14,400	15.8
7	1,000,000	300	9	2,700	6	16,200	14
8	1,000,000	300	10	3,000	6	18,000	12.6
9	1,000,000	300	12	3,600	6	21,600	10.5
10	1,000,000	300	16	4,800	6	28,800	7.9
11	1,000,000	300	24	7,200	7	50,400	4.5
12	500,000	300	8	2,400	5	12,000	9.5
13	500,000	300	9	2,700	5	13,500	8.4
14	500,000	300	10	3,000	5	15,000	7.6
15	500,000	300	12	3,600	5	18,000	6.3
16	500,000	300	16	4,800	5	24,000	4.7
17	500,000	300	8	2,400	6	14,400	7.9
18	500,000	300	9	2,700	6	16,200	7
19	500,000	300	10	3,000	6	18,000	6.3
20	500,000	300	12	3,600	6	21,600	5.3
21	500,000	300	16	4,800	6	28,800	3.9
22	500,000	300	24	7,200	7	50,400	2.3
23	200,000	300	8	2,400	5	12,000	3.8
24	200,000	300	9	2,700	5	13,500	3.4
25	200,000	300	10	3,000	5	15,000	3
26	200,000	300	12	3,600	5	18,000	2.5
27	200,000	300	16	4,800	5	24,000	1.9
28	200,000	300	8	2,400	6	14,400	3.2
29	200,000	300	9	2,700	6	16,200	2.8
30	200,000	300	10	3,000	6	18,000	2.5
31	200,000	300	12	3,600	6	21,600	2.1
32	200,000	300	16	4,800	6	28,800	1.6
33	200,000	300	24	7,200	7	50,400	0.9
34	100,000	300	8	2,400	5	12,000	1.9
35	100,000	300	9	2,700	5	13,500	1.7
36	100,000	300	10	3,000	5	15,000	1.5
37	100,000	300	12	3,600	5	18,000	1.3
38	100,000	300	16	4,800	5	24,000	1
39	100,000	300	8	2,400	6	14,400	1.6
40	100,000	300	9	2,700	6	16,200	1.4
41	100,000	300	10	3,000	6	18,000	1.3
42	100,000	300	12	3,600	6	21,600	1.1
43	100,000	300	16	4,800	6	28,800	0.8
44	100,000	300	24	7,200	7	50,400	0.5

Table 82 Sediment Backpassing Production, 450 cyh

Scenario	Volume	Average production	Working hours	Avg Daily	Working days	Avg Weekly	Job Duration
1	1,000,000	450	8	3,600	5	18,000	12.6
2	1,000,000	450	9	4,050	5	20,250	11.2
3	1,000,000	450	10	4,500	5	22,500	10.1
4	1,000,000	450	12	5,400	5	27,000	8.4
5	1,000,000	450	16	7,200	5	36,000	6.3
6	1,000,000	450	8	3,600	6	21,600	10.5
7	1,000,000	450	9	4,050	6	24,300	9.4
8	1,000,000	450	10	4,500	6	27,000	8.4
9	1,000,000	450	12	5,400	6	32,400	7
10	1,000,000	450	16	7,200	6	43,200	5.3
11	1,000,000	450	24	10,800	7	75,600	3
12	500,000	450	8	3,600	5	18,000	6.3
13	500,000	450	9	4,050	5	20,250	5.6
14	500,000	450	10	4,500	5	22,500	5.1
15	500,000	450	12	5,400	5	27,000	4.2
16	500,000	450	16	7,200	5	36,000	3.2
17	500,000	450	8	3,600	6	21,600	5.3
18	500,000	450	9	4,050	6	24,300	4.7
19	500,000	450	10	4,500	6	27,000	4.2
20	500,000	450	12	5,400	6	32,400	3.5
21	500,000	450	16	7,200	6	43,200	2.6
22	500,000	450	24	10,800	7	75,600	1.5
23	200,000	450	8	3,600	5	18,000	2.5
24	200,000	450	9	4,050	5	20,250	2.2
25	200,000	450	10	4,500	5	22,500	2
26	200,000	450	12	5,400	5	27,000	1.7
27	200,000	450	16	7,200	5	36,000	1.3
28	200,000	450	8	3,600	6	21,600	2.1
29	200,000	450	9	4,050	6	24,300	1.9
30	200,000	450	10	4,500	6	27,000	1.7
31	200,000	450	12	5,400	6	32,400	1.4
32	200,000	450	16	7,200	6	43,200	1.1
33	200,000	450	24	10,800	7	75,600	0.6
34	100,000	450	8	3,600	5	18,000	1.3
35	100,000	450	9	4,050	5	20,250	1.1
36	100,000	450	10	4,500	5	22,500	1
37	100,000	450	12	5,400	5	27,000	0.8
38	100,000	450	16	7,200	5	36,000	0.6
39	100,000	450	8	3,600	6	21,600	1.1
40	100,000	450	9	4,050	6	24,300	0.9
41	100,000	450	10	4,500	6	27,000	0.8
42	100,000	450	12	5,400	6	32,400	0.7
43	100,000	450	16	7,200	6	43,200	0.5
44	100,000	450	24	10,800	7	75,600	0.3

5.1.9 Major Replacement Requirements

Major replacement quantities were developed in accordance with ER 1110-2-1407 to identify additional erosion losses from the project due to higher intensity (low frequency) storm events. The nourishment rates developed for the project measures include losses due to storms that have occurred within the analysis period. Storms of approximately 50-year return period and more frequent are encompassed in those rates. Major replacement losses are computed as the losses that would occur from the 50% risk event over the period of analysis. The annual percent frequency event with a 50% risk during the 50-year period of analysis is 1.37%. The period of record of stages recorded at the study area is approximately 73 years. SBEACH was employed to compute volumetric erosion from the selected beach alternative design profile utilizing the 50- and 100-yr return period storm parameters utilized in the without- and with project analyses. Volumetric erosion quantities for the 73-yr event were obtained by interpolating between the 50- and 100-yr events. Water levels and waves were hindcast at the study area for the storm, and all model parameters were identical to the without and with-project analyses. Volumetric storm induced erosion was computed for each reach for the design beach profile. Based on local profile analyses and experience developed at the Philadelphia, and other Corps coastal Districts, it is estimated that approximately 60% of the material displaced during large storms will return to the foreshore within weeks and only the remaining 40% will require mechanical replacement onto the sub aerial beach to regain the design cross-section and insure the predicted level of storm damage reduction. It is estimated that a volume of approximately153,000 cu yds would be required to perform major rehabilitation in response to the 50% risk event. This quantity is added to the periodic nourishment quantity discussed above at year 24 for cost estimating purposes. Therefore, total major replacement sand quantity in year 24 is **153,000** cu yds **Table 83**, minus periodic nourishment. Because a high intensity storm would likely impact dune grass, crossovers, and sand fence, these items were included in the total major replacement costs.

Table 83 Major Replacement Volumes

Cell	Quantity cubic yards
1	57,000
2	60,000
3	13,000
4	9,000
5	12,000
6	2,000
TOTALS	**153,000**

5.1.10 Project Transitions and Tapers

There is one taper section at the northern end of the project area. At the northern end, the project terminates at second street and JFK boulevard, with the terminus extending into Hereford Inlet along the North Wildwood Seawall for approximately 200'. On the southern end the project will terminate at the northern terminus of the United States Fish and Wildlife property in Lower Township. Beach fill transitions between different design berm and dune dimensions are included in the selected plan layout and are reflected in the total quantity estimates. .

5.2 Environmental Impacts

5.2.1 Physical Environment

Mobile hydraulic backpassing of sand from the beaches in Wildwood and Wildwood Crest would result in the temporary excavation of shallow pits deeper than the surrounding bathymetry within the intertidal zone. This is due to the existing flat nature of the bottom. Initially, backpassing cuts may produce abrupt edges. However, these cuts will quickly become reworked by the wave action in the intertidal zone and refilled with sand from the surrounding area, resulting in a landward shift of the mean high water (MHW) line. Based on the location of the sand removal, similar substrate characteristics would remain following dredging. The average depth of excavation will be 4-8' and will vary based on the existing ground elevation. Sand will be removed from the intertidal zone to a maximum depth of -8' NAVD.

5.2.2 Water Quality

The backpassing associated with the beach nourishment alternative would result in short-term adverse impacts to water quality in the immediate vicinity of the excavation and beach nourishment operations. Excavating sand from within the proposed intertidal borrow area will generate turbidity, resulting in sedimentation impacts within the immediate vicinity of the operations. Short-term increased turbidity can affect organisms in several ways. Primary production in phytoplankton and/or benthic algae may become inhibited from turbidity. Suspended particulate matter can clog gills and inhibit filter-feeding species. Reilly *et.al*. 1983 determined that high turbidity could inhibit recruitment by pelagic larval stocks. In addition, mid-water nekton like finfish and mobile benthic invertebrates may migrate outside of the area where turbidity and deposition occur.

The amount of turbidity and its associated plume is mainly dependent on the grain size of the material. Generally, the larger the grain-size, the smaller the area of impact. The period of turbidity is also less with larger grain-sized materials. The proposed borrow location contains medium to fine sands, which are coarser grained than silts and clays. Turbidity resulting from the re-suspension of these sediments is expected to be localized and temporary in nature. Utilization of a hydraulic pump with a pipeline delivery system will help minimize the impact, however, some disturbance will occur.

Similar water quality effects on aquatic organisms could likely be incurred from the deposition of borrow material on the beach. Increased turbidity resulting from the deposition of a slurry of sand will be temporary in nature and localized. This effect will not be significant as turbidity levels are naturally high in the high-energy surf zone. Organisms in the surf zone versus deep water areas will be less likely to suffer adverse effects from turbidity because they have already adapted to these conditions. Fine sediments sifted from the deposited material would be transported by waves and currents into the nearshore with varying environmental impacts from a few months to at least several years (Hurme and Pullen, 1988). Parr *et. al*., 1978 determined that fine materials were rapidly sorted out and transported offshore after beach deposition. In their study, the dredged material had a much higher silt content than the beach, however, all of the silt was removed within 5 months. The selection of borrow material from a high energy beach environment should minimize the fine particle content. Material taken from the proposed borrow area will have low quantities of silt, therefore, high levels of turbid waters after deposition should not persist.

5.2.3 Biological Environment

5.2.3.1 Terrestrial

Impacts on terrestrial flora and fauna will be minimal within the project area. Existing dune vegetation, where present, would not be disturbed by renourishment activities. New dunes will be planted with dune grass following construction activities. Rapid recolonization of other types of vegetation on the beach face such as sea rocket and seaside goldenrod is expected. Impacts to wildlife species inhabiting the beach and dune areas are expected to be short-term and minor as most species are highly mobile and capable of moving outside the impacted areas until construction ceases.

5.2.4 Aquatic

5.2.4.1 Effects on Benthos

The majority of the impacts of beach fill borrow and placement will be felt on organisms in the intertidal zone and near shore zones. The near shore and intertidal zone is highly dynamic, harsh, and is characterized by great variations in various abiotic factors. Fauna of the intertidal zone are highly mobile and respond to stress by displaying large diurnal, tidal, and seasonal fluctuations in population density (Reilly *et al*. 1983). Despite the resiliency of intertidal benthic fauna, the initial effect of beach fill deposition will be the smothering and mortality of existing benthic organisms within the shallow near shore (littoral) zone on the oceanfront. This will initially reduce species diversity and number of animals. Burial of less mobile species such as amphipods and polychaete worms would result in losses, however, densities and biomasses of these organisms are relatively low on beaches. Beach nourishment may also inhibit the return of adult intertidal organisms from their near shore-offshore overwintering refuges, cause reductions in organism densities on adjacent unnourished beaches, and inhibit pelagic larval recruitment efforts. Parr *et al*. (1978) notes that the near shore community is highly resilient to this type of disturbance. The ability of a nourished area to recover depends heavily on the grain size compatibilities of material pumped on the beach (Parr *et al.*,1978). Due to the fact that the sand being placed in North Wildwood is coming from similar intertidal habitat and has accumulated as a result of the sediment transport mechanisms in the project area, grain size compatibility will allow for rapid re-colonization.

Over the life of the project, it is estimated that approximately 415 acres of intertidal benthic habitat will be impacted in Wildwood and Wildwood Crest during the life of the hydraulic backpassing activities. Approximately 250 acres will be impacted during initial construction as sand is removed from the intertidal zone and the MHW line is moved landward. Dredging will primarily impact the benthic organisms in the surf zone. Mortality of some of these organisms may occur as they pass through the dredge device. A secondary disturbance would be the generation of turbidity and deposition of sediments on the benthic community adjacent to the backpassing. Despite the initial effects of dredging on the benthic community, recolonization is anticipated to occur quickly due to the dynamic nature of the intertidal zone. Due to the location of the borrow zone within the intertidal zone, any pits created by the removal of sand are expected to fill in quickly as a result of wave action in the surf zone. It is important that for recovery, the bottom sediments are composed of the same grain sizes as the pre-dredge bottom. Since waves will quickly fill the borrow area with sand from the adjacent surf zone, grain size within the borrow area after excavation is expected to be nearly identical to sand removed. It should be noted that the backpassing operation will utilize an eight-inch pipe for sand transport which is much smaller than the 24-36" pipes used for traditional dredging projects. The smaller pipe size equates to a lower velocity within the pipe and a lower volume of material placed on the beach on any given day. These lower volumes and velocities will reduce benthic impacts associated with the operations.

5.2.5. Impacts on Fisheries

5.2.5.1 Finfish

With the exception of some small finfish, most fish found in the surf zone are highly mobile, and should be capable of avoiding entrainment into the dredging intake stream. It is anticipated that some finfish would avoid the turbidity plume while others may become attracted to the suspension of food materials in the water column. Little impact to fish eggs and larvae are expected because these life stages are widespread throughout the Middle Atlantic Bight, and not particularly concentrated in the surf zone of the project area (Grosslein and Azarovitz, 1982). The primary impact to fisheries will be felt from the disturbance of benthic community. The loss of benthos entrained or smothered during the project will temporarily disrupt the food chain in the impact area. This effect is expected to be temporary as these areas become rapidly recolonized by pioneering benthic species.

5.2.5.2 Essential Fish Habitat

As discussed previously, there are a number of Federally managed fish species where essential fish habitat (EFH) was identified for one or more life stages within the project area. Fish occupation of waters within the project area is highly variable spatially and temporally. Some of the species are strictly offshore, while others may occupy both near shore and offshore waters. In addition, some species may be suited for the open-ocean or pelagic waters, while others may be more oriented to bottom or demersal waters. This can also vary between life stages of Federally managed species. Also, seasonal abundances are highly variable, as many species are highly migratory.

In general, adverse impacts to Federally managed fish species may stem from alterations of the bottom habitat, which would result from backpassing and beach fill placement in the intertidal zone and near shore area. EFH may also be adversely impacted temporarily through water quality impacts such as increased turbidity and decreased dissolved oxygen content in the dredging and placement locations. These impacts would subside upon cessation of construction activities.

Biological impacts on EFH are more indirect involving the temporary loss of benthic food prey items or food chain disruptions. Turbidity at the placement site could impact the ability of sight feeders to find prey and construction activities in general could cause certain species to avoid the area. As previously stated, however, the affect on benthic food-prey organisms present in the borrow area and sand placement areas is considered to be temporary as benthic studies have demonstrated recolonization occurs quickly in the dynamic near shore environment. In addition, the impact area is a naturally turbid environment and species found in this zone are accustomed to a certain level of suspended sediments in the water column. The sandy nature of the borrow material, and the fact it is already well sorted from being in the intertidal zone, will keep excess turbidity to a minimum.

Direct impacts could also occur to Federally managed species if they were to become entrained in the dredge pump. Only egg, larvae and very small fish that would be found in the intertidal zone would be susceptible to entrainment as most species and life stages would be able to avoid the dredging activity. The small size (8-inch) of the pipeline makes entrainment less likely than with a traditional dredge apparatus.

5.2.6 Threatened and Endangered Species

The piping plover, which is State listed as endangered and Federally listed as threatened, is a frequent inhabitant of New Jersey's sandy beaches. Plovers have nested in North Wildwood for at least the past 10 years. Plovers have also nested at the Cape May National Wildlife Refuge and the adjacent Coast Guard property during this time period, but not on a regular basis. It is expected that plovers will continue to nest in these areas, especially following beach restoration activities. Currently, piping plover monitoring is being conducted in North Wildwood, through the New Jersey Department of Environmental Protection, Division of Fish and Wildlife and the U.S. Fish and Wildlife Service. This practice will continue throughout the life of the project, or until such time as the duty is handed over to the local municipalities. In addition, protection measures laid out by NJDEP, Division of Fish and Wildlife and the U.S. Fish and Wildlife Service will be followed during all renourishment activities in order to protect the piping plovers from being disturbed. These measures may include establishing a buffer zone around the nest, and limiting construction to be conducted outside of the nesting period (15 March - 15 August).

Beach replenishment activities can potentially have significant direct and indirect adverse impacts on piping plovers. Sand placement can bury nests, and machinery and vehicles on the beach can crush eggs, nestlings, and adults. Human disturbance related to recreational activities can disrupt successful nesting of these birds by preventing birds from feeding and scaring adults off established nests. Also, pipelines used during construction may become barriers to young chicks trying to reach intertidal areas to feed. It is believed that in New Jersey, predation is probably the primary cause of mortality for plover chicks. Observations by NJDEP, however, support the finding that chick survival and susceptibility to predation is strongly influenced by other factors, especially human disturbance and the availability and access to optimal foraging areas (Jenkins, 1999).

