US Army Corps
of Engineers
Philadelphia District

New Jersey
Shore Protection Study

New Jersey Department of
Environmental Protection

Manasquan Inlet
to
Barnegat Inlet

Feasibility Study

Volume 1

Final Feasibility Report

Integrated Environmental Impact Statement

Appendix G* – Pertinent Correspondence

June 2002

New Jersey Shore Protection Study
Manasquan Inlet to Barnegat Inlet

Final Feasibility Report
Integrated Environmental Impact Statement

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New Jersey Shore Protection Study
Manasquan Inlet to Barnegat Inlet

Final Feasibility Report and Integrated Environmental Impact Statement (EIS)

June 2002

ABSTRACT: This feasibility report and Environmental Impact Statement presents findings of a study to determine a feasible hurricane and storm damage reduction plan for coastal communities located between Manasquan Inlet and Barnegat Inlet, 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 NEPA and Section 106 of the National Historic Preservation Act of 1966.

NOTE TO READER: To provide full and convenient access to the environmental, economic, and engineering documentation prepared for the study, the EIS for this project has been integrated into this feasibility report in accordance with Engineering Regulation 1105-2-100. Sections required for compliance with the National Environmental Policy Act (NEPA) are noted by an asterisk (*) in the Table of Contents. Furthermore, Appendix G* – Pertinent Correspondence was bound with Volume 1 of the final report due to the significance of the content and to simplify the coordination process.

New Jersey Shore Protection Study
Manasquan Inlet to Barnegat Inlet

Final Feasibility Report and Integrated Environmental Impact Statement (EIS)

EXECUTIVE SUMMARY

Proposed Action:	Hurricane and storm damage reduction for communities between Manasquan Inlet and Barnegat Inlet, New Jersey using beach fill to construct a protective berm and dune.
Location of Action:	Boroughs of Point Pleasant Beach, Bay Head, Mantoloking, Lavallette, Seaside Heights, and Seaside Park; and Townships of Brick, Dover, and Berkeley.
Type of Statement:	Final Feasibility Report and Integrated Environmental Impact Statement (EIS)
Lead Agency:	U.S. Army Corps of Engineers, Philadelphia District
More Information:	For further information please contact: Paul Gaudini, P.E., Acting Chief, Planning Division Attn: Beth Brandreth, Environmental Resources Branch U.S. Army Engineer District, Philadelphia Wanamaker Building, 100 Penn Square East Philadelphia, PA 19107-3390 Telephone: (215) 656-6555

Summary

This report presents the results of a feasibility study to determine an implementable 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 Manasquan Inlet and Barnegat Inlet. The lead agency for this study is the U.S. Army Corps of Engineers, Philadelphia District. The Manasquan Inlet to Barnegat Inlet study covers one of six study areas recommended by the New Jersey Shore Protection Study. The study was authorized by resolutions by the U.S. House of Representatives and U.S. Senate in December 1987.

This feasibility report was prepared based on recommendations of the reconnaissance study completed in March 1996 that identified potential solutions to erosion and storm damage problems within the study area. The reconnaissance study determined that such a solution was in the Federal interest and identified the Non-Federal sponsor.

The feasibility study was cost shared between the Federal Government and the State of New Jersey Department of Environmental Protection (NJDEP) and was conducted under provisions of the Feasibility Cost Sharing Agreement executed 17 April 1997.

The study area is located in central New Jersey and extends approximately 24 miles from Manasquan Inlet to Barnegat Inlet. The study area lies in Ocean County and consists of a barrier spit that is connected to the mainland at the northern end and extends to the south.

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. Severe storms in recent years have continued to erode the beaches and have exposed communities to potential for catastrophic coastal erosion and flooding damages.

Two reaches were delineated within the study area and evaluated separately for proposed solutions. The southern reach extends approximately 10 miles from Barnegat Inlet northward to Berkeley Township and encompasses Island Beach State Park. No action is recommended for this reach, based on minimal storm damage reduction benefits and State agencies' desires to preserve this area as a natural setting with no direct intervention to control beach processes.

The northern reach extends approximately 14 miles from Berkeley Township northward to Point Pleasant Beach at Manasquan Inlet with oceanfront that is essentially fully developed. The selected plan for this reach consists of berm and dune restoration using sand obtained from offshore borrow sources. The design dune crest has a top elevation of +22 ft NAVD at all areas except Seaside Heights and northern Point Pleasant Beach, where the design dune crest elevation is +18 ft NAVD. The design berm extends 75 ft in front of the dune except at Seaside Heights and northern Point Pleasant Beach, where the design berm width is 100 ft. The design berm crest elevation corresponds to the average existing berm elevation, which is +8.5 ft NAVD at all

areas except northern Point Pleasant Beach where the natural berm crest transitions to +11.5 ft NAVD due to influence of the Manasquan Inlet south jetty.

The proposed project extends approximately 14 miles. The selected beach fill plan tapers to the existing beach width at the southern end of the project, adjacent to Island Beach State Park. The northern end of selected plan terminates at the Manasquan Inlet south jetty, with no taper.

Initial sand quantity is estimated at 10,689,000 cu yds and includes design fill quantity, advanced fill, and overfill. Periodic nourishment quantity is estimated at 961,000 cu yds on a 4-year nourishment cycle. Identified borrow areas contain approximately 17.5 million cu yds for initial construction and approximately 6 nourishment cycles (through year 24). Additional borrow sites may be required for subsequent nourishment cycles, assuming no future infilling of the identified borrow areas. Alternate borrow sites to provide the remaining quantity will be identified in an off-shore area beyond the three-mile limit. Investigations during the Preconstruction, Engineering, and Design (PED) phase will identify the specific sites to be used.

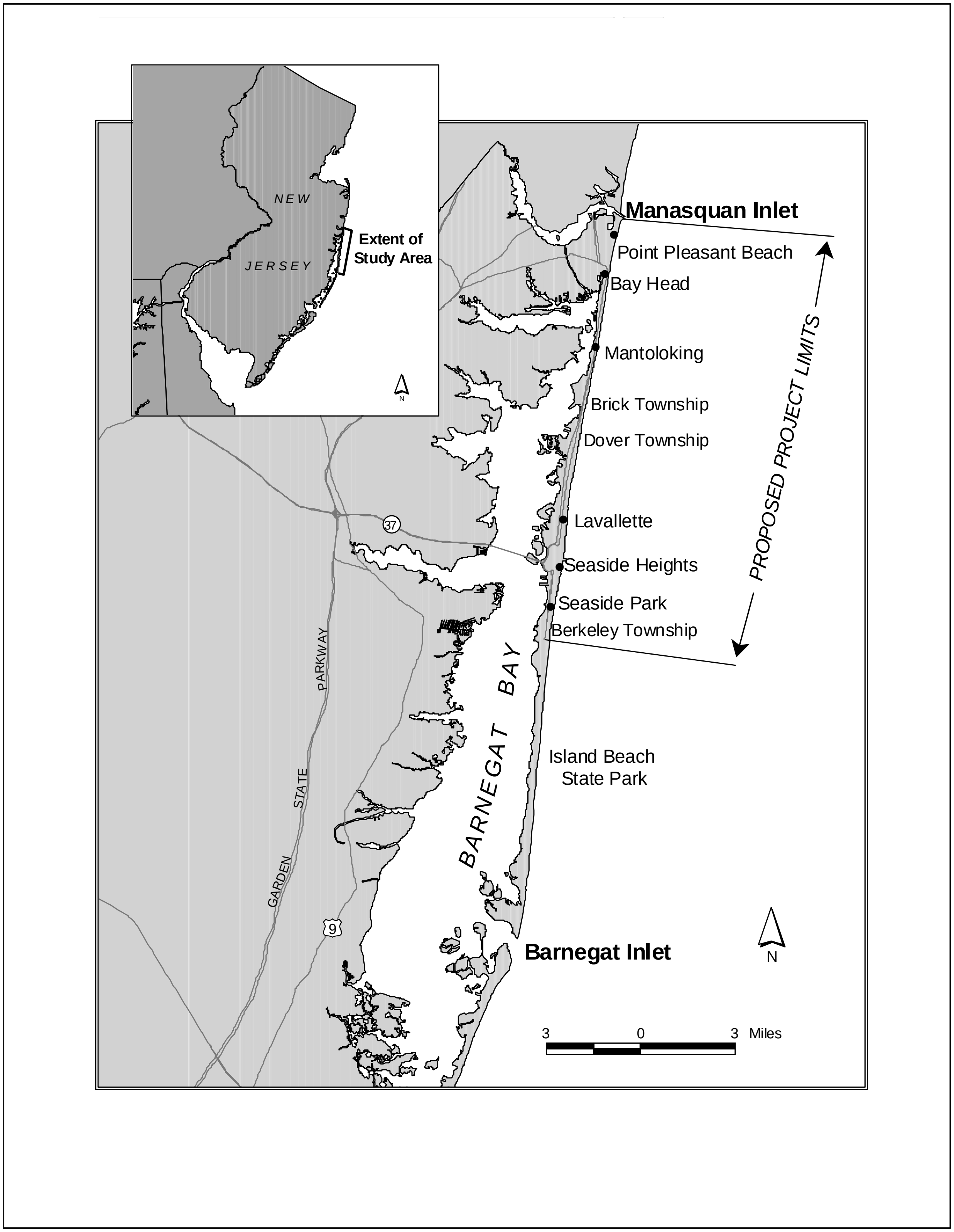
A Section 404(b)(1) evaluation has been prepared and is included in this Feasibility Report and Environmental Impact Statement. This evaluation concludes that the proposed action would not result in any significant environmental impacts relative to the areas of concern under Section 404 of the Federal Clean Water Act.

The selected plan has primary output based on hurricane and storm damage reduction. The plan provides average annual net benefits of approximately $5,350,000 and a benefit-to-cost ratio of 1.9.

The total initial project construction cost is estimated at $58,223,000 (September 2000 price level) and would be cost-shared 65% Federal, 35% non-Federal. The Federal share of this first cost is $37,845,000 and the non-Federal share is $20,378,000. Lands, Easements, Rights-of Ways, Relocations, and Dredged Material Disposal Areas (LERRD) costs are estimated at $3,691,000 and will be credited towards the Non-Federal Sponsor’s cash contribution.

Periodic nourishment is expected to occur at 4-year intervals subsequent to completion of initial construction (year 0). Over 50 years, total periodic nourishment cost is estimated at $96,920,000 (September 2000 price level) and includes E&D monitoring during construction. Based on the Water Resources Development Act (WRDA) of 1999, cost sharing for periodic nourishment would be 50% Federal and 50% non-Federal for sand placement costs and 100% non-Federal for major replacement of dune grass, sand fence, and crossovers.

The ultimate cost of construction which includes initial construction, project monitoring, and 50 years of periodic nourishment is estimated to be $155,143,000 (September 2000 price level), cost-shared 54% Federal and 46% non-Federal, based on WRDA 1999 cost-sharing. All costs include planning, engineering, and design. Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R), estimated at $100,000 annually, is not included in this cost and is a non-Federal responsibility.



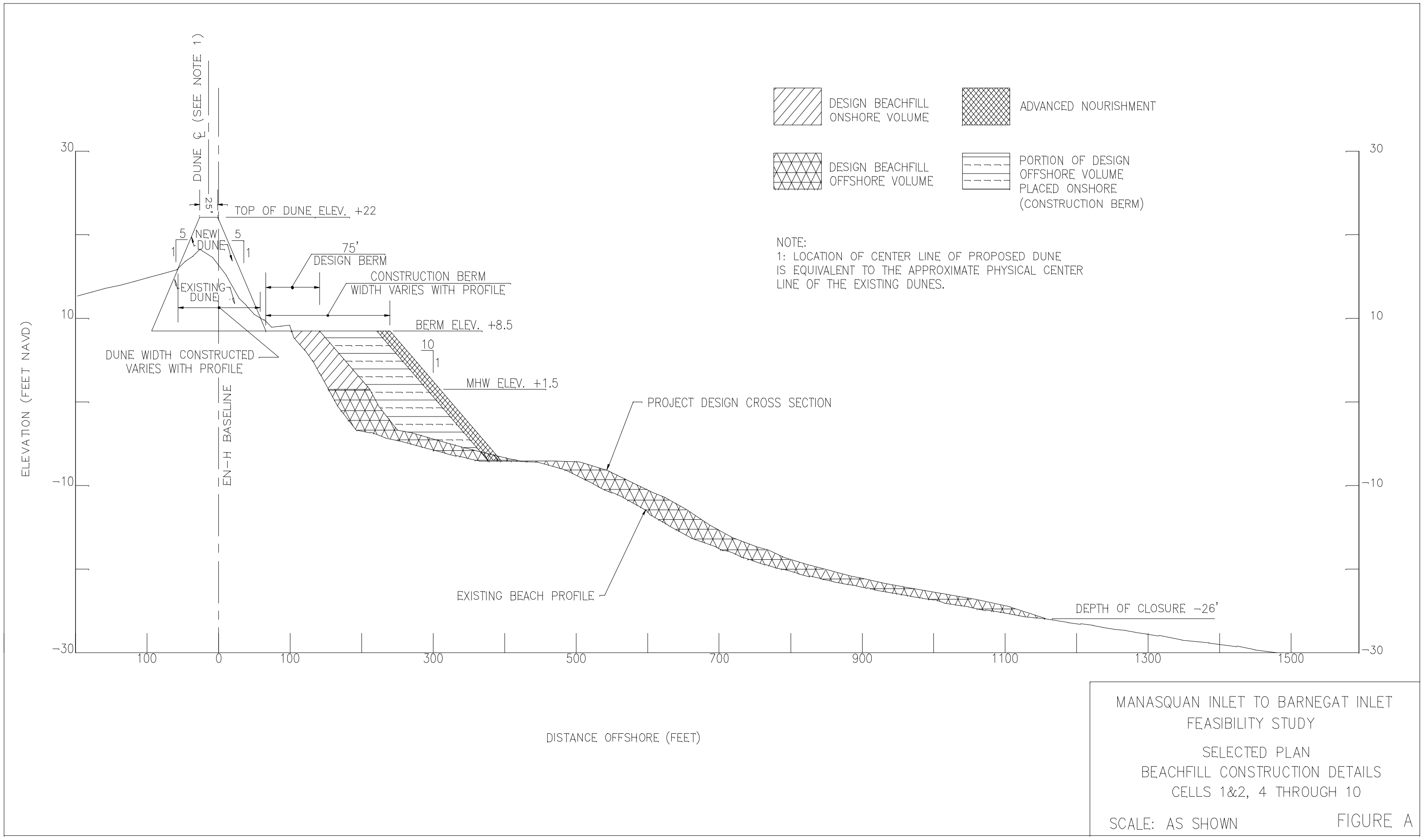
Location of Proposed Project

New Jersey Shore Protection Study
Manasquan Inlet to Barnegat Inlet

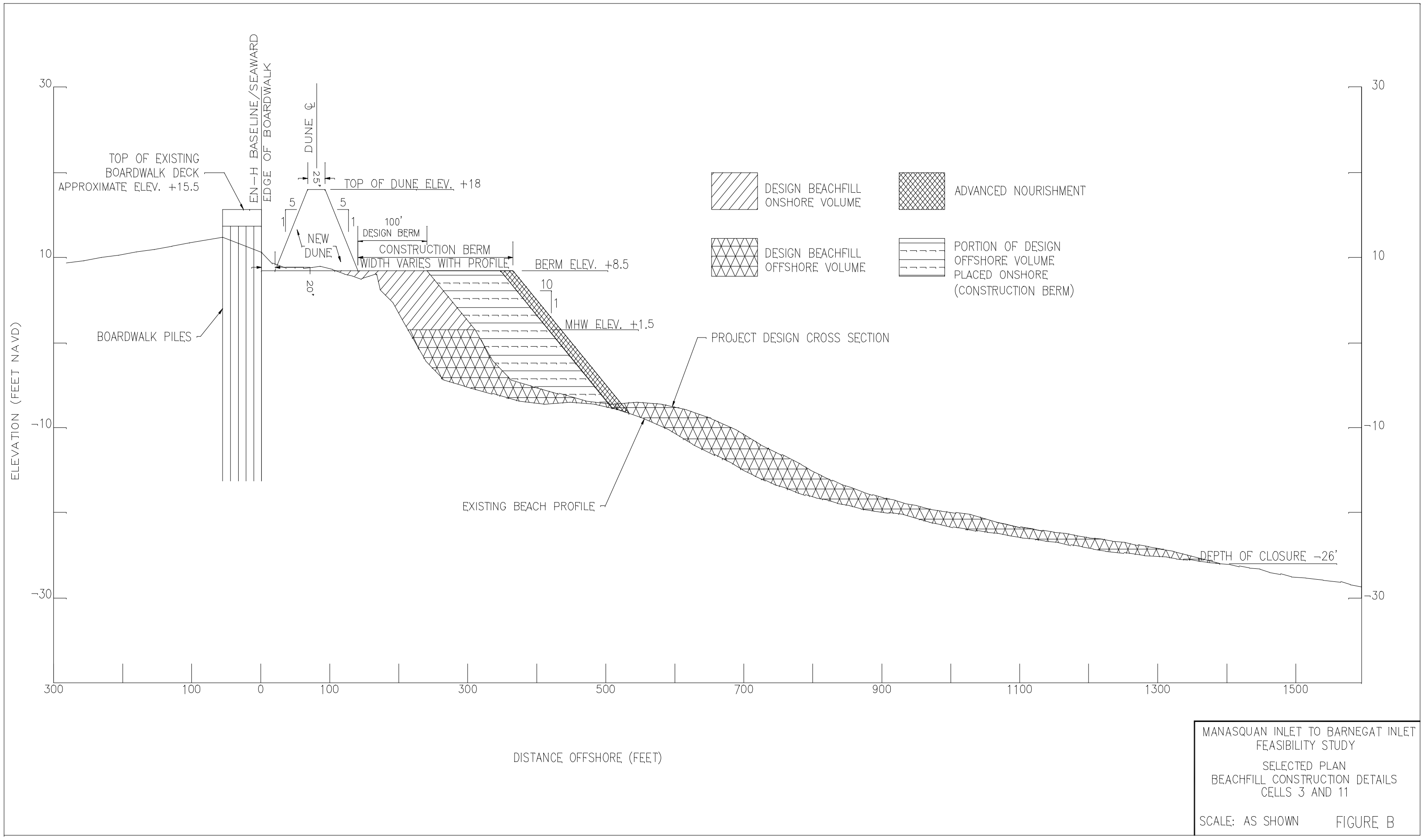
Final Feasibility Report and Integrated Environmental Impact Statement (EIS)

Description of the Selected Plan

Design Component	**Dimension/Quantity**	**Remarks**
Berm Elevation	+8.5 ft NAVD; +11.5 ft NAVD at northern Point Pleasant Beach	Same as average existing condition
Berm Width	75 ft; 100 ft at Seaside Heights and northern Point Pleasant Beach	Berm width measured from seaward base of dune to berm crest
Seaward Berm Slope	1:10	Same as average existing condition
Dune Elevation	+22 ft NAVD; +18 ft NAVD at Seaside Heights and northern Point Pleasant Beach	
Dune Width at Crest	25 ft	Standard Caldwell section
Dune Side Slopes	1:5	Standard Caldwell section
Dune Offset for Maintenance of Existing Structures	20 ft (as required)	Required dune offsets are reflected in selected plan layout
Length of Fill	13.7 miles	
Initial Sand Quantity	10,689,000 cu yds	Includes advanced nourishment with overfill
Periodic Nourishment Quantity	961,000 cu yds / 4 year cycle	Includes overfill
Major Replacement Quantity	1,788,000 cu yds	Includes periodic nourishment with overfill; same dune grass and sand fence quantities as initial fill
Taper Section	Tapers to existing within project reach at southern end; no taper at northern end	Manasquan Inlet south jetty functions as terminal structure at northern end
Borrow Source Location	Area A – approximately 2 miles offshore of Island Beach State Park; Area B – approximately 2 miles offshore of Mantoloking	Overfill factor of 1.5 for borrow material
Dune Grass	175 acres	18” spacing
Sand Fence	206,000 feet	Along base of dune and at crossovers
Outfall Extensions	None	
Pedestrian Dune Crossovers	247	Includes handicap access ramps
Vehicle Dune Crossovers	11	



Selected Plan – Typical Design Cross-Section with 22-ft NAVD Dune (All Communities except Seaside Heights and northern Point Pleasant Beach)



Selected Plan – Typical Design Cross-Section with 18-ft NAVD Dune (Seaside Heights and northern Point Pleasant Beach)

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ENVIRONMENTAL IMPACT STATEMENT SUMMARY*

PURPOSE AND NEED

The purpose of this statement is to evaluate the anticipated environmental impacts of the considered alternatives with emphasis on the selected plan that was developed for the purpose of storm damage reduction for the communities of Point Pleasant Beach Borough, Bay Head Borough, Mantoloking Borough, South Mantoloking Beach, Normandy Beach, Chadwick, Ocean Beach, Lavallette Borough, Ortley Beach, Seaside Heights Borough, Seaside Park Borough, South Seaside Park, and Island Beach State Park, Ocean County, New Jersey.

The need to which the U.S. Army Corps of Engineers, Philadelphia District is responding is based on the need to reduce the potential for storm damage to structures and property within these communities.

The principal source of economic damages identified is storms. Severe storms in recent years have caused a reduction in the overall beach height and width along the study area. This exposes these communities to catastrophic damage from ocean flooding, wave attack, and erosion in the absence of a long-term commitment of protection.

ALTERNATIVES CONSIDERED

A number of structural and non-structural storm damage reduction alternatives were identified and evaluated individually and in combination on the basis of their suitability, applicability and merit in meeting the planning objectives, planning constraints, economic criteria, environmental criteria and social criteria for the study. The following paragraphs describe several of the alternatives considered. A more detailed analysis of the alternative screening is presented in the Plan Formulation section of the report.

Three levels of screening investigated an array of structural and non-structural alternatives that address storm damage reduction for the communities between Manasquan Inlet and Barnegat Inlet. The first level of screening (Cycle 1) involved the following alternatives:

- No Action
- Regulation of Future Development
- Permanent Evacuation
- Berm Restoration
- Dune Restoration
- Berm and Dune Restoration
- Berm and Dune Restoration with Groin Field
- Berm and Dune Restoration with Offshore Detached Breakwater

* This information is presented as a requirement for the Environmental Impact Statement (EIS).

- Berm and Dune Restoration with Submerged Reef
- Berm and Dune Restoration with Perched Beach
- Berm and Dune Restoration with Geotextile Tube Core
- Seawall/Bulkhead
- Offshore Submerged Feeder Berm
- Beach Dewatering

Several of the alternatives were eliminated after the first level of screening based on technical feasibility and relative costs. The remaining alternatives considered for Cycle 2 Screening were:

- No Action (Island Beach State Park)
- Berm Restoration
- Berm and Dune Restoration
- Berm and Dune Restoration with Groin Field
- Berm and Dune Restoration with Geotextile Tube Core
- Seawall/Bulkhead

Cycle 2 screening further reduced the number of alternatives. Only those alternatives that are practical, in terms of the engineering, economics, environmental, social impacts, and costs remained after the completion of Cycle 2.

Since most of the plans analyzed in Cycle 2 included some aspect of beach fill placement, an investigation was undertaken to identify a suitable borrow source. The utilization of an upland borrow source was ruled out due to the volume of sand needed for a beach fill project in the study area, distance of such sources, the expense of retrieving sand from these sources and impacts on the roads and the local economy. Two potential offshore sand borrow areas were identified at this level.

The alternatives remaining after Cycle 2 analysis and considered for optimization in Cycle 3 analysis were:

- No Action (Island Beach State Park)
- Berm Restoration
- Berm and Dune Restoration
- Berm and Dune Restoration with Groin Field
- Berm and Dune Restoration with Geotextile Tube Core

Cycle 3 analysis involved optimization of the remaining alternatives into various configurations that were compared against their relative costs. Most of the beach fill plans considered meet the planning objectives in that they provide a degree of storm damage protection, which is greater than the cost of implementation. The optimization in Cycle 3 identified the National Economic Development (NED) plan, which is the plan that maximizes beneficial contributions to the Nation while meeting planning objectives. Cycle 3 screening concluded that only berm and dune restoration utilizing sandy material dredged from a nearby offshore source should be considered further. The identified NED plan includes a dune with a crest elevation of +22 ft NAVD fronted by a 75-ft wide berm at elevation +8.5 ft NAVD; except at Seaside Heights and northern Point Pleasant Beach where the plan includes an 18-ft NAVD dune fronted by a 100-ft wide berm at elevation +8.5 ft NAVD (Seaside Heights) and elevation +11.5 ft NAVD (Point Pleasant Beach). This plan was chosen because it provides the maximum net benefits over costs based on storm damage reduction. Details of the NED Plan are discussed in greater detail in the Selected Plan section of the report.