Other indirect impacts associated with the proposed plan include the temporary reduction in the quality of forage habitat for piping plover and other shorebirds within the intertidal zone until the area becomes recolonized by benthic fauna such as polychaete worms, mollusks, and crustaceans. This impact will be short-lived as the benthic invertebrates can immediately recolonize the newly created habitat (Burlas *et al*, 2001). The construction of a wider beach may result in the beach becoming more attractive to nesting birds such as piping plover, least tern, and black skimmers. Although this may appear to be beneficial, it is believed that this could have adverse impacts on these species. This is based on the fact that a replenished wider beach may attract these birds away from natural areas where human disturbance effects are less.

Another species which may be found within the project area is the Federally-listed threatened plant, seabeach amaranth, which inhabits overwash flats, accreting ends of coastal barrier beaches and lower foredunes of non-eroding beaches. While no extant populations are known to currently exist within the study area, this species has recently recolonized or has been observed in coastal sites within New York, Delaware, Maryland, and most recently New Jersey (USFWS,1999). Therefore, it is possible that seabeach amaranth may become naturally established within the project area within the life of the project. Since the proposed project may actually create habitat for the seabeach amaranth, impacts to this species are also possible related to construction of beach stabilization structures, beach erosion and tidal inundation, beach grooming, and destruction by off-road vehicles (USFWS, 1999).

To address these issues, the Philadelphia District developed a programmatic Biological Assessment (BA) for the piping plover and seabeach amaranth as part of formal consultation requirements with the U.S. Fish and Wildlife Service (USFWS) under Section 7 of the Endangered Species Act. The USFWS reviewed the BA and subsequently issued a Biological Opinion in December 2005. The requirements outlined in the Biological Opinion have been adopted in order to comply with this statute. Formal consultation will be ongoing throughout the period of analysis since the USFWS recommends formal consultation be reinitiated at least 135 days prior to construction and each periodic nourishment cycle. The Section 7 consultation process is expected to result in monitoring before, during and after construction, imposing timing restrictions if nests are found, construction of temporary protective fencing, and avoidance during construction. It is anticipated, however that nourishment activities will usually take place outside of the plover nesting season due to the quantity of fill required. Other issues to be addressed through community developed plover management plans include local practices such as beach raking, off-road vehicles, and general public access in or near nesting locations. The project area, specifically the foredune area, would be periodically monitored for the seabeach amaranth. Contingency plans for the presence of seabeach amaranth at the time of periodic maintenance may involve avoidance of the area (if possible), collection of seeds to be planted in non-impacted areas, and timing restrictions.

The red knot, which is a Federally-listed Candidate species may be present at the site during the spring and fall migration, with some birds still being present in the early winter time period. As is the case with plovers, the project has the potential to temporarily impact food resources within the borrow and placement areas. Since portions of the projects will not be impacted during nourishment cycles, sufficient food should still be readily available within the project area. In addition, due to the timing of initial construction, which will take approximately 8 months, it is possible that birds will be present during construction activities. If any birds are present, they will easily be able to move away from the construction activities to another portion of the beach where they will not be disturbed.

From June through November, New Jersey's coastal waters may be inhabited by transient sea turtles, especially the loggerhead (Federally listed threatened) and the Kemp's ridley (Federally listed endangered). Sea turtles have been known to be adversely impacted during hopper dredging operations. Endangered whales, such as the highly endangered Right whale, may also be transient visitors within the project area.

The Federally listed Atlantic sturgeon is a migratory species along the Atlantic coast and has the potential to be found within the project area. While it is possible for Atlantic sturgeon to become entrained in the hydraulic pump during dredging operations, this is highly unlikely due to the transient nature of the species in the marine environment and their tendency to avoid dredging operations (O'Herron et al.1985). Minor and temporary impacts to water quality and prey resources are expected within the borrow and placement areas. Minor and temporary impacts associated with regard to noise are also expected.

Due to the fact that sand for this project will be obtained by hydraulic back-passing using a land-based dredge pump, no impacts to sea turtles, sturgeon or whales are expected. NMFS agreed with this assessment during their review of the Draft Feasibility Report and EA in a letter dated 19 February 2014 which stated that no further ESA coordination would be necessary for this project.

5.2.7 Cultural Resources

Coordination with the New Jersey State Historic Preservation Office (SHPO) has been ongoing since the initiation of the Feasibility study. More recently, a letter was drafted on 2 July 2 2013 outlining the potential Area of Potential Effect (APE) and sent to the Historic Preservation Offices in Trenton. The District received a concur on this letter on 6 August 2013 from David Saunders, the State Historic preservation Officer, Volume 3, Appendix G., p 49 .

The USACE has determined that the Area of Potential Effect (APE) for the selected plan includes the beaches and intertidal areas from Hereford Inlet to Cape May inlet, marking the northern and southern limits, and from the existing dunes to the intertidal area marking the eastern and western limits. The limits of construction disturbance for the selected plan are located within the APE (Enclosure 2).

Although there are several recorded historic properties eligible for or listed on the National Register of Historic Places (NRHP) within the vicinity of the APE for the selected plan, the USACE has determined that dune and berm construction along approximately 4.5 miles from Hereford Inlet to Cape May Inlet using recently accreted sand from the intertidal zone from the southern end of Five Mile Island will have No Effect.

A cultural resource assessment of the proposed intertidal sand source was conducted by FEMA as part of the Section 106 review for post-Hurricane Irene beach restoration of North Wildwood. An assessment of the beach in the adjacent communities of Wildwood Crest in the south to North

Wildwood was conducted to determine the sensitivity of below ground archaeological resources. Several aspects were analyzed including the project's proximity to know archaeological resources, waterways and historic properties as well as the site's environmental characteristics such as spoil analysis and previous ground disturbing activities within the project APE, which is roughly the APE of the selected plan. Remnants of the Nancy, a revolutionary war brig set afire by troops at Turtle Gut Inlet (Site 28CM0013) are located southwest of the APE and site 28CM0008 is currently underneath the existing Wildwood Boardwalk.

There are no structures within the project APE; however the Chateau Blue Motel, the Hereford Inlet Lighthouse and the J. Thompson Baker House are all listed on the NRHP, but will not be affected. Also, the Wildwood Shore Resort Historic District runs parallel to the beach and is within the project view shed but will also not be affected. The APE is a previously disturbed, engineered beaches. The proposed project will collect, transport and place sand entirely within the previously disturbed areas. No part of the proposed undertaking is located within an archaeologically sensitive area, and no historic properties are within the APE.

A copy of this July 2013 letter and the concurrence from the State Historic Preservation Office is contained in the General Correspondence Appendix (G) of this document.

5.2.8 Impacts on Air and Noise Quality

Short-term impacts to air quality and noise levels would result from the construction phases of the beach nourishment alternative. Dredging activities and grading equipment use would produce noise levels in the 70 to 90 dBA (50' from the source) range, but these would be restricted to the beach area. These noises would be masked by the high background levels of the surf or dissipated by distance. Ambient air quality would also be temporarily degraded, but emission controls and limited duration aid in minimizing the effects. In the case of equipment use associated with the periodic nourishment efforts, conducting the work in the off-season would further minimize the impact.

Noise and air quality impacts would be restricted to site construction preparation (generally beginning two weeks prior to dredging) and the actual dredging and placement operation. Noise is limited to the utilization of heavy equipment such as bulldozers to manipulate the material during placement. Depending on future circumstances, the construction may be conducted overnight to meet construction schedules. An analysis of the project emissions may be found in Appendix C. Air quality impacts would similarly be limited to emissions from the heavy equipment. No long-term significant impacts to the local air quality are anticipated. The Clean Air Act Statement of Conformity is included in this Report in Section 9.0.

Cape May County, New Jersey is within the Philadelphia-Wilmington-Atlantic City, PA-NJ-MD-DE area, which is classified as moderate nonattainment for ozone. As such, emissions from the Hereford Inlet to Cape May Inlet project must be below 100 tons of NOx and 50 tons of VOC per year. . The results of these analyses indicate that the total estimated emissions that would result from the construction of the Hereford project are 91 tons of NOx and 12.8 tons of VOCs. The emissions for the project are below the General Conformity trigger levels of 100 tons per year of NOx and 50 tons per year of VOCs. In addition, due to the fact that initial construction of this project will most likely be completed during the fall/winter months, the emissions for the project will actually be spread out over two calendar years which further minimizes the per year emissions.

5.2.9 Environmental Justice

All of the measures identified in this document are expected to comply with Executive Order 12989 – Environmental Justice in Minority Populations and Low-Income Populations, dated February 11, 1994. The selected plan is not located in close proximity to a minority or low-income community, and no impacts are expected to occur to any minority or low-income communities in the area.

5.2.10 Cumulative Impacts

Cumulative Impacts, as defined in CEQ regulations (40 CFR Sec. 1508.7), are the "impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

Along the Atlantic Coast of New Jersey, several existing Federal, state and municipal beach replenishment projects that utilize inlet shoals or offshore areas have been completed in the recent past or are currently active. Nine active Federal projects are located along the coast of New Jersey that each utilize either an offshore sand source or an adjacent inlet. The Hereford Inlet to Cape May Inlet project is currently the only project utilizing a beach borrow area. non-Federal projects have been conducted recently by NJDEP and several municipalities in Avalon, Stone Harbor, Sea Isle City, Strathmere, Southern Ocean City, and Brigantine. These areas have all used either inlet borrow sites or offshore sites, which have impacted over 3,000 acres of marine habitat. The proposed Federal projects combined with the existing project would affect approximately 68 miles of beach along the New Jersey coast (south of Manasquan Inlet). This represents nearly 71% of beaches along this segment of coast.

In recent years, the New Jersey Coast has been affected by catastrophic coastal storms, most notably Hurricane Sandy in October 2012. In response to the devastation of the Atlantic coastal communities in New Jersey from Hurricane Sandy, the USACE and the Federal Emergency Management Agency (through aid to State and local municipalities) have undertaken unprecedented measures to repair and/or restore the affected beaches under P.L. 84-99 Flood Control and Coastal Emergencies (FCCE) and P.L. 113-2: Disaster Relief Appropriations Act. P.L. 84-99 allows for the repair of beaches with active Federal projects to pre-storm conditions and P.L. 113-2 allows for the restoration of affected beaches to full template that have existing active Federal projects. Also, as part of P.L. 113-2, there is the funding to complete authorized, but unconstructed projects, which include the Great Egg Harbor Inlet to Townsends Inlet and the Manasquan Inlet to Barnegat Inlet projects.

Since November of 2012, several of the authorized and constructed projects within the Philadelphia District have been completed or are currently undergoing repairs and restoration in accordance with P.L. 84-99 and P.L. 113-2. These projects include: portions of the Barnegat

Inlet to Little Egg Inlet (Harvey Cedars, Surf City, and Brant Beach), Brigantine Island, and Absecon Island (Atlantic City and Ventnor), and Townsends Inlet to Hereford Inlet (Avalon and Stone Harbor). The Ocean City - Peck Beach (Northern Ocean City) project and Lower Cape May Meadows were already scheduled for periodic nourishment at the time Hurricane Sandy struck. Cape May City is scheduled to start repair and restore activities in September 2013. The remaining authorized, but unconstructed projects are Great Egg Harbor Inlet to Townsends Inlet (Southern Ocean City, Strathmere, Upper Township, and Sea Isle City) and Manasquan Inlet to Barnegat Inlet (Seaside Park, Seaside Heights, Normandy Beach, Mantoloking, and Point Pleasant Beach). Some minor and temporary impacts would result in a loss of food source in the affected areas (**Figure 124**).

In addition to the potential impacts to benthic and fisheries resources discussed, the proposed and active Federal projects also have the potential of cumulative impacts to the Federally listed piping plover and seabeach amaranth. Due to the amount of uncertainty that exists regarding when and how any of the active and proposed projects will be built, and the uncertainty of the number and location of plover nests in any given year, it is extremely difficult to quantify the potential impacts to piping plovers for any, and all of the projects. If the majority of the ongoing and proposed construction activities are accomplished outside of the nesting season, the overall impacts to plovers will be minimal, and the birds most likely will benefit from the additional beach areas. Through the implementation of plover management plans and the monitoring program, impacts related to human activities on the new beaches will be greatly reduced.

Although nearly 71% of the beaches along the N.J. coast south of Manasquan Inlet could potentially be impacted by beach fill placement activities, the cumulative effect of these combined activities is expected to be temporary and minor on resources of concern such as benthic species, beach dwelling flora and fauna, water quality and essential fish habitat. This is due to the fact that flora and fauna associated with beaches, intertidal zones and near shore zones are adapted to and resilient to frequent disturbance as is normally encountered in these highly dynamic and often harsh environments. Among the existing and proposed projects along this stretch of coast, renourishment cycles vary from two to seven years, which would likely preclude all of the beach fill areas being impacted at one time.

The majority of impacts associated with all these projects are related to the temporary disturbance to the benthic community, and do not represent a permanent loss of marine benthic habitat. The borrow areas for each project would be impacted incrementally over the 50-year period of analysis with each periodic nourishment cycle. It is anticipated that the benthic community in offshore borrow areas would be recovered within several years after disturbance. For the Hereford project, recovery is expected to occur more quickly due to the dynamic nature of the beach borrow area. The cumulative impacts on Essential Fish Habitat (EFH) are not considered significant. Like the benthic environment, the impacts to EFH are temporary in nature and do not result in a permanent loss in EFH. The borrow site proposed for this project does not contain prominent shoal habitat features, wrecks and reefs, or any known hard bottom features that could be permanently lost due to the impacts from dredging. Some minor and temporary impacts would result in a loss of food source in the affected areas.

In addition to the potential impacts to benthic and fisheries resources discussed, the proposed and active Federal projects also have the potential of cumulative impacts to the Federally listed piping plover and seabeach amaranth. Due to the amount of uncertainty that exists regarding when and how any of the active and proposed projects will be built, and the uncertainty of the number and location of plover nests in any given year, it is extremely difficult to quantify the potential impacts to piping plovers for any, and all of the projects. If the majority of the ongoing and proposed construction activities are accomplished outside of the nesting season, the overall impacts to plovers will be minimal, and the birds most likely will benefit from the additional beach areas. Through the implementation of plover management plans and the monitoring program, impacts related to human activities on the new beaches will be greatly reduced and in

Figure 124 Sandy Recovery Projects, NJ and DE

some cases eliminated. The results of the Ocean City nearshore benthic sampling which was conducted in 2001 indicated that while the abundance of major taxa within the benthic community of the lower intertidal zone was reduced 4 months after sand placement, 6 months after placement, the community appeared to be recovering to pre-placement conditions. Impacts within the upper intertidal area, where plovers directly feed, were not detected in either the 4 or 6 month sampling periods. Based on this data, it is possible that plover habitat may be negatively impacted on a temporary basis during the nesting season immediately following construction due to diminished food resources. This impact is more likely following the initial construction due to the quantity of fill and duration of the activities. The timing of the fill will also play a role in the rate of benthic recovery. Following initial fill, nourishment activities will take place only in areas with a high rate of erosion. Areas which have not eroded past the design template will not be filled. For this reason, it is even less likely that nourishment activities will affect areas with nesting plovers since it is unlikely that the birds will be nesting in areas with more narrow beaches and greater erosion. This has been the case in Ocean City where fill has not been placed south of 14th street for several cycles since this area is fairly stable.

In addition, due to the short duration of nourishment activities, and the limited quantity of sand associated with most cycles, it is anticipated that most, if not all, of these activities will take place outside of the plover nesting season. The possibility does still exist however that the fill activities may result in a reduction of prey resources available to plovers during the next nesting season. Due to the fact that, on average, only two or three of the existing or proposed locations will be impacted during any given year, however, these activities should not cause the species any undue risk or greatly impact the species as a whole. Since newly placed sand will most likely create additional habitat for the plovers and seabeach amaranth that does not currently exist, it is expected that even with these activities, more undisturbed habitat will be available to the species than currently exists. It should be noted that large portions of the New Jersey coast will still be available for use as nesting habitat on any given year.

Similar uncertainty exists when trying to quantify the potential impacts to seabeach amaranth since the species has a very patchy distribution within southern New Jersey. The protection measures being developed with USFWS, however, should ensure that impacts are avoided or minimized to the greatest extent possible and therefore construction activities should not jeopardize the species and may actually create suitable habitat for the species. The Corps will work closely on this issue with the Service in order to develop the best protection plan for the species should it become re-established.

5.2.11 Coordination

Pubic coordination for the proposed project took place through the circulation of the Draft Feasibility Study and Environmental Assessment that was released on 20 December 2013 and closed for review on 10 March 2014. Coordination with various resource agencies has been ongoing throughout the Feasibility phase and has included correspondence, meetings and field visits. Multiple meetings were held in Wildwood Crest, Wildwood and Lower Township with the respective mayors, their engineering firms and council representatives to explain the project and answer questions or comments. The NJDEP coordinated a Public Hearing on 21 February 2014.

This EA was circulated to Federal, State, and local resource agencies with particular jurisdiction and interest over the affected resources and applicable statutes. In addition, the public was notified of the availability of this document for public review via a public notice, which was distributed to interested individuals, organization, and media outlets listed on the Philadelphia District's coastal New Jersey mailing list. Comment letters received from the various agencies and the general public during the review period can be found in Appendix G.

5.2.12 Compliance with Environmental Statutes

Compliance with applicable Federal Statutes, Executive Orders, and Executive Memoranda is summarized in which shows a complete listing of compliance status relative to environmental quality protection statutes and other environmental review requirements.

A Section 404(b)(1) evaluation in compliance with Section 404 of the Clean Water Act was prepared and is provided in **Section 10.0** of this document. A Section 401 Water Quality Certification was received from NJDEP on 7 March 2014 and can be found in Appendix G.

The proposed sand back-passing and maintenance activities comply with, and will be conducted in a manner consistent with New Jersey's requirements with regard to the Coastal Zone Management Act. A Federal Consistency Determination was obtained from NJDEP can be found in Appendix G.

The use of the sand borrow source described in this document is not expected to have significant air quality impacts. A Clean Air Act Statement of Conformity has been prepared and is presented in **Section 9.0** of this document. The Conformity Determinations prepared for this project can be found in **Appendix B**. The proposed action is expected to comply with Section 176(c)(1) of the Clean Air Act amendments of 1990.

Table 84 Compliance with Environmental Statutes

COMPLIANCE WITH ENVIRONMENTAL QUALITY PROTECTION STATUTES AND OTHER ENVIRONMENTAL REVIEW REQUIREMENTS	
FEDERAL STATUTES	**COMPLIANCE W/PROPOSED PLAN**
Archeological - Resources Protection Act of 1979, as amended	Full
Clean Air Act, as amended	Full
Clean Water Act of 1977	Full
Coastal Barrier Resources Act	N/A
Coastal Zone Management Act of 1972, as amended	Full
Endangered Species Act of 1973, as amended	Full
Estuary Protection Act	N/A
Federal Water Project Recreation Act, as amended	N/A
Fish and Wildlife Coordination Act	Full
Land and Water Conservation Fund Act, as amended	N/A
Marine Protection, Research and Sanctuaries Act	Full
Magnuson-Stevens Fishery Conservation and Management Act	Full
National Historic Preservation Act of 1966, as amended	Full
National Environmental Policy Act, as amended	Full
Rivers and Harbors Act	Full
Watershed Protection and Flood Prevention Act	N/A
Wild and Scenic River Act	N/A
Executive Orders, Memorandums, etc.	
EO 11988, Floodplain Management	Full
EO 11990, Protection of Wetlands	Full
EO12114, Environmental Effects of Major Federal Actions	Full
EO 12989, Environmental Justice in Minority Populations and Low-Income Populations	Full
County Land Use Plan	Full

Full Compliance - Requirements of the statute, EO, or other environmental requirements are met for the current stage of review.
Ongoing Compliance - Some requirements and permits of the statute, E.O., or other policy and related regulations remain to be met.
Noncompliance - None of the requirements of the statute, E.O., or other policy and related regulations have been met.
N/A - Statute, E.O. or other policy and related regulations are not applicable.

5.3 Project Cost Estimate

All costs required to implement the selected plan were calculated by a cost engineer. Project costs were initially calculated at a June 2007 price level. The final cost analysis was updated to a March 2014 price level.

5.3.1 Cost Contingencies

The estimated cost for each major element or feature of the selected plan includes an item for “contingencies.” Contingencies are allowances against some adverse or unanticipated condition not susceptible to exact evaluation from the data at hand, but which must be represented in the project cost estimate. Contingency allowances used in the development of the cost estimate were estimated as percentages. Twenty five percent was applied to beach placement work to account for potential variations in pumping distances and borrow area selection, and to account for potentially larger required beach fill quantities at the time of construction due to future preconstruction erosion. Twenty five percent was applied to mobilization, demobilization, and preparatory work to account for availability of dredges and variances in travel distance for the dredge plant. Twenty percent was applied to dune grass, sand fence, dune crossover, and vehicle crossover quantities to account for variances in the beach profile at the location of the dune due to possible preconstruction shifting and/or eroding beach conditions

5.3.2 Initial Construction Costs

The estimated initial construction cost for the selected plan is $21,605,000 (March 2014 price level) which includes real estate acquisition costs (including administration costs); planning, engineering, and design (P,E,&D), construction management (S&A), and associated contingencies. A summary of initial construction costs is presented in **Table 85.**

Table 85 Initial Construction Cost Summary

Total First Cost - Selected Plan							Price Level: Mar 14
Plan C (75' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)							Construction duration: 9-months
ACCOUNT	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED	CONTINGENCY	TOTAL COST
						@ 25.0%	
01.	Lands and Damages	1	Job	LS	$1,018,972	$254,539	$1,273,511
17.	Beach Replenishment					**@ 25.1%**	
17.01	Mobilization, Demob. And Preparatory Work	1	Job	LS	$1,026,656	$257,691	$1,284,346
17.70	Beach Fill	1	Job	LS	$9,883,656	$2,480,798	$12,364,454
17.99	Associated General Items	1	Job	LS	$2,763,564	$693,655	$3,457,219
	Total Beach Replenishment				$13,673,876	$3,432,143	$17,106,019
						@ 15.0%	
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,617,299	$242,595	$1,859,894
31.	Construction Management (S & A)	1	Job	LS	$1,187,843	$178,177	$1,366,020
	Total Project First Cost				$17,497,990	$4,107,453	$21,605,444
	Rounded				$17,498,000	$4,107,000	$21,605,000

5.3.2.1 Real Estate

The project will be constructed on existing beachfront lands that include private, commercial, and public ownerships. The project will impact 91 privately owned parcels within the project area, 10 within North Wildwood, 49 within Wildwood, 27 within Wildwood Crest and 5 within Lower Township. Detailed ownership data is provided in The Real Estate Appendix (Appendix F) of this report. The construction area excludes any existing structures.

Submerged lands below the Mean High Water Line (MHWL) of the Atlantic Ocean are owned by the State of New Jersey and managed by the New Jersey Department of Environmental Protection Bureau of Tidelands Management, except lands below MHWL where riparian grants exist.

Prior to construction of the project, the non-Federal Sponsor will acquire a non-standard Perpetual Beach Storm Damage Reduction Easement along the length of the project, including all privately owned parcels. A standard Temporary Work Area Easement with a duration of 2 years will be required for staging during construction. No facility or utility relocations are required. Real estate costs were estimated at $1,273,987 for project construction.

5.3.2.2 Public Access

Engineering Regulation 1165-2-130, Federal Participation in Shore Protection Projects, requires that reasonable public access be provided in accordance with the recreational use objectives of the particular area and public use is "*construed to be effectively limited to within one-quarter mile from available points of public access to any particular shore.*" No two public access points can be further than 1/2 mile (.5) apart, and no visitor can be further than 1/4 (.25) mile from an individual access point.

Public access within Hereford Inlet to Cape May Inlet is provided at each street end along the beach front in North Wildwood, Wildwood, Wildwood Crest and Lower Township. These public access points are within the Federal Access requirement in ER 1165-2-130. Access points and the average distance between each point are outlined below for each municipality (**Table 86**) and in the Public Access section of Volume 3 of this report.

Table 86 Public Access by Municipality

Access Points	North Wildwood	Wildwood	Wildwood Crest	Lower Township
Distance (feet)	6,600	7,705	9,768	1,689
Number of Access Points	25	24	41	4
Average Distance Between Access Points (miles)	0.05	0.06	0.05	0.08

The regulation described above also discusses parking requirements and states that parking on free or reasonable terms should be available within a reasonable walking distance of the beach. The study area contains approximately 7,000 parking spaces within ¼ mile of the access points identified above with street parking, metered parking, or public parking lots based on aerial photography interpretation and estimating. An estimate of the location of these areas by municipality and by street can be seen in the Public Access Plan of Volume 3 of this report. The area is also served by public transportation with NJ Transit providing regional access to the Wildwood Bus Terminal between Davis and Burk Avenue in Wildwood, and local access via bus stops located along New Jersey Avenue in North Wildwood and Wildwood.

Based on this analysis the study area from Hereford Inlet to Cape May Inlet meets the access and parking requirement outlined in ER 1165-2-130 since it contains access points less than ½ mile apart and reasonable parking and public transportation.

5.3.3 Periodic Nourishment and Major Replacement Costs

The selected plan includes periodic nourishment at 4-yr intervals subsequent to the completion of initial construction (year 0) of the project. Major replacement is included in the design to replace project losses in response to a major storm event. For cost calculation purposes, major

replacement is assumed to occur in year 24 together with periodic nourishment.
Table 87 - **Table 89**.

Table 87 Periodic Nourishment Costs Years 4 and 8

Periodic Nourishment Cost (Years 4 and 8)							Price Level: Mar 14
Plan C (75' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)							Construction duration: 4-months
ACCOUNT	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT	ESTIMATED	CONTINGENCY	TOTAL COST
17.	Beach Replenishment					**@ 25.1%**	
17.01	Mobilization, Demob. And Preparatory Work	1	Job	LS	$895,921	$224,876	$1,120,797
17.70	Beach Fill	1	Job	LS	$2,904,614	$729,058	$3,633,672
17.99	Associated General Items	1	Job	LS	$257,874	$64,726	$322,600
	Total Beach Replenishment				$4,058,408	$1,018,661	$5,077,069
						@ 15%	
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$221,632	$33,245	$254,877
31.	Construction Management (S & A)	1	Job	LS	$539,552	$80,933	$620,485
	Total Project First Cost				$4,819,593	$1,132,838	$5,952,431
	Rounded				$4,820,000	$1,133,000	$5,952,000

Table 88 Periodic Nourishment Costs remaining 8-50

Periodic Nourishment Cost (Years 12, 16, 20, 28, 32, 36, 40, 44 and 48)							Price Level: Mar 14
Plan C (75' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)							Construction duration: 4-months
ACCOUNT	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT	ESTIMATED	CONTINGENCY	TOTAL COST
17.	Beach Replenishment					**@ 31%**	
17.01	Mobilization, Demob. And Preparatory Work	1	Job	LS	$895,921	$277,735	$1,173,656
17.70	Beach Fill	1	Job	LS	$2,904,614	$900,430	$3,805,045
17.99	Associated General Items	1	Job	LS	$257,874	$79,941	$337,814
	Total Beach Replenishment				$4,058,408	$1,258,107	$5,316,515
						@ 15%	
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$221,632	$33,245	$254,877
31.	Construction Management (S & A)	1	Job	LS	$539,552	$80,933	$620,485
	Total Project First Cost				$4,819,593	$1,372,284	$6,191,877
	Rounded				$4,820,000	$1,372,000	$6,192,000

Table 89 Major Rehabilitation Costs

Major Replacement Cost (Yr. 24)							Price Level: Mar 14
Plan C (75' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)							Construction duration: 5-months
ACCOUNT	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT	ESTIMATED	CONTINGENCY	TOTAL COST
17.	Beach Replenishment					**@ 31%**	
17.01	Mobilization, Demob. And Preparatory Work	1	Job	LS	$935,261	$289,931	$1,225,192
17.70	Beach Fill	1	Job	LS	$3,961,931	$1,228,199	$5,190,130
17.99	Associated General Items	1	Job	LS	$332,175	$102,974	$435,149
	Total Beach Replenishment				$5,229,368	$1,621,104	$6,850,472
						@ 15%	
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$264,697	$39,705	$304,402
31.	Construction Management (S & A)	1	Job	LS	$665,719	$99,858	$765,577
	Total Project First Cost				$6,159,784	$1,760,666	$7,920,450
	Rounded				$6,160,000	$1,761,000	$7,920,000

5.3.4 Construction Management (S&A)

Costs for construction management include supervision and administration activities in overseeing project construction efforts.

5.3.5 Planning Engineering and Design

Planning Engineering & Design (PED) costs include; preparation of plans and specifications, development and execution of the Project Cooperation Agreement (PCA), value engineering, engineering and design during construction, and project monitoring.

5.3.6 Project Monitoring

A beach fill project has a specific longevity and must undergo periodic inspection, maintenance and nourishment in order to preserve and project functionality over the design life. The project monitoring plan will document beach fill performance and evaluate conditions within the borrow areas over the period of analysis. Periodic assessments and monitoring data analysis will assist in producing recommendations for modifications to the quantities, location and cycle of future fills based on actual trends of fill behavior. The program was developed in accordance with EM-1110-2-1004, ER-1110-2-1407, CETN-II-26 and the draft CETN-II-35. The following items are to be included in the project monitoring plan: beach profile surveys, surveys of borrow areas, sediment sampling of the beach and borrow areas, aerial photography, and tidal data collection. The field data will be regularly analyzed to support engineering and design of ongoing nourishment. The proposed monitoring program will begin with initial construction and continue throughout the period of analysis. The monitoring program includes environmental and physical monitoring.

5.3.6.1 Project Performance Monitoring

Beach fill project will be monitored to support project engineering and design activities. Beach profile data will be collected to determine long shore erosion rates, define renourishment quantities, and indentify cross shore and long shore transport patterns in the project area. Approximately 30 lines will be surveyed and monitored for the project monitoring phase.

Beach Profiles

Beach profiles will be monitored to support project engineering and design activities. Beach profile data will be used to quantify sand losses from the project, define periodic nourishment quantities, and identify cross-shore and long shore transport patterns of the beach fill. Approximately 37 profile lines along the project reach will be surveyed annually.

Inlet Hydrographic Surveys

Routine surveys of Hereford Inlet and Cape May Inlet are supported by other programs. This information will be used to analyze project impacts to adjacent inlets.

Borrow Site Surveys

Borrow site surveys of the Wildwood and Wildwood Crest beaches will be performed before and after initial construction and nourishment and annually in between nourishment years. Data will be used to monitor borrow area changes, evaluate infilling rates, and quantify availability of borrow material for future nourishment activities.

Aerial Photography

Routine flights along study area are already conducted by the State of New Jersey and other agencies. Aerials collected for these other efforts will be utilized to analyze the performance of the project.

Tide Data

Tide and storm water level information is available from existing tide gages at Cape May and Atlantic City. Tide and water level data from these sources will provide a record of background and storm conditions controlling project response

Sediment Sampling

Beach sediment samples will be collected before and after initial construction and each nourishment to identify existing and fill sand sizes, determine sorting characteristics, and evaluate overfill factor design procedures.

5.3.6.2 Environmental Monitoring

To insure compliance with Section 7 of the Endangered Species Act, the U.S. Fish and Wildlife Service (USFWS) and the conditions of the 2005 Programmatic BO, Tier 2 consultation be initiated at least 135 days prior to construction. If construction activities are to take place during the nesting and brooding season of the Federally listed (threatened) piping plover (*Charadrius melodus*), the USFWS recommends that a survey be conducted to determine whether piping plovers are actively nesting in the project area. As part of the survey, any previous nesting locations will be identified. This would provide the basis for delineation (e.g., fencing and signing) of protective zones around identified piping plover nests. This survey may also include identification and location of State listed (endangered) species such as the least tern (*Sterna antillarum*) and black skimmer (*Rynchops niger*).

As recommended by the USFWS, a survey will be performed to identify and locate the Federally listed (threatened) plant, seabeach amaranth (*Amaranthus pumilus*) within the project area prior to initial construction and subsequent nourishment cycles.

Endangered Species Survey

To insure compliance with Section 7 of the Endangered Species Act, the U.S. Fish and Wildlife Service (USFWS) recommends that consultation be reinitiated at least 135 days prior to construction. If construction activities are to take place during the nesting and brooding season of the Federally listed (threatened) piping plover (*Charadrius melodus*), the USFWS recommends that a survey be conducted to determine whether piping plovers are actively nesting in the project area. As part of the survey, any previous nesting locations will be identified. This would provide the basis for delineation (e.g., fencing and signing) of protective zones around identified piping plover nests. This survey may also include identification and location of State listed (endangered) species such as the least tern (*Sterna antillarum*) and black skimmer (*Rynchops niger*).

As recommended by the USFWS, a survey will be performed to identify and locate the Federally listed (threatened) plant, seabeach amaranth (*Amaranthus pumilus*) within the project area prior to initial construction and subsequent nourishment cycles.

Sea Turtle/Marine Mammal Monitoring

Monitoring for Federally protected sea turtles and marine mammals will not be necessary for this project due to the location of the borrow area in the intertidal zone.

Piping Plover Monitoring

If construction takes place during the nesting season of the piping plover, monitoring will be conducted in conjunction with NJDEP Division of Fish and Wildlife to determine the presence and locations of nests. Based on this monitoring, appropriate measures in accordance with findings of the 2005 USFWS Biological Opinion will be taken to ensure that adequate protection is provided. This monitoring will continue throughout the duration of construction during the nesting season as well as nesting seasons after initial construction and subsequent nourishment activities. Tier 2 consultation with the USFWS will be reinitiated at least 135 days prior to any periodic nourishment in order to update project details.

Seabeach Amaranth Monitoring

A survey for seabeach amaranth will be conducted prior to initial construction and each periodic renourishment. If seabeach amaranth populations are located within the project area prior to construction, monitoring shall be conducted to ensure that these plants are not adversely impacted during project construction. This monitoring will be conducted in accordance with findings of the 2005 Biological Opinion. Tier 2 consultation with the USFWS will be reinitiated at least 135 days prior to any periodic nourishment in order to update project details.