MAJOR CONCLUSIONS AND FINDINGS

Berm and dune restoration utilizing beach fill with periodic sand nourishment represents one of the least environmentally damaging structural methods for reducing potential storm damages at a reasonable cost and in a way that is both socially acceptable and yet feasible and proven to work in high energy environments. The somewhat transient nature of beach fill is actually advantageous because the beach fill is capable of being dynamic and adjusting to changing conditions until equilibrium can again be achieved. Despite being structurally flexible, the created beach can effectively dissipate high storm energies, although at its own expense. Costly rigid structures like seawalls and breakwaters utilize massive amounts of material foreign to the existing environment to absorb the force of the waves. Berm and dune restoration with nourishment uses material typical of the adjacent areas (sand) to buffer against storm damage. Consequently, this alternative is more aesthetically pleasing as it represents the smallest departure from the existing conditions in a visual and physical sense. When the protective beach is totally dispersed by wave action, the original beach remains. On the other hand, bulkheads, seawalls, and revetments may lead instead to eventual loss of beach as the end of their project life is approached.

One of the suggested non-structural storm damage reduction alternatives, development regulation, is currently being practiced and therefore requires no further study. The other non-structural alternative, permanent evacuation (land acquisition) is prohibitively expensive and socially unacceptable and was eliminated early in the plan formulation process.

AREAS OF CONCERN

During the course of the feasibility study, several issues were identified regarding the proposed action that required consideration in the integrated Environmental Impact Statement (EIS). A project of this nature will have temporary adverse impacts on water quality and aquatic organisms. Dredging will increase suspended solids and turbidity at the point of dredging and at the discharge (beach fill) site. The area to be dredged and the area where the material will be deposited will be subject to extreme disturbance. Many of the benthic organisms will become smothered at the beach fill site. Dredging will result in the temporary complete loss of the benthic community in the borrow area. These disruptions are expected to be of short-duration and of minor significance. Rapid recolonization of the borrow site by benthic organisms is expected to occur after dredging ceases (Saloman, Naughton, and Taylor, 1982; Cutler and Mahadevan, 1982; and Hurme and Pullen, 1988). Dredging will consequently temporarily displace a food source for most finfish, and could have potential adverse impacts on Essential Fish Habitat. Concerns were raised over potential impacts to surf clams (*Spisula solidissima*) and their habitat during dredging operations and the size of the borrow areas were limited as a result. Concerns regarding the use of a hopper dredge and its potential impact on Federally listed threatened and endangered sea turtles were raised with respect to this project. A Biological Assessment that discusses Philadelphia District hopper dredging activities and potential effects on Federally threatened or endangered species of sea turtles has been prepared, and was formally submitted to the National Marine Fisheries Service in accordance with Section 7 of the Endangered Species Act. NMFS has subsequently issued a Biological Opinion, which discusses their requirements to be in compliance with the Endangered Species Act. A Biological Assessment has also been completed and submitted to the U.S. Fish and Wildlife Service with regard to potential impacts to the Federally listed piping plover (*Charadrius melodus*) and seabeach amaranth (*Amaranthus pumilus*). Seabeach amaranth, which was historically found in New Jersey, has recently been re-established north of the project area. Piping plovers, which have nested in Mantoloking and on Island Beach State Park, have been absent from these areas for several years. The implementation of the selected plan has the potential to create suitable habitat for both species in the future. All aspects of the plan will be in compliance with the Endangered Species Act and the recommendations set forth in the upcoming Biological Opinion.

The placement of sand in the nearshore area has the potential to impact cultural and fisheries resources. Nineteen potential cultural resource targets have been identified in the nearshore area. Several of these targets have been tentatively identified as shipwrecks that are frequented by local divers. In addition to the potential cultural value of these sites, these hardened structures may provide fishery habitat. Further investigations will be conducted on these targets during the Pre-Construction Engineering and Design phase of the study. Any targets deemed significant on a cultural or habitat basis will be monitored for impacts during and after project implementation. If impacts do occur, coordination will be done with NJSHPO and NJDEP to make adjustments to the project to mitigate such impacts.

New Jersey Shore Protection Study
Manasquan Inlet to Barnegat Inlet

Feasibility Study

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* Indicates information required for National Environmental Impact Statement

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APPENDIX C: ENVIRONMENTAL ANALYSIS
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1 INTRODUCTION

The New Jersey Shore Protection Study is an ongoing study of the shore protection and water quality problems facing the entire ocean coast and back bays of New Jersey. The study will provide recommendations for future actions and programs to reduce storm damage and improve the information available to coastal planners, engineers, and resource agencies to help preclude further degradation of the coastal waters. This report presents formulation of the National Economic Development (NED) plan for the Manasquan Inlet to Barnegat Inlet Feasibility Study.

1.1 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 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.

1.2 Study and Report Process

The Water Resources Development Act of 1986 (P.L. 99-662) directs the Corps to conduct water resources studies in two phases: reconnaissance and feasibility. The objective of a reconnaissance study is to enable the Corps of Engineers to determine whether or not planning to develop a project should proceed to the more detailed feasibility stage. This is accomplished through: the definition of problems and opportunities consistent with Army policies; the identification of a potential solution including costs, benefits, and environmental impacts; estimating the time and costs for the feasibility study, and an assessment of the level of interest and support of non-Federal interests regarding further study.

In March 1995, the Manasquan Inlet to Barnegat Inlet Reconnaissance Study was initiated to address shoreline erosion and storm damage vulnerability. The reconnaissance study was conducted through the General Investigations program at 100% Federal expense under the New Jersey Shore Protection authority. The study was completed in March 1996 and identified a hurricane and storm damage reduction project that is environmentally, economically, and engineeringly sound.

The Manasquan Inlet to Barnegat Inlet Feasibility Study was conducted as a hurricane and storm damage reduction initiative under the General Investigations program utilizing the New Jersey Shore Protection Study authority. The study was cost-shared 50% with the Non-Federal Sponsor, the New Jersey Department of Environmental Protection (NJDEP).

1.3 Study Purpose and Scope

The objective of the feasibility study is to investigate and recommend an implementable solution to identified problems. This feasibility report will accomplish the following:

a. Provide a complete presentation of study results and findings so that readers can reach independent conclusions regarding the reasonableness of recommendations

b. Indicate compliance with applicable statutes, executive orders and policies

c. Provide a sound documented basis for decision-makers at all levels to judge the recommended solution

The report documents the analysis of existing conditions, without-project conditions, plan formulation, and development of the NED plan for the study area. The evaluations were based on site-specific technical information developed during the course of the study. These evaluations included photogrammetry; surveys; hydraulic and economic evaluations; geotechnical investigations and environmental and cultural resource inventories. This report will detail the following:

a. Problems and potential solutions for the study area

b. Costs, benefits, environmental and social impacts of potential solutions

c. The optimized NED plan

d. Project Cooperation Agreement (PCA) responsibilities of the Non-Federal Sponsor

1.4 Study Area

The study area is centrally located along the Atlantic coast of New Jersey, entirely within Ocean County (See Figure 1-1). At one time, the study area was divided in two separate land masses by an inlet located opposite the mouth of Kettle Creek. The northern area was a barrier spit, commonly referred to as Squan Beach. The southern area was a barrier island, which was known as Island Beach.

Today, the study area consists of a single land mass known as Island Beach. Island Beach is attached to the mainland at Point Pleasant Beach and extends a distance of 24 miles from Manasquan Inlet to Barnegat Inlet. From Point Pleasant Beach southward, Island Beach extends as a barrier spit separated from the mainland by Barnegat Bay. Barnegat Bay is the largest bay along the New Jersey Coast and is a significant source of fish, shellfish and recreation, as well as habitat for a variety of species of fish and wildlife.

The Manasquan Inlet jetties were completed as a Federal project in 1933 in response to forty years of unsuccessful attempts by the State of New Jersey and other local interests to stabilize the inlet. Through the 1940's, the jetties were repeatedly damaged by storms, which displaced the armor stones on both structures and allowed sand to shoal in the navigation channel. Between 1979 and 1982, the Philadelphia District, Corps of Engineers rehabilitated the jetties utilizing 16-ton dolosse. Between 1982 and 1985, an intensive Corps-sponsored monitoring program was conducted to document the stability and strength of the dolosse. This is the only site on the US east coast where dolosse have been placed.

Barnegat Inlet has been a Federally maintained inlet since 1940 with the completion of rock jetties on its north and south sides. Due to shoaling and channel instability related to a design deficiency with the original jetty configuration, a new south jetty was built in 1991.

Historical records show that three other inlets existed within the present shoreline of the Manasquan Inlet to Barnegat Inlet study area. The Metedeconk River Inlet closed in 1755 and was located between Bay Head and Mantoloking, opposite the mouth of the Metedeconk River. The Cranberry Inlet existed from 1750 to 1812, and was located opposite Toms River at the present north border of Seaside Heights Borough. Not much information is recorded regarding Kettle Creek Inlet other than its location opposite Kettle Creek within the present boundaries of Brick Township.

Two causeways over Barnegat Bay connect to Island Beach from the mainland. New Jersey Route 70 connects to the Borough of Seaside Heights. Ocean County Route 528 connects to the Borough of Mantoloking. Island Beach is also accessed via New Jersey Route 35 that runs north-south along the barrier spit and connects to the mainland at Point Pleasant. Except for Island Beach State Park, the study area is densely developed. Developed areas along the study shoreline include the Boroughs of Point Pleasant Beach, Bay Head, Mantoloking, Lavallette, Seaside Heights, and Seaside Park and the Townships of Brick, Dover, and Berkeley. Unincorporated coastal communities within the study area include: South Mantoloking Beach in Brick Township; Normandy Beach, Chadwick Beach, and Ortley Beach in Dover Township; and South Seaside Park in Berkeley Township.

Figure 1-2 through Figure 1-13 show various points along the study area moving north to south from Manasquan Inlet to Island Beach State Park. The photos were taken following the February 05, 1998 northeaster.

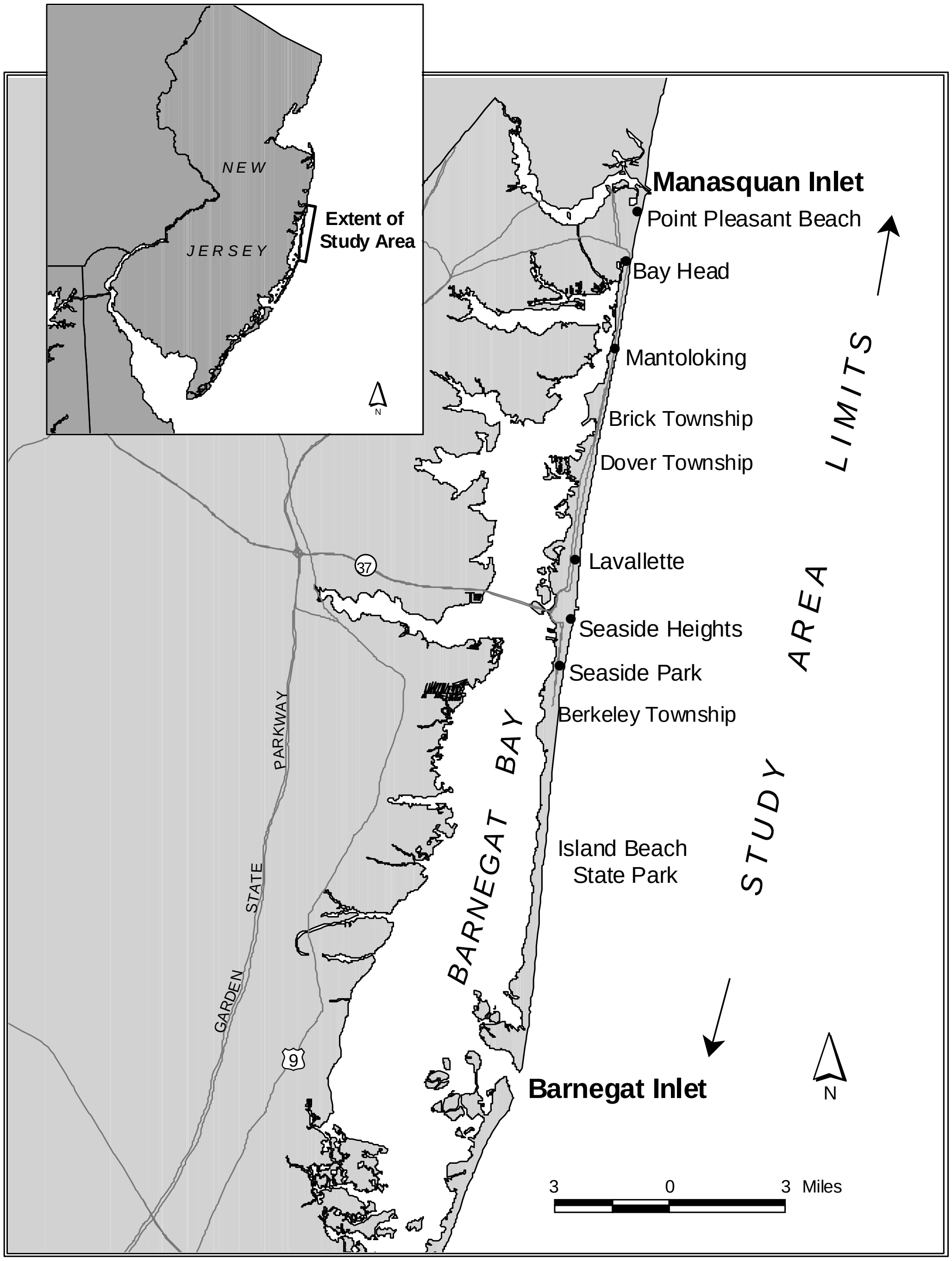


Figure 1-1 Study Area Location Map

Figure 1-2 Manasquan Inlet, NJ - 02/06/98

Figure 1-3 Manasquan Inlet/Point Pleasant Beach, NJ - 02/06/98

Figure 1-4 Bay Head, NJ - 02/06/98

Figure 1-5 Mantoloking, NJ - 02/06/98

Figure 1-6 Mantoloking, NJ - 02/06/98

Figure 1-7 Brick Township, NJ - 02/06/98

Figure 1-8 Dover Township, NJ - 02/06/98

Figure 1-9 Dover Township, NJ - 02/06/98

Figure 1-10 Lavallette, NJ - 02/06/98

Figure 1-11 Seaside Heights, NJ - 02/06/98

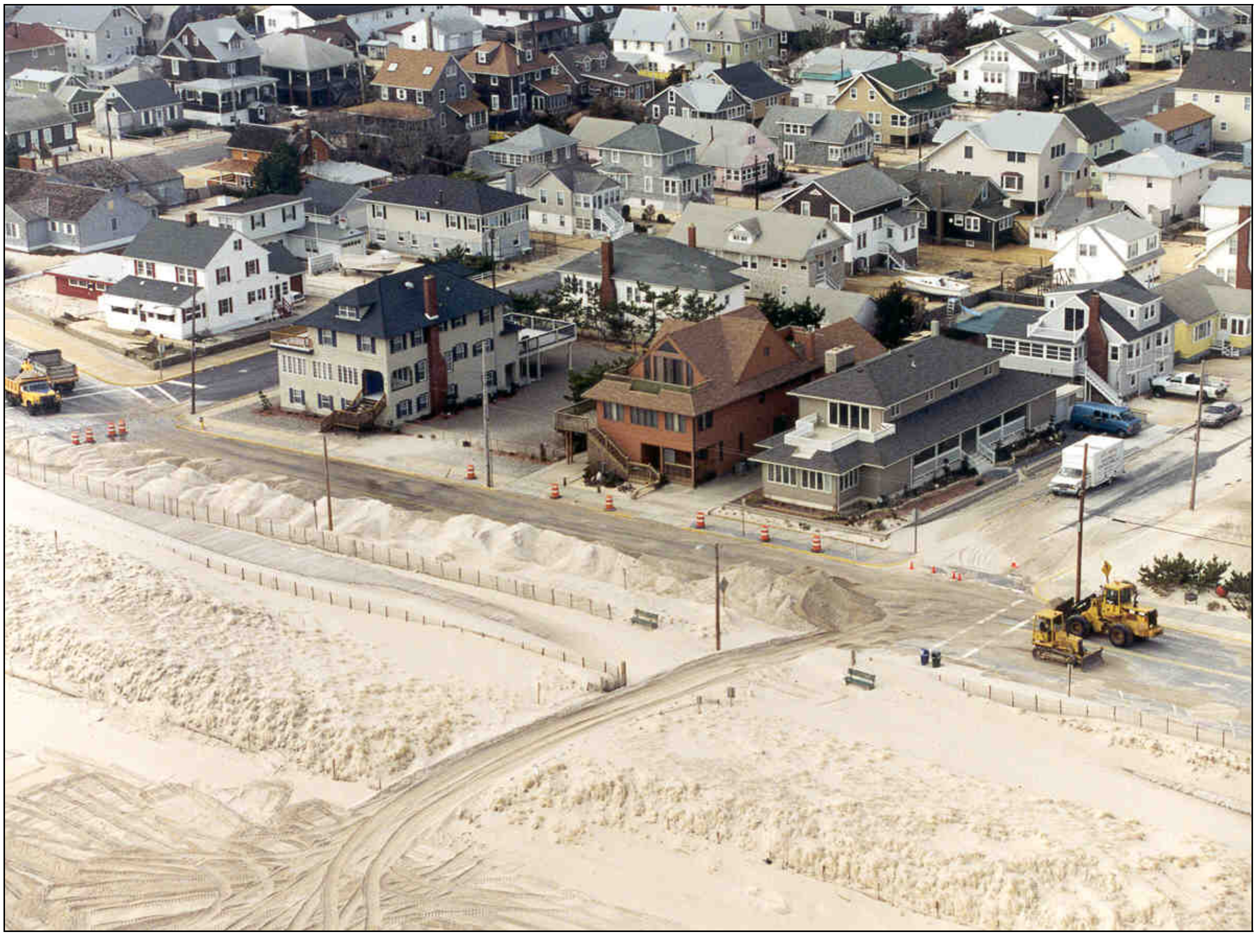


Figure 1-12 Seaside Park, NJ - 02/06/98

Figure 1-13 Island Beach State Park, NJ - 02/06/98

1.5 Prior Studies, Reports and Related Projects

Numerous prior studies have been completed for the study area. The work has been initiated by various groups including the Federal government, the State of New Jersey, local municipalities, and private interests. A description of prior work is presented below.

1.5.1 Federal Involvement

<u>Navigation Projects</u>

a. Manasquan Inlet Jetties (New Jersey Intracoastal Waterway) – This Federal construction project was completed in 1933 and provided for a stabilized navigation channel and two parallel stone jetties. Between 1979 and 1982, the jetties were rehabilitated in response to the storm damage incurred to the armor-stone during the 1940's. The new armor consists of 16-ton dolosse.

b. Barnegat Inlet Navigation Project – This project was originally authorized under Rivers and Harbors Committee, Document 73-19 in 1933 and modified in Document 74-85 in 1936 to provide for a navigation channel and two converging stone jetties that were constructed in 1939 and 1940. Federal involvement at Barnegat Inlet before and after construction of the jetties included construction of a timber and stone groin west of Barnegat Lighthouse in 1938 and construction of three timber groins to accompany two built by the State in Barnegat Light in 1943.

The north jetty was raised in 1974 to prevent sand and waves from passing across the jetty and into the inlet. In 1991, a new south jetty was completed to correct for shoaling and channel instability caused by the inlet's original configuration.

<u>Beach Erosion Control Projects</u>

a. The Sandy Hook to Barnegat Inlet Beach Erosion Control Project was authorized in 1958 and recommended construction of a 100-ft wide beach at elevation 10 ft above mean low water. The project was deauthorized on January 1, 1990 by the Water Resources Development Act of 1986, Public Law 99-662, Section 1001.

b. Beach erosion control projects were authorized for the communities of Bay Head and Lavallette following the March 1962 storm under authority of Public Law 81-875. These projects were never constructed.

<u>Studies</u>

a. A Monitoring of Completed Coastal Projects (MCCP) study included intensive Corps-sponsored monitoring of the dolosse jetties at Manasquan Inlet between 1982 and 1985.

b. An MCCP study of Barnegat Inlet monitored performance of the new south jetty, channel modifications, and possible effects on adjacent beaches, the inlet shore, and the back bay.

Reports

a. New Jersey Shore Protection Study: Report of Limited Reconnaissance Study, September 1990, U.S. Army Corps of Engineers (USACE), Philadelphia District. This study investigated shore protection and water quality problems facing the entire ocean coast and back bays of New Jersey and provided recommendations for future actions and programs to reduce storm damage, improve the information available to coastal planners and engineers, minimize the harmful effects of shoreline erosion, and preclude further water quality degradation of the coastal waters.

b. Barnegat Inlet Phase 1 General Design Memorandum, 1981; and Barnegat Inlet Phase II General Design Memorandum, 1984. These design documents were prepared by the USACE to finalize planning and policy for modification to the Barnegat Inlet navigation project.

c. New Jersey Coastal Inlets and Beaches – Fourth and Final Report: Study of Sandy Hook to Island Beach State Park, July 1978, USACE, Philadelphia District. This study investigated damage problems caused by storm tides and waves, inlet navigation problems, coastal erosion problems, and beach recreation needs along the oceanfront from Sandy Hook to Island Beach State Park, New Jersey.

d. Shore of New Jersey from Sandy Hook to Barnegat Inlet, Beach Erosion Control Study, July 1955, USACE. This report provided a recommended plan for restoration and protection of the publicly owned portions of the New Jersey shore from Sea Bright to Seaside Park by placement of sand to widen the beaches to a minimum width of 100 ft and construction of a groin field.

e. Atlantic Coast of New Jersey – Sandy Hook to Barnegat Inlet: Beach Erosion Control Report, March 1954, USACE, New York District. This study developed a comprehensive plan to restore adequate protective beaches, provide recreational beaches adequate for prospective beach use, and formulate a program for providing continued stability to the shores within the study area.

1.5.2 State Involvement

The State of New Jersey has been involved in providing technical and financial assistance to its shore towns for decades. The State officially tasked the Department of Environmental Protection, formerly the Department of Conservation and Economic Development, to repair and construct all necessary structures for shore protection in the early 1940's (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 severe storms, an additional $30 million was appropriated in 1977. In addition to initiating their own research and construction efforts, the State of New Jersey also cost-shares portions of many Federal projects. Shore protection is currently handled by the New Jersey Department of Environmental Protection, Division of Natural and Historic Resources, Engineering and Construction.

The issue of providing stable funding for shore protection at the State level had been raised on several occasions. Two major storms during the winter of 1991-92 prompted a Governor's Shore Protection Summit in February 1992. As a result, the Shore Protection and Tourism Act of 1992 was passed, thereby creating the first stable source of funding for shore protection equaling, at minimum, $15 million annually.

The following reports were prepared either for state agencies or local communities in the Island Beach study area. All of these reports were utilized in the development of this study.

a. Beach and Dune System Audit, Borough of Mantoloking, Ocean County, New Jersey, Spring 1994, Killam Associates, Coastal Management Division in conjunction with Stockton State College, Coastal Research Center. This document was prepared for the Borough of Mantoloking to assess the existing condition in relation to FEMA guidelines for coastal storm damage, and to establish minimum criteria for protection of Borough properties.

b. New Jersey Beach Profile Network: Analysis of the Shoreline Changes for Reaches 1-15, Raritan Bay to Stow Creek, May 1993, Stockton State College, Coastal Research Center. This research was prepared for the New Jersey Department of Environmental Protection in response to 1) coastal damage caused by a March 1984 northeast storm and Hurricane Gloria in 1985, and 2) the lack of sufficient survey data for any New Jersey coastal region to fully quantify material losses during storms. This ongoing study provides established profile lines with accompanying descriptions, individual survey data plots, volumetric changes at each line, and detailed area maps.

c. New Jersey Shore Protection Master Plan, October 1981, State of New Jersey, Department of Environmental Protection, Division of Coastal Resources. This plan was prepared to 1) help guide the State of New Jersey on decisions for financial assistance for all shore related construction, repair and maintenance, as well as investing the funds available through bonds and other sources; 2) provide the framework for technical assistance on shore protection matters to the public; 3) recognize the importance of existing land use regulations in protecting the sensitive beaches and dunes from development; 4) raise public awareness of the fragility of New Jersey's barrier islands and the risk of coastal development; and 5) define policy regarding advocacy of proper management of shoreline processes.