Cultural Resources Monitoring

The District will periodically monitor sand placement activities during project construction to identify subsurface fill materials that could indicate the presence of buried prehistoric land surfaces within sand borrow areas. Any significant cultural resources that exist within the near shore project area will be monitored to determine impacts from sand movement offshore from the construction template. Monitoring results will be coordinated with NJSHPO and NJDEP, and adaptive management will be completed as necessary.

5.3.6.3 Total Monitoring Costs

Monitoring costs for the entire length of the period of analysis was estimated to be $6,874,500. This includes initial construction, periodic nourishment and major replacement monitoring. Total average annual costs for all monitoring are estimated at $140,000 over the 50-year period of Federal participation .

5.3.7 Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)

Routine operation and maintenance of the project is the responsibility of the non-Federal Sponsor and includes maintenance of dunes (including sand fence and dune grass), pedestrian and vehicle accesses, and beach shaping. Beach shaping will be performed by heavy equipment to maintain the design template. Based on experience with similar projects, the average annual maintenance costs were estimated at $150,000.

5.3.8 Construction and Funding Schedule

The duration of initial construction was estimated at 8 months, including mobilization and demobilization. Construction duration for periodic nourishment was estimated at 4 months per cycle. Major replacement was estimated to take 5 months.

5.3.9 Interest During Construction

Interest During Construction (IDC) was computed in accordance with Engineering Regulation 1105-2-100. Construction costs were assumed to be evenly distributed over the construction period. Planning, Engineering & Design (PED) and real estate acquisition costs were included in the calculations (March 2014 P.L.) .

Table 90 Total Estimated Costs

Total Estimated Costs	
Discount Rate	3.50%
Period of Economic Analysis	50 years
Price Level	Mar-14
Base Year	2016
Initial Construction Cost (including R.E.)	$21,605,000
Interest During Construction	$349,000
Total Periodic Nourishment	$82,428,000.00
Average Annual Costs (AAC)	
Initial Construction (without IDC)	$921,000
Periodic Nourishment	$1,462,000
Interest During Construction (IDC)	$15,000
Subtotal Average Annual Costs	$2,398,000
Monitoring Costs	$140,000
Operations and Maintenance (OMRR&R)	$150,000
Total Average Annual Cost	**$2,688,000**

5.4 Project Benefits

Total project benefits include storm damage reduction benefits, local costs foregone and recreation benefits. All benefits are the March 2014 price level. The project was economically justified on hurricane and storm damage reduction benefits but also included benefits such as recreation and Local Costs Forgone. Interior flood damage reduction was not included in the benefits calculation since interior drainage is a non-Federal responsibility.

5.4.1 National Economic Development Benefits

The selected plan was optimized based on storm damage reduction benefits to structures. Total NED benefits include storm damage reduction benefits to structures, improved property and infrastructure. Average Annual NED benefits are at a discount rate of 3.5% March 2014 P.L, for the base year of 2016 for the fifty year length of the project

5.4.2 Local Costs Forgone

The Local Costs Forgone benefits described in the following paragraphs are expected to be realized with implementation of any proposed project. Benefits of coastal storm management projects include reductions in non-physical damages as well as reductions in physical damages to homes, commercial buildings, public property and critical infrastructure. The Coastal Storm Risk Management National Economic Development (NED) Manual includes reduced costs for public protective measures or Local Costs Forgone, as it is referred to in this document, as a benefit category. This benefit captures future costs that would be expended by the state and local municipalities to protect coastal property in the absence of a plan of protection.

The beaches of *The Wildwoods* have been historically protected and maintained through state and local government-sponsored beach fill projects in North Wildwood to allay erosion, daily outfall maintenance to remove sand and place barriers around water that ponds at clogged outfalls, and construction projects in Wildwood and Wildwood Crest to extend outfall pipes beyond the accreted shoreline. In 2009, the State of New Jersey constructed a beach fill project of over one million cubic yards of sand at the northern section of *The Wildwoods* to control erosion with subsequent emergency sand placements after other storm events. The future without project condition was based on the expectation that the state would continue to partner and provide protection to the communities. The implementation of a federal project will preclude this action and provide a savings from public protective measures to the State of New Jersey and the local municipalities.

Savings to the State of New Jersey and local communities could potentially be, depending upon the source of material, an estimated average annual $1,140,000 as a result of the beach fill and nourishment components of a proposed plan and $75,000 and $148,000 in Wildwood and Wildwood Crest from reduced outfall maintenance. Acquisition of sand from Hereford Inlet (dredging option) would eliminate realization of Local Costs Forgone benefits to Wildwood or Wildwood Crest. Local Costs Forgone were included in the average annual benefits for the backpass measures since the protective dune and berm will be constructed with the accreted beach material from Wildwood and Wildwood Crest. The estimated average annual benefits include storm damage reduced and Local Costs Forgone or reduced maintenance costs from a 16' dune and 75' berm with excess sand conveyed from Wildwood and Wildwood Crest to an engineered 16' dune to supplement oceanfront protection in North Wildwood, Wildwood, Wildwood Crest, and Lower Township. The estimated costs include initial construction, periodic nourishment, and interest during construction.

5.4.3 Incidental Benefits

Incidental benefits are benefits that are not directly attributable to storm damage reduction in the initial economic analysis. They include Recreation Benefits, the benefits that beachgoers enjoy as a result of an improved beach experience and Benefits During Construction which consist of benefits from partially constructed portions of the beach prior to completing the initial construction. These benefits are summarized below.

5.4.3.1 Recreation Benefits

Beaches are consistently the number one travel destination in New Jersey. Tourist dollars contribute directly and indirectly to the regional economy. In 2008, the New Jersey Division of

Travel and Tourism reported that travel and tourism generated 359,000 jobs in the state with a total payroll of $11.8 billion.

The Rutgers State University completed in 1994, for previous New Jersey coastal studies, a contingent valuation method survey for the New Jersey Department of Environmental Protection and Energy and the U.S. Army Corps of Engineers (Corps) to determine willingness to pay for the existing beach and an enhanced beach. This was done on a regional basis, encompassing the major beach communities of the New Jersey Atlantic coast such as the communities of Absecon Island, Seven Mile Island, Brigantine, as well as Stone Harbor and Avalon which is just north of *The Wildwoods*. The survey was designed in accordance with the NED Procedures Manual – Recreation II (A Guide for Using the Contingent Value Methodology in Recreation Studies). The original report is included as an attachment to this appendix. The survey consisted of 1,063 interviews of a random sample of recreational beach users. The interviews were conducted in person on the beach. The survey scope was intended for use with all South Jersey shore feasibility studies. *The Wildwoods* is also close, both qualitatively and geographically, to Stone Harbor therefore, it is reasonable that survey results can be representative of the conditions on the island.

Beachgoers were asked to indicate how important different factors were in deciding whether to visit a New Jersey beach. Respondents voiced similar desires. The primary factors of consideration were the quality of the beach scenery, the maintenance of the beach, the width of the beach, the number of lifeguards, and the family-friendliness of the beach.

The survey also used a density measure developed in cooperation with the Corps to determine if crowding was a problem. It was found that over 60% of the time there was at least several yards of space between beach towels or blankets, and only 7% of the time was it very crowded (only 2' between towels). Further it was determined that crowding was not considered a very important issue to the majority of beachgoers by asking respondents how important being alone is and how important is it to be with a large number of people. As might be expected, areas with more crowding tended to be frequented by people who like large numbers. People who like to be alone frequented areas that tended to have little crowding

To estimate the value of the beach, as it exists currently, an iterative bidding process was applied. Beachgoers were first asked if a day at the beach would be worth $4.00 to each member of their household. Based on their answers, they were then asked progressively higher or lower amounts until the amount they value the beach was determined. It was determined that the average value of a day at the beach is $4.22.

Beachgoers were asked how much more they were willing to pay if the beach were widened. While the majority was unwilling to pay any extra, approximately 16% of Stone Harbor beachgoers were willing to pay, on average, $2.47 more per visit. This would be equivalent to an average of $0.39 for all beachgoers. This willingness to pay value for Stone Harbor was adopted because it is the nearest beach to North Wildwood. This value was indexed to a June 2007 price level for the purposes of this study. Since access to the beaches of *the Wildwoods* is free, the number of visitor days was obtained from City of North Wildwood estimates and by comparing beach size within the project area of North Wildwood with that of Stone Harbor. The total number of visitor days for the beach within the project area is estimated at 1,000,000

Benefits were not found to accrue from increased capacity because crowding was found not to be a significant factor and the selected plan involves conveying accreted sand from Wildwood and Wildwood Crest. Removal of sand from the down drift areas is not expected to negatively affect the recreation experience because the beaches are extremely wide and require beachgoers to walk quite some distance to reach the water's edge. Benefits do arise from an increase in the value of the recreational experience in North Wildwood. Recent recreation proposals in the downdrift beaches cannot be impacted with the implementation of our selected plan and efforts are being made to determine how storm damage reduction and recreation can co-exist in this portion of the project area.

Benefits resulting from this increase in recreational experience were calculated by multiplying the average daily value per beachgoer by the number of visitor days within the project area. This gives total recreational benefits of $693,000.

5.4.3.2 Benefits During Construction

The proposed project will be constructed over nine months with an additional month before and after construction for mobilization and demobilization. Portions of the beach will be fully nourished before the project is completed in its entirety. The portions of the beach nourished early in the construction phase will provide storm damage reduction benefits. The summary shows the monthly benefits during construction (BDC) and the resulting estimated average annual benefit of $102,000.

5.4.4 Benefit-Cost Summary

BENEFITS AND COSTS FOR THE SELECTED PLAN

DISCOUNT RATE (FY14)	3.50%
PERIOD OF ANALYSIS	50 YEARS
PRICE LEVEL	March 2014
BASE YEAR	2016

AVERAGE ANNUAL BENEFITS:

Storm Damage Reduction	$4,095,000
Local Costs Forgone (1)	1,363,000
Recreation	693,000
Benefits During Construction	102,000

TOTAL NED BENEFITS $6,253,000

TOTAL COSTS:

Initial Construction Costs (2)	$21,605,000
Interest During Construction	349,000
Periodic Nourishment (cycles 1, 2)	5,952,000
Periodic Nourishment (other cycles)	6,192,000
Major Rehabilitation (3) (year 24)	7,920,000
Average Annual Construction Costs	$2,398,000
Average Annual Monitoring Costs	140,000
Average Annual OMRR&R Costs	150,000

TOTAL AVERAGE ANNUAL COSTS	**$2,688,000**
NET BENEFITS	**$ 3,565,000**
BENEFIT-COST RATIO	**2.3**
BENEFIT-COST RATIO (computed at 7%)	**1.9**
RESIDUAL DAMAGES	**$ 5,818,000**

(1) Local Costs Foregone include updated March 14 P.L. costs from Table B-38 in the Economics Appendix for North Wildwood ($1,140,000), Wildwood ($75,000), Wildwood Crest ($148,000) for a total of $1,363,000.
(2) Initial constrcution includes Real Estate costs
(3) Periodic Nourishment totals $82,248,000

5.5 Risk and Uncertainty Associated with Coastal Projects

Engineering Regulation 1105-2-101, dated January 2006, states "all flood damage reduction studies must address risk and uncertainty." This is due to the fact that natural systems are complex and measured variables, are to some degree, inaccurate. These inaccuracies could have impacts on project outputs including the BCR and NED benefits. Risk analysis incorporates these uncertainties so the engineering and economic performance of a project can be expressed in terms of a probability distribution instead of a traditional "point value" or single value for AAD, AAB, NED benefits and BCR.

5.5.1 Risk and Uncertainty Coordination

This Risk and Uncertainty (R&U) plan was the result of the coordination after the 23 July 2009 Feasibility Scoping Meeting held at the Philadelphia District. This meeting was attended by the Office of Water Policy and Review (OWPR), North Atlantic Division, the NJDEP (Sponsor) and the District Vertical team. At that meeting the attendees came to the conclusion that a plan that should incorporate risk and uncertainty to comply with regulations contained in ER 1105-2-101. This plan was documented in the July 23 District Memorandum For Record (MFR) of the meeting, and later confirmed in correspondence from OWPR attendees in a 3 June 2011 letter to the District. "*HQ, the MSC and District have concurred on the outcome of the FSM and understand the following actions will be required prior commencement of the Alternative Formulation Briefing: a. Certification for one-time use of the SBEACH-COSTDAM methodology for the storm, damage and damage reduction benefits analysis., b. Update the Peer Review Plan to include IEPR., c. Initiation of IEPR process."* This new Risk and Uncertainty plan and SBEACH-COSTDAM certification was developed by the District Project Development Team, and forwarded to NAD on 17 June 2010. On 17 November 2011 NAD replied " *Pending ATR [Agency Technical Review] team concurrence, the District can complete the updated analysis, to include risk and uncertainty and economic risk considerations. The analysis and results would undergo ATR and the Planning Center of Expertise - Coastal and Storm Damage Reduction will determine if an "approved for one time use" model request to HQUSACE, Office of Water Project Review is warranted and will submit the required materials, as appropriate."* The District began working on the R&U analysis, and forwarded their results to Jacksonville District for their ATR. The R&U analysis was forwarded to the review team in Jacksonville, and the proposal was modified to incorporate their suggestions, the ATR team then approved the R&U approach and results in a two memoranda dated 2 February 2011 and 7 December 2011. The ATR team found that *"the proposed analysis, if added to the current storm damage reduction model process employing COSTDAM, may be reasonable enough to incorporate the variability associated with economic and hydraulic systems in order to meet the requirement identified at the Feasibility Scoping Meeting of enhancing the existing effort in order to address risk and uncertainty."* Upon review of the model results the ATR recommendation was a one-time-approval-for-use in accordance with the process established by the Coastal Planning Center of Expertise (PCX) in a letter to the District and North Atlantic Division. Headquarters Planning and Policy Division (CECW-P) approved the model review plan in a memo dated 13 April 2012 stating "*The Hereford Inlet to Cape May Inlet, New Jersey model review plan is approved"* and *"This model will be applicable for use on the Hereford Inlet to Cape May Inlet, New Jersey Feasibility Study".* The Pertinent Correspondence Section of the Appendices, Volume 3, Appendix G, also contains the May 2014 approval for the use of the proposed model and previous approval memos.

5.5.2 Risk Analysis

The Hereford to Cape May Risk and Uncertainty Analysis explicitly incorporates variations in key H&H (Hydrology and Hydraulics) and economic inputs in order to develop a range of damage levels and determine the impacts these variables play in project outputs.

Outputs from the risk analysis will include a range of Average Annual Damages (AAD), Average Annual Benefits (AAB), Net Benefits and Benefit Cost Ratios (BCR) that will better represent the potential damages and benefits that the project may encounter rather than single AAD, AAB, and BCR values based upon fixed assumptions about the study area.

5.5.3 Risk and Uncertainty Methodology

Sources of risk and uncertainty arise from the underlying variability of complex natural, social, hydraulic, structural and economic systems. The role of a risk analysis is to characterize the extent of these variations so their impact on model outputs can be understood. Outputs include a range of reasonably likely damage and benefit levels rather than a single point estimate. This can be accomplished through a type of risk analysis, the technique of varying assumptions as to alternative factors and examining the effects of these assumptions on the outcomes of benefits and costs (ER 1105-2-100).

By definition, risk is the probability an area will be impacted by undesirable consequences, and uncertainty is the degree of imprecision of measured parameters used to describe the hydraulic, hydrologic and economic aspects of a project plan. Consequently, a R&U analysis determines the level of risk and uncertainty a project can potentially be exposed to throughout its lifetime. The role of this analysis is to quantify the extent of those variations in order to understand their impact on model outputs.

The Hereford to Cape May Risk and Uncertainty Analysis will explicitly incorporate variations in key H&H (Hydrology and Hydraulics) and economic inputs in order to develop a range of damage levels and determine the impacts these variables play in project outputs. H&H inputs to the risk and uncertainty analysis will include variations in eroded dune location, 0.5 foot vertical erosion location, wave impact zone location, eroded dune elevation, maximum water elevation, water run–up elevation and bulkhead performance. Economic inputs to the risk and uncertainty analysis will include variations in the Federal discount rate, depreciated replacement cost value, and content-to-structure percentage. Outputs from the risk analysis will include a range of Average Annual Damages (AAD), Average Annual Benefits (AAB), Net Benefits and Benefit Cost Ratios (BCR) that will better represent the potential damages and benefits that the project may encounter rather than single AAD, AAB, and BCR values based upon fixed assumptions about the study area.

5.5.4 H&H Risk and Uncertainty methodology

The approach to address risk and uncertainty was to quantify a statistical bound representing a +/- 90% confidence interval associated with the storm erosion, wave attack, and inundation analysis from the SBEACH model runs done for the without project conditions and for the selected plan. Previous outputs from SBEACH for the without project conditions and selected plan were used to develop these bounds. The upper limit of the +90% confidence interval bound represented a "high" risk alternative and the lower limit of the -90% confidence interval bound represented a "low" risk alternative. Previously computed erosion, wave attack, and inundation estimates served as mean conditions for each storm frequency event .