1.5.3 Local Shore Protection Projects

No ongoing shore protection projects exist within the study area. Local municipalities have placed sand at various times to mitigate for beach and dune loss after storms and to maintain a minimal level of protection. Although these actions have provided temporary protection to individual communities, they have not addressed the ongoing problems of coastal erosion and storm damage vulnerability along the study area.

2 EXISTING CONDITIONS

2.1 Socio-Economic Resources

The study area consists of 24 miles of shoreline within Ocean County, New Jersey that extend from Manasquan Inlet south to Barnegat Inlet. The study area includes the Boroughs of Point Pleasant Beach, Bay Head, Mantoloking, Lavallette, Seaside Heights, and Seaside Park; the unincorporated communities of South Mantoloking Beach, Normandy Beach, Chadwick, Ocean Beach, Ortley Beach, and South Seaside Park; and Island Beach State Park which extends along the southern 10 miles of the study area.

The communities in this study area are small, both in terms of population and in land area. They are predominantly residential and experience large population increases in the summer months.

In 1990 Ocean County had a population of 433,203 residents within its 637 square miles. This represents a 25.2% increase in population since 1980. Ocean County has a population density of 680 people per square mile. This is significantly less than New Jersey's average density of 1,032 people per square mile.

Ocean County had a total of 219,863 housing units with an average price of $146,725 for a single-family home in 1990 based on Census data. The rate of home development is slowing. In 1986 there were 7,033 building permits issued for single-family homes. This dropped to 3,843 in 1988 and to 1,566 in 1990. The U.S. Census Bureau projects that the rate of future development will continue to decrease.

In 1990 the labor force was 185,349, with an unemployment rate of 5.6%. The projected labor force increased to 192,700 by 1993 with an unemployment rate of 5.9%. Though unemployment increased, the rate was below the state's unemployment rate of 7.4%. The median family income in 1990 was $39,797 with 6% of the population below the poverty line.

The northern most community is the Borough of Point Pleasant Beach. It is bordered by Manasquan Inlet to the north, Point Pleasant to the west, and Bay Head to the south. Point Pleasant Beach is the only community within the study area that does not touch Barnegat Bay. It is also the largest community in the study area with 1.4 square miles of land and a 1990 population of 5,600. There has been little change in population since the 1980 population count of 5,415. Point Pleasant is a beach resort community and summer population can swell to as high as 45,000. Part of the attraction to this community is its boardwalk that runs the length of the beach. This boardwalk includes many commercial buildings, amusement rides, a large pier and an aquarium.

According to the Tax Assessor's Office the community has 2,589 single-family residences, 16 multifamily, and 275 commercial structures. The Borough has 281 undeveloped lots. Of these, 60 are on the beach but are not open to development because they are located within the dune system. The 1990 census listed the Borough as having 3,235 total housing units.

This reflects an increase of 134 units of the 1980 census count. New building permits issued recently are far fewer than in the 1980's but exhibit an increasing trend. In 1990, there were only three permits issued for new single family homes, In 1992, this increased to six, and in 1993, it increased again to eight. Future development will decrease as the number of available building lots is depleted. The median value of houses in the 1990 census was $197,300. Values ranged from $162,400 at the lower quartile to $247,400 at the upper quartile.

To the south of Point Pleasant Beach is the Borough of Bay Head. Bay Head is where the barrier peninsula that separates Barnegat Bay from the ocean connects to the mainland. It is also where the northern most portion of the bay meets Metedeconk River. Bay Head is only six tenths of a square mile. Its population was 1,226 according to the 1990 census. This is an 8.5% decrease from the 1,340 people in the 1980 census and the estimated 1992 population declined to 1,195 people. The summer population is estimated to increase to 4,000.

The Tax Assessor's Office lists 950 residences and 62 commercial structures in the community. The 1990 census lists the Borough as having 1,001 housing units, an increase of 66 units over 1980. The town also has 78 vacant lots. The number of building permits for new residential construction has remained constant with three issued for 1990, 1992, and 1993 respectively. The median value of houses according to the 1990 census was $339,200 with a range from $230,600 at the lower quartile to $479,900 at the upper quartile.

South of Bay Head on the peninsula is the Borough of Mantoloking. Mantoloking connects to Brick Township across the bay to the east by the Herbert Street Bridge. This is a small wealthy community where many of the homes are occupied only part of the year. Mantoloking has a land area of four tenths of a square mile. The 1990 census counted 334 residents with no increase in the 1992 estimate. This population represents a 22% decline since the 1980 census. The summer population increases to approximately 500.

The Borough of Mantoloking has 504 single-family residences and 6 commercial structures on its tax rolls. The 1990 census however lists only 467 housing units, 7 less than in 1980. While the Borough does have 60 undeveloped lots, none are located along the beach. The Borough issued 2 building permits for new residential construction in 1990 and 1992 and 5 building permits in 1993. The median value of the homes according to the census was $500,000.

South of Mantoloking are several small unincorporated communities that have no individually compiled census information, since they are small parts of mainland townships. These communities include South Mantoloking Beach and Normandy Beach in Brick Township; and Chadwick, Ocean Beach, and Ortley Beach in Dover Township. These communities are probably better represented by census data from adjacent beach communities than from the townships of which they are a part.

The next community with an individual census breakdown is the Borough of Lavallette. Lavallette occupies eight tenths of a square mile just below Ocean Beach and north of Ortley Beach. The Borough population was 2,299 in the 1990 census. This represents an 11% increase over the 1980 count of 2,072. The estimated 1992 population was 2,362. The population grows considerably in the summer and was estimated at 30,000 by the Borough clerk.

Lavallette has 2,447 single family homes, seven multifamily units, and 62 commercial structures on its tax rolls. The 1990 census reported 3,069 housing units, an increase of 115 over 1980. The town has 98 vacant lots but the tax assessor believes that none are located along the beach. The town issued 5 building permits for new single family homes in 1990, nine in 1992, and six in 1993. The median value of the homes according to the 1990 census was $248,000 with the lower quartile at $177,800 and the upper quartile at $351,700.

South of Lavallette and Ortley Beach is the Borough of Seaside Heights. Seaside Heights has direct access to the mainland via a bridge across the bay that connects to Dover Township. Seaside Heights is a small community with a land area of half a square mile, and a population of 2,360 in the 1990 census. While the 1990 census represented a 31% increase in population over the 1980 count of 1,802 people, it is estimated that the population has been declining recently with the 1992 estimate at 2,317 residents. The population is estimated to grow to 35,000 in the summer. The summer population is largely attracted by the community's boardwalk along the beach. The boardwalk has 79 commercial structures along it and a large pier with amusement rides and games.

Seaside Heights has 188 commercial structures, a substantial number of which are located on the Boardwalk, and 2,844 housing units according to the 1990 census. This is an increase of 116 housing units over the 1980 census. Between 1990 and 1993 however the community has not issued any permits for new residential construction. The housing values of this community are lower than those of other communities in the study area. The median value according to the 1990 census was $135,100, with the lower quartile at $100,500 and the upper quartile at $180,400.

The Borough of Seaside Park is 0.65 square miles in area with a population of 1,871 according to the 1990 census. The Borough is estimated to have increased in population to 1,886 in 1992. The population is estimated to grow to about 30,000 in the summer. It has an oceanside boardwalk with 30 commercial buildings and amusement rides. Unlike Seaside Heights, Seaside Park has only a small portion of its shorefront developed with commercial boardwalk. The remaining majority of shorefront is residential.

The Seaside Park has 100 commercial structures and 2,454 housing units according to the 1990 census. Between 1990 and 1992 the Borough issued 10 building permits for residential construction and 2 for commercial construction. The housing units had a median value of $226,800.

South Seaside Park is a small ocean front community that is part of the mainland township of Berkeley located south of Seaside Park. No separate census data were available for this community.

Also in the study area is Island Beach State Park, which encompasses 3,000 acres and has 10 miles of ocean frontage. It is considered one of the last stretches of relatively undisturbed barrier beaches within the state. Recreational opportunities include: swimming, surfing, scuba diving, horseback riding, picnicking and fishing. The park also offers daily nature tours and activities during the summer months.

2.2 Environmental Resources

2.2.1 General Environmental Setting

The study area is located along the Atlantic coast of New Jersey in Ocean County and extends approximately 24 miles between Manasquan Inlet and Barnegat Inlet. The study area includes the communities of Point Pleasant Beach Borough, Bay Head Borough, Mantoloking Borough, South Mantoloking Beach, Normandy Beach, Chadwick, Ocean Beach, Lavallette Borough, Ortley Beach, Seaside Heights Borough, Seaside Park Borough, South Seaside Park, and Island Beach State Park, which is a natural wildlife area extending along the southern 10 miles of the study area.

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. A large segment of the lands to the northwest of the barrier spit are classified as a backbay/coastal salt marsh system. Common species of the beach and dune area on the barrier system include beach grass, sea-rocket, seaside goldenrod, poison ivy, groundsel-tree, and marsh elder.

The backbays 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 saltmarsh 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 saltmeadow 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, saltgrass, sea-blite, glasswort, poison ivy, and common reed.

In the 1800's, several existing inlets within the project area were closed off, resulting in this reach being appropriately referred to as the Squan Beach Barrier Spit. Barnegat Inlet is maintained by jetties and has undergone a modification to the south jetty in recent years. The Point Pleasant Canal connects the Manasquan Inlet River to the northern end of Barnegat Bay. Barnegat Bay is an important estuary fed by the Metedeconk River, Toms River and ground water seepage from the Pine Barrens. This estuary provides over-wintering habitat for 35% of the total Atlantic flyway's population of black duck (*Anas rubripes*), as well as 70% of the flyway's American brant (*Branta bernicla*) population. Furthermore, the bay itself provides important nesting, feeding, and migratory habitat for 287 other species of waterfowl and birds.

2.2.2 Air Quality

Through the State Implementation Plan (SIP), the New Jersey Department of Environmental Protection (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 Northern Coastal Region, which covers Ocean County.

The nearest air monitoring stations in the Northern Coastal Region are located in Colliers Mills and Toms River. In 1998, the station in Colliers Mills monitored for ozone. The station at Toms River monitored for carbon monoxide and smoke shade. With the exception of ozone at the Colliers Mills station, there were no exceedances in ambient air quality standards for the parameters measured in 1998. 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, 1999). Because of high levels of ozone, the pollutant standards index (PSI) approached the health standard on 29 days and exceeded the health standard on 31 days in 1998 for the Northern Coastal Region. For ozone specifically, measurements at the Colliers Mills station exceeded the New Jersey and National Standards for the maximum daily 1-hour average primary standard on several occasions with hours above 0.12 ppm. The entire state of New Jersey is classified as a non-attainment area for ozone. 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). Ocean County is classified as severe #2 non-attainment for ozone (NJDEP, 1999).

2.2.3 Climate

The climate on the coastal boundary of the study area is generally referred to as continental; characterized by cold winters and moderately hot summers. The mean temperature during the summer months varies between the mid 60's to the mid 70's, making this area an ideal resort for escape from the oppressive heat and humidity often experienced in the nearby inland suburban and urban centers.

The average annual precipitation reported from Sandy Hook, New Jersey is approximately 45 inches. The distribution of precipitation throughout the year is rather uniform, with a slightly higher amount during the summer months. Most of the rainfall from June through September comes from brief showers that may at times be relatively intense. From October to April, precipitation is associated with widespread storm areas and extended periods of rain and snow may be common.

2.2.4 Natural Forces

Coastal barrier 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 seawater, river and ground water.

Waves approach the project area from a southward orientation relative to the shoreline, generating a prevailing northward longshore current that carries littoral drift. 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 is approximately 2 - 3 feet with a period of 6 seconds, while storm waves have been recorded which exceed 20 feet.

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 control movement of sand to adjacent areas. However, at the ends of the barrier beach where inlets are carved by the tides, sand transport is influenced more by tidal currents.

Recently, the importance of large-scale currents has been recognized. A nearshore 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 effect 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 and spring tide ranges for the Atlantic Ocean shoreline at Barnegat Inlet are reported as 4.2 feet and 5.1 feet, respectively. The mean tide level (MTL) for the study area is 2.3 feet above mean lower low water (MLLW), with mean low water (MLW) and mean high water (MHW) being 0.2 and 4.4 feet above MLLW, respectively.

Sea level rise is generally considered by 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 effect sea level rise, predicting trends with any certainty is difficult. There are a number of scenarios of future sea level rise. USACE guidance (EC-1105-2-185, dated April 1989) states that it will be at least twenty-five years before sufficient data are available to estimate with reasonable confidence the appropriate rate of increase, or even to reach some consensus on which of the various pathways is most logical. Until substantial evidence indicates otherwise, USACE policy specifies considering only the regional history of sea level change to forecast a change in sea level for a specific project area. Based on historical tide gauge records between 1912 and 1986 at Atlantic City and Ventnor, New Jersey, sea level has been rising at an approximate average rate of 0.0129 feet per year (Hicks and Hickman, 1988). Over a fifty-year project, it is anticipated that sea level will rise by 0.6 feet. However, 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.

2.2.5 Temperature and Salinity

Mixing occurs in nearshore waters due to 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^{o}C (January) to 21.4^{o}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 only 12 to 13 feet. 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 feet.

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 the proposed sand borrow sites during the benthic sampling effort conducted in August 1999 (Versar, 2000). Surface and bottom water measurements were taken at several sampling sites during each 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 an electronic depth meter on the sampling vessel. Results of the sampling show that the surface water quality parameters were homogeneous between the borrow areas, with little differences detected (Table 2-1). Water column stratification was detected between the surface and bottom measurements in both borrow sites especially in regard to dissolved oxygen concentration (DO) and temperature. Surface water temperatures in August were between 21 and 23 °C whereas bottom temperatures averaged around 13 °C. Dissolved oxygen concentrations were close to 100% saturation at the surface but were substantially lower in the bottom waters. Surface values changed from around 7.0 mg/l to between 2.5 to 5.0 mg/l at the bottom (Table 2-1). DO was higher at a depth of 15.7 m in Borrow Area A than at depths of 16.6 and 21.5 m in Borrow Area B. Salinity also had a 1 to 2 ppt differential from surface to bottom in the borrow areas (Table 2-1).

Table 2-1 Water Quality Measurements at Selected Borrow Stations (Versar, Inc., 2000)

Borrow Area	Date		Depth (m)	Temperature (°C)	pH	DO (mg/l)	Conductivity (µmhos/cm)	Salinity (ppt)
A	8/12/99	Surface	0.5	23.12	8.07	7.65	47.3	30.9
		Bottom	15.7	12.71	7.63	5.01	49.3	32.3
B	8/12/99	Surface	0.5	21.05	7.97	7.22	47.9	31.3
		Bottom	21.5	12.42	7.37	2.49	50.2	32.9
B	8/12/99	Surface	0.5	23.17	7.98	7.20	47.3	30.9
		Bottom	16.6	13.19	7.48	3.71	49.6	32.5

2.2.6 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. Total and fecal coliform bacteria are used as indicators for pathogens in measuring water quality. When the fecal coliform level exceeds state criteria (i.e. greater than 200 colonies per 100 ml of water) for two consecutive water samples, taken 24 hours apart, beach closures may result.

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

Nonpoint source pollution (NPS) is the primary pollution of backbay and near-shore coastal waters. 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. By its very nature, NPS is difficult to identify and control (Rutgers University, 1988).

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 1996, the majority of the nearshore waters to a maximum distance of 2 miles from Manasquan Inlet to Barnegat Inlet were classified as prohibited for shellfish harvesting. The waters in the backbays immediately adjacent to the study area were for the most part classified as prohibited or seasonally restricted. The one exception is in the area of Island Beach State Park where the nearshore waters are classified as a surf clam conservation zone and the backbays are approved harvest areas with some seasonal restrictions.

The Bureau of Marine Water Classification and Analysis (BMWCA) under the authority of N.J.S.A. 58:24 classifies the shellfish growing waters, and administers the special resource recovery programs. A comprehensive sanitary survey is conducted according to National Shellfish Sanitation Program (NSSP) guidelines in order to satisfy Food and Drug Administration (FDA) requirements. 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. This information is then integrated into shellfish classification charts by the Shellfisheries Bureau of NJDEP.

Point source discharges from coastal wastewater treatment facilities can affect water quality in nearshore and offshore waters. Consequently, the NJDEP routinely monitors the treatment of effluent at such facilities, to ensure that they operate in accordance with the requirements of their permits. There are two potential point sources of contamination in the study area. The northern Ocean County Utilities Authority (OCUA) Wastewater Treatment Plant (WWTP), and the central OCUA WWTP (*NJDEP, Water Monitoring Management, Marine Water Classification and Analysis, "Reevaluation Shellfish Growing Areas 49-51, 1988-1991"*). At one time, a Ciba-Geigy Wastewater Treatment Plant outfall was located along Ortley Beach off Second Avenue. However, on December 31, 1991, Ciba-Geigy's Pollutant Discharge Elimination System (NJPDES) Permit expired. Only dye standardization and packaging activities are presently being conducted at the plant. The facility's pretreated wastewater flow is now being directed to OCUA's central WWTP for treatment and eventual ocean discharge off of south Seaside Park. Ciba-Geigy outfall sediment and tissue samples were recently analyzed for contaminants; all samples were tested for the presence of priority pollutants, as well as fecal and total coliform. According to Bill Eisele, of NJDEP's Water Monitoring Management Division, the chemical test results from this analysis require further verification, as methylene chloride a component of Ciba-Geigy effluent was discovered. Dover Sewage has an outfall 2,650 feet off of 9th Avenue in Ortley Beach, which is not currently functional. Several other abandoned outfalls are still in place within the study area, yet are no longer functional. The discharges from these outfalls were incorporated into the regional sewage system back in the late 70's and pose no threat to water quality in the study area. They are located at Point Pleasant Beach (Little Silver Lake), Bay Head (Twilight Lake), Lavallette (Philadelphia Avenue), Seaside Heights (Grand Avenue), Seaside Park, and the old Berkeley Township Plant outfall.

The central OCUA's waste treatment plant outfall extends out 7,000 feet, and is located just south of Seaside Park off of 23rd street. It services all the municipalities in the area extending north from the Gatehouse at Island Beach to Mantoloking along the coast, and Dover Township to Central Ocean County on the mainland. The northern OCUA's WWTP discharges secondary treated sewage effluent into the ocean approximately 6,500 feet off Princeton Avenue, Mantoloking. The current effluent received by ocean waters from both wastewater treatment plants continues to meet the National Shellfish Sanitation Program (NSSP) guidelines and exceedance criteria for total and fecal coliform levels. Island Beach State Park uses a subsurface system to dispose of its sewage. These subsurface systems work according to design and require minimal maintenance. The State believes that these do not pose a significant problem to water quality as they are 200 yards in from the surf line.

For recreational beaches, the health agency also surveys the area visually, and collects additional samples ("bracket samples") at either side of the station to determine the extent of pollution and possible pollution sources. The results of the bracket samples determine the extent of restrictions imposed along the shore, and the number of beaches closed.

In 1998 and 1999, the Ocean County Health Department monitored swimming beaches for bacteria and pathogens at approximately 26 locations within the project area. The results of this monitoring showed that in 1998, only one of the samples collected exceeded the monitoring criteria, resulting in one, day-long beach closure. The closure was the result of elevated bacteria levels in the sample due to storm water run-off and wildlife. Similarly, in 1999, two beaches were closed for one day each when sampling results indicated elevated bacteria levels as a result of storm water run-off and wildlife. As noted, these closings were generally attributable to stormwater discharges rather than discharges from wastewater treatment facilities. No wastewater treatment facilities discharge directly to barrier island or back bay waters, although freshwater systems that input to the bays may receive these discharges.

All of Manasquan Borough's stormwater is directed towards the tributaries of the Manasquan River, and the tidal waters of the inlet. There is no direct discharge of stormwater from the Borough of Manasquan into the ocean. The ebbing waters from Manasquan and Shark Rivers, however, have the potential to adversely affect this region's water quality, despite the fact that water quality in these rivers has improved over the past few years, especially in the Manasquan River (NJDEP, 1997a). A major portion of the Manasquan River is currently classified as Special Restricted, whereby harvested shellfish are required to undergo purification in "clean" water (Relay/Depuration) before being marketable. Except for the most southern section of Point Pleasant Beach Borough, all of the town's runoff is directed to either tributaries of the Manasquan River, the river itself, or the inlet. Stormwater in the southern portion of Point Pleasant Beach (comprising less than 10% of the borough's surface area) is pumped through an outfall and onto the ocean beach adjacent to Sea and Ocean Avenues. Bay Head and Mantoloking storm water runoff is directed toward the bayside only. Storm water runoff from South Seaside Park and Seaside Park is also directed toward and into Barnegat Bay.

Stormwater can be contaminated during overland flow during rainfall events and during transport through underground conveyance systems before being discharged into a waterway. The stormwater 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 stormwater catch basins, where it either contaminated the stormwater or continued to waterways that normally receive stormwater.

The State of New Jersey has initiated a coastal nonpoint pollution control program in response to the Coastal Zone Act Reauthorization Amendments of 1990 (CZARA). An EPA/NOAA program document is assisting states in developing program elements, and their "threshold review" process offers states a forum to present their proposals and receive feedback before they have expended work effort and resources.

It is expected that the primary cause of nonpoint source pollution is related to development on land and/or the activities that result from land development. Sources may include run-off of petroleum products, fertilizers and animal wastes from roadways and lawns. When it is generated on land, such nonpoint source pollution is carried by rainwater, which can drain to surface or ground water, and ultimately reach the Bay. In Barnegat Bay, land-based nonpoint source pollution is evident by the fact that water quality declines after significant rainfall. Non-point source pollution from other sources, such as boats and septic tanks, can enter the Bay at any time. Nonpoint source pollution becomes significant as the effects of actions within an entire population of a watershed are magnified.

Based on patterns of land development and trends in water quality, it appears that much of the nonpoint source pollution entering Barnegat Bay as a result of land development occurs more intensively in the northern portions of the Bay watershed. Despite the apparent causal relationships between land development and water quality degradation, there are insignificant monitoring data, and Bay processes are not sufficiently understood, to attribute a measurable water quality effect to a specific type, amount, or location of development. Because of the direct link of rainfall associated events to the flushing of contaminants, management schemes become complicated by such variables as the quantity, frequency and duration of precipitation. Consequently, it is not possible to establish a limit to development that is based on predicted, quantifiable effects on Bay water quality and Bay ecosystem vitality.

Versar, Inc. (2000) found that surficial sediments in the borrow areas were predominantly composed of medium to coarse sands with some stations containing higher percentages of gravel sized particles. No stations had a silt/clay content above 10%. Organic contaminants and metals are typically low in sediments dominated by sands and are normally correlated with fine-grained sediments high in organic content (Louis Berger, 1999). There is no specific sediment quality (contaminant) data on the sediments within the proposed sand sources. Generally, the State of New Jersey does not require sediment testing if the material to be dredged is greater than 90% sand (grain size >0.0625 mm) and there is no other background information (for example, no known historical spills or discharges of pollutants in the project area, previous sediment chemistry data, etc.) that would provide evidence for potential contamination (NJDEP, 1997c).

Based on the results of a Hazardous, Toxic, and Radioactive Waste (HTRW) Environmental Site Assessment (see Section 2.5), there are no known significant contamination sources in the vicinity of the project area such as industrial outfalls or known dumpsites, however, the possibility of unknown illegal discharges or accidental spills exists. Based on this, it is generally expected that there is a low potential for contamination within the sand borrow area because the substrate is primarily sand that has been subjected to high circulation and flushing from ocean currents. However, this cannot be conclusively supported without analytical data to confirm that no contamination exists within the borrow sites.

2.2.7 Wetland Habitats

The study area encompasses both the barrier spit complex and backbay/coastal saltmarsh systems. In addition, there are four (4) manmade lakes to the west of the barrier spit complex. Island Beach State Park is characterized by estuarine intertidal emergent wetlands behind a marine intertidal beach/bar. 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 four deep water lake habitats Twilight Lake, Lake of the Lilyes, Lake Louise and one unnamed lake are adjacent to, but outside potential sand placement areas for the proposed project. Manasquan River Inlet, Twilight Lake and Lake Louise are subject to tidal inundation and undergo periodic brackish conditions. These water bodies are accessible to anadromous fish such as blueback herring (*Alosa aestivalis),* striped bass (*Morone saxatilis),* American shad (*Alosa sapidissima),* and alewife (*Alosa pseudoharengus*). Freshwater species may include those typical of urban and suburban coastal environments, for example: American eel (*Anguilla rostrata*), goldfish (*Carassius auratus*), carp (*Cyprinus sp.*), shiners (*Notropis sp.*), bullhead (*Ictalurus sp.*), bluegill sunfish (*Lepomis macrochirus*), and largemouth bass (*Micropterus salmoides*).

The backbays 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 saltmarsh 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 saltmeadow 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 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.*), saltgrass (*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 Barnegat Bay shoreline is expected, the continued existence of brackish tidal saltmarsh and coastal wetlands (fringe wetlands) is threatened; consequently elimination of habitat and degradation of water quality due to nonpoint sources of pollution may increase.

2.2.8 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.

Natural dunes or remnants of ones are present at some locations within the study area, especially in the area of Island Beach State Park. However, large segments of 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 is 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 beachgrass (*Ammophila breviligulata*), which is tolerant to salt spray, shifting sands and temperature extremes. American beachgrass is a rapid colonizer that can spread by horizontal rhizomes, and also has fibrous roots that can descend to depths of 3 feet to reach moisture. Beachgrass 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*) and beach clotbur (*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*), saltmeadow hay (*Spartina patens*), broom sedge (*Andropogon virginicus*), beach plum (*Prunus maritima*), seabeach evening primrose (*Oenothera humifusa*), sand spur (*Cenchrus tribuloides*), seaside spurge (*Ephorbia polygonifolia*), joint-weed (*Polygonella articulata*), slender-leaved goldenrod (*Solidago tenuifolia*), and prickly pear (*Opuntia humifusa*).

Along the undeveloped portion of the study area in Island Beach State Park, the primary and secondary dunes grade into a zone of shrubby vegetation. These zones are typically located on the barrier flats of the barrier beaches. This zone is called the scrub-thicket zone where sand movement is more diminished. Many of the flora are dwarf trees and shrubs which include: wax-myrtle (*Myrica cerifera*), bayberry (*M. pensylvanica*), dwarf sumac (*Rhus copallina*), poison ivy (*Toxicodendron radicans*), black cherry (*Prunus serotina*), American holly (*Ilex opaca*), greenbrier (*Smilax spp*.), groundsel bush (*Baccharis halimifolia*), loblolly pine (*Pinus taeda*), pitch pine (*Pinus rigida*), Virginia creeper (*Parthenocissus quinquefolia*), beach plum (*Prunus maritima*), and the non-native Japanese black pine (*Pinus thunbergii*).

2.2.9 Upper Beach Habitat

The upper beach, or supralittoral 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.

2.2.10 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.

2.2.10.1 Benthos of Intertidal and Subtidal Zone

Benthic macroinvertebrates 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.

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 macrofauna 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 marcoinvertebrates 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 Zone

The nearshore coastal zone generally extends seaward from the subtidal zone to well beyond the breaker zone (U.S. Army Corps of Engineers, 1984). 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 nearshore zone as an indefinite area that includes parts of the surf and offshore areas affected by nearshore currents (Figure 2-1). The boundaries of these zones may vary depending on relative depths and wave heights present.

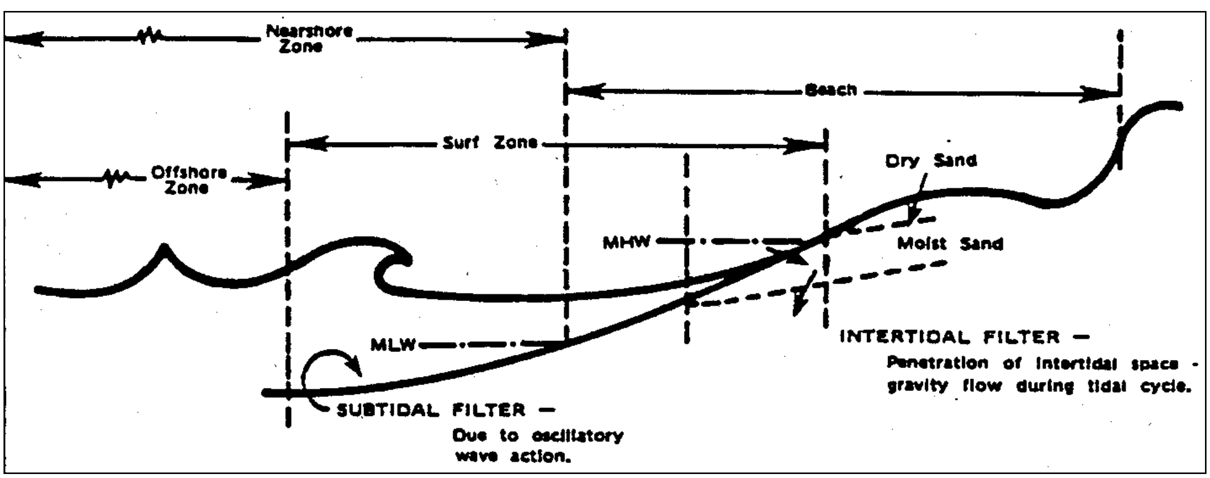


Figure 2-1 Beach, Intertidal, Nearshore, and Offshore Zones

2.2.12 Benthos of Nearshore and Offshore Zones

New Jersey Atlantic nearshore waters provide a dynamic environment heavily influenced by the tidal flows and long shore currents. The nearshore 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).

A benthic-sediment assessment was conducted focusing on infauna species within the two proposed offshore borrow sites, to establish a baseline for the benthic macroinvertebrate assemblages within the proposed borrow sites as shown in Figure 2-2 (Versar, Inc., 2000). Other objectives were to identify the presence of any commercial and/or recreationally important benthic communities within the proposed sand borrow sites. The data obtained from each borrow area were compared to each other, nearby reference areas, and other local borrow areas sampled under other studies.

For this study, 30 benthic macroinvertebrate samples were collected from the two proposed borrow areas. The number of stations sampled from each borrow area was proportional to the size of the proposed borrow area (Area A included an area of approximately 460 acres while Area B included area of approximately 130 acres). Based on this acreage breakdown, 23 samples were collected from Borrow Area A and 7 samples were collected from Borrow Area B. Two additional samples were collected from reference stations located near each borrow area for a total of 4 nearshore reference stations (Figure 2-3).

The results of the Versar, Inc. investigation (Versar, Inc., 2000) indicate that the community composition of the borrow areas and the nearby reference areas were similar. The borrow areas were dominated by a few very abundant taxa. The mean abundance of the most dominant taxa of each borrow area contributed to over 94% of the mean total abundance in each area (Table 2-2). Of the 20 dominant taxa collected from the areas, eleven were polychaete taxa. The most dominant polychaete taxa, the small bristle worm, *Polygordius* spp. contributed between 69% (reference area) and 91% (Area B) of the total mean abundance of the areas. One large polychaete worm that was a dominant in the reference area, *Pherusa affinis*, was not collected from any station in the borrow areas. Small, juvenile *Spisula solidissima* were the dominant bivalve in the two borrow areas, whereas, they were not collected from any of the nearby reference areas.

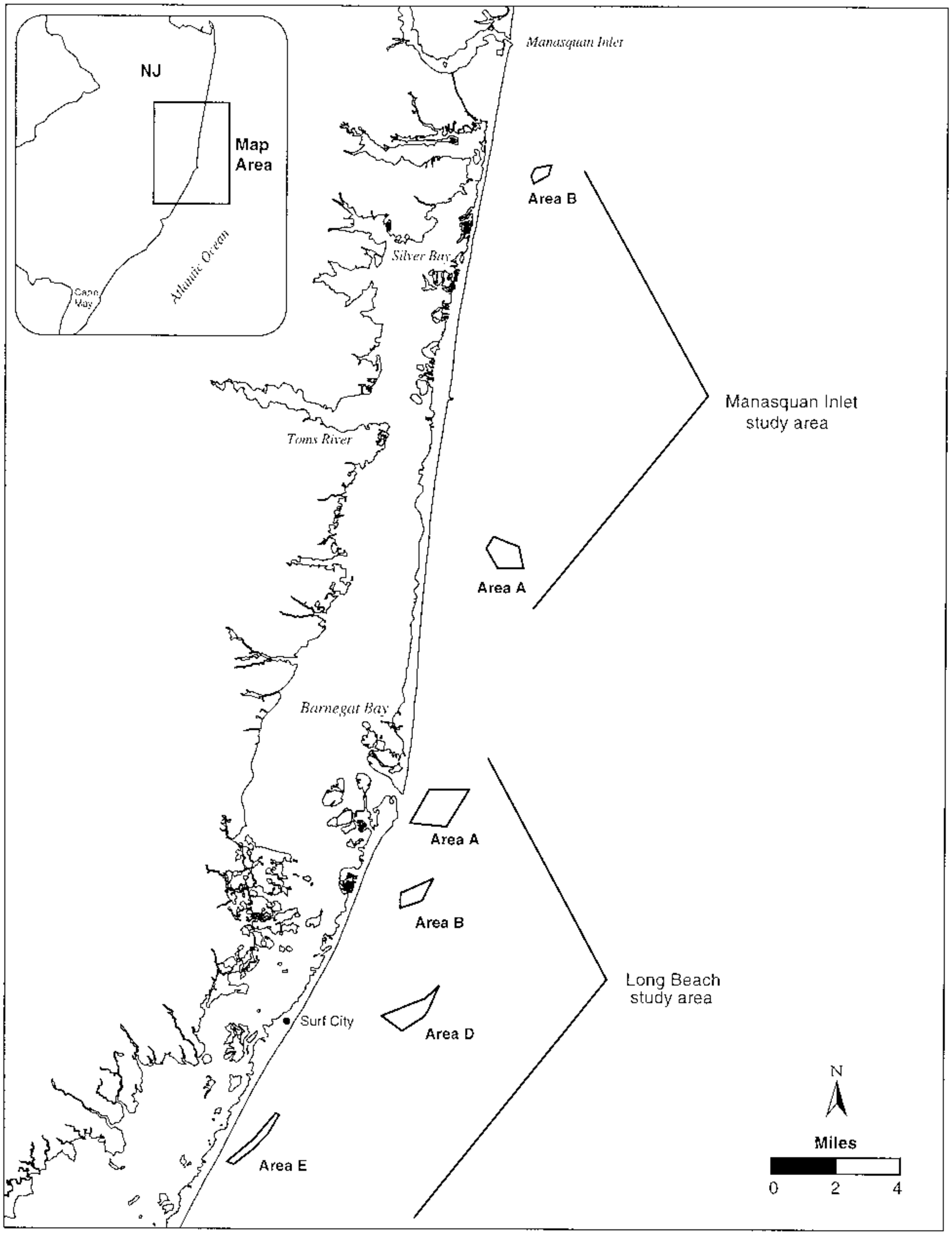


Figure 2-2 Location of Manasquan Inlet to Barnegat Inlet Borrow Areas and Adjacent Long Beach Island Regional Reference Areas

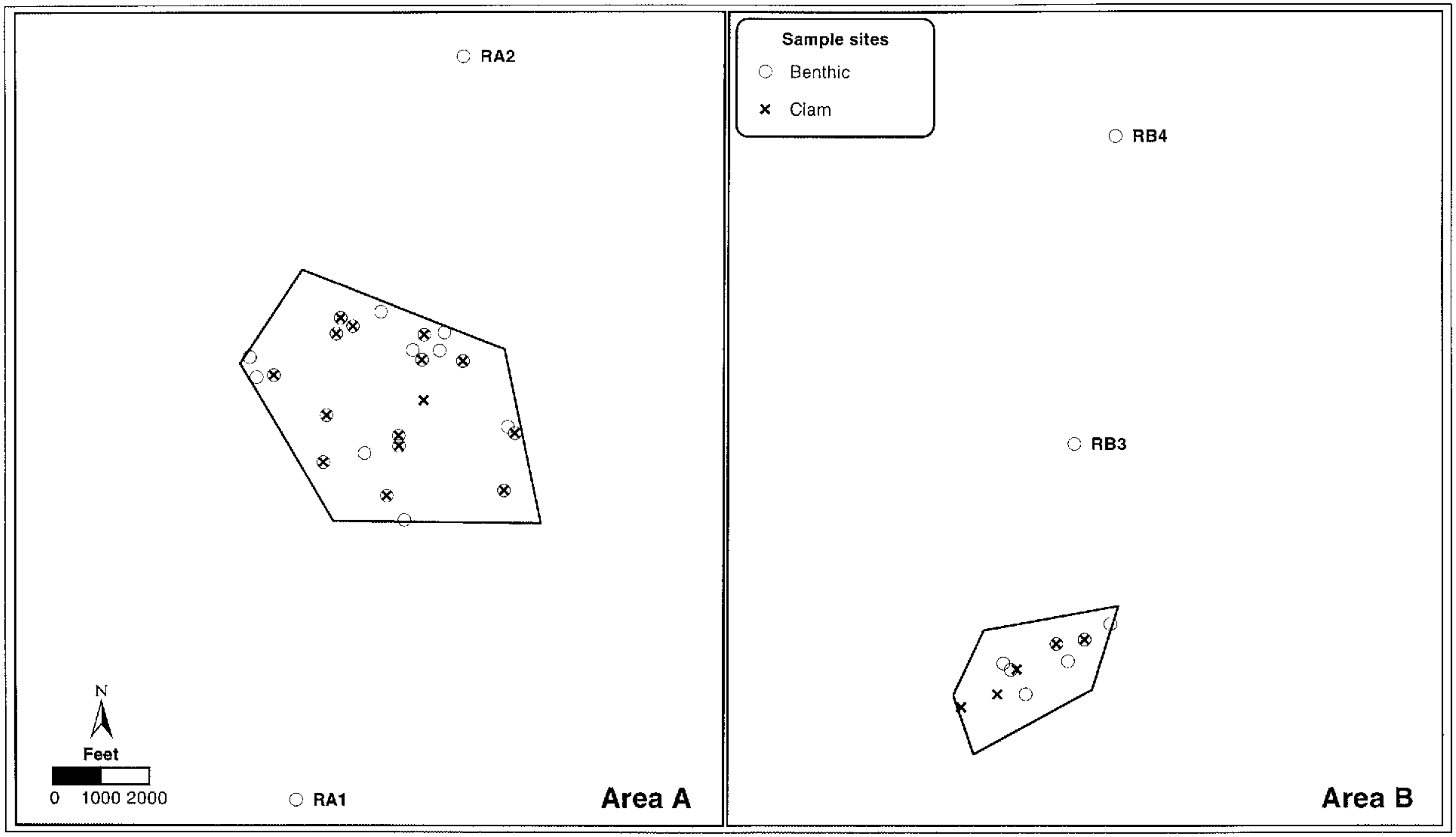


Figure 2-3 Benthic Sampling Sites and Location of Nearby Reference Stations

Table 2-2 Mean Abundance of Dominant Infaunal Taxa

Taxon	Area A ($\#/m^2$)	Area B ($\#/m^2$)	Reference Area ($\#/m^2$)
Nemertinea			
Nemertinea	345.8	100.7	136.4
Annelida : Polychaeta			
Aphelochaeta spp.	324.1	48.7	272.7
Caulleriella sp. B (Blake)	80.0	48.7	244.3
Hemipodus roseus	253.9	68.2	73.9
Lumbrineridae	19.8	168.8	164.8
Monticellina baptisteae	67.2	9.7	312.5
Paradoneis sp. B (Morris)	131.4	113.6	22.7
Parougia caeca	403.2	331.2	1562.5
Pherusa affinis	0	0	221.6
Polygordius spp.	22022.7	27948.0	36107.8
Sphaerosyllis brevifrons	158.1	3.3	11.4
Tharyx sp. A Morris	2.0	61.7	3306.8
Annelida : Oligochaeta			
Oligochaeta	1563.2	149.4	6102.3
Mollusca : Bivalvia			
Nucula proxima	4.9	9.7	2187.5
Spisula solidissima	118.6	220.8	0
Tellina agilis	13.8	123.4	79.6
Arthropoda : Tanaidacea			
Tanaissus psammophilus	2.0	110.4	0
Arthropoda : Amphipoda			
Pseudunciola obliquua	13.8	366.9	17.1
Unciola irrorata	193.7	68.2	85.2
Unciola spp.	263.8	42.2	34.1

A total of 88 distinct taxa were identified from the borrow and reference areas. The total number of taxa identified from each borrow area ranged from 54 at Area B to 71 at Area A (Table 2-3). As expected, more taxa were identified from the larger borrow area where more samples were collected. Taxa richness, as measured by mean number of taxa, was generally high for the borrow areas and ranged from 23.7 at Area B to 27.5 at the nearby reference area (Table 2-3). There were no significant differences in mean number of taxa between the borrow areas and the nearby reference area.

The diversity indices, as measured by the Shannon Wiener Index and the Simpson's Dominance Index, indicated that although the taxa richness was relatively high, the community was not as evenly distributed as other New Jersey coastal benthic communities. Shannon Wiener Diversity Index (*H'*) and the Simpson's Dominance Index (*D*) were both very low. *H'* ranged from a low of 1.3 at Area B to a high of 2.0 at the nearby reference area (Table 2-3). Simpson's Dominance Index followed the same pattern as *H'* where the lowest value, 0.33, occurred at Area B and the highest value, 0.52, occurred at the nearby reference area (Table 2-3). These values are not unexpected since, as previously stated, the most dominant taxa in the borrow areas accounted for over 80% of the total abundance. Neither borrow area was statistically different from the nearby reference area for both diversity measures.

Table 2-3 Summary of Benthic Community Parameters

Parameter	Area A	Area B	Nearby Reference Area
Total number of taxa	71	54	60
Number of Taxa (#/Sample)	27.3[(a)*] (0.83)	23.7[(a)] (1.49)	27.5[(a)] (1.32)
Shannon-Wiener Index	1.74[(a)] (0.19)	1.33[(a)] (0.31)	2.00[(a)] (0.37)
Simpson's Dominance Index	0.43[(a)] (0.05)	0.33[(a)] (0.09)	0.52[(a)] (0.08)
Total Abundance (#/m^2)	27216[(a)] (3355)	30844[(a)] (10978)	52448[(a)] (32718)
Amphipod Abundance (#/m^2)	472[(a)] (85)	496[(a)] (176)	142[(a)] (39)
Bivalve Abundance (#/m^2)	205[(a)] (28)	380[(a)] (113)	2352[(a)] (2254)
Polychaete Abundance (#/m^2)	24402[(a)] (3412)	29477[(a)] (11195)	43545[(a)] (29551)
Total Biomass (g/m^2) AFDW	6.69[(a)] (1.22)	7.43[(a)] (1.63)	29.74[(b)] (18.2)
Amphipod Biomass AFDW (g/m^2)	0.09[(a)] (0.02)	0.04[(a)] (0.01)	0.04[(a)] (0.02)
Bivalve Biomass AFDW (g/m^2)	1.78[(a)] (0.95)	3.04[(a)] (1.94)	5.88[(a)] (5.86)
Polychaete Biomass AFDW (g/m^2)	2.93[(a)] (0.31)	3.79[(a)] (1.11)	18.50[(b)] (11.31)
* Means with the same letter are not significantly different as indicated by Duncan's Multiple Range Test.			

The macrobenthic assemblages in the borrow areas were similar to each other and to the assemblages of the nearby reference area. More than 83% of the taxa present in the Manasquan borrow areas were also present in either the nearby reference area or the regional reference areas. The few unique taxa to the Manasquan borrow areas were present in extremely low numbers and most are present at other New Jersey locations. A total of 18 taxa classified as epifaunal were collected in the grab samples from the borrow areas. Borrow Area A had 17 epifauna taxa while Borrow Area B had 8. The larger number of epifaunal taxa collected from Area A is most likely related to the number of samples taken from each borrow area.

The complete benthic survey report can be found in Appendix C of this document.

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 nearshore 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 Fisheries

2.2.14.1 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 Manasquan area 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.

Species known to utilize estuaries along the Atlantic Coast of New Jersey include summer flounder (*Paralichthys dentatus*), sea bass (*Centropristis striata*), striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), winter flounder (*Pseudopleuronectes americanus*), tautog (*Tautoga onitis*), weakfish (*Cynoscion regalis*), scup (*Stenotomus chrysops*), white perch (*Morone americana*), and Atlantic menhaden (*Brevoortia tyrannus*). In a study conducted at nearby Peck Beach, 178 species of saltwater fishes were recorded. Of these, 156 were from the nearshore waters. Of the 124 species recorded in Great Egg Harbor Inlet, 28 are found in large number in offshore waters. Eighty-seven species were found in the nearshore ocean, bay and inlets adjacent to Peck Beach. Of these, 46 were located in the near shore waters. Sixty-two species were identified in Great Egg Harbor Inlet. Many species inhabit estuaries year-round; however, a large number of species only use estuaries for specific parts of their life history. Most of these latter species fall into four general categories: 1) diadromous species, which use estuaries as migration corridors, and in some instances, nursery areas; 2) species that use estuaries for spawning, often at specific salinities; 3) species that spawn in marine waters near the mouths of estuaries and depend on tidal and wind-driven currents to carry eggs, larvae, or early juveniles into estuarine nursery areas; and 4) species that enter estuaries during certain times of the year to feed on abundant prey and/or utilize preferred habitats.

A comprehensive survey of finfish in the nearby Hereford Inlet Estuary was conducted by Lehigh University from June 1973 through December 1977. A total of 105 species of finfish were identified. Among the most frequent year-round residents were the Atlantic silverside (*Menidia menidia*), bay anchovy (*Anchoa mitchilli*), mummichog (*F. heteroclitus*), sheepshead minnow (*Cyprinodon variegatus*), winter flounder, windowpane (*Scophthalmus aquosus*), and tidewater silverside (*Menidia peninsulae*). Spring migrant species included the spot, black sea bass, white mullet (*Mugil curema*), and summer flounder.

Man-made structures within the study area such as groins and jetties add more habitat diversity within the study area for finfish. Juvenile and larval finfish such as black sea bass (*Centropristis striata*), summer flounder (*Paralichthys dentatus*), winter flounder (*Pseudoharengus dentatus*) and striped bass (*Morone saxatilis*) utilize these areas for feeding, protection from predators, and nursery habitat.

Recreational fishing in New Jersey consists of scup (*Stenotomus chrysops*), black sea bass (*Centropristis striata*), summer flounder (*Paralichtys dentatus*), weakfish (*Cynoscion regalis*), bluefish (*Pomatomus saltatrix*), red hake (*Urophycis chuss*), white hake (*Urophycis tenuis*), silver hake (*Merluccius bilinearis*), Atlantic mackerel (*Scomber scombrus*), chub mackerel (*S. japonicus*), Atlantic cod (*Gadus morhua*), northern *kingfish (Menticirrhus saxatilis*), and tautog (*Tautoga onitis*). Northern puffer (*Sphaeroides maculatus*), spot (*Leiostomus xanthurus*), red drum (*Sciaenops ocellatus*), pollock (*Pollachius virens*), and Atlantic bonito (*Sarda sarda*) may also be taken occasionally.

Commercially important species include menhaden (*Brevoortia tyrannus*), winter flounder, weakfish, bluefish, scup, mackerel, silver hake, red hake, yellow flounder, black sea bass, butterfish (*Perpilus triacanthus*), and shad (*Alosa mediocris*). Harvesting is accomplished by use of purse seines, otter trawls, pots, and gill nets.