SBEACH generates six "response" parameters for each input beach profile at each frequency event (5- 10-, 20-, 50-, 100-, 200-, and 500-year). These response parameters are:

1. Eroded Dune Location
2. 0.5 foot Erosion Location
3. Wave Impact Zone Location
4. Eroded Dune Elevation
5. Maximum Water Elevation
6. Runup Elevation

These six response parameters are used to generate the three damage mechanisms used by the economics model (COSTDAM) to calculate Average Annual Damages (AAD), Average Annual Costs (AAC), Net Benefits, and the subsequent Benefit Cost Ratios (BCR). The 3 damage mechanisms are:

1. Storm Erosion
2. Storm Wave Attack
3. Storm Inundation (flooding)

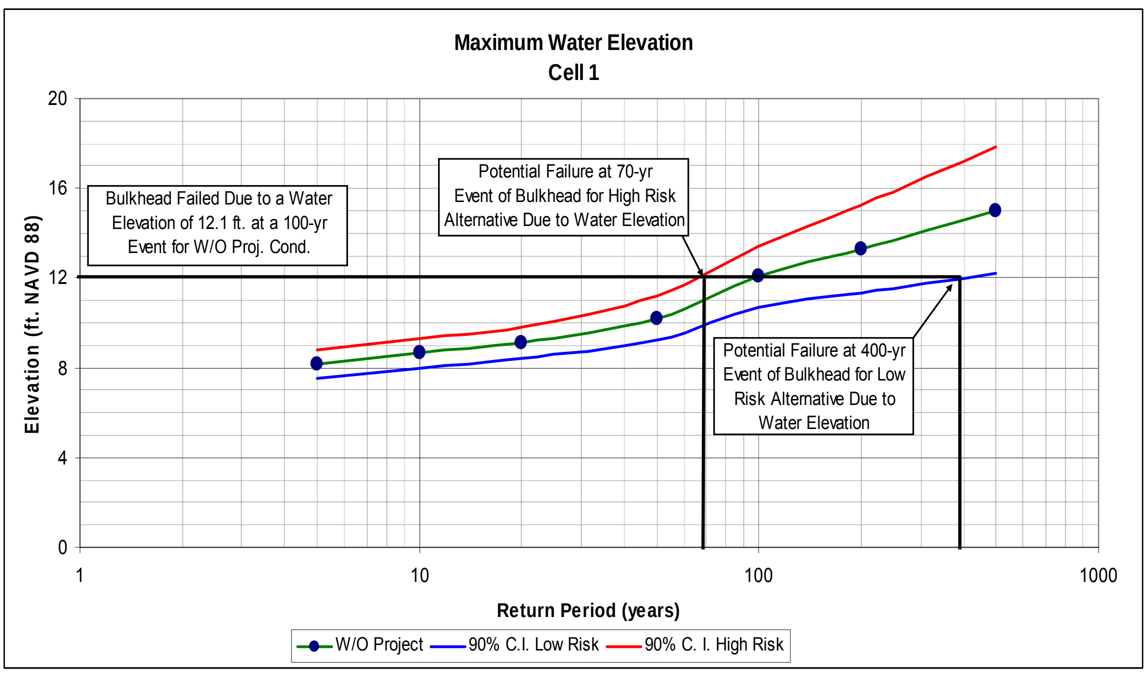
Since there is a degree of uncertainty associated with these parameters, the computer program EST (Empirical Simulation Technique) was used to develop the "high" risk and "low" risk statistical bound for each of the response parameters. EST can utilize multiple computed parameters associated with site-specific historical events as a basis for developing a methodology for generating multiple simulations of storm activity and the effects associated with each simulated event. The six response parameters are not independent, but are interrelated to each other in some nonlinear sense. Events follow a Poisson distribution in the EST portion of the modeling.

The peak water elevation for each frequency event (5, 10, 20, 50, 100, 200, and 500 year) used in the previous SBEACH simulations along with the corresponding peak wave height and wave period were used as the input variables in the EST analysis. A graph showing the +/-90% confidence interval bands for each output parameter were developed in EST for each frequency within each cell for the "without project" analysis and "selected plan". A "low" and "high" value was picked off the confidence interval curves at each frequency. The "low" values represented a low risk alternative as compared to the mean and the "high" values represented a high risk alternative as compared to the mean.

The H&H risk and uncertainty analysis produced six EST +/- 90% confidence interval curves for the key parameters used to calculate erosion, inundation and wave damages for COSTDAM inputs. The 90% confidence interval was selected because the magnitude and range of the distribution defined by a 95% and 99% confidence interval was determined to be too large when compared to the 90% confidence interval. An example of the water level curve for the storm events modeled in SBEACH is presented in **Figure 125**. The EST program generated the “high” risk (red line) and a “low” risk (blue line) scenario based on the +/- 90% confidence interval. New control files for the COSTDAM economic model were generated based on the results of these six curves. EST uses a Poisson distribution for the life cycle events to determine the average number of expected events in a given year and it calculated a standard deviation and mean for each of the six response variables.

In order to incorporate uncertainty into the analysis, the failure criteria of the existing shore protection structures were also varied. The original failure criterion assumed that the shore protection bulkhead would fail after being overtopped by 1foot of water. By incorporating a degree of uncertainty into the 1 foot failure threshold, the bulkhead was assumed to fail at a less frequent and more frequent water elevation compared to the original analysis. The "more frequent" (red line in **Figure 125**) and "less frequent" (blue line in **Figure 125**) failure events for shore protection structures were scaled off the graph for the response parameters produced by EST.

Figure 125 Empirical Simulation Technique (EST) 90% confidence curve for water level



The new failure criteria resulted in structure failures that were respectively, less probable and more probable to fail when compared to the previous analysis. Previous without project analysis showed that the bulkhead failed at the 100-year event in North Wildwood. **Figure 125** shows potential failure events at the 70- and 400-year events when uncertainty is applied to the 1 foot failure threshold. It was assumed that by applying uncertainty, the bulkhead could fail at the 50-year event for the “high risk” scenario, and at the 200-year event for the “low risk” scenario.

These events were chosen since a 70 year event and a 400 year event were not run in the SBEACH. These two scenarios were included in low and high risk damage calculations.

The effects of Sea Level Rise (SLR) were incorporated using the guidance provided in Engineering Circular 1165-2-212. That guidance suggests accounting for a historic rate of sea level rise based on tide gauge data; a medium level of SLR; and a high level of SLR based on two National Research Council (NRC) curves. The range of values calculated using the guidance in EC 1165-2-211 was between 0.65 to 2.3' of SLR as a result of 50 years of projected rise at the Atlantic City tide gauge.

Sea-level adjustments were incorporated into the development of the ocean stage frequency which was used for the without project hydraulic analysis for the study. Water elevations from historical storms as recorded at the nearby tide station at Atlantic City, NJ were adjusted for sea level rise accordingly and served as input to the SBEACH models. SLR was incorporated into the R&U analysis by calculating shoreline recession rates for each cell due to each sea-level rise scenario (NRC-Curves I and III) by using the Bruun Rule. This result was then compared to the shoreline recession values that were previously computed for the future without project condition. The larger of the two values was adopted and used in order to adjust the without project beach profile landward. This assumed a worst-case scenario of future beach profile response to accelerated sea-level rise. Any adjusted beach profile took into account the physical limitations of the area such as bulkheads and development locations as well as potential future actions by Locals and/or the State to intervene when beach conditions degrade to a point where action to replenish the beach must be taken. The previously computed future without project erosion value were based upon a calculated long-term erosion rate which examined historical trends in shoreline movement as well as potential future intervention by Locals and/or the State when the beach erodes back to the bulkhead in Cell 1.

The elevations of the storm surge hydrograph used in SBEACH for the without project conditions were increased by an amount that corresponded to the worst-case accelerated sea-level change projection (2.3'). SBEACH was used again using the modified hydrographs and the adjusted beach profile. The values for the six response parameters SBEACH computed were compiled and plotted against the previously computed curves representing the 90% confidence interval that was done for earlier in the risk and uncertainty analysis. The curve that plotted furthest away from the mean was designated to be the "high risk" alternative. The erosion, wave impact zone, and inundation profiles that were used as input for the COSTDAM economics model were then calculated based upon these updated curves.

5.5.5 Economic Risk and Uncertainty Methodology

The economic risk and uncertainty analysis will use the new control files from EST, which will incorporate sea level rise parameter changes as model inputs for COSTDAM while performing a sensitivity analysis by varying key economic parameters that could affect AAD, AAB, Net Benefits and BCRs. Discount rate, depreciated replacement cost value, content-to-structure percentage, and the curves for stage damage will be varied for the economic portion of the analysis. The economic evaluation was performed over a 50-year period of analysis at the plan formulation discount rate and price level.

The federal discount rate is established annually and according to law is not allowed to vary by more than one quarter of one percentage point in any fiscal year. It is recognized that this parameter is likely to change. The discount rate will be varied by -¼ from the baseline rate in effect at the time of the risk and uncertainty analysis for the "low" risk scenario and by +¼ for the "high" risk scenario.

The Marshall and Swift Valuation Service was used for estimating depreciated replacement cost values from a combination of structure characteristics such as square footage, construction material, foundation type, and systems. The current depreciated replacement cost values will serve as the mean value for each structure. Typically, depreciated replacement cost values have been modified by +/- 10% in a sensitivity analysis to determine the "low" and "high" risk scenarios. This approach will be employed to examine the effects on net benefits of the 90% confidence interval bands determined in the H&H analysis. Depreciated replacement cost values will also be varied for the most likely case scenario independently from the revised H&H parameters.

The content-to-structure percentage will be established using existing percentages from previous studies on the topic. Empirical data established a content value to be approximately 40% of structure value in primary homes and 15 to 20% of structure value in vacation homes. Nearly 70% of the residential structures in North Wildwood are vacation or rental homes. A conservative weighted content-to-structure value of 25% was adopted because it was determined that use of a 40% content-to-structure ratio would overestimate damage potential in a predominately vacation coastal community. The current content-to-structure value ratio of 25% for district coastal studies will serve as the mean. A sensitivity to show the impact of varying the ratio to 10% for the "low" risk scenario and 40% under the "high" risk scenario will be performed. The content-to-structure ratio will also be varied for the most likely scenario independently from the EST low and high H&H model results.

The stage damage curves for the mean condition will be varied by a reasonable level to determine the results' sensitivity to changes in this inundation damage variable. Reasonable levels of variation were obtained by prorating the original curves by percentage of change for minimum and maximum saltwater curves empirically observed in another coastal area. The significant coastal hydraulics parameters which determine erosion and wave damage vulnerability will be addressed within the SBEACH and EST models which are incorporated in the storm damage analysis through revised control files, the engineering component of the program. These critical response parameters include, as explained above, sea level rise (SLR), eroded beach volume, shoreline retreat, wave height above dune, and other variables.

The COSTDAM model evaluates structure erosion damage based on the presence of pile or slab foundation. The land below the structure must have eroded through the footprint of the structure before total damage is claimed for structures that are identified as having piles. Prior to this, for both foundation types, the percent damage claimed is equal to the linear proportion of erosion under the structure's footprint also referred to as the percent of the footprint compromised. Variation in pile depths will not be evaluated as part of this analysis because pile depths for each building are not available and actual pile depth or a range of depths is not a model parameter and was not surveyed. Therefore, the R&U for this variable cannot be addressed within the confines of the COSTDAM model. Also, variation in the first floor elevation surveys will not be evaluated. The level of uncertainty in the parameters of structure first floor elevation and square footage is considered low. Professional surveyors conducted the elevation survey on a structure by structure basis and the square footage was derived from a Geographic Information Systems (GIS) database.

5.5.6 Risk and Uncertainty Results

Primary outputs of the analysis include a range of Average Annual Damages (AAD), Average Annual Benefits (AAB), Net Benefits and Benefit Cost Ratios (BCR) represented by the damage level scenarios: (1) low risk scenarios; (2) the existing baseline damage level; and (3) high risk scenarios. The low risk scenarios will be based on the model inputs from the H&H analysis that incorporate the lower limit 90% confidence interval curve values for the eroded dune location, 0.5 foot erosion location, wave impact zone location, eroded dune elevation, maximum water elevation and run-up elevation from the H&H analysis, coupled with variation in four key economic input variables that include discount rate, depreciated replacement costs, content-to-structure percentage, and stage damage curves. The existing baseline damage level will be based on the previously calculated AAD, AAB, Net Benefits and BCRs. The high risk scenarios will be based on the model inputs from the H&H analysis that incorporate the values from the upper limit 90% confidence interval curve eroded dune location, 0.5 foot erosion location, wave impact zone location, eroded dune elevation, maximum water elevation and run-up elevation from the H&H analysis, coupled with variation in four key economic input variables that include discount rate, depreciated replacement costs, content-to-structure percentage, and stage damage curves. All outputs from the proposed additional risk and uncertainty analyses will be tabulated and plotted to display the potential range of values that result. They will indicate the relative level of risk and uncertainty that would be associated with implementing the selected plan (**Table 91).**

The variables from the risk and uncertainty analysis that are most likely to contribute to the variations in project outputs are the aggregated combined variations that combine low/high discount rates, low/high structure to cost value, low/high stage damage curves etc, are the combined Hydrology and Hydraulic parameters including water level, structure performance, erosion distances that were varied within the Empirical Simulation Technique (EST) Analysis. When combined, these variables have the potential to increase average annual benefits, Benefit Cost Ratios and Net Benefits from the MLS (Most Likely Scenario).

Table 91 Risk and Uncertainty Results

	MLS- Most Likely Scenario (selected plan)	Discount Rate		Structure Depreciated Replacement Cost Value		Content-to-Structure Ratio		Stage Damage Curves		EST Confidence Interval		Combined Variations	
Category	***na***	**3⅞%**	**4⅜%**	**-10%**	**10%**	**10%**	**40%**	**Min**	**Max**	**-90%**	**90%**	**Low**	**High**
Storm Damage Reduction:	*$5,042*	$5,042	$5,042	$4,539	$5,547	$4,460	$5,756	$4,547	$5,624	$1,545	$23,240	$1,040	$34,123
Benefits During Construction:	*$93*	$89	$97	$84	$102	$82	$106	$84	$104	$28	$429	$19	$629
Recreation:	*$580*	$580	$580	$580	$580	$580	$580	$580	$580	$580	$580	$580	$580
Total AAB:	*$5,715*	$5,711	$5,719	$5,203	$6,229	$5,122	$6,442	$5,211	$6,308	$2,153	$24,249	$1,639	$35,332
% Deviation from MLS	***na***	**-0.07%**	**0.07%**	**-8.96%**	**8.99%**	**-10.38%**	**12.72%**	**-8.82%**	**10.38%**	**-62.33%**	**324.30%**	**-71.32%**	**518.23%**
AAB Rank from MLS	***na***	11	10	9	7	9	5	8	6	4	2	3	1
Average Annual Costs													
Avg. Ann. Construction Costs:	*$2,178*	$2,519	$2,602	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178
Avg. Ann. Monitoring Costs:	*$119*	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119
Total AAC:	*$2,297*	$2,638	$2,721	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297
Benefit Cost Ratio													
BCR	*2.5*	2.2	2.1	2.3	2.7	2.2	2.8	2.3	2.7	0.9	10.6	0.7	15.4
% Deviation from MLS	*na*	**-12.00%**	**-16.00%**	**-8.00%**	**8.00%**	**-12.00%**	**12.00%**	**-8.00%**	**8.00%**	**-64.00%**	**324.00%**	**-72.00%**	**516.00%**
BCR Rank from MLS	*na*	6	5	7	7	6	6	7	7	4	2	3	1
Net Benefits													
Net Benefits:	*$3,418*	$3,073	$2,998	$2,906	$3,932	$2,825	$4,145	$2,914	$4,011	-$144	$21,952	-$658	$33,035
% Deviation from MLS	***na***	**-10.09%**	**-12.29%**	**-14.98%**	**15.04%**	**-17.35%**	**21.27%**	**-14.75%**	**17.35%**	**-104.21%**	**542.25%**	**-119.25%**	**866.50%**
Net Benefits Rank from MLS	*na*	10	9	8	7	6	5	9	6	4	2	3	1
Combined Rank	*na*	27	24	24	21	21	16	24	19	12	6	9	3
Final rank against MLS	*na*	**11**	**10**	**9**	**8**	**7**	**5**	**6**	**5**	**4**	**2**	**3**	**1**

The variables with the greatest to least impact (+/-) on Average Annual Benefits, Benefit Cost Ratios and Net Benefits from the Most Likely Scenario (MLS) are ranked below. The ranking was based on the percentage that each variable deviated from the Most Likely Scenario (MLS). These percentages were then ranked based on the absolute value (+/-) of the deviation from the MLS for Average Annual Benefits, Benefit Cost Ratio and Net Benefits. These rankings were then totaled in the row titled Combined Rank, and then the totals from the Combined Rank were ranked from 1-11. The lower values had the highest impact on variables in the table above.

1. Combined High Variation
2. EST +90 Confidence Interval
3. Combined Low Variation
4. EST -90 Confidence Interval
5. Stage Damage Curve Max/ Content to Structure Percentage -40%(tie)
6. Stage Damage Curve Minimum
7. Content to Structure Percentage +10%
8. Structure Depreciated Replacement Costs Value +10%
9. Structure Depreciated Replacement Cost Value -10%
10. Discount Rate at 4 $^{3/8}$
11. Discount Rate at 3 $^{7/8}$

Factors that had the highest contribution to uncertainty based on variation from the most likely scenario in **Table 91** were variations in the EST confidence intervals (sea level rise, structure performance, erosion distances) fluctuations in the Stage Damage Curves and Content to Structure ratio 40%.

The variables that had the least impact on project outputs were related to Discount Rates, Structure Depreciated Replacement Cost Value and Content to Structure Percentages 10%. .

Other key variables that contribute to risk and uncertainty are first floor elevations of structures within the study area. This uncertainty was dealt with by quality control of the surveyed data by district personnel and contractors and it was not explicitly varied in the risk and uncertainty analysis.

Mitigation for variables that will contribute to the increase in project AAB, BCR and Net Benefits are difficult for shore protection projects since natural and engineered berm levels are determined by local water levels, and increasing existing berm levels to deal with future water level increases associated with sea level rise and storm stage will cause the berm to scarp and produce steep beachface cliffs. Also, increasing dune elevations to mitigate for increase water levels during storms would require the selection of an elevation above NED optimized elevations which is in violation of Corps Planning Guidance. Increasing dune heights to created additional "freeboard" above the optimized dune height would require material that is above the NED optimum. Therefore, the PDT decided that adaptive management to future sea level rise was the best measure for mitigation of risk and uncertainty.

There is a very low risk and uncertainty to the recommendation for the selected plan of improvement from the derivation of the recreation benefits by utilizing the somewhat dated Rutgers University Contingent Valuation Method (CVM) report as a key input. This report was contracted by the Philadelphia District to Rutgers University, and was spearheaded by a professor with substantial CVM expertise. The Rutgers University effort entailed a large random sample of interviews with approximately 1000 New Jersey beachgoers. The initial starting point for a visitor day beach experience valuation of $4.22 from the Rutgers report was within the lower range of valuation that could be expected to be applied from an alternate recreation benefit evaluation technique, Unit Day Values. The incremental increase in the willingness to pay, applied as the basis for benefits for an improved recreational experience with a widened with project condition beach berm, was a modest $0.69 per person per day (2014 PL). Also, the recreation benefits are strictly a secondary incidental project purpose for this study and were not used in the formulation/optimization process. The selected plan has positive BCRs for all the communities within the project area (without recreation benefits): North Wildwood (1.4); Wildwood (10.6); Wildwood Crest/Lower Township (5.1); and the Total Project (2.1). The recreation average annual benefits of $693,000 represent only 11% of the total project average annual benefits of $6,253,000. The impact of adding the recreation benefits at the end of the formulation process resulted in the project Benefit-Cost Ratio being adjusted slightly upward from 2.1 to 2.3.

5.6 Cost Sharing and Local Cooperation

Cost Sharing for the selected plan is based on the Water Resource Development Act (WRDA) of 1986. Section 103 (d) of WRDA 86 established the cost sharing percentages for beach nourishment projects. The selected plan is justified based on hurricane and storm damage reduction benefits. No separable recreation features are included with the project. Recreation benefits produced by the selected plan are not required for justification and are assumed to be incidental to the project. In accordance with Section 103 WRDA1986 and appropriate Federal regulations such as ER 1165-2-130, Federal participation in a project formulated for hurricane and storm damage reduction is 65% of the estimated total initial project construction costs including Lands, Easements, Rights-of-way, Relocations, and Dredged material disposal areas (LERRD). The estimated value of LERRD provided by the non-Federal Sponsor is included in total project costs. The non-Federal Sponsor shall receive credit for the value of LERRD cost towards the non-Federal cost share. Operation, Maintenance, Repairs, Replacement, and Rehabilitation (OMRR&R) costs are 100% non-Federal responsibility. Section 215 of the WRDA 1999 amended cost sharing for periodic nourishment of shore protection projects. Under Section 215 of WRDA 1999, periodic nourishment for the selected plan is 50% Federal and 50% non-Federal.

Table 92 Cost Sharing for the Selected Plan

Initial Construction					
Cost share Description	**Federal Cost Share %**	**Federal Cost**	**Non-Federal Cost Share %**	**Non-Federal Cost**	**Project First Cost**
Coastal Storm Damage Reduction Costs	**65%**	**$14,043,000**	**35%**	**$7,562,000**	**$21,605,000**
Real Estate Costs (LERRD Credit)	0%	$0	100%	$1,274,000	$1,274,000
Cash Portion		$14,043,000		$6,288,000	$20,331000
Periodic Nourishment					
Periodic Nourishment	**50%**	**$41,214,000**	**50%**	**$41,214,000**	**$82,428,000**
Initial Constrcution + Periodic Nourishment					
Final Project Cost Share and Cost (50 Years)	**53%**	**$55,257,000**	**47%**	**$48,776,000**	**$104,033,000**

5.6.1 Sponsor Cooperation and Financial Capability

In accordance with Section 105(a)(1) of WRDA 1986, the Hereford Inlet Feasibility Study was cost-shared 50%-50% between the Federal Government and the State of New Jersey. The contributed funds of the non-Federal Sponsor, the New Jersey Department of Environmental Protection, demonstrate their intent to support a project for the study area. The State of New Jersey has a $25,000,000 stable source of annual funding for shore protection projects. The sponsor has demonstrated their financial capability through their ongoing cost sharing of current Philadelphia District shore protection projects including; Barnegat Inlet to Little Egg Inlet, Brigantine Inlet to Great Egg Inlet, Absecon Island, Brigantine Inlet to Great Egg Inlet, Brigantine Island, Cape May Inlet to Lower Township, NJ and Great Egg Harbor Inlet to Peck Beach, Ocean City, NJ. The future estimated expenditures based on the initial construction, periodic nourishment, monitoring and operations and maintenance for the 50 period of analysis are shown in **Table 92**. The cost-sharing percentages presented herein are tentative based on the intent of the non-Federal Sponsor to ensure public use and access within the full project area. Public use and access will be addressed during the Preconstruction Engineering and Design (PED) phase and prior to construction. Final apportionment will be based on conditions of public use and access at the time of construction or subsequent nourishment.

Table 93 Estimated Schedule of Federal and non Federal Expenditures

		Federal	Non Federal			Total
Year	**Phase**	**Cost**	**Cash**	**LERRD**	**OMRR&R**	**Total Costs**
2015	PED	$1,394,921	$464,974	$0	$0	$1,859,894
2016	Initial	$14,043,000	$6,288,239	$1,273,511	$0	$21,604,750
2017	Mon.	$140,000	$0	$0	$150,000	$290,000
2018	Mon.	$140,000	$0	$0	$150,000	$290,000
2019	Mon.	$140,000	$0	$0	$150,000	$290,000
2020	Periodic	$2,975,000	$2,975,000	$0	$0	$5,950,000
2021	Mon.	$140,000	$0	$0	$150,000	$290,000
2022	Mon.	$140,000	$0	$0	$150,000	$290,000
2023	Mon.	$140,000	$0	$0	$150,000	$290,000
2024	Periodic	$2,975,000	$2,975,000	$0	$0	$5,950,000
2025	Mon.	$140,000	$0	$0	$150,000	$290,000
2026	Mon.	$140,000	$0	$0	$150,000	$290,000
2027	Mon.	$140,000	$0	$0	$150,000	$290,000
2028	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2029	Mon.	$140,000	$0	$0	$150,000	$290,000
2030	Mon.	$140,000	$0	$0	$150,000	$290,000
2031	Mon.	$140,000	$0	$0	$150,000	$290,000
2032	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2033	Mon.	$140,000	$0	$0	$150,000	$290,000
2034	Mon.	$140,000	$0	$0	$150,000	$290,000
2035	Mon.	$140,000	$0	$0	$150,000	$290,000
2036	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2037	Mon.	$140,000	$0	$0	$150,000	$290,000
2038	Mon.	$140,000	$0	$0	$150,000	$290,000
2039	Mon.	$140,000	$0	$0	$150,000	$290,000
2040	Major	$3,960,000	$3,960,000	$0	$0	$7,920,000
2041	Mon.	$140,000	$0	$0	$150,000	$290,000
2042	Mon.	$140,000	$0	$0	$150,000	$290,000
2043	Mon.	$140,000	$0	$0	$150,000	$290,000
2044	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2045	Mon.	$140,000	$0	$0	$150,000	$290,000
2046	Mon.	$140,000	$0	$0	$150,000	$290,000
2047	Mon.	$140,000	$0	$0	$150,000	$290,000
2048	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2049	Mon.	$140,000	$0	$0	$150,000	$290,000
2050	Mon.	$140,000	$0	$0	$150,000	$290,000
2051	Mon.	$140,000	$0	$0	$150,000	$290,000
2052	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2053	Mon.	$140,000	$0	$0	$150,000	$290,000
2054	Mon.	$140,000	$0	$0	$150,000	$290,000
2055	Mon.	$140,000	$0	$0	$150,000	$290,000
2056	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2057	Mon.	$140,000	$0	$0	$150,000	$290,000
2058	Mon.	$140,000	$0	$0	$150,000	$290,000
2059	Mon.	$140,000	$0	$0	$150,000	$290,000
2060	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2061	Mon.	$140,000	$0	$0	$150,000	$290,000
2062	Mon.	$140,000	$0	$0	$150,000	$290,000
2063	Mon.	$140,000	$0	$0	$150,000	$290,000
2064	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2065	Mon.	$140,000	$0	$0	$150,000	$290,000

5.6.2 Project Partnership Agreement

A fully coordinated Project Partnership Agreement (PPA) will be prepared subsequent to the approval of the feasibility phase and will reflect final recommendations of this feasibility study. The non-Federal Sponsor, the New Jersey Department of Environmental Protection, has indicated support of the recommended plan and desire to execute a PCA. NJDEP has committed to providing adequate public access for all project lands throughout the life of the project. Should Congress appropriate funds for construction of the project, the non-Federal Sponsor would have to assume non-Federal responsibilities relating to cost-sharing, financing, and other applicable requirements of the Water Resources Development Acts of 1986, 1996, and 1999 as indicated in the following paragraphs:

a. Provide 35 percent of initial project costs assigned to hurricane and storm damage reduction plus 100 percent of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits and 50 percent of periodic nourishment costs assigned to hurricane and storm damage reduction plus 100 percent of periodic nourishment costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits and as further specified below:

(1) Enter into an agreement which provides, prior to construction, the required non-Federal share of design costs;

(2) Provide, during construction, any additional funds needed to cover the non-Federal share of design costs;

(3) Provide all lands, easements, and rights-of-way, and perform or ensure the performance of any relocations determined by the Federal Government to be necessary for the initial construction, periodic nourishment, operation, and maintenance of the project;

(4) Provide, during construction, any additional amounts as are necessary to make its total contribution equal to 35 percent of initial project costs assigned to hurricane and storm damage reduction plus 100 percent of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits and 50 percent of periodic nourishment costs assigned to hurricane and storm damage reduction plus 100 percent of periodic nourishment costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits;
b. For so long as the project remains authorized, operate, maintain, and repair the completed project, or functional portion of the project, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

a. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal Sponsor, now or hereafter, owns or controls for access to the project for the purpose of inspecting, operating, maintaining, repairing, replacing, rehabilitating, or completing the project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall relieve the non-Federal Sponsor of responsibility to meet the non-Federal Sponsor's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance;

b. Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs

c. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the project").

d. Hold and save the United States free from all damages arising from the initial construction, periodic nourishment, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the United States or its contractors;

e. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

f. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended, 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the initial construction, periodic nourishment, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal Sponsor with prior specific written direction, in which direction;

g. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the initial construction, periodic nourishment, operation, or maintenance of the project;

h. Agree that the non-Federal Sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, and repair the project in a manner that will not cause liability to arise under CERCLA;

i. If applicable, comply with the applicable provisions of the Uniform Relocation

Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the initial construction, periodic nourishment, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

j. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army", and Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), requiring non-Federal preparation and implementation of flood plain management plans;

k. Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project, in accordance with the cost sharing provisions of the agreement;

l. Participate in and comply with applicable Federal floodplain management and flood insurance programs;

m. Do not use Federal funds to meet the non-Federal Sponsor's share of total project costs unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project.

n. Prescribe and enforce regulations to prevent obstruction of or encroachment on the project that would reduce the level of protection it affords or that would hinder future periodic nourishment and/or the operation and maintenance of the project;

o. Not less than once each year, inform affected interests of the extent of protection afforded by the project;

p. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the floodplain, and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

q. For so long as the project remains authorized, the non-Federal Sponsor shall ensure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based;

r. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms;

s. Recognize and support the requirements of Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal Sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element; and

t. At least twice annually and after storm events, perform surveillance of the beach to determine losses of nourishment material from the project design section and provide the results of such surveillance to the Federal Government.

6.0 Conclusions and Recommendations

6.1 Conclusions

A plan was developed to reduce potential ocean-related storm damages. This plan consists of the construction of a beach berm and dune from Hereford Inlet to Cape May Inlet encompassing North Wildwood, Wildwood, Wildwood Crest and Lower Township. This plan includes periodic nourishment every 4 years. Specific project details are presented in Section 5.1 of this report. The selected plan reflects information available at the time and current Corps policies governing formulation of hurricane and storm damage reduction projects. This plan may be modified before being transmitted to Congress as a proposal for authorization and implementation. The project sponsor, interested Federal and non-Federal agencies, and other parties will be advised of any such modification and given an opportunity to comment further prior to transmittal to Congress.

6.1.1 Study Continuation: Needs and Requirements

In the Disaster Relief Appropriations Act of 2013, Public Law 113-2, Congress provided funding and authority for the Corps of Engineers to execute actions related to the consequences of Hurricane Sandy. The Federal share of initial construction of the recommended plan is eligible to be funded using construction funds provided in Public Law 113-2. The Corps will address whether Public Law 113-2 construction funds will be used to complete initial construction of the recommended plan at a later date.

If the Corps determines that Public Law 113-2 funds will be used for the Federal share of initial construction of the recommended plan, initial construction of the project may be completed following notification to the Committees on Appropriations of the House of Representatives and the Senate by the Assistant Secretary of the Army (Civil Works) that the recommended plan is technically feasible, economically justified, and environmentally acceptable. Congressional authorization and appropriations will be required in order to carry out periodic renourishment.

If the Corps, however, determines that Public Law 113-2 funds will not be used for the Federal share of initial construction of the recommended plan, Congressional authorization and appropriations will be required in order to carry out both initial construction and periodic renourishment.

6.1.2 Additional Tasks

Hurricane Sandy impacted the coastline of the mid-Atlantic and northeast United States in October 2012, making landfall less than 40 miles northeast of the Hereford Inlet to Cape May Inlet study area. As a result of Hurricane Sandy, Congress passed Public Law 113-2, the "Disaster Relief Appropriations Act, 2013". Chapter 4 of PL 113-2 specified actions for USACE, including the following [underlining added]:

> *". . .the Secretary of the Army <u>shall expedite and complete ongoing flood and storm damage reduction studies</u> in areas that were impacted by Hurricane Sandy"*

and further that:

> *“. . . an interim report identifying . . . any project under study by the Corps for reducing flooding and storm damage risks in the affected area . . . shall be submitted to the appropriate congressional committees”.*

USACE transmitted the “Second Interim Report to Congress” on 30 May 2013, which stated:

> *“. . . the Secretary of the Army may also use these funds to construct any project under study by the Corps for reducing flooding and storm damage risks in areas along the Atlantic Coast within the North Atlantic Division that were affected by Hurricane Sandy”.*

The Second Interim Report to Congress included the Hereford Inlet to Cape May Inlet study as a “Project Under Study”, thus making it eligible for study completion funding, as well as authorizing initial project construction funding at 100% Federal expense, with the non-Federal share of initial construction costs repayable over a period of 30 years from the date of project completion. Although PL 113-2 authorized initial construction of the project, it did not include future periodic nourishment of the project, which will require a separate authorization by Congress.

North Atlantic Coast Comprehensive Study (NACCS)

PL 113-2 also directed USACE to perform *“a comprehensive study to address the flood risks of vulnerable coastal populations in areas that were affected by Hurricane Sandy within the boundaries of the North Atlantic Division of the Corps”*. The “North Atlantic Coast Comprehensive Study” (NACCS) is ongoing and is scheduled for completion in January 2015. The focus of the NACCS is to reduce risk to vulnerable coastal populations and the infrastructure it supports.

When the Hereford Inlet to Cape May Inlet study was scoped and initiated, the focus was to address risk of potential storm damage along the oceanfront of Five Mile Island. It was recognized at the time that there was residual risk of back bay flooding to the communities on Five Mile Island and additional residual risk areas that were not able to be protected with the selected plan on the beachfront piers. The back bay shoreline flood risk will be reduced by implementation of a shore protection project (beachfill) along the oceanfront. Nevertheless, back bay shorelines and other residual risk areas remain susceptible to flooding during coastal storms and as a result of ocean storm surge.

However, the magnitude of that problem was determined to be beyond the scope of the feasibility study, in part because the emphasis of the New Jersey Shore Protection Program, and specifically the Hereford Inlet to Cape May Inlet component of that program, was to complete the line of oceanfront shore protection projects that extend from Sea Bright, NJ on the north to Cape May Point on the south, a distance of about 125 miles. As stated previously in this report, the coastal reach between Hereford and Cape May Inlets was the only segment of the New Jersey ocean coast lacking an authorized shore protection project.

Given that Hurricane Sandy caused significant back bay flooding of the Five Mile Island study area between Hereford and Cape May Inlets, and given the emphasis of the NACCS to identify areas at risk of coastal flooding in the future, an opportunity exists to evaluate risks associated with the back bay flood problem of the study area and other residual risk areas that are not addressed by the recommended plan of this report.