2.2.14.2 Aquaculture

Barnegat Bay's fishery resources supplement the state's economy by adding several million dollars in recreational expenditures, and raising the equity of the commercial harvest. The hard-shell clam harvest in the northern half of the Bay earns high commercial fishery revenues.

Statewide, approximately 32,000 acres of bay bottom are leased by commercial shellfishers, primarily along the Delaware Bay. Sixty-six acres are leased in Barnegat Bay for commercial harvesting of oysters and hard shelled clams. Commercial shellfishers utilized these areas for holding or “wet storage” prior to harvesting them for sale on the market. They also grow the shellfish to marketable size on these parcels.

2.2.14.3 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 backbays and inlets.

The surf clam has a wide distribution and abundance within the mid-Atlantic Region (Figure 2-4). 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. The surf clam fishery supports the largest molluscan fishery in New Jersey, accounting for, by weight, 67% of the State's total molluscan commercial landing in 1999, with a value of 29 million dollars. The NJDEP has established surf clam conservation zones along the NJ coast, which prohibits harvest in these areas. However, there are no areas identified within the study area (NJDEP, 1996).

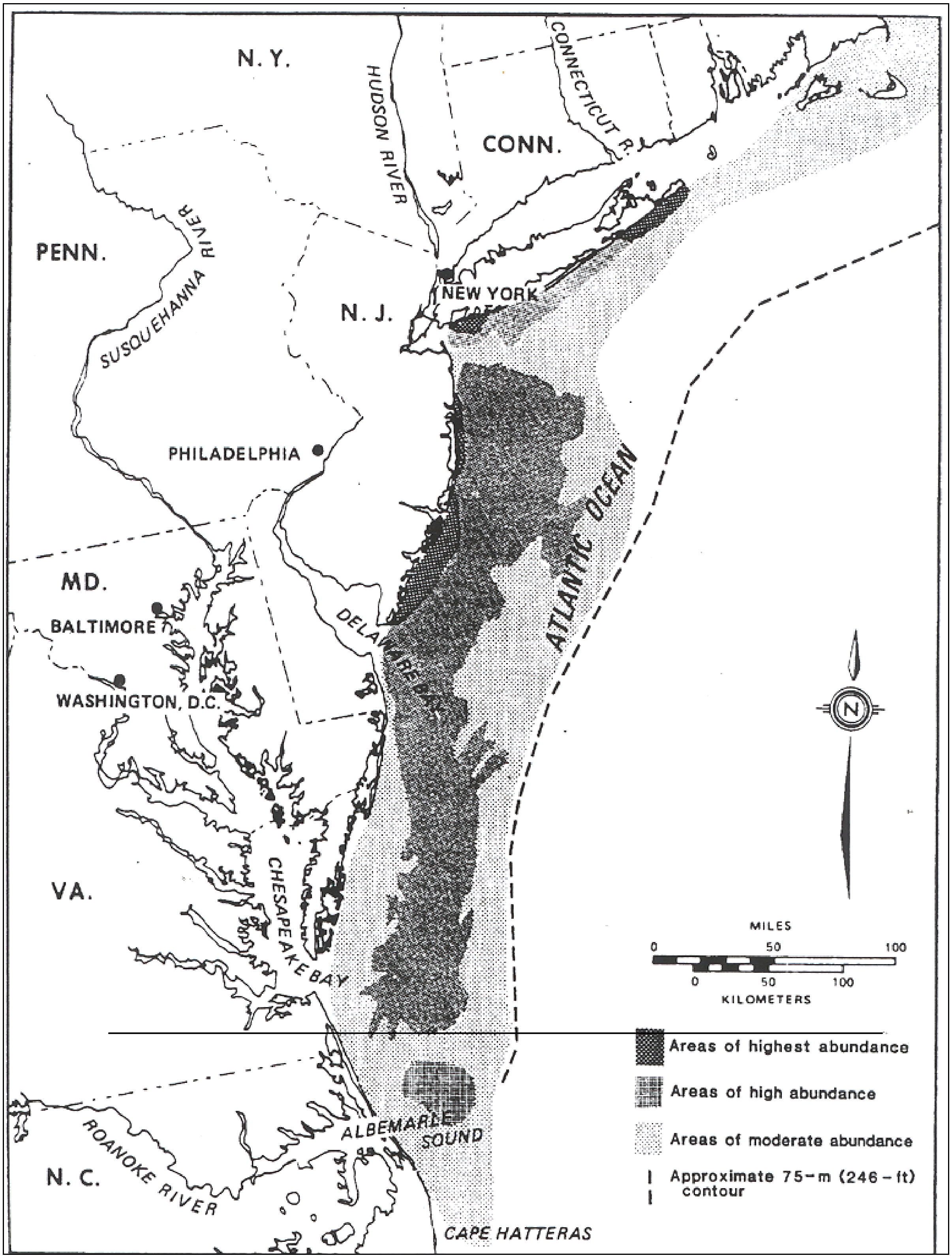


Figure 2-4 Distribution of Mid-Atlantic Surf Clams within the Mid-Atlantic Bight (Fay et al.,1983)

The NJDEP, Bureau of Shellfisheries annual shellfish inventory has revealed that there are commercially viable populations of surf clam (*Spisula solidissima*) present in the nearby vicinity of the proposed borrow areas. Commercially viable populations are defined as: "those whose catch per unit effort yield > 2 bushels per five (5) minute tow" (personal communication with Jeffrey Normant, Bureau of Shellfisheries). State waters between Shark River and Barnegat Inlet have historically supported significant surf clam activities. During the 2000-2001 harvest season, 23.26% of the total harvest occurred within this reach. The Bureau of Shellfisheries, Shellfish Growing Water Classification Charts, depict shellfish conservation and prohibited zones. A conservation zone runs the entire length of Island Beach State Park, and it is these areas where shellfish harvest is permissible for conservation purposes only. The three areas where shellfish harvest is prohibited are north of Island Beach State Park, and extend between 1 and 2 miles out from shore for almost the entire remaining distance of the study area.

For the feasibility study, the potential offshore borrow areas were surveyed in 1999 and 2001 to document the presence and density of juvenile and adult surf clam stocks within the two borrow areas. In the initial survey, Versar, Inc., (2000) found that the mean abundance of juvenile clams at the two Manasquan borrow areas were, in general, significantly lower than the clam abundances at the nearby Long Beach Island borrow areas (LBI regional areas). Clams larger than 2 cm length were collected from all four regional reference areas in the Young grab samples but were not collected from either of the two Manasquan borrow areas.

In the 1999 survey, adult surf clams were collected in 87% of the dredge tows conducted in Area A (Table 2-4). Among the 15 tows conducted in Area A, approximately 2,000 surf clams were collected. The estimated number of surf clams collected per tow averaged 130 and ranged as high as 703 clams. Density estimates for the borrow area averaged 6 clams/100 sq ft and ranged to 51 clams/100 sq ft. Overall, the standing stock of adult surf clams of Area A was estimated to be 1.2 million clams (Table 2-5). No adult surf clams were collected in the five tows conducted within Area B located near Manasquan Inlet (Table 2-4 and Table 2-5). Subequent to this survey, the size of Borrow Area B was increased to accommodate sand quantities required for the project so additional surf clam tows were conducted within the entire borrow area in October, 2001. During this study, adult surf clams were taken in 72% of the dredge tows coducted in Borrow Area B. Among the 25 tows conducted, approximately 6,400 surf clams were collected. The estimated number of clams collected per tow averaged 256 and ranged as high as 1,050 clams. Density estimates for the borrow area averaged 11.9 clams/100 sq. ft. and ranged to 69.6 clams/100 sq. feet. Overall, the standing stock of adult surf clams of Borrow Area B was estimated to be 1.86 million clams. The distribution of clams within the borrow area is patchy, however. No clams were collected in the 1999 survey of Borrow Area B and the five Borrow Area B stations that were sampled in 1999 and repeated in 2001 also produced no clams.

The hard clam is the most economically important shellfish of the back bays, supporting both commercial and recreational fisheries (N.J. Bureau of Fisheries, 1979). Although data on exact locations and densities of adult hard clams within the project area is limited, they are known to be found in the intertidal and subtidal zones of bays and lower estuaries.

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 backbay 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).

Table 2-4 Surf Clams (*Spisula Solidissima*) Collected at Borrow Areas and Reference Stations

Sample #	Bushels of material/ tow[1]	Mean # live of clams/ Bushel of material[2]	Tow time (seconds)	Actual or estimated # of live clams/tow	Bushels of live clams/ five-minute tow	Area sampled (sq ft)	Density (clams/100 sq ft)	Mean clam size (cm)
Borrow A								
1			21	8	1.7	1737	0.5	14.0
3			34	0	0	1503	0.0	-
4			17	0	0	700	0.0	-
5	10.3	22	80	227	12.6	2905	7.8	14.8
6			27	103	16.9	1462	7.0	13.7
7			45	7	0.7	1951	0.4	14.4
8			54	2	0.2	2151	0.1	13.5
9	17	41.3	300	703	10.4	5889	11.9	13.6
10			18	1	0.2	1350	0.1	14.6
11			15	56	16.5	1420	3.9	13.7
12			20	2	0.4	1513	0.1	13.5
13			40	3[3]	0.3	200	1.5	-
14			25	105	18.6	2590	4.1	14.6
19	19	30	277	570	9.1	1121	50.9	13.8
27			190	167	3.9	4898	3.4	14.0
Mean				130	6.1	2093	6.1	14.0
Borrow B								
3			270	0	0	5848	0	-
6			30	0	0	1750	0	-
8			35	0	0	1732	0	-
9			120	0	0	2369	0	-
10			30	0	0	1165	0	-
Mean				0	0	2573	0	
Nearby Reference								
R1			18	0	0	1258	0	-
R2			158	56	0.8	3334	1.7	14.7
R3			38	144	8.7	2107	6.8	12.6
R4	5.3	74	18	392	50.3	1656	23.7	12.2
Mean				148	15.0	2089	8	13.2

1. Number of bushels of material when catch was subsampled
2. Calculated as the mean of 3 bushels counted; for tows collecting less than 3 bushels, all clams were counted
3. Clams were broken and not measurable

Table 2-5 Summary of Adult Surf Clam Stocks in Borrow Areas, Nearby Reference Areas, and Long Beach Island Regional Reference Areas

Area	Area (acres)	# of Dredge Tows	Mean # of Clams/ Tow	Mean Area Dredged/Tow (sq ft)	Mean Density (Clams/ 100 sq ft)	Total Surf Clam Stock (million)
Area A	460	15	130	2093	6.1	1.2 ± 1.2
Area B (1999)	130	5	0	2573	0	N/A
Area B (2001)	360	25	256	2929	11.9	1.8
Nearby Reference		4	148	2089	8	N/A
LBI Area A	846	18	1475	4224	32.6	12.0 ± 4.4
LBI Area B	273	7	21	4305	0.4	0.05 ± 0.06
LBI Area D	510	11	198	4118	4.1	0.9 ± 1.1
LBI Area E	273	5	1791	3951	65.6	7.8 ± 8.0
N/A =Not Applicable						

2.2.14.4 Prime Fishing Areas

Mapping of the two proposed borrow areas indicates that these areas do not fall within the boundaries of any NJDEP designated Sport and Commercial Fishing Grounds/ Prime Fishing Areas (Figure 2-5). In correspondence dated February 19, 1999, January 5, 2000, and September 28, 2001, NJDEP, Division of Fish and Wildlife, concurred with this mapping and approved the areas for use for beach nourishment activities (See Appendix G). An additional potential sand source has been delineated on Figure 2-7 that lies outside the three-mile limit. During the Pre-Construction Engineering and Design (PED) Phase of the study, the area will be further evaluated, and a borrow area(s) will be identified to provide sand for periodic nourishment beyond Year 24. Coordination will be conducted with the appropriate resource agencies during the next phase of the project and specific borrow sources will be delineated that do not fall within the boundaries of any NJDEP designated Sport and Commercial Fishing Grounds/ Prime Fishing Areas.

Several locations within the study area such as the “Seaside Lumps” and “Fish Heaven” are classified as Prime Fishing Areas (NJAC 7:7E-3.4) by NJDEP (Figure 2-5). Prime Fishing Areas include tidal water areas and water’s edge areas, which have a demonstrable history of supporting a significant local quantity of recreational or commercial fishing activity. These areas were delineated by Long and Figley (1984) in a publication titled “New Jersey’s Recreational and Commercial Ocean Fishing Grounds.” Other important fish habitats, which are considered to be Prime Fishing Areas within the study area, include artificial reefs, wreck sites, groins and jetties. Two large artificial reefs are located offshore of the project area. One reef is located off the northern edge of the study area, approximately 4 miles east of Manasquan Inlet. The second artificial reef is located approximately 2.5 miles east of Mantoloking.

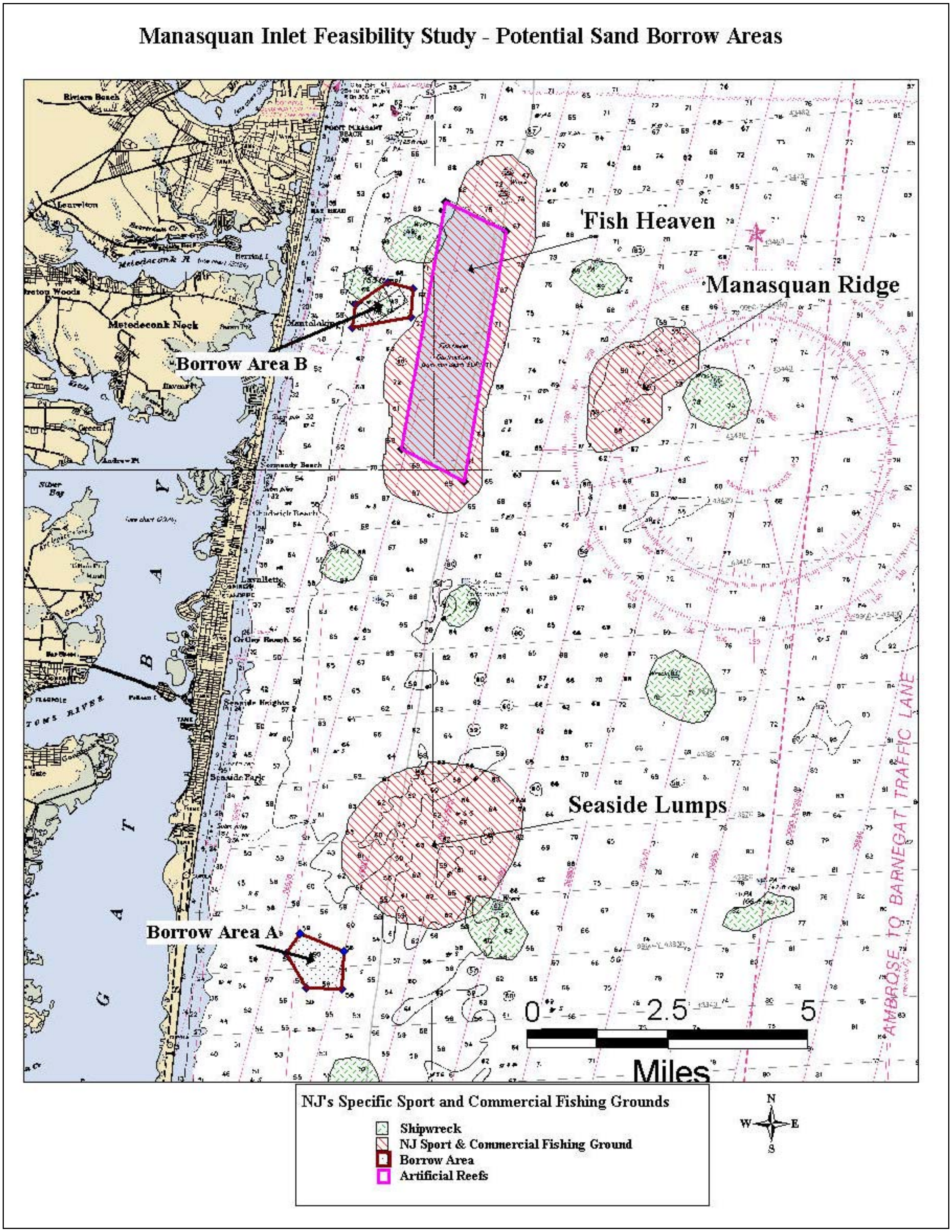


Figure 2-5 Prime Fishing Areas

Preliminary cultural resources surveys have identified 19 “high probability underwater remote sensing targets” in the nearshore project area (Figure 2-6). While the identification of these targets, and their exact position and depth of sand coverage is not currently known, 7 of the sites have been tentatively identified as nearshore wreck sites frequented by local divers (Dolan Research, 2001). These 7 targets/wrecks, and any of the other targets which are not completely buried, may represent important fish habitat within the project area. Further investigations will be conducted on the 19 targets during PED in order to determine their significance as cultural resources, fisheries habitat, and recreational resources. Further investigations will also be necessary on any potential borrow areas identified outside the three-mile limit.

2.2.14.5 Essential Fish Habitat

Under provisions of the reauthorized Magnuson-Stevens Fishery Conservation and Management Act of 1996, the entire study area including the borrow areas, nearshore and intertidal areas were designated as Essential Fish Habitat (EFH) for species with Fishery Management Plans (FMP’s), 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 27 species of managed fish and shellfish. Table 2-6 presents the managed species and their life stage for which EFH is identified within the 10 x 10 minute squares (#14, 19 and 20) that cover the study area. These squares are within the seawater biosalinity zone (NOAA, 1999). The habitat requirements for identified EFH species and their representative life stages are provided in Table 2-7.

Table 2-6 Species with EFH Designation in Squares 14, 19, and 20 (NOAA, 1999)

MANAGED SPECIES	EGGS	LARVAE	JUVENILES	ADULTS
Atlantic cod *(Gadus morhua)*				14, 20
Whiting (*Merluccius bilinearis)*	19, 20	19, 20	19, 20	14, 19, 20
Red hake *(Urophycis chuss)*	14, 19, 20	14, 19, 20	14, 19, 20	
Redfish *(Sebastes fasciatus)*	n/a			
Witch flounder (*Glyptocephalus cynoglossus)*	14			
Winter flounder (*Pleuronectes americanus*)	14, 19, 20	14, 19, 20	14, 19, 20	14, 19, 20
Yellowtail flounder *(Pleuronectes ferruginea)*	19, 20	14		
Windowpane flounder *(Scopthalmus aquosus)*	14, 19, 20	14, 19, 20	14, 19, 20	14, 19, 20
Ocean pout *(Macrozoarces americanus)*	14, 19, 20	14, 19, 20		14, 19, 20
Atlantic sea herring *(Clupea harengus)*			19, 20	14, 19, 20
Monkfish *(Lophius americanus)*	14, 19, 20	14, 19, 20		
Bluefish *(Pomatomus saltatrix)*			14, 19, 20	14, 19, 20
Long finned squid *(Loligo pealei)*	n/a	n/a		
Short finned squid *(Illex ilecebrosus)*	n/a	n/a		
Atlantic butterfish *(Peprilus tricanthus)*			19, 20	
Summer flounder (*Paralicthys dentatus)*		19, 20	14, 19, 20	14, 19, 20
Scup (*Stenotomus chrysops)*	n/a	n/a	14, 19, 20	14, 19, 20
Black sea bass *(Centropristus striata)*	n/a		14, 19, 20	14, 19, 20
Surf clam *(Spisula solidissima)*	n/a	n/a	14, 19, 20	14, 19, 20
Ocean quahog *(Artica islandica)*	n/a	n/a		
Spiny dogfish *(Squalus acanthias)*	n/a	n/a		
King mackerel *(Scomberomorus cavalla)*	14, 19, 20	14, 19, 20	14, 19, 20	14, 19, 20
Spanish mackerel *(Scomberomorus maculatus)*	14, 19, 20	14, 19, 20	14, 19, 20	14, 19, 20
Cobia *(Rachycentron canadum)*	14, 19, 20	14, 19, 20	14, 19, 20	14, 19, 20
Dusky shark *(Charcharinus obscurus)*		14, 19, 20		
Sandbar shark *(Charcharinus plumbeus)*		14, 19, 20	14, 19, 20	14, 19, 20
Tiger shark *(Galeocerdo cuvieri)*		14	14	

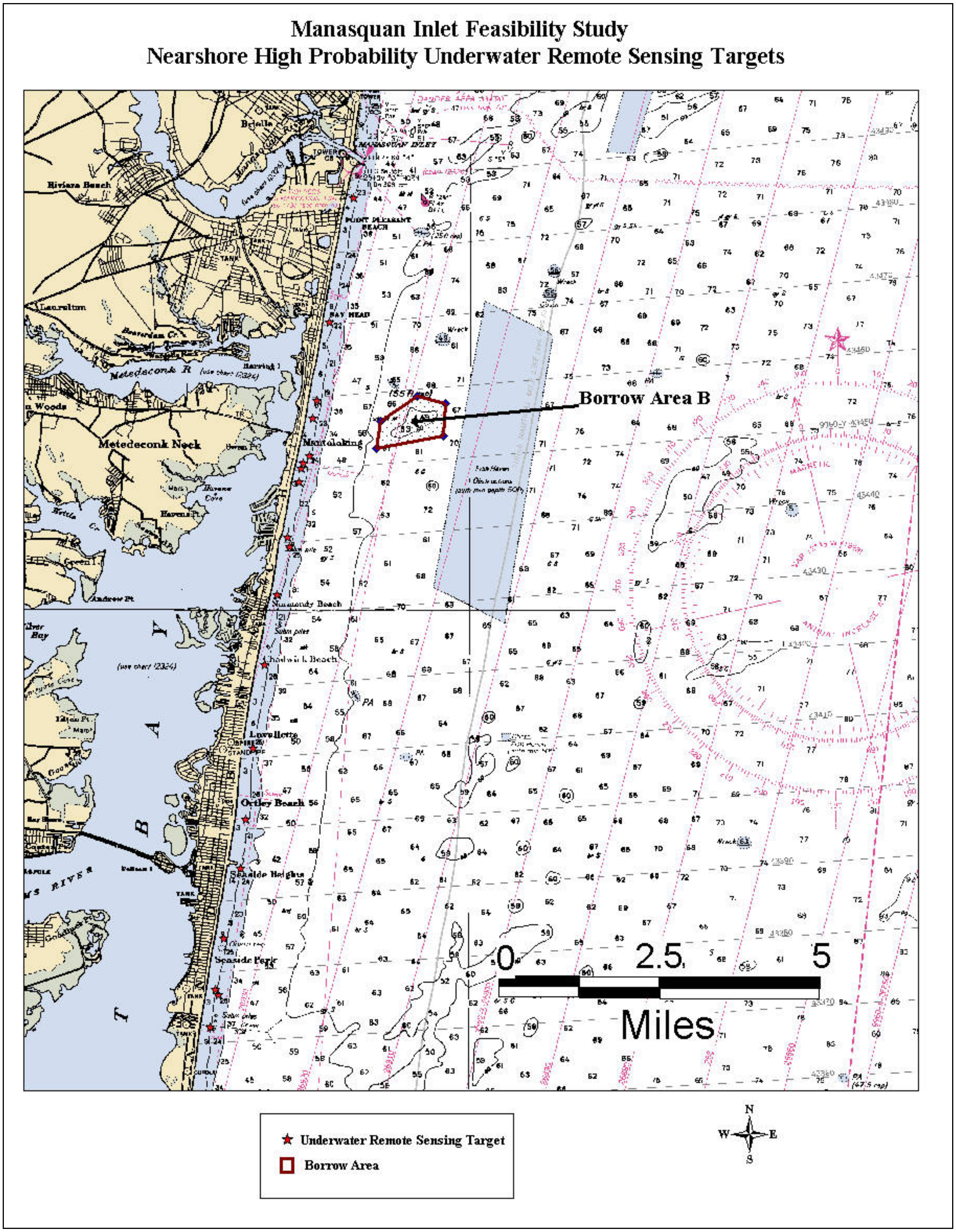


Figure 2-6 Location of Remote Sensing Targets Identified by Cultural Resources Survey

Table 2-7 Habitat Utilization of Identified EFH Species for Representative Life Stages

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)* (Morse et al. 1998)	**Habitat:** Pelagic continental shelf waters in preferred depths from 50-150 m.	**Habitat:** Pelagic continental shelf waters in preferred depths from 50-130 m. (Morse et al. 1998)	**Habitat:** Bottom (silt-sand) nearshore waters in preferred depths from 150-270 m in spring and 25-75 m in fall. **Prey:** fish, crustaceans (euphasids, shrimp), and squids (Morse et al. 1998)	
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 m and bottom at 35-40 m. 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).	
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:**	**Habitat:**	**Habitat:** Young of the year (YOY) are demersal, nearshore 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

MANAGED SPECIES	EGGS	LARVAE	JUVENILES	ADULTS
Yellowtail flounder *(Pleuronectes ferruginea)* (Johnson et al., 1998)	**Habitat:** Pelagic waters ranging from 10 to 750 m	**Habitat:** Pelagic waters **Prey:** Polychaetes		
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 nearshore 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 nearshore bays and estuaries less than 75 m **Prey**: small crustaceans (mysids and decapod shrimp) polychaetes and various fish larvae
Ocean pout *(Macrozoarces americanus)* (Steimle et. al., 1998)	**Habitat:** Demersal, cool waters across the continental shelf	**Habitat:** Coastal and saline (>25ppt) estuarine waters		**Habitat:** Intertidal areas across continental shelf and on upper continental slope to about 200 m. **Prey:** Variety of benthic inverts, including polychaetes, molluscs, crustaceans, and echinoderms
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.	**Habitat:** Pelagic waters; found in Mid Atlantic estuaries April – Oct.
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 in 10 – 360 m	
Summer flounder *(Paralicthys dentatus)*		**Habitat:** Pelagic waters, nearshore at depths of 10 – 70 m from Nov. – May	**Habitat:** Demersal waters (mud and sandy substrates)	**Habitat:** Demersal waters (mud and sandy substrates). Shallow coastal areas in warm months, offshore in cold months
Scup *(Stenotomus chrysops)*	n/a	n/a	**Habitat:** Demersal waters	**Habitat:** Demersal waters offshore from Nov – April

MANAGED SPECIES	EGGS	LARVAE	JUVENILES	ADULTS
Black sea bass *(Centropristus striata)*	n/a		**Habitat:** Demersal waters over rough bottom, shellfish and eelgrass beds, man-made structures in sandy-shelly areas and wintere off shore at depths of 1-38 m in shell beds and shell patches	**Habitat:** Demersal waters over structured habitats (natural and man-made), and sand and shell areas and winters off shore at depths of 25-50 m in shell beds and shell patches.
Surf clam *(Spisula solidissima)*	n/a	n/a	**Habitat:** Throughout bottom sandy substrate to 60 m depth	**Habitat:** Throughout bottom sandy substrate to 60 m depth
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	**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
Spanish mackerel *(Scomberomorus maculates)*	**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	**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
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. 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	**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
Sand tiger shark *(Odontaspis taurus)*		**Habitat:** Shallow coastal waters, bottom or demersal		**Habitat:** Shallow coastal waters, bottom or demersal
Dusky shark *(Charcharinus obscurus)*		**Habitat:** Shallow coastal waters		
Sandbar shark *(Charcharinus plumbeus)*		**Habitat:** Shallow coastal waters	**Habitat:** Coastal and pelagic waters	**Habitat:** Shallow coastal waters
Tiger shark *(Galeocerdo cuvieri)*		**Habitat:** Shallow coastal waters	**Habitat:** Shallow coastal waters	

2.2.15 Birds

Nesting activity by mallards (*Anas platyrhynchos*) and black ducks has been documented in the study area. The U.S. Fish and Wildlife Service has identified 23,250 acres in and adjacent to Barnegat Bay as key wintering areas for black ducks. In New Jersey, black ducks winter primarily in tidal estuary systems where they feed on macroinvertebrates and aquatic vegetation. Other species of waterfowl likely to utilize upper Barnegat Bay for wintering include: American widgeon (*Anas americana*), canvasback (*Aythya valisineria*), greater scaup (*Aythya marila*), goldeneye (*Bucephala clangula*), oldsquaw (*Clangula hyemalis*), common merganser (*Mergus merganser*), and Canada goose (*Branta canadensis*).

The Barnegat Bay area of New Jersey also provides high quality habitat for migratory shorebirds. Specifically, many of the islands in Barnegat Bay (Clam and Sedge Islands), and the isolated or undeveloped marshes and beaches on Long Beach Island and the mainland, provide nesting ground for a wide variety of shorebirds. Erwin and Korschgen (1979) confirmed colonial nesting of the following bird species within the study area: glossy ibis (*Plegadis falcinellus*), green-backed heron (*Butorides striatus*), little blue heron (*Egretta caerulea*), snowy egret (*Egretta thula*), great egret (*Casmerodius albus)*, black-crowned night heron (*Nycticorax nyticorax*), yellow-crowned night heron (*Nyctanassa violacea*), great black-backed gull (*Larus marinus*), herring gull (*Larus argentatus*), laughing gull (*Larus atricilla*), least tern (*Sterna antillarum*), black skimmer (*Rynchops niger*) and common tern (*Sterna hirundo*).

In addition to nesting colonies of the species listed above, many species of shorebirds utilize high-energy beaches for feeding, including: ringed plovers (*Charadrius sp.*), golden plovers, (*Pluvialis sp.*), stints (*Calidris sp.*), and ruddy turnstone (*Arenaria interpres*). Both the biomass and species composition of infaunal communities are critical for supplying the nutritional needs of shorebirds, especially during spring and fall migrations.

Some of the local inhabitants that can be expected in the area of Island Beach State Park are as follows: black duck (*Anas rubripes*), oldsquaw (*Clangula hyemalis*), common loon (*Gavia immer*), great black-backed gull (*Larus marinus*), herring gull (*Larus argentatus*), ring-billed gull (*Larus delawarensis*), dunlin or red-backed sandpiper (*Calidris alpina*), semipalmated sandpiper (*Calidris pusilla*), sanderling (*Calidris alba*), eastern willet (*Catoptrophorus semipalmatus*), black-bellied plover (*Pluvialis squatarola*), American oystercatcher (*Haematopus palliatus*), northern harrier (*Circus cyaneus*), snow bunting (*Plectrophenax nivalis*), hooded merganser (*Lophodytes cucullatus*), yellow-rumped warbler (*Dendroica coronata*), mallard duck (*Anas platyrhynchos*), double-crested cormorant (*Phalacrocorax auritus*), glossy ibis (*Plegadis falcinellus*), roseate tern (*Sterna dougallii*), and gadwall (*Anas strepera*).

2.2.16 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 mink (*Mustela vison*). In addition, gray fox (*Urocyon cinereoargenteus*), and river otter (*Lutra canadensis*) have been identified on colonial seabird islands. In the back bays and ocean front of the project area, the harbor seal (*Phoca vitulina*) has been observed as a winter visitor. The seals have been observed, generally from the end of September through April in the back bays and along the Inlet on the southern end of Island Beach State Park. They have also recently been observed on some of the islands inside Manasquan Inlet (Personal Communication; Marine Mammal Stranding Center 2001).

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*), 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.

2.2.17 Threatened and Endangered Species

The federally-listed (threatened) and state-listed (endangered) piping plover (*Charadrius melodus*) has historically nested within the study area, including Mantoloking, and occasionally along the beach at Island Beach State Park, according to NJDEP and U.S. Fish and Wildlife field surveys. No birds have nested in these areas since 1997, due in part to the eroded conditions of the shoreline at Mantoloking and excessive levels of red fox predation throughout the study area. 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, washover 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 washover areas, mudflats, sandflats, wrack lines (organic material left behind by high tide), shorelines of coastal ponds, lagoons, and salt marshes.

The least tern (*Sterna antillarum*), a State endangered species, has nested (rarely) at the south end of Island Beach State Park, and on various dredged material islands in the back bay and inlets. The back bay islands and marshes also host nesting colonies of black skimmer

(*Rynchops niger*), a State endangered species. . The State threatened yellow-crowned night heron and the black-crowned night heron can also be found nesting in the back-bay areas.

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 overwash 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.

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 (*Caretta caretta*) sea turtle. These sea turtles may be found in New Jersey's continental shelf waters, inshore bays and estuaries from late spring to mid-fall. 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 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.

2.2.18 Recreation

Recreational opportunities abound within the study area, drawing millions of people to Ocean County each year. The beaches are the primary attraction, however varieties of wildlife-oriented activities are also available. The beaches along Island Beach State Park 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 Fish Heaven and Seaside Lumps are popular destinations for sport fishermen. Island Beach State Park 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.

2.2.19 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 Island Beach State Park, the beachfront of the study area is developed with homes, condominiums, businesses, boardwalks and promenades. However, these resort 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. Island Beach State Park offers visitors a more natural aesthetic quality with natural beaches, vegetation, wildlife, and surf.

2.2.20 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

There have been limited cultural resources investigations previously conducted in the general project vicinity. The most extensive study was conducted in 1975-1978 from South Mantoloking south to South Seaside Park. No prehistoric or historic cultural resources were located. A more localized investigation of Clark's Landing on the Manasquan River in Point Pleasant identified late 1800's amusement park related features. Architectural surveys have included an evaluation of late 19th century structures related to the Bluffs Hotel at Bay Head, National Register nomination of Life-Saving Station 14 in Island Beach State Park, and State Historic Preservation Officer opinion on the National Register eligibility of the Point Pleasant

Beach U.S. Coast Guard Station. The historic architecture of several area communities was recorded in detail by the Ocean County Cultural and Heritage Commission. A remote sensing survey of Barnegat Inlet was completed in 1979 in association with beach erosion control, navigation and flood protection proposals. The study identified three potential shipwrecks, but precise locations were not determined.

The Philadelphia District has completed three cultural resources studies in the general and immediate project area. The first study, entitled "A Phase 1A Cultural Resources Investigation of the Manasquan River Basin, Monmouth and Ocean Counties, New Jersey" (Hunter Research Inc. 1993), generated a cultural resource data base for the Manasquan River watershed as a planning tool in the development of flood control improvements in the 80 square mile basin. Initiated as part of the present study, the second investigation entitled "Phase 1A Cultural Resources Investigations, Manasquan Inlet to Barnegat Inlet, Ocean County, New Jersey" (Hunter Research Inc. 1997) compiled existing cultural resource information from archival and historic map sources to identify known and expected historic properties in the project area. In addition, a low-tide pedestrian archeological survey was conducted along the shoreline in the northern portion of the project area from Manasquan Inlet to the northern boundary of Island Beach State Park. One possible shipwreck site was identified in the near-shore surf zone. In the third study, entitled "Phase I Submerged and Shoreline Cultural Resources Investigations, Manasquan Inlet to Barnegat Inlet, Ocean County, New Jersey" (Dolan Research, Inc. 2001), researchers investigated proposed project offshore borrow areas, submerged near-shore locations, and terrestrial shoreline areas utilizing magnetometer, side-scan, and bathymetric data collection techniques. Nineteen remote sensing targets exhibiting shipwreck characteristics were identified in the submerged portion of the near-shore area.

The following historical summary is taken directly from the above referenced reports. The majority of documented prehistoric sites in the project vicinity are from the Woodland Period and are concentrated around the tidal estuaries of the Barnegat Bay and Manasquan Rivers. Notable features of the archaeology of this area are shell-middens and Native American burials. No burials are recorded from the Atlantic shoreline itself. Three prehistoric sites have been documented in the project area, including sites in Point Pleasant Beach and Ortley Beach, Dover Township. The recent discovery of a Paleo-Indian fluted point in Island Beach State Park is a significant find from this early period along the New Jersey shore.

The increasing population of the area in the third quarter of the 19th century led to the establishment of a number of incorporated communities from 1886 onward. These include Bay Head Borough (1886), Island Beach Borough (1933-1965), Lavallette Borough (1887), Mantoloking Borough (1911), Point Pleasant Beach Borough (1886), Seaside Heights Borough (1913) and Seaside Park Borough (1898). Some unincorporated areas remain in the project area and fall within Brick, Dover and Berkeley Townships.

A review of the historic map coverage of the project area documents the development of the shore from a barely-inhabited barrier island to a fully developed resort community. At the time of the 1776 Holland Map no settlements or isolated dwellings were shown on the barrier islands. The mainland area is described as "Sandy Barren Deserts", and only one road reached the coast in the project area, opposite Barnegat Inlet. A second inlet, identified as "New Inlet" lay north of Barnegat Inlet in the area of the present Tom's River. By 1850, eight individual structures, five of them with owner's names attached, are shown on the island. The New Inlet of 1776 was subsequently renamed Cranberry Inlet but is marked as closed on the 1850 map. It had apparently filled in by about 1812.

The 1872 Beers map shows a minor increase in recreational use of the region. The development of Point Pleasant continues and three roads lead to the shoreline from the Manasquan River area. Numerous hotels and boarding houses shown include the Ocean Hotel and Cook property near the Manasquan River, Chadwick's Hotel in Chawick, an unnamed hotel in the present Seaside Heights, and Reed's Hotel within the present limits of Island Beach State Park. Three life saving stations are also shown.

An 1878 map shows two planned seaside resort communities in the project area, Lavallette and Seaside Heights, and six life-saving stations, all numbered on the national system and given identifying names. By 1883, a railroad connection ran down the Island from the north as far down as Seaside Park, from where it crossed Barnegat Bay south of Toms River. Since the late 19th century much of the remainder of the coast has been developed. Island Beach State Park was set aside prior to World War II, during which time this area was used for missile development and testing. The park was formally opened in 1959.

Between 1848 and 1878, a total of at least 125 shipwrecks have been documented off the Atlantic coastline between Barnegat Inlet and Manasquan Inlet. A single historic vessel has been archaeologically recorded in the project area. In 1988, the remains of a boat were located at the intersection of the southbound lane of Route 35 with Fielder Avenue in Ortley Beach, about 250 yards west of the shore. The vessel was undated.

The United States Life-Saving Service was created in 1848 and fully organized in 1871. The Sandy Hook - Barnegat Coast was the first in the nation to receive life-saving stations at Government expense. The 1898 U.S. Life-Saving Station #14 at Island Beach State Park is listed on the National Register of Historic Places and the Point Pleasant Beach Coast Guard Station is considered eligible for listing. The USACE has been involved in beach fill programs in the region since 1957.

2.4 Geotechnical Analysis

2.4.1 Geomorphology

The study area of the central coast of New Jersey lies within the coastal plain province of Eastern North America. In New Jersey, the province extends from a line through Trenton and Perth Amboy southeastward for approximately 150 miles to the edge of the continental shelf. The land portion of the province is bounded on the northeast by the Raritan Bay and on the west by the Delaware River. The line of maximum elevation run from the Navesink Highlands southeastward to the Mt. Holly area, with the land rising gradually from the sea as a moderately dissected plain to an elevation of approximately 300 feet in the center, from where it slopes toward the Delaware River and Raritan River drainage systems. The submerged portion of the plain slopes gently southeastward at 5 or 6 feet per mile for nearly 100 miles to the edge of the continental shelf. The surface of the shelf consists of broad swell and shallow depressions with evidence of former shorelines and extensions of river drainage systems.

The Atlantic coastal shelf is essentially a sandy structure with occasional silty, gravelly or cobble deposits. It extends from Cape Cod to Florida, and is by far the world's largest sandy continental shelf.

2.4.2 Physiography

The New Jersey shoreline can be divided into those sections where the sea meets the mainland, at the northern and southern ends of the State, and where the sea meets the barrier beaches, in the central portion of the State. The barrier beaches extends from Bay Head, down the coast for approximately 90 miles and is continuous, except for the interruption by 10 inlets. The shoreline of the study area, extends for approximately 24 miles, from Point Pleasant Beach to Island Beach State Park and lies predominately within the barrier beach section.

2.4.3 Barrier Islands

The New Jersey barrier islands belong to a landform susceptible to comparatively rapid changes. In this study area the barrier islands range in width from 600 feet to about 5,000 feet. Landward of the barrier islands and inlets of the study area are tidal bays, which range from three to five miles in width. These bays have been filled by natural processes until much of their area is covered with tidal marshes. The remaining water area consists of smaller bays connected by water courses called thoroughfares. Four geologic processes are considered to be responsible for the detritus (or loose material) in the bay area. Stream sedimentation which contributes a small amount of upland material, waves washing over the barrier during storms, direct wind action blowing beach and dune sand into the lagoon, and the work of tidal currents which normally bring more sediments in suspension from the ocean on flood tide than on ebb tide. The vegetation of the lagoon, both in marsh and bay, serves to trap and retain the sediments.

2.4.4 Drainage of the Coastal Plain

The stream drainage pattern of the New Jersey coastal plain was developed at a time when sea level was lower then 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, N.J., a distance of 134 miles. The formation of the barrier islands removed all direct stream connection with the ocean between Barnegat Bay and Cape May. These streams now flow into the lagoons formed in the back of these barrier islands and their waters reach the Atlantic Ocean by way of the inlets. The significance of these features of the drainage system to the problem 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.

2.4.5 Geologic History

The sea successfully advanced and retreated across the 150-mile width of the Coastal Plain during the Cretaceous and Quaternary time. 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 advances brought a lowering in sea level as water was locked up in the hugh ice masses. As the sea level fell to a beach line miles 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 inland of the present shore.

2.4.6 Surficial Deposits

The coastal plain of New Jersey consists of beds of gravel, sand and clay, which dip gently towards the southeast, and certain fossils showing them to be of the Cretaceous, Tertiary, and Quaternary ages. The older and lower layers appear at the surface along the northwest margin of the coastal plain and pass beneath successively younger strata in the direction of their dip. The parallel outcrops of successive strata make this a belted coastal plain. Since the formations dip toward the southeast, successively younger layers appear along the shore and progresses southward. These formations have contributed to the sands of the present beaches. Between Bay Head and Cape May City, the coastal lagoons, tidal marshes and barrier islands fringe the coast. 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 30 to 40 feet higher than at present. The material was deposited along valley bottoms, grading into the estuarine and marine deposits of the former shoreline. There is a cap of 2 to 3 feet of Cape May formation in most places along the New Jersey coast. This cap is of irregular thickness and distribution and generally forms a terrace about 25 to 35 feet 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.

2.4.7 Subsurface Geology

The Atlantic coastal plain consists of sedimentary formations overlying a crystalline rock mass known as the “basement.” From well drilling logs, it is known that the basement surface slopes at about 75 feet per mile to a depth of more than 6,000 feet 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 beds of lower Cretaceous sediments. These beds vary greatly in thickness, increasing seaward to a maximum thickness of 13,000 feet then decreasing to 8,000 feet near the edge of the continental shelf. On top of the semi-consolidated material lie unconsolidated sediments of Upper Cretaceous and Tertiary formation. These materials, in relatively thin beds on the land portion of the coastal plain, increase in thickness to a maximum of 5,000 feet near the edge of the continental shelf.

2.4.8 Borrow Areas/Sand Sources

In an attempt to locate potential sources of borrow sand for beach fill operations, several extensive investigations were conducted along the study area in the Atlantic Ocean. These investigations have resulted in the delineation of two borrow areas with sufficient material for the initial fill and first several nourishment cycles. Additional areas will be identified for future nourishment cycles in the area outside the three-mile limit and will be further investigated during PED phase.

In July of 1997, Woodward-Clyde Federal Services was contracted to obtain subsurface geo-acoustic data and subsequent vibracores within 3 miles of the shoreline along the study area and beyond the depth of closure. Approximately 100 miles of sub-bottom geophysical survey lines were conducted along with the acquisition of 45 vibracores. The results of this work indicated that delineating potential borrow areas was going to require additional investigation. The samples obtained through vibracoring contained predominately very fine-grained soils ranging from clays and silts to very fine sands. Where coarser grained materials were found, the distance between these cores or the randomness of their location made it impossible to specifically identify a potential borrow area. Woodward-Clyde recommended several areas for further investigation. These included several shoals and offshore of Seaside Park and the north end of Island Beach State Park.

Between July of 1998 and June of 2000, Duffield Associates of Wilmington, DE was contracted to continue the investigation to obtain new vibracores and conduct geophysical surveys within the vicinity of several shoals and offshore of Seaside Park and the north end of Island Beach State Park. The results of this investigation permitted the preliminary delineation of a large potential borrow area approximately 2 miles offshore of the north end of Island Beach State Park and a smaller area approximately 1.75 miles offshore of Mantoloking. The area offshore of Mantoloking is an apparent shoal. The results of these investigations have shaped the extent of the borrow areas as they appear in Figure 2-7.

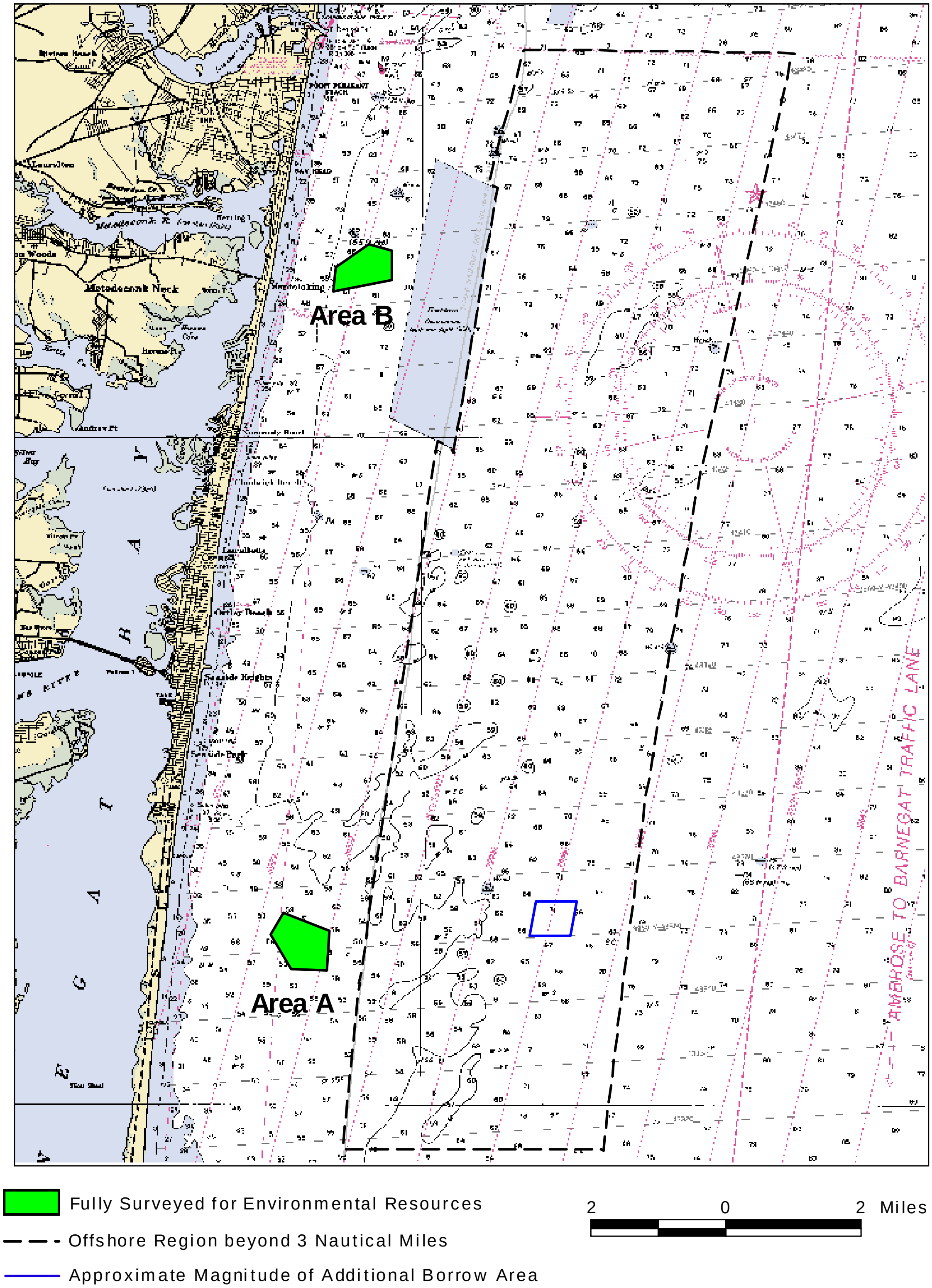


Figure 2-7 Identified Borrow Areas

2.4.8.1 Identified Borrow Areas

Borrow Area A is located about 2.25 miles offshore of the northern end of Island Beach State Park. This area is approximately 460 acres in size and contains approximately 11.2 million cubic yards of suitable beach fill material with a maximum disturbance depth of approximately -81 feet NAVD. The mean grain size of the sand located within this area is 0.3 mm. This material is proposed for use as fill from Berkeley Township northward through Brick Township (cells 1 through 7 -- see Figure 3-6 for cell delineation).