6.2 Recommendations

Overall Assessment

In making the following recommendations, I have given consideration to all significant aspects in the overall public interest, including environmental quality, social effects, economic effects, engineering feasibility, and compatibility of the project with policies, desires, and capabilities of the State of New Jersey and other non-Federal interests. I have evaluated several alternative plans for the purpose of hurricane and storm damage reduction. A project has been identified that is technically sound, economically cost-effective over the 50-year period of analysis, socially and environmentally acceptable, and has support from the non-Federal Sponsor.

Project Benefits

The selected plan has primary benefits based on hurricane and storm damage reduction and provides average annual total net benefits of approximately $3,565,000 and a benefit-to-cost ratio of 2.3

Initial Project Cost

The total initial project cost of construction is estimated at $21,605,000 (March 2014 P.L.). Lands, Easements, Rights-of-Ways, Relocations, and Dredged Material Disposal Areas (LERRD) costs are $1,273,987 and will be credited towards the non-Federal Sponsor cash contribution.

Continuing Construction Cost

Periodic nourishment is expected to occur at 4-year intervals subsequent to the completion of initial construction. Periodic nourishment is estimated to cost $82,428,000 (March 2014 P.L.) over the 50-year period of analysis.

Ultimate Project Cost

The ultimate cost of construction which includes initial construction, project monitoring, and fifty years of periodic nourishment is estimated to be $104,033,000 (March 2014 P.L.), cost-shared 52% Federal and 48% non-Federal based on WRDA 1999 cost-sharing of periodic nourishment at 50% Federal and 50% non-Federal and initial construction at 65% Federal and 35% non-Federal.

Modifications

These recommendations reflect the information available at the time and current Departmental policies governing formulation of individual projects. These recommendations may be modified before they are transmitted to Congress as proposals for authorization and implementation funding. However, prior to transmittal to Congress, the Sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded the opportunity to comment further.

30 May 2014
Date

John C. Becking
Lieutenant Colonel, Corps of Engineers
District Commander

7.0 List of Preparers

The following individuals were responsible for preparation and technical support for the Feasibility Study and Integrated Environmental Assessment.

Brian Bogle, P.M.P, Project Manager
M.S. Applied Geoscience
B.S. Hydro-geology
B.A. Political Science
12 years Project Management Experience

Jeff Gebert, Coastal Planning Chief
B.S. Geology and Geophysics
25 years Engineering and Planning Experience

Bob Selsor, Economist
BA Economics
MBA Finance
34 Years Experience

Sharon Grayson, Economist
B.A. Economics
M.B.A. Information Systems
Certificate Geographic Information Systems
16 years economics experience

Heather Sachs, Real Estate Specialist
Realty Specialist
Civil Projects/IIS Support Branch
M.S. Real Estate
21 years Federal Real Estate Experience

Beth Brandreth, EA Preparation
B.S. Marine Biology
22 years EA and EIS preparation and review experience

Alyssa Dunlap. P.E., Civil Works Design
B.S. in Architectural Engineering
B.S. Civil Engineering
14 years design experience

Chuck Sutphen, P.G., Geologist
B.S. Geology
M.S. Geoscience
Geotechnical and Beach Fill Analysis
20 years geotechnical experience

Bruce Uibel, P.E., Geotechnical Engineer
BS Civil Engineering
Geotechnical and Beach Fill Analysis
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Peter Gori, P.G., Geologist
B.S. Geology
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Robert Lowinski, Coastal Engineer
B.S. Civil Engineering
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Nichole Minnichbach, EIS Preparation
(Cultural Resources)
B.A. Anthropology
M.S. Anthropology
15 years field experience and 10 years federal experience

William Welk, Cost Estimator
B.S. Civil Engineering
M.S. Mechanical Engineering
19 years cost engineering experience

8.0 Public Involvement

Coordination of this project was done with Federal, State and local resource agencies. Agencies notified for this study included the U.S. Fish and Wildlife Service (USFWS), U.S. Environmental Protection Agency (USEPA), National Marine Fisheries Service (NMFS), New Jersey Department of Environmental Protection (NJDEP), and New Jersey State Historic Preservation Office (NJSHPO).

A Planning Aid Letter, prepared by the USFWS, is provided in Appendix G. A draft Section 2(b) Fish and Wildlife Coordination Act Report was requested from the USFWS and is contained in the technical appendices. A final Section 2(b) was prepared by the USFWS following the final review of this Final document. This report will provide official USFWS comments on the project pursuant to the Fish and Wildlife Coordination Act.

A copy of the Feasibility Study and Integrated Environmental Assessment is being provided to the following individuals/agencies for review in addition to the interested public that requested copies.

Federal

Honorable Frank Lobiondo
House of Representatives
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Local

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Mayor Patrick Rosenello
North Wildwood
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Mayor Carl Groon
Wildwood Crest
6101 Pacific Avenue
Wildwood Crest, NJ 08260

Mayor Micheal Beck
Lower Township
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Villas, NJ 08251

Dr. Stewart Farrell, Director
Coastal Research Center
P.O. Box 195
Jim Leeds Road
Pomona, NJ 08240-0195

9.0 Clean Air Act Statement of Conformity

CLEAN AIR ACT
STATEMENT OF CONFORMITY
HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY
CAPE MAY COUNTY, NEW JERSEY

Based on the conformity analysis in the subject report, I have determined that the proposed action conforms to the applicable State Implementation Plan (SIP). The Environmental Protection Agency had no adverse comments under their Clean Air Act authority. The air quality comments received from the New Jersey Department of Environmental Protection were addressed in the final feasibility report and integrated Environmental Assessment (EA). The proposed project would comply with Section 176 C (1) of the Clean Air Act Amendments of 1990.

23 May 2014
Date

John C. Becking
Lieutenant Colonel, Corps of Engineers
District Commander

10.0 District Legal Certification

CERTIFICATE OF LEGAL REVIEW

The Philadelphia District, Office of Counsel has reviewed the:

NEW JERSEY SHORE PROTECTION STUDY, HEREFORD INLET TO CAPE MAY INLET, FEASIBILITY REPORT AND INTEGRATED ENVIRONMENTAL ASSESSMENT, 4/28/2014.

A policy and legal compliance review for the subject document has been completed and all comments have been resolved in the enclosed report. The subject report was prepared in accordance with the requirements of ER 1105-2-100 and meets all applicable requirements.

Date: May 30, 2014

William A. Wilcox, Jr.
Principal Assistant District Counsel

11.0 Evaluation of 404 (B) (1) Guidelines

I. PROJECT DESCRIPTION

A. Location

The proposed project site is located along the Atlantic Coast shoreline of New Jersey from Hereford Inlet to Cape May Inlet and includes the communities of North Wildwood, Wildwood, Wildwood Crest and Lower Township. An onshore borrow site is the source of the nourishment material. This borrow area lies within Wildwood, Wildwood Crest and Lower Township and straddles the MHW line and material will be taken from the intertidal zone and upland beaches. This area has historically accreted sand through natural process associated with long-shore sediment transport.

B. General Description

The purpose of the project is hurricane and storm damage reduction through the placement of dredged material (sand) obtained from the borrow sites on the beachfront in the form of a berm and dune. The plan includes a dune with crest elevation at +16ft NAVD fronted by a 75-ft wide berm at elevation +6.5 ft NAVD. The design template for both dune configurations includes a 25-ft dune crest width with 1V:5H dune side slopes. The design template extends seaward from the berm crest down to mean low water (MLW) at a slope of 1V:10H, and extends further down to a closure depth of 26 ft following the average existing beach profile shape. Initial sand quantity is approximately 1,362,000 cubic yards, which includes overfill factors and advanced nourishment. Periodic nourishment of approximately 305,000 cubic yards is scheduled to occur every 4 years.

C. Authority and Purpose

The Hereford Inlet Feasibility study is part of the overall New Jersey Shore Protection Study, which was authorized under resolutions adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environmental and Public Works of the U.S. Senate in December 1987 that states:

That the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 13, 1902, be, and is hereby requested to review existing reports of the Chief of Engineers for the entire coast of New Jersey, with a view to study, in cooperation with the State of New Jersey, its political subdivisions and agencies and instrumentalities thereof, the changing coastal processes along the coast of New Jersey. Included in this study will be the development of a physical, environmental, and engineering database on coastal area changes and processes, including appropriate monitoring, as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage; and, in cooperation with the Environmental Protection Agency and other Federal agencies as appropriate, develop recommendations for actions and solutions needed to preclude further water quality degradation and coastal pollution from existing and anticipated uses of coastal waters affecting the New Jersey coast. Site specific studies for beach *erosion control, hurricane protection, and related purposes should be undertaken in areas identified as having potential for a Federal project, action, or response.*

The House resolution adopted by the Committee on Public Works and Transportation on December 10, 1987 states:

That the Board of Engineers for Rivers and Harbors is hereby requested to review existing reports of the Chief of Engineers for the entire coast of New Jersey with a view to study, in cooperation with the State of New Jersey, its political subdivisions and agencies and instrumentalities thereof, the changing coastal processes along the coast of New Jersey. Included in this study will be the development of a physical, environmental, and engineering database on coastal area changes and processes, including appropriate monitoring, as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage; and, in cooperation with the Environmental Protection Agency and other Federal agencies as appropriate, the development of recommendations for actions and solutions needed to preclude further water quality degradation and coastal pollution from existing and anticipated uses of coastal waters affecting the New Jersey Coast. Site specific studies for beach erosion control, hurricane protection, and related purposes should be undertaken in areas identified as having potential for a Federal project, action, or response which is engineeringly, economically, and environmentally feasible.

See Supplemental Authority in Section 1.0

D. General Description of Dredged or Fill Material

1. General Characteristics of Material. The proposed borrow material is medium to coarse sands with some fines and gravel. Clay, silt, and organic content are low with neutral pH and low fertility. Grain size analyses have demonstrated that the borrow material is comparable to the native beach sand. As such, the borrow material is considered ideal for berm and dune restoration.

2. Quantity of Material. The quantity of beach fill material required for initial fill for the project is estimated to be approximately 1,527,000 cy, which includes overfill factor and advanced nourishment. Periodic nourishment of 391,000 cy is scheduled to occur every 4 years.

3. Source of Material. The proposed source of the beach fill material is from the southern portion of the project area in Wildwood and Wildwood Crest and Lower Township.

E. <u>Description of the Proposed Discharge Site</u>

1. Location. The proposed discharge locations will be from Hereford Inlet to Cape May Inlet along the beachfront and in the near shore environment.

2. Size. The proposed plan will create 64 acres of dune habitat above MHW. Below MHW, sand will cover intertidal and subtidal habitat. These habitats will not be lost however, as the sand placement simply shifts the area seaward.

3. Type of Site. The proposed discharge is comprised of eroding sandy beaches located from Hereford Inlet to Cape May Inlet. The proposed discharge sites are unconfined with placement to occur on shoreline beach areas and open water.

4. Type(s) of Habitat. The type of habitat present at the proposed discharge locations are marine sandy beach intertidal and sub tidal near shore habitats and marine open water.

5. Timing and Duration of Discharge:

There are no seasonal restrictions for beach fill placement and associated discharges with the exception that certain areas or segments may require avoidance if piping plovers are nesting within the impact area(s) during the nesting season (March – August). For initial construction, the discharge would be continuous for approximately 8 months. Periodic nourishment would occur over approximately 4-6 months every 4 years during the 50-year period of Federal participation. Estimated year of initial construction is 2016.

F. Description of Discharge Method

A land based hydraulic dredge will be used to excavate the sandy material from the borrow area. The material would be transported from the dredge pump using an 8 inch high density polyethylene pipeline (HDPE) to booster pumps stationed every 3,000-4,000 along the beach. The final grading would be accomplished using bulldozers and front end loaders working in the upland beach and near shore area.

II. FACTUAL DETERMINATION

A. Physical Substrate Determinations

1. **Substrate Elevation and Slope.** For the entire project area the final proposed elevation of the beach substrate after fill placement would be +6.5' NAVD at the top of the berm and +16' NAVD at the crest of the dune. The proposed profile would have a foreshore slope of 1V:10H and an underwater slope that parallels the existing bottom to the depth of closure.

2. **Sediment Type.** The sediment type involved would be sandy beach fill material (consists 90% or greater of fine, medium and coarse sands and gravels) obtained from the intertidal beach area in Wildwood and Wildwood Crest.

3. **Dredged/Fill Material Movement.** The planned construction would establish an initial construction template, which is higher and wider than the final intended design template or profile. It is expected that compaction and erosion would be the primary processes resulting in the change to the design template. Also, the loss of fine grain material into the water column would occur during the initial settlement. These materials may become re-deposited within sub tidal near shore waters.

4. **Physical Effects on Benthos.** The proposed construction and discharges would result in initial

burial of the existing beach and near shore benthic communities when this material is discharged during berm construction. Substrate is expected to be composed of material that is similar to existing substrate, which is expected to become recolonized by the same type of benthos. The dredging within the borrow site would result in the removal of the benthic community from the substrate, however, due to the dynamic nature of the intertidal zone, recolonization will occur quickly following the completion of dredging activities.

5. **Other Effects.** Other effects would include a temporary increase in suspended sediment load and a change in the beach profile, particularly in reference to elevation. Bathymetric changes in the placement sites would raise the bottom several feet, which would be offset seaward. The shoreline in the borrow area will be offset landward.

6. **Actions Taken to Minimize Impacts.** Actions taken to minimize impacts include selection of fill material that is located in an upland site rather than a site from an offshore source. Using upland source will minimize impacts to benthic resources, fisheries, shellfish habitat and cultural resource targets.

B. Water Circulation, Fluctuation, and Salinity Determinations

1.Water. Consider effects on:
a. Salinity - No effect.
b. Water chemistry - No significant effect.
c. Clarity - Minor short-term increase in turbidity during construction.
d. Color - No effect.
e. Odor - No significant effect.
f. Taste - No effect.
g. Dissolved gas levels - No significant effect.
h. Nutrients - Minor effect.
i. Eutrophication - No effect.
j. Others as appropriate - None.

2. Current patterns and circulation

a. **Current patterns and flow** – Minor impacts to circulation patterns and flow in the beach zone and near shore where the existing circulation pattern and flow would be offset seaward the width of the beach fill placement. Minor circulation differences are expected within the immediate vicinity of the borrow area due to the change in the shoreline location.

b. **Velocity** - No effects on tidal velocity and long shore current velocity regimes.

c. **Stratification** - Thermal stratification normally occurs beyond the mixing region created by the surf zone. There is potential for both winter and summer stratification. The normal pattern should continue after construction of the proposed project.

d. **Hydrologic regime** - The regime is largely tidal marine and oceanic. This will remain the case following construction of the proposed project.

3. **Normal water level fluctuations** - The tides are semidiurnal. The mean tide range for Cape May Inlet is reported to be 4.85' and for Atlantic City it is reported to be 4.02' in the Tide Tables published annually by the National Oceanic and Atmospheric Administration (NOAA).Construction of the proposed plan would not affect the tidal regime.

4. **Salinity gradients** - There should be no significant effect on the existing salinity gradients.

5. **Actions that will be taken to minimize impacts**- None are required: however, the use of sand backpassing techniques for this project will minimize potential impacts associated with the use of an offshore borrow area and will also keep the sand in the littoral system of the project area. The use of a hydraulic pump and 8 inch pipe will minimize potential water quality impacts.

C. Suspended Particulate/Turbidity Determinations

1. **Expected Changes in Suspended Particulates and Turbidity Levels in the Vicinity of the Disposal (Beach fill Placement) Site** - There would be a short- term elevation of suspended particulate concentrations during construction phases in the immediate vicinity of the dredging and the discharge locations. Elevated levels of particulate concentrations at the discharge locations may also result from "washout" after beach fill is placed.

2. **Effects (degree and duration) on Chemical and Physical Properties of the Water Column** -

a. **Light penetration** - Short-term, limited reductions would be expected at the discharge sites from dredge activity and berm washout, respectively.

b. **Dissolved oxygen** - There is a potential for a decrease in dissolved oxygen levels but the anticipated low levels of organics in the borrow material should not generate a high, if any, oxygen demand.

c. **Toxic metals and organics** - Because the borrow material is 90% or more sand, and originates from areas where no known sources of significant contamination exist, the material is expected to be free of any significant contamination in accordance with 40 CFR 227.13(b).

d. **Pathogens** - Pathogenic organisms are not known or expected to be a problem in the borrow area. Therefore, beach fill placement is not expected to significantly increase indicator bacteria levels above normal conditions.

e. **Aesthetics** - Construction activities and the initial construction template associated with the fill placement site would result in a minor, short-term degradation of aesthetics. This is due to the temporary impacts to noise, sight, and smell associated with the discharges and beach de-watering during construction and periodic nourishment.

3. **Effects on Biota**

a. **Primary production, photosynthesis** - Minor, short-term effects related to turbidity.

b. **Suspension/filter feeders** - Minor, short-term effects related to suspended particulates outside the immediate deposition zone. Sessile organisms would be subject to burial if within the deposition area.

c. **Sight feeders** - Minor, short-term effects related to turbidity.

4. **Actions taken to minimize impacts** include the selection of clean sand with a small fine grain component and a low organic content. Standard construction practices would also be employed to minimize turbidity and erosion.

D. **Contaminant Determinations**

The discharge material is not expected to introduce, relocate, or increase contaminant levels at either the borrow or placement sites. This is assumed based on the characteristics of the sediment, the proximity of the borrow site to sources of contamination, the area's hydrodynamic regime, and existing water quality. In accordance with 40 CFR 227.13(b), the dredged material/beach fill is not expected to contain any significant contamination.