Borrow Area B is located about 1.75 miles offshore of Mantoloking, NJ. This area is approximately 360 acres in size and contains approximately 6.3 million cubic yards of suitable beach fill material with a maximum disturbance depth of approximately -81 feet NAVD. The mean grain size of the sand located within this area is 0.36 mm. This material is proposed for use as fill at Mantoloking, Bay Head, and Point Pleasant Beach (cells 8 through 11). Table 2-8 provides coordinates that delineate bounds of the identified borrow areas.

Table 2-8 Identified Borrow Area Bounding Coordinates

Point	New Jersey 2900 State Plane Coordinates NAD 83 Datum		Latitude (deg, min, sec)	Longitude (deg, min, sec)
	Northing (ft)	Easting (ft)		
Borrow Area A				
1	379920	618820	39 52 32	74 02 55
2	376700	620700	39 52 00	74 02 31
3	376655	624050	39 52 00	74 01 48
4	380210	624210	39 52 35	74 01 46
5	381845	620060	39 52 51	74 02 39
Borrow Area B				
1	440935	624865	40 02 35	74 01 33
2	438755	624555	40 02 13	74 01 37
3	439800	630020	40 02 23	74 00 27
4	442500	630020	40 02 50	74 00 27
5	443050	627840	40 02 56	74 00 55

Maps from the State of New Jersey Department of Environmental Protection delineating areas of no dredging because of historical fishing operations were compared to the selected borrow areas to ensure no overlap with restricted areas. Benthic and archeological surveys have been completed for Area A and Area B, as indicated by the shaded areas in Figure 2-7. Further archeological and benthic surveys are currently being planned for the next phase of study for the off-shore areas being considered for nourishment after year 24. Final borrow area delineation will be coordinated during the PED phase.

Two areas were proposed as potential borrow sites in the Reconnaissance Report, including an area approximately 2 miles offshore of Seaside Heights and an area in the vicinity of Manasquan Inlet. These areas were originally identified using preliminary information from navigation charts and general studies. Based on feasibility investigations, neither of these proposed areas appears to have suitable quality or quantity of beach fill material, and these areas were not considered further in this study.

2.4.8.2 Compatibility of Identified Sources with Existing Beach Sand

A beach profile and sediment sampling survey was conducted by Offshore & Coastal Technologies, Inc. during October 1997. Eight sediment grab samples were collected along each of thirteen survey lines. Based on analysis of these samples, the existing beach material was found to be predominately medium sand with a mean particle diameter ranging between 0.3 and 0.6 mm. Utilization of the ACES computer program resulted in an average overfill factor of 1.5 due to the coarse nature of the existing beach material as compared to the finer sand found in the borrow areas.

2.4.8.3 Potential Alternate Sand Sources

Material outside of Areas A and B may be required at a later point in the project life, assuming no future infilling of the borrow areas with sufficient quality and quantity of material. Based on estimated quantities for the selected plan presented in Section 5, approximately 6 million additional cubic yards may be required for nourishment after year 24. Following initial construction, there is potential that sand placed in the project area will migrate into the Manasquan Inlet area and provide a possible future borrow source which could be used to recycle material back into the project area. The inlet area will be further investigated as a potential source prior to future periodic nourishment activities. Investigations will evaluate sand quality and quantity in the inlet system, and assess potential impacts to inlet stability and dynamics, and adjacent shorelines impacts associated with removing material from the inlet.

Through coordination with representatives of the New Jersey Geologic Survey, potential alternate sand sources have been identified in areas beyond the three-mile limit of coastal waters. The District historically understood sources outside the three-mile limit to be cost prohibitive due to payments that would have to be made to Minerals Management Service. Recently it has been determined that Corps projects can be exempted from tariffs on the use of such material by Memorandum of Agreement between the USACE and the Minerals Management Service. Therefore, areas beyond the three-mile limit are feasible as a future borrow source.

Further investigation to define specific borrow areas beyond the three-mile limit will be completed during the PED phase of the study and as part of ongoing monitoring for future periodic nourishment, as needed. Any proposed future use of alternate areas will be fully coordinated with environmental and cultural resource agencies. Figure 2-7 shows the limits of the area, represented by a dashed line, from which additional sand may be acquired outside the three-mile limit in the future. The smaller box represents the approximately 6 million additional cubic yards that may be required for nourishment after year 24. The smaller box does not indicate the exact location of a future borrow area; it is provided to obtain perspective on the approximate acreage of sand required relative to the entire area of study outside the three-mile limit.

There is limited information for the area outside the 3-mile limit. Minerals Management Service (MMS) and New Jersey Geological Survey (NJGS) are conducting a study to find additional sources of sand along the coast. Bathymetric data and limited borings from MMS and NJGS indicate that there are large quantities of compatible sand; however, additional information is needed to determine specific borrow area(s) that will be acceptable for environmental and cultural requirements. Presently, we anticipate the use of a hopper dredge and a mooring barge for the beach filling due to the increased pumping distances for the three options.

The area delineated with a dashed line on Figure 2-7, represents the area to be assessed during the PED phase for sources of sand. The entire area extends from the extreme north end of the project area to the extreme south end and east of the three-mile limit an additional four miles. The cost of placing sand on the beach in each cell during periodic nourishment was determined based on the worst-case scenario, the best-case scenario, and the most-likely scenario, which is representative of the area. Each scenario was calculated based on an average pumping distance from the farthest location in the box, the closest location in the box, and an intermediate location, which is the most likely. Different techniques, such as high wall mining and trenching, were considered and factored into the analyses. As indicated in the following table, the costs of the periodic nourishment beyond year 24 do not have a significant impact on the project.

Periodic Nourishment	Cost per cycle	Average Annual Cost	BCR
Selected Plan	$ 7,334,000	$1,774,000	1.9
Option 1 (Worst Case)	$14,270,000	$2,169,000	1.8
Option 2 (Best Case)	$11,173,000	$1,993,000	1.8
Option 3 (Representative)	$11,761,000	$2,026,000	1.8

2.5 Hazardous, Toxic, and Radioactive Waste (HTRW)

A Hazardous, Toxic and Radioactive Waste (HTRW) Environmental Site Assessment for the subject study area was conducted by contract through Woodward-Clyde Federal Services during the reconnaissance phase of this study. The report of this assessment is included as Appendix C. The results of this assessment indicate that the impacts of HTRW on any beach filling in the study area will be minimal and further investigation will not be required unless significant changes are made to the current plan.

2.6 Ordnance and Explosive Waste (OEW)

The Formally Used Defense Sites (FUDS) database was searched to ensure that there was minimal potential of the presence of OEW in the study area, especially within the potential borrow areas. Only one site was listed on the database. A complete investigation and report was completed by the USACE, Rock Island District, for the Island Beach Test Site located in what is now Island Beach State Park. This site was used briefly after WWII for the propulsion testing of early ramjets, which were jet-powered, anti-aircraft missiles. The report concludes that only propulsion systems were tested at this site and that all the inert ramjets were fired over the island in a south-westerly direction into the Delaware Bay. There should be no impact from the activities of this site on the project.

2.7 Erosion Control Structural Inventory

2.7.1 Existing Structures

Data gathered on existing structures were grouped by cell. This includes structures constructed to control erosion (in this case, groins, bulkheads and seawalls) and those that do not control erosion but, because of their location and extent near existing shorelines, could contribute to estimated damages by erosion (boardwalks and outfall structures). Some cells do not have either of these types of structures. As-built drawings for existing erosion control structures were obtained from NJDEP and used in the assessment.

Significant existing erosion control structures include the bulkhead in Seaside Park (cell 2) which is 1350' long, and a stone seawall in Bay Head (cell 9) which is 4300' long. Both the bulkhead and the seawall are currently covered by dunes. Dunes extend for most of the length of the shoreline of the island with varying heights, the exception being cell 3 (Seaside Heights) and cell 11 (Point Pleasant Beach), which have no dunes. Typical survey profiles of the existing beach for each cell are included in Appendix A, Section 2.

Nine existing groins are located in Lavallette (cell 5) and 7 are located in Bay Head (cell 9). These groins consist of a timber portion at the landward end and a stone portion at the seaward end. The structure condition survey is included in Appendix A, Section 5.

The most significant non-erosion control structures located in the study area are boardwalks. Boardwalks exist in cells 2 (Seaside Park), 3 (Seaside Heights), 4 (Ortley Beach), 5 (Lavallette), and 11 (Point Pleasant Beach). These boardwalks were included in determining infrastructure damages produced by storms.

2.7.2 Infrastructure Replacement Costs

Infrastructure damages produced by storm-induced erosion were determined to estimate the cost of replacing utilities and public works within the project area. This was accomplished by evaluating the estimated without-project erosion line for a range of storm probabilities, once these lines were transferred onto topographic mapping. A combination of site investigations and additional utility mapping obtained from municipal engineer firms was also used to estimate the quantity of road pavement, sidewalks, under and above ground utilities, and other structures that would have to be replaced if subject to erosion.

Boardwalk damages were computed separate from infrastructure erosion damages. The pile-mounted boardwalk structures are typically not damaged by erosion, but by total water level and wave attack. Analyses were performed to determine the frequency at which the boardwalk structures are damaged and require replacement. Infrastructure erosion damages and boardwalk damages were quantified and combined to estimate total infrastructure replacement costs.

2.7.3 Bulkhead Failure Analysis

As part of the without-project analysis and as input to the storm erosion modeling efforts, a simplified bulkhead failure analysis was completed. This information was input into hydraulic modeling to determine at what point the erosion would continue beyond the existing bulkhead structures. This was simplified by assuming static equilibrium conditions and failure due to loss of sand seaward of the toe. The analysis involved assuming a level of erosion on the seaward side of the bulkhead and investigating ever smaller amounts of passive fill resistance. The point at which passive soil resistance became too small resulted in failure.

2.7.4 Seawall Failure Analysis

The stone seawall in Bay Head (cell 9) was evaluated for failure from wave attack impacting directly on the stone. Assumptions were also made as to failure of the seawall due to scour at the toe. These calculations are included in the Appendix A, Section 5.

2.8 Coastal Processes

2.8.1 Basic Physical Characteristics.

The basic physical characteristics of Island Beach are similar to those of many developed barrier islands found along the mid- and southern segments of the Atlantic Seaboard. The island's beach strand is comprised of quartz sand with median grain diameter of roughly 0.47 mm. The intratidal and swash zone, i.e. the foreshore, has a slope of about 1V:10H and meets the beach berm at an elevation which varies from 8 to 11.5 ft above the North American Vertical Datum (NAVD). The astronomical tide range at Seaside Heights is approximately 4.3 ft and mean sea level is roughly 0.7 ft below NAVD.

The average beach berm widths along Island Beach are about 75 ft but may vary from as narrow as 30 ft to as broad as 250 ft in Point Pleasant Beach. The reach's oceanside development is fronted by a single dune line which has base widths of 150 to 200 ft and maintains peak elevations which generally vary between 17 and 19 ft above NAVD. An exception to these basic dune characteristics can be found along Seaside Heights and Point Pleasant Beach where no dune exists, but a larger berm is backed by a boardwalk.

Along the frontal dune, vegetative cover ranges from dense to very sparse and use of sand fencing is common practice, employed by local authorities, to enhance dune development and fix the position of the dune line against wind-induced migration. Pedestrian access to the beach varies significantly from community to community. However, access, where provided, is generally over the dune line and often found at street ends. Landward of the frontal dune, the developed area is relatively flat with a high point usually found along NJ Route 35.

2.8.2 Winds, Waves, Tides, and Storm Surges

Given its northern alignment, Island Beach has a direct exposure to normal oceanic conditions as well as storm tides and waves which are generated over a broad sector of Atlantic Ocean from north-northeast to south-southwest. These natural agents and the primary generating force of wind, to which the study area is exposed, are discussed in the following subsections of this report. The resulting effects of these natural agents on the study area's beach and dune system, in large measure, dictate the degree of damage-potential which exists in the study area, and the type and extent of additional shore protection necessary to effectively reduce the existing damage-potential to economically efficient levels of risk.

2.8.2.1 Winds

Data on prevailing winds over the ocean areas between New York Harbor Entrance and the Entrance to Delaware Bay, as published by the U.S. Navy Hydrographic Office, have been evaluated for the 10-year period 1932-1942 (USACE, Philadelphia District, 1974). These data show that, in the 5-degree quadrangle nearest the New Jersey coast, the winds over the offshore areas are distributed with respect to duration as follows: onshore (northeast, east and southeast winds), 27 percent; upshore (south winds), 11 percent; offshore (southwest, west and northwest winds), 44 percent; downshore (north winds), 15 percent; and calms, 3 percent. Analysis of onshore winds recorded during the period 1923-1952 at Atlantic City, New Jersey shows that the prevailing winds are from the south and of moderate velocity of from 14 to 28 miles per hour (USACE, Philadelphia District, 1990). Winds from the northeast have the greatest average velocity of about 20 miles per hour. The wind data for this period also show that winds in excess of 28 miles per hour occur from the northeast more than twice as frequently as from any other direction.

The maximum five-minute average wind velocity at Atlantic City was recorded during the hurricane of September 1944, with a value of 82 miles per hour from the north. Over the period 1960-1984, the fastest wind speed of 63 miles per hour was measured at the Atlantic City Marina during the passage of Hurricane Doria in August 1971. These statistics indicate that the most extreme winds occur with the relatively infrequent passage of hurricanes near the study area. However, of equal and perhaps more significance as regards effects on the shores of Island Beach, are the high winds associated with common, yearly occurrences of extratropical cyclones, i.e., northeasters.

An analysis was conducted to determine the frequency of storm winds in the general study area based on Atlantic City records for the period 1936-1958 (USACE, Philadelphia District, 1974). The basic index used in that analysis was "storm-hours," defined as a one-hour period in which wind velocities equaled or exceeded 32 miles per hour and which occurred during a 24-hour period when the average wind velocity was 25 miles per hour or higher. The analysis found that the number of storm-hours during each year varied from 101 to 293 with an average of approximately 175, and that the preponderance of these storm winds were blowing in the onshore directions from the north-east to south sector of the ocean. These results suggest that the study area could experience roughly 4 to 12 full days of storm activity during any year, an inference which is supported by the record of storm occurrences affecting Island Beach in the 12-year period 1962-1973. In that period, 77 storm events, some of which had durations greater than 24 hours, affected Island Beach. Therefore, in terms of the number of storm events from 1962 through 1973, the average annual storm exposure at Island Beach was 6 to 7 storms, with the average duration in excess of 24 hours.

An analysis of the recent Wave Information Study (WIS) hindcast data (Brooks and Brandon, 1995) was performed to obtain insight into average wind conditions. WIS Station 71 centered off of Normandy Beach was selected for the Study area. Table 2-9 and Table 2-10 provide information on monthly distribution of wind magnitude and direction. The maximum wind speed over the time period analyzed was approximately 32 m/sec (72 mph) on 13 March 1993 from a direction of 95 degrees with respect to true north. The tables indicate the predominant wind direction is from 270 degrees or blowing offshore; however, there is no way to directly infer from these tables which direction bands contain the larger wind magnitudes.

Table 2-9 WIS Station 71 Occurences of Wind Speed by Month for all Years (1976-1993)

Wind Speed (ft/sec)	0.00-2.49	2.50-4.99	5.00-7.49	7.50-9.99	10.00-12.49	12.50-14.99	15.00-17.49	17.50-19.99	> 20.00	TOTAL
JAN	147	900	833	1100	556	531	215	146	36	**4464**
FEB	101	875	766	1128	489	433	127	96	57	**4072**
MAR	165	995	886	1193	541	394	152	99	39	**4464**
APR	267	1266	885	1079	428	309	66	20	.	**4320**
MAY	490	1660	1111	854	221	115	13	.	.	**4464**
JUN	545	1895	1070	668	107	30	4	1	.	**4320**
JUL	737	2263	957	432	68	7	.	.	.	**4464**
AUG	900	2188	895	387	66	21	1	4	2	**4464**
SEP	651	1829	928	694	454	59	3	3	2	**4320**
OCT	417	1406	957	1071	354	194	39	19	7	**4464**
NOV	202	1032	884	1131	532	391	91	43	14	**4320**
DEC	121	999	836	1181	578	461	150	91	47	**4464**
TOTAL	**4743**	**17308**	**11008**	**10918**	**4091**	**2945**	**861**	**522**	**204**	**52600**

Table 2-10 WIS Station 71 Occurrences of Wind Direction by Month for all Years (1976-1993)

Direction Band	337.50 - 22.49	22.50 - 67.49	67.50 - 112.49	112.50 - 157.49	157.50 - 202.49	202.50 - 247.49	247.50 - 292.49	292.50 - 337.49	TOTAL
Center of Band	**(0.0)**	**(45.0)**	**(90.0)**	**(135.0)**	**(180.0)**	**(225.0)**	**(270.0)**	**(315.0)**	
JAN	502	330	289	223	372	538	856	1354	**4464**
FEB	598	397	286	256	323	545	564	1103	**4072**
MAR	703	400	356	314	568	590	556	977	**4464**
APR	523	360	332	500	552	589	582	882	**4320**
MAY	468	431	392	397	713	813	632	618	**4464**
JUN	410	292	220	272	695	1059	718	654	**4320**
JUL	435	275	242	372	551	1122	769	698	**4464**
AUG	491	442	401	290	584	1024	652	580	**4464**
SEP	570	588	440	376	476	749	579	542	**4320**
OCT	490	619	327	338	520	682	657	831	**4464**
NOV	471	355	352	300	453	672	773	944	**4320**
DEC	516	232	266	221	408	710	858	1253	**4464**
TOTAL	**6177**	**4721**	**3903**	**3859**	**6215**	**9093**	**8196**	**10436**	**52600**

2.8.2.2 Waves

The earliest recorded wave statistics for the region are based on limited visual observations made at Barnegat Light between July and October in 1939 (USACE, Philadelphia District, 1974). The results of those observations gave an average nearshore significant wave height of 2.7 ft and a maximum wave height of 13 ft, with 12 percent of the observed waves having significant heights greater than 5 ft. Significant wave heights are defined as the average height of the highest one-third of the waves observed for a specified time period. Wave periods, during the 1939 observation, ranged from 6 to 11 seconds.

Results of the first detailed studies of wave characteristics in waters off the New Jersey coast were reported in 1959, and were based on computational (hindcasting) procedures utilizing synoptic weather information (U.S. House Document No. 208, 1959). The results of those studies gave an average significant wave height of about 2 feet, and expected annual storm wave heights of 11 to 12 feet. Average wave periods were computed at approximately 8 seconds. The highest waves were found to approach the coast most frequently from the east-northeast. The 1959 report also provided information on swells based on the analysis of shipboard observations documented by the U.S. Navy Hydrographic Office. These data showed that swells of 6 to 12 feet in height approach the coastline from the east, while swells over 12 feet in height come predominantly from the easterly and southerly quadrants of the sea.

General wave statistics for the study area shoreline are presented in a report entitled "Hindcast Wave Information for the U. S. Atlantic Coast" (Wave Information Study (WIS) Report 30) prepared by Hubertz et al., 1993. The WIS data is also available digitally through the Coastal Engineering Data Retrieval System developed by the Coastal Engineering Research Center (CERC). WIS Report 30 and information in CEDRS provides revised wave data for 108 locations along the U. S. Atlantic coast, and supersedes 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 is derived from wind fields developed in a previous hindcast covering the period 1956 through 1975, exclusive of hurricanes, and the present version of the WIS wave model, WISWAVE 2.0 (Hubertz, 1992). Wave heights are universally higher for the revised hindcast than for the original hindcast since the values more closely correspond to maximum measured (buoy) values. A separate report (Abel et al., 1989) documents hindcast wave information for Atlantic Coast hurricanes during the 1976-1995 time period.

The most recent analysis of general wave statistics for the study area shoreline covers the time period of 1976-1993 and is presented by Brooks and Brandon (1995). 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. Extratropical and tropical events were analyzed separately, but combined to form complete time series and annual statistics. The hindcast has recently been updated to extend through 1995; however, the methods and resulting statistics have not been documented to date.

Hindcast results are available as time series every 3-hr for the 20-yr period or as tabular summaries. WIS Reports 30 and 33 contains tables presenting the distribution of spectral wave height, peak period and peak mean direction by month for the 20-yr period; the number of occurrences by 0.5-m height and 1-sec period categories for eight different direction bands and a final table for all directions and finally summary tables of mean and maximum wave heights by month for each of the 20 years hindcast. These tables also include the peak period and peak mean wave direction associated with the maximum wave height occurrence.

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 at Island Beach. The wave statistics pertinent to the Island Beach study are those derived for Station 71. The location of Station 71 is Latitude 40.00 N, Longitude 74.00 W, in a water depth of approximately 59 ft (Figure 2-8). Monthly mean wave heights at Station 71 for the entire 1956-1975 hindcast range from 2.2 ft in August to 4.2 ft in December. Mean wave heights for the 1976-1995 hindcast are slightly larger, ranging from 2.3 ft in July to 4.3 ft in December. The maximum wave height (H_{mo}) at Station 71 for the 1956 - 1975 hindcast is reported as 21.3 ft, with an associated peak period of 13 seconds and a peak direction of 97 deg on 7 March 1962. Maximum wave conditions for the 1976-1993 hindcast are reported as 24.3 ft, with an associated peak period of 14 seconds and a peak direction of 137 degrees on 27 September 1985. Summary Statistics for WIS Station 71 are provided in Table 2-11, Table 2-12, and Table 2-13 for the years 1976-1995.

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 Barnegat and Manasquan Inlets, ebb shoal morphology at the two inlets, local shoreline alignment, nearshore 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 60 ft depth, the effects enumerated 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. Computer programs which transform offshore waves over varying bathymetry must be used to further investigate wave conditions closer to the shoreline.

Prototype wave data has been collected at both Manasquan and Barnegat Inlets as part of the Monitoring of Completed Coastal Projects Program. Data collection was performed September 1982 through September 1985 at Manasquan Inlet to evaluate the stability of the Dolos armor units on the southern jetty. A Waverider wave measuring buoy was deployed in 50 ft of water about one mile northeast of the seaward end of the northern jetty (Figure 2-8). Average wave heights of 2 to 3 ft and wave periods of 6 seconds were reported (Gebert and Hemsley, 1991). Wave heights of less than 9 ft were reported to occur 95 percent of the time along with wave periods of less than 10 seconds. The maximum wave height recorded, 21.8 ft, was measured during a severe northeaster on 29 March 1984.

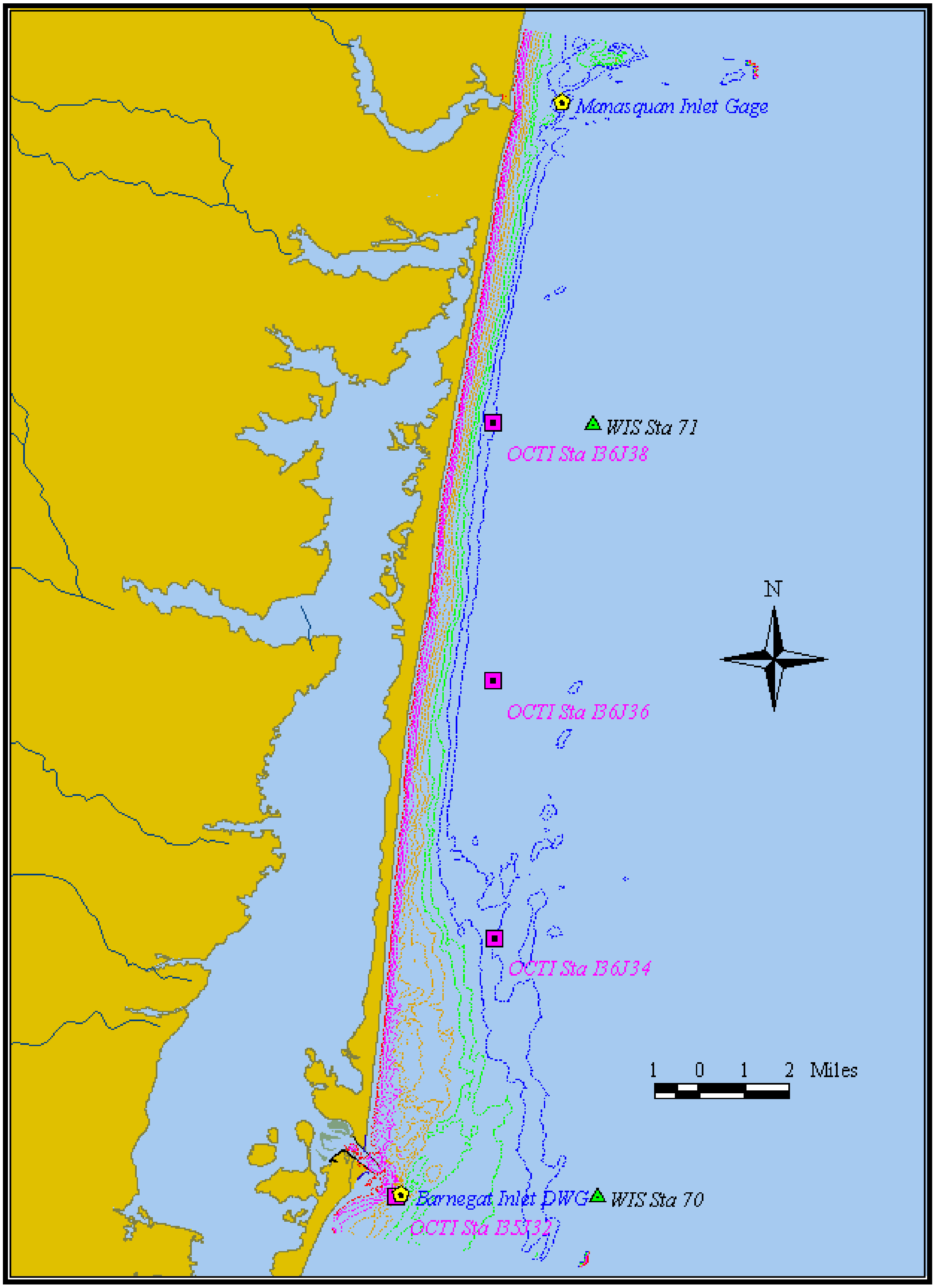


Figure 2-8 Wave Data Station Locations

Table 2-11 WIS Station 71 Mean Wave Height Summary Statistics

MEAN WAVE HEIGHT (IN FEET) BY MONTH AND YEAR STATION A2071 (40.00N/74.00W/18.0M)													
YEAR	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**	**MEAN**
1976	4.9	4.9	4.9	3.9	3.9	3.3	2.3	3.6	3.0	4.9	3.9	4.3	**3.9**
1977	4.6	4.3	4.9	3.9	2.6	3.0	2.0	2.0	3.0	4.6	6.2	5.2	**3.9**
1978	6.6	3.9	5.2	4.6	4.9	3.0	2.6	2.3	3.6	3.9	4.6	3.9	**4.3**
1979	6.2	5.9	5.9	4.9	3.9	2.6	2.3	2.6	4.6	3.3	4.6	5.2	**4.3**
1980	5.9	4.3	6.2	5.6	3.0	2.6	2.3	3.3	3.6	4.3	4.6	5.2	**4.3**
1981	4.3	7.5	4.9	4.9	4.9	2.3	3.0	2.3	4.6	3.9	4.6	4.3	**4.3**
1982	4.6	4.3	3.3	3.9	3.0	3.3	1.6	1.6	3.0	4.3	3.9	3.3	**3.3**
1983	4.6	5.2	5.6	4.6	3.9	2.6	2.0	2.0	3.0	4.9	4.6	5.9	**4.3**
1984	4.6	5.6	6.6	4.6	3.6	3.0	2.6	2.0	2.6	3.9	4.6	4.3	**3.9**
1985	4.3	4.9	4.3	3.9	3.3	2.6	2.3	2.3	3.3	3.0	5.6	3.9	**3.6**
1986	5.2	4.3	4.9	4.9	3.6	3.0	2.0	2.6	3.6	3.6	3.9	5.2	**3.9**
1987	4.9	3.9	5.2	5.9	3.6	2.6	1.6	2.3	3.0	3.6	4.3	3.6	**3.6**
1988	3.9	4.6	3.6	3.9	3.3	3.0	2.6	2.3	3.3	3.9	3.9	3.3	**3.6**
1989	3.9	3.9	5.2	3.6	3.9	2.6	2.3	3.6	6.6	3.6	4.6	3.9	**3.9**
1990	3.6	4.6	4.3	4.6	3.9	3.3	3.0	3.6	3.9	4.6	3.3	4.9	**3.9**
1991	4.3	3.6	4.9	3.9	2.6	2.6	2.3	3.0	3.9	4.3	3.9	3.9	**3.6**
1992	4.9	3.9	4.9	3.0	3.6	2.3	2.0	2.0	3.3	2.6	3.3	4.9	**3.3**
1993	4.6	4.9	4.9	5.6	3.3	2.3	2.3	2.3	3.3	3.6	4.6	4.6	**3.9**
1994	3.6	3.0	3.6	2.6	2.3	2.3	2.3	2.0	2.3	1.6	3.6	3.3	**2.6**
1995	3.6	2.6	2.6	2.3	2.3	2.6	2.0	3.6	3.6	3.3	3.9	3.3	**3.0**
MEAN	**4.3**	**4.3**	**3.9**	**3.3**	**3.0**	**2.6**	**2.3**	**2.3**	**3.0**	**3.3**	**3.9**	**4.3**	

Table 2-12 WIS Station 71 Largest Wave Height Summary Statistics

LARGEST WAVE HEIGHT (IN FEET) BY MONTH AND YEAR STATION A2071 (40.00N/74.00W/18.0M)												
YEAR	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
1976	11.8	13.8	12.8	9.2	10.5	6.6	4.6	16.7	7.2	11.8	9.5	9.2
1977	14.4	15.7	14.1	13.5	6.2	10.2	6.9	6.6	10.2	10.5	17.1	17.1
1978	18.0	13.8	15.1	16.7	14.1	10.2	9.2	7.2	8.2	9.5	13.5	11.2
1979	20.3	19.7	18.7	13.5	8.2	6.2	6.2	9.2	12.1	8.5	13.5	11.8
1980	19.0	14.4	16.4	13.8	9.2	6.6	5.2	12.1	8.2	21.7	11.8	16.4
1981	9.5	22.0	13.1	12.8	11.5	6.6	8.9	6.6	11.5	8.5	15.1	11.2
1982	14.1	14.1	9.5	12.5	5.9	8.9	3.9	6.9	9.5	21.7	11.2	8.5
1983	13.1	19.7	18.0	11.8	11.2	6.2	5.6	7.2	10.2	16.4	12.1	19.7
1984	12.5	14.4	20.3	15.4	8.5	8.2	6.2	4.9	7.2	19.7	10.2	9.2
1985	10.2	19.0	13.1	16.1	9.5	7.5	7.5	5.6	24.3	9.5	19.7	11.2
1986	12.1	14.8	16.4	15.1	11.2	8.5	4.3	11.8	8.9	8.9	11.2	24.0
1987	15.7	11.8	17.1	14.8	8.5	6.6	3.9	4.9	8.2	7.9	10.8	12.1
1988	8.9	14.4	8.5	11.2	8.9	7.2	7.9	7.2	8.9	10.5	10.8	7.9
1989	9.5	16.7	14.8	10.8	12.5	5.6	6.9	10.8	23.3	13.8	11.2	9.5
1990	9.5	11.5	13.1	10.2	11.2	8.9	6.9	11.5	8.5	12.8	7.5	11.8
1991	13.1	6.9	11.2	10.5	7.2	7.5	7.2	19.0	20.7	11.2	10.5	9.5
1992	17.7	7.9	10.8	7.5	7.5	6.6	4.9	5.6	9.8	8.2	9.5	19.0
1993	13.5	16.1	16.4	11.5	6.2	5.2	5.2	8.5	13.1	14.4	18.0	13.1
1994	11.8	10.2	17.1	5.9	9.2	8.2	5.2	4.9	9.2	5.9	13.1	12.8
1995	12.1	7.2	9.5	7.5	6.2	6.9	3.6	12.1	9.8	13.5	18.4	9.8

Table 2-13 WIS Station 71 Wave Summary Statistics

Mean Spectral Wave Height	3.6 ft
Mean Peak Wave Period	7.7 sec
Most Frequent Wave Direction Band	112.5 deg
Standard Deviation of Wave Height	2.6 ft
Standard Deviation of Wave Period	3.0 sec
Largest Wave Height	24.3 ft
Wave Period associated with Largest Wave	14.0 sec
Peak Direction associated with Largest Wave	137 deg
Date and Time Largest Wave Occurred	09/27/1985 18:00 hr GMT

Wave data collection at Barnegat Inlet was initiated May 1994. A directional wave gage (DWG) was deployed approximately 4000 ft off the south jetty tip, located in 43 ft of water seaward of the ebb shoal (Figure 2-8) for one year. Preliminary analysis of the first years worth of data (May 1994 - March 1995) resulted in an average wave height (Hs_{avg}) of 2.5 ft, an average peak period of 8.9 seconds, and an average mean direction of 128 degrees. Maximum wave conditions were measured on 23 September 1994. The maximum significant wave height of 12.6 ft had a corresponding peak period of 8.5 seconds and mean direction of 104 degrees. Another event (24 December 1994) had a slightly smaller wave height of 11.4 ft with a significantly longer peak period of 14.2 seconds. A nearshore wave gage, located in approximately 17 ft of water 200 ft off of the south jetty, recorded non-directional wave data every 3 hours from May 1994 through June 1995. Analysis of the first 6 months of data (May 1994 - January 1995) resulted in an average significant wave height of 2.4 ft and an average peak period of 8.9 seconds. The September 1994 event showed slight attenuation of the offshore conditions by the ebb shoal, resulting in a nearshore significant wave height of 8.2 ft and peak period of 9 seconds. The December 1994 event showed similar attenuation of the wave height by the ebb shoal, resulting in a 7.41 ft wave height. However, the impact of the shoal is seen by the shift in peak period (frequency) from 14.2 seconds offshore to 9.8 seconds nearshore.

Detailed studies have recently been conducted by the USACE, Philadelphia District to develop combined wave/water-level frequency relationships for various open coast and estuarine areas within the district boundaries. The analysis relevant to the Island Beach area involved hindcasting by means of a two-dimensional wave model and statistical analyses related to 30 storms of record, for which time histories of wave characteristics were developed. The selected storm record included 15 hurricanes and 15 northeasters that generated major surges and/or waves along the study area. Several output nodes were analyzed for the Study reach with detailed analyses performed for OCTI Station I36J38 centrally located in the study reach and adjacent to WIS Station 71 (Figure 2-8). Details of the analysis will be presented later in this report in the subsection dealing with assessment of storm effects and damage parameters. Suffice it to mention at this point, that hindcasted significant wave heights for the 15 hurricanes of record varied from about 8 ft to 19 ft, with wave periods ranging from 7 to 14 seconds. In the case of the 15 major northeasters which were evaluated, significant wave heights varied from about 9 ft to 22 ft, with wave periods ranging from 10 to 17 seconds. It is noted that, in the study area, the storm waves having the greatest heights as well as the longest periods are associated with northeasters. The same relationship also holds for the magnitude of storm surges. The fact that northeasters represent the most intense storm conditions experienced in the study area reflects a recorded history which is absent of an event in which a hurricane has made a direct landfall at or proximate to Island Beach. Figure 2-9 contains histograms which graphically summarize the distribution of wave conditions (Height, Period, and Direction). The Wave roses shown in Figure 2-10 further illustrate the directional distribution of wave height and period, showing the larger wave heights and periods originate from the northeast and southeast.

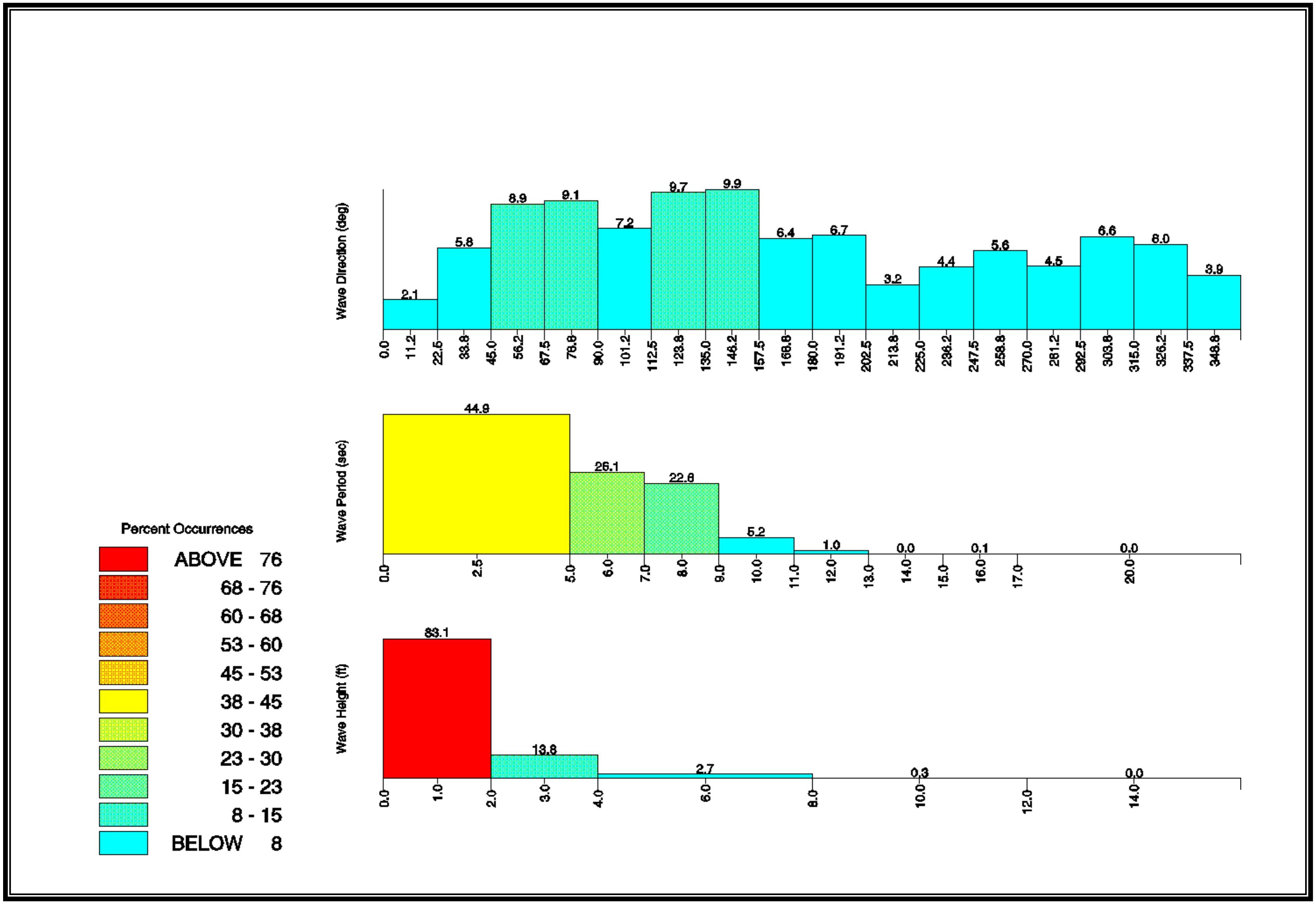
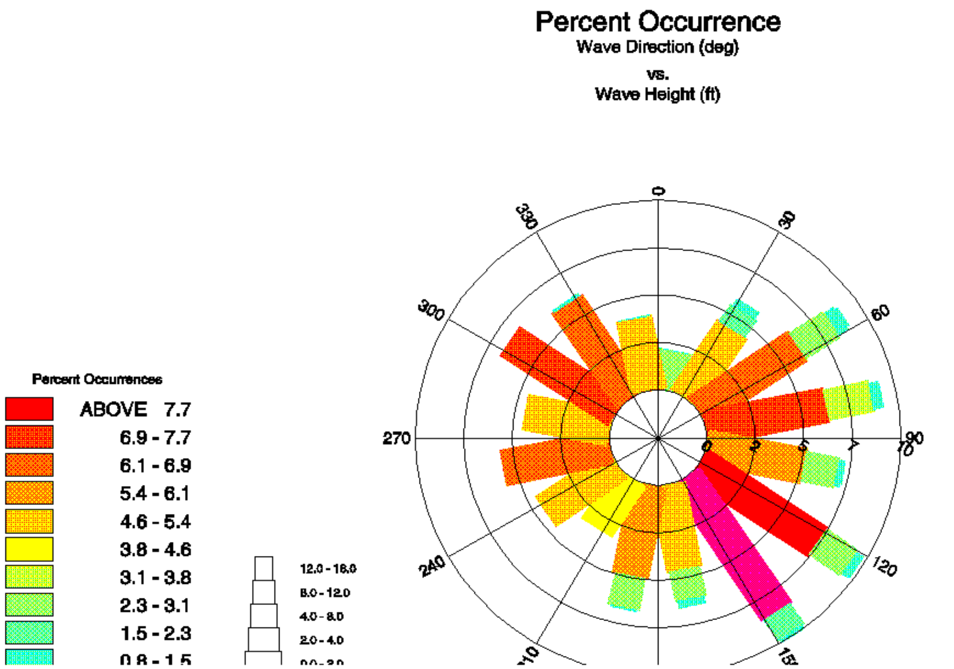


Figure 2-9 OCTI Station I36J38 Wave Histogram (1987 – 1993)



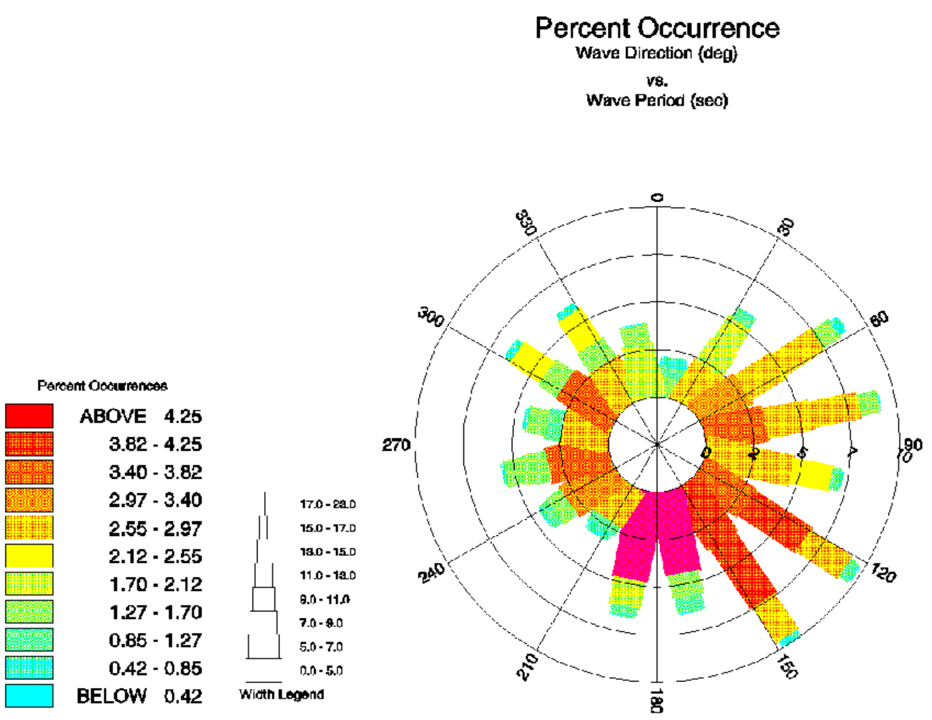


Figure 2-10 Wave Rose of OCTI Station I36J38 for Wave Height and Period

2.8.2.3 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 4.29 ft at Seaside Heights in the Tide Tables published annually by the National Oceanic and Atmospheric Administration (NOAA). The spring tide range is reported as 5.15 ft Barnegat Inlet and the back bay areas adjacent to the study area show a large attenuation of the tide range relative to the ocean shoreline, resulting in a mean tide range of approximately 0.5 ft throughout Barnegat Bay.

No official datum relationships have been established for National Ocean Service (NOS) tide gage stations in the project area; therefore, interpolation between the nearest NOS stations with datum relationships was required. Two primary NOS stations are nearly equidistant to the study area, with one gage located south of the area at Atlantic City, NJ and the other to the north at Sandy Hook, NJ. An additional secondary station is located in Long Branch, NJ. Interpolation between Atlantic City and Long Branch data, with consideration of Sandy Hook data, resulted in NAVD being approximately 2.9 ft above mean lower low water (MLLW) and approximately 1.5 ft below mean high water (MHW) for Seaside Heights (Table 2-14). Recent analyses have been conducted to establish datum relationships in the vicinity of Barnegat Inlet. Several tide gages were installed on the open Ocean and in Barnegat Bay for a 2-month period in the Fall of 1996. Resulting datum relationships for the Ocean gage are also presented in Table 2-14.

Table 2-14 Tidal Data and Datum Relationships from Barnegat Inlet to Manasquan Inlet

	Atlantic City	Barnegat Inlet (field study)	Seaside Heights* (interpolated ocean)	Long Branch	Sandy Hook
Tidal epoch (years data)	1960 - 1978 (1911-present)	1996 (27 Sep - 6 Nov)	N/A	1960-1978 (78-79,81-84)	1960-1978 (1910-present)
Latitude Longitude	39 deg 21 min N 74 deg 25 min W	39 deg 45 min N 74 deg 05 min W	39 deg 56 min N 74 deg 04 min W	40 deg 18 min N 73 deg 59 min W	40 deg 28 min N 74 deg 01 min W
Distance from AC	0 miles	34	46 miles	70 miles	80 miles
MHHW	4.68 ft	4.74 ft	**4.84 ft**	4.92 ft	5.20 ft
MHW	4.25 ft	4.43 ft	**4.45 ft**	4.56 ft	4.86 ft
NAVD 88	2.97 ft	2.94 ft	**2.90 ft****	2.86 ft	2.90 ft
MTL	2.20 ft	2.37 ft	**2.32 ft**	2.38 ft	2.53 ft
NGVD	1.64 ft	1.68 ft	**1.73 ft**	1.77 ft	1.77 ft
MLW	0.16 ft	0.17 ft	**0.17 ft**	0.18 ft	0.20 ft
MLLW	0.00 ft	0.00 ft	**0.00 ft**	0.00 ft	0.00 ft
Tidal Range (MHW-MLW)	4.09 ft	4.12 ft	**4.29 ft*****	4.38 ft	4.66 ft
Tide Tables Mean Range Spring Range	4.09 4.95	N/A N/A	**4.29 ft*** 5.15 ft*****	4.38 5.26	4.66 5.60

* Seaside Heights values based on interpolation between Atlantic City and Long Branch data.
** NAVD 88 is 1.175 ft above NGVD based on CORPSCON Datum Conversion Program.
*** Seaside Heights from NOS Tables (secondary gage): Mean Tide Range of 4.29 ft and Spring Tide Range of 5.15 ft

2.8.2.4 Storm Surges

The study area experiences events each year in which meteorological conditions generate water levels exceeding the levels of predicted astronomical tides. As noted previously in regard to wave characteristics, the USACE, Philadelphia District recently completed studies to establish wave and water-level frequency relationships for the open coast and estuarine areas within the district. Time histories of storm tides have been hindcasted for the areas of interest by means of a two-dimensional storm surge model along with associated wave hindcasting. Time histories of storm-induced water levels were developed for the same 30 storms and at the same computational stations used in the companion wave analysis. As noted previously, several computation stations exist along Island Beach. The details of the surge hindcast results will be presented in a later subsection of this report, along with comparable wave information. The general results for the study area were the development of water level histories for 30 extreme events for which the combined surge and astronomical tides had peak elevations ranging from as low as 3.4 ft above NAVD to as high as 8.4 ft above NAVD. The highest computed elevation value of +8.4 ft NAVD is related to a hurricane that passed the study area on August 18, 1899; however, a storm tide with almost an equivalent peak