E. **Aquatic Ecosystem and Organism Determinations**

1. **Effects on Plankton** - The effects on plankton should be minor and mostly related to light level reduction due to turbidity. Significant dissolved oxygen level reductions are not anticipated.

2. **Effects on Benthos** – Initially, a removal of the benthic community within the borrow area and burial of benthos within the discharge (beach fill) location. The losses of benthic organisms are somewhat offset by the expected rapid opportunistic recolonization from adjacent areas that would occur following cessation of construction activities. Recolonization is expected to occur rapidly in both the borrow and discharge (beach fill placement) area through horizontal and in some cases vertical migrations of benthos

3. **Effects on Nekton** - Only a temporary displacement is expected, as the nekton would probably avoid the active work area.

4. **Effects on Aquatic Food Web** – Localized significant impacts in the affected areas due to loss of benthos as a food source through burial at the beach fill placement site or removal at the dredging site. This is expected to be short-term as the borrow and beach fill placement sites should become recolonized by benthos within a few days following the impact.

5. **Effects on Special Aquatic Sites** - No special aquatic sites such as sanctuaries and refuges, wetlands, mud flats, vegetated shallows, coral reefs and riffle and pool complexes are present within the project area.

6. **Threatened and Endangered Species** - The piping plover (*Charadrius melodus*), a Federal and State threatened species, has, in the past, utilized some of the sandy beach habitat within the project impact area. This bird nests on the beach and could potentially be impacted by beach fill placement activities if present within the affected area. Monitoring to determine the extent of nesting activity prior to initial construction (if construction will take place during the nesting

season) and periodic nourishment is required to insure that the nesting locations can be avoided during construction until the chicks fledge the nest. If birds do re- establish themselves within the project area following construction, monitoring will be conducted on a yearly basis in conjunction with NJDEP, Division of Fish and Wildlife. Following construction activities, it is also possible that the Federally threatened seabeach amaranth (*Amaranthus pumilus*) could become established within the project area, as it has been recently found north of the project area. Surveys will be conducted prior to any construction or nourishment activities to determine the presence/location of any plants in order to protect them from construction impacts. Additional issues such as local beach-use management after construction and nourishment with regard to the piping plover and seabeach amaranth are addressed through a programmatic Biological Opinion as part of formal consultation with the U.S. Fish and Wildlife Service pursuant to Section 7 of the Endangered Species Act. Several species of threatened and endangered sea turtles, as well as the Atlantic sturgeon may be migrating along the coast adjacent to the project. Sea turtles and sturgeon have been known to become entrained and killed by suction hopper dredges. Since hopper dredges will not be used for this project, no impacts to sea turtles or sturgeon, related to dredging activities, are expected.

7. **Other Wildlife** - The proposed plan would not significantly affect other wildlife.

8. **Actions to minimize impacts** - The use of a borrow area in the intertidal zone will minimize or eliminate potential impacts to most species found within the project area.

F. <u>Proposed Disposal/Discharge (Beachfill Placement) Site Determinations</u>

1. Mixing Zone Determination

a. Depth of water - 0 to-20' mean low water
b. Current velocity - Generally less than 3'per second
c. Degree of turbulence - Moderate to high
d. Stratification - None
e. Discharge vessel speed and direction - Not applicable
f. **Rate of discharge** - Typically this is estimated to be 300-400 cubic yards per hour
g. **Dredged material characteristics** - medium-course sand and gravels with low (< 10%) silts, clays and organics
h. **Number of discharge actions per unit time** - Continuous over the construction period

2. **Determination of compliance with applicable water quality standards** -A Section 401 Water Quality Certificate (WQC) and consistency concurrence with the State's Coastal Zone Management (CZM) Program has been obtained from the State of New Jersey (**App. G**).

3. Potential Effects on Human Use Characteristics -

a. Municipal and private water supply - No effect
b. **Recreational and commercial fisheries** - Short-term effect during construction; there would be a temporary loss of surf clam stocks within the near shore placement sites and within the borrow area. Loss of benthos would result in temporary loss of food source for finfish.
c. **Water related recreation** - Short-term effect during construction where potential beachgoers, bathers, and surf-fishermen would be prohibited from accessing active construction locations.
d. **Aesthetics** - Short-term adverse effects to noise sight and smell during construction are

anticipated.

e. **Parks, national and historic monuments, national seashores, wilderness areas, research sites and similar preserves** – The dredging and fill placement will not impact any national sites, however, the U.S. Fish and Wildlife Service is adjacent to the placement site in Lower Township. Since only a small portion of the construction will occur near the Park, but the effects are expected to be zero.

G. **Determination of Cumulative Effects on the Aquatic Ecosystem**- Impacts on benthos and the aquatic ecosystem in general are considered to be temporary and do not represent a significant loss of habitat since the borrow and placement areas are both located in the dynamic near shore and intertidal area.. This project in concert with other existing or proposed similar actions, may produce measurable temporary cumulative impacts to benthic resources. However these impacts are short-term.

H. **Determination of Secondary Effects on the Aquatic Ecosystem** – Secondary impacts such as turbidity on aquatic organisms or temporary loss of food sources through the burial or removal of the benthos are considered to be of short duration.

III. FINDINGS OF COMPLIANCE OR NON-COMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE

A. **Adaptation of the Section 404(b)(1) Guidelines to this Evaluation.** No significant adaptation of the Section 404(b)(1) Guidelines were made relative to this evaluation.

B. **Evaluation of Availability of Practicable Measures to the Proposed Discharge Site, Which Would Have Less Adverse Impact on the Aquatic Ecosystem.** The alternative measures considered for accomplishing the project objectives are detailed in the Feasibility Report and Integrated Environmental Assessment of which this 404(b)(1) analysis is a part. Several measures including No Action, Permanent Evacuation and Regulation of Future Development would likely have less adverse impacts on the aquatic ecosystem. However, these measures were determined to not be practicable or economically justified in meeting the needs and objectives of providing storm damage reduction. Selection of sand sources heavily considered impacts on the aquatic ecosystem, and the source was chosen over other sites, which potentially could have had a higher adverse impact on the aquatic ecosystem.

C. **Compliance with Applicable State Water Quality Standards.** This action is not expected to violate State of New Jersey Water Quality Standards. A Section 401 water quality certificate was obtained from the New Jersey Department of Environmental Protection prior to initiation of discharges associated with this project (**App G.**).

D. **Compliance with Applicable Toxic Effluent Standard or Prohibition Under Section 307 of the Clean Water Act.** The proposed action is not expected to violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

E. **Compliance with Endangered Species Act.** The proposed action will comply with the Endangered Species Act of 1973 and be consistent with the Terms and Conditions outlined in the District's Biological Opinion which addresses impacts and mitigation measures for piping plovers and seabeach amaranth.

F. **Compliance with Specified Protection Measures for Marine Sanctuaries Designated by the Marine Protection, Research, and Sanctuaries Act of 1972.** The proposed action will not violate the protective measures for any Marine Sanctuaries designated by the Marine Protection, Research, and Sanctuaries Act of 1972.

G. **Evaluation of Extent of Degradation of the Waters of the United States.** The proposed action is not expected to result in permanent significant adverse effects on human health and welfare, including municipal and private water supplies, recreation and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. Significant adverse effects on life stages of aquatic life and other wildlife dependent on aquatic ecosystems; aquatic ecosystem diversity, productivity, and stability; and recreational, aesthetic, and economic values is not expected to occur or have long-term effects on impacted resources.

H **Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem.** Appropriate steps to minimize potential adverse impacts of the discharge on aquatic systems include selection of borrow material that is low in silt content, has little organic material, and is expected to be uncontaminated.

I. **On the basis of the guidelines**, the proposed discharge sites for the dredged material are specified as complying with the requirements of these guidelines, with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects on the aquatic ecosystem.

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14.0 Glossary of Terms

Active profile zone - The nearshore zone across which the dominant sediment motion occurs.

Barrier island - A sand body that is essentially parallel to the shore, the crest of which is above normal high water level.

Beach - The zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach unless otherwise specified is the mean low water line.

Beach profile - The intersection of the ground surface with a vertical plane; may extend from behind the dune line or the top of a bluff to seaward of the breaker zone.

Beach renourishment - Pumping sand onto the beach and building up former dunes and upper beach after construction of an initial nourishment.

Benthic community - Organisms that live on the sub-aquatic bottom.

Biogenically derived sediments - Biogenous sediments consist of the remains of either marine plant or animal skeletons, either coarse grained as found in shallow coastal waters, or fine grained as found in deeper waters.

Borrow site - A term used to describe the site identified for, or remaining after, borrow material has been removed for placement onto a beach. In upland areas, the site frequently becomes a body of water. In marine areas, the site becomes a hole in a bay or nearshore area.

Carbonate platform - A large and thick accumulation of carbonate strata that it typically isolated from other land masses.

Carbonate sediments - Sediment formed by the organic or inorganic precipitation from aqueous solution of carbonates of calcium, magnesium, or iron.

Closure depth - The depth of water beyond which sediments are not normally affected by waves.

Coastal geology - Origin, structure, and characteristics of the sediments that make up the coastal region, from the uplands to the nearshore region. Sediments can vary from small particles of silt or sand to larger particles of gravel and cobble, to formations of consolidated sediments and rock.

Coastal plain - A broad, low relief region composed of horizontal or gently sloping strata of clastic materials fronting the coast, and generally representing a strip of sea bottom that has emerged from the sea in recent geologic time.

Coastal sediment budget - The identification of sediment sources and sinks, and the quantification of the amounts and rates of sediment transport, erosion, and deposition within a defined region.

Compatibility analysis - Methods used to evaluate the suitability of the sediments in a borrow area for beach nourishment purposes based on the characteristics of the native beach material and / or the profile shape of the constructed beach.

Continental shelf - The region of the oceanic bottom that extends outward from the shoreline with an average slope of less than 1:100, to a line where the gradient begins to exceed 1:40.

Cross-shore direction - Perpendicular to the shoreline.

Cross-shore transport - A wave and / or tide-generated movement of shallow-water coastal sediments toward or away from the shoreline.

Drowned barrier island - A long, narrow coastal sandy body, representing a broadened barrier beach that was above high tide and parallel to the shore in prior sea level conditions and is now underwater.

Dune - A ridge or mound of loose, wind-blown material, usually sand.

Ebb tidal delta - The bulge of sand formed at the seaward mouth of tidal inlets as a result of interaction between tidal currents and waves.

Equilibrium beach profile - The slightly concave slope of the floor of a sea or lake, taken in a vertical plane and extending away from and transverse to the shoreline, being steepest near the shore, and having a gradient such that the amount of sediment deposited by waves and currents is balanced by the amount removed by them; the transverse slope of a graded shoreline. The profile is easily disturbed by strong winds, large waves, and exceptional high tides.

Estuary - (1) A coastal embayment where there is freshwater input that is influenced by tides. (2) The part of a river that is affected by tides. (3) The region near a river mouth in which the fresh water of the river mixes with the salt water of the sea.

Flood tidal-delta - The bulge of sand formed at the landward mouth of tidal inlets as a result of flow expansion.

Gross sediment transport - The sum of the sediment transport magnitudes in the dominant and secondary directions. The gross sediment transport does not have a direction or sign.

Hot spot - Shoreline segment characterized by erosion rates that are significantly greater than adjacent shoreline segments.

Hydraulic sand placement - Sediment (sand) moved using water and centrifugal pumps mounted on a barge or large seagoing vessel (hydraulic dredging), usually moving sediment originating from an offshore site.

Hydrographic surveys - 1) The description and study of seas, lakes, rivers, and other waters. (2) The science of locating aids and dangers to navigation. (3) The description of physical properties of the waters of a region.

Inlet improvement - Modifications to an existing inlet, usually for purposes of navigation, which may include channel deepening and/or jetty construction. Other reasons for inlet improvement may include positional stabilization and improved flushing of the bay served by the inlet.

Inlet positional stability - A type of stability related to the orientation of the inlet's tidal jet.

Intertidal Zone - The zone between spring high tide and spring low tide.

Jet-probe - A long pipe into which water under high pressure is pumped in order to penetrate into unconsolidated sediment.

Littoral cell - A reach of the coast that is isolated sedimentologically from adjacent coastal reaches and that features its own sources and sinks. Isolation is typically caused by protruding headlands, submarine canyons, inlets, and some river mouths that prevent littoral sediment from one cell from passing into the next.

Littoral zone - In beach terminology, an indefinite zone extending seaward from the shoreline to just beyond the breaker zone.

Longshore bar - A sand bar that extends roughly parallel to the shoreline.

Longshore direction - Parallel to and near the shoreline, alongshore.

Longshore sand bars - A sand ridge or ridges, running roughly parallel to the shoreline and extending along the shore outside the trough, that may be exposed at low tide or may occur below the water level in the offshore.

Longshore transport - A wave- and/or tide-generated movement of shallow-water coastal sediments parallel to the shoreline.

Low energy environments - Coastlines where wave and tidal forces are typically relatively small due to the climate, the location of the site and / or due to nearshore submerged features that function to reduce incoming wave energy.

Magnetometer survey - A geophysical test to determine the ferrous returns for subsurface materials such as shipwrecks, debris and other anomalies located within a borrow site. Such materials must be located to avoid damage to dredge equipment or to determine the precise location of historic relics, shipwrecks, or other artifacts.

Marsh - An area of soft, wet, or periodically inundated land, generally treeless and characterized by grasses.

Miocene Epoch - The period of geologic time that extends from 24 million years to 5 million years before the present.

Moraine - An accumulation of earth, stones, etc. deposited by a glacier, usually in the form of a mound, ridge, or other prominence on the terrain.

Nearshore - In beach terminology, an indefinite zone extending seaward from the shoreline well beyond the breaker zone.

Nearshore zone - In beach terminology, the zone that extends seaward from the low tide line including the bar and trough topography that commonly extends well beyond the breaker zone.

Net sediment transport - The difference between the sediment transport magnitude in the dominant direction and the transport magnitude in the secondary direction. Sediment transport is usually considered to be positive to the right as an observer looks seaward. The net sediment transport can be positive, negative, or zero.

Oblique sand ridge - A generic name for any low ridge of sand formed at some distance from the shore, either submerged or emergent at an angle to the shoreline.

Planform - The outline or shape of a body of water as determined by the still-water line, that is, a map.

Planform evolution - The morphodynamic changes that take place over time on a particular geographic entity.

Profile equilibration - The process of adjustment of a beach profile from one shape to one which is in more of an equilibrium condition with the waves and tides. Occurs after placement of nourishment materials at a slope steeper than equilibrium.

Quartz sediment - Sediment formed by solid fragmental material that originates from the weathering of quartz rocks and comprises most sediment along the Atlantic Coast.

Reconnaissance level sand source investigations - Broad scale field investigation to provide sediment stratigraphy and particle size information to identify prospective candidate sand source and to provide information for the preparation of preliminary project design and cost estimates.

Regional sand management - Management of sediment resources based on broad geographic considerations.

Relict - Remnant left after decay, disintegration, or disappearance.

Sediment budget - The mass balance between inputs and outputs of sediment within a defined coastal environment.

Sediment characteristics - Physical attributes of a sediment sample measured by the statistical variations in particle size, chemical composition, density, moisture content, and color. Sediment is a solid fragmental material that originates from weathering of rocks and is transported or deposited by air, water, or ice, or that accumulates by other natural agents, such as chemical precipitation from solution or secretion by organisms (biological origin), and that forms in layers on the Earth's crust or surface at ordinary temperatures in a loose, unconsolidated form (for example, sand, gravel, silt, mud).

Sediment composites - A particle size distribution that represents the overall average of all sediment strata within a borrow site, usually based on multiple sediment grain size distributions weighted accordingly.

Sediment pathways - The routes along which sediment movement occurs.

Shore-parallel structures - Structures that are constructed onshore and parallel to the beach, including seawalls and revetments designed to protect the land and buildings located immediately landward. Shore-parallel structures also include breakwaters and submerged sills located in nearshore waters which act to intercept and reduce the energy of approaching waves.

Shore-perpendicular structures - Structures such as groins and jetties that are constructed perpendicular to the beach and extend out into the water. These types of structures are designed to retard or interrupt the longshore movement of sand and accumulate sand on the beach updrift of the structure.

Shoreline stabilization - Measures to retard erosion to protect upland property. Recognized erosion control measures include seawalls, revetments, jetties, groins, breakwaters, and beach nourishment.

Siliciclastic sediment - Sediment that is composed primarily of fragments of silicate minerals or rock fragments, most commonly quartz.

Storm tide - A rise above normal water level on the open coast due to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes that rise in level due to atmospheric pressure reduction as well as that due to wind stress.

Tidal delta - An alluvial deposit, usually triangular or semi-circular, at the mouth of a tidal inlet that accumulates as the result of the combination of wave processes and tidal currents.

Tidal flat - Unvegetated sandy or muddy land area that is covered and uncovered by the rise and fall of the tide.

Tombolo - A bar or spit of sand that connects or "ties" an island to the mainland or to another island.

Trough sand accumulation - Where sand accumulates in a long and broad bathymetric low between adjacent sand bars or reefs.

Washover fan - Sediment deposited inland of a beach by overwash processes associated with storms where elevated water level and large waves transport sediment across the beach.

Wetland - Land whose saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities that live in the soil and on its surface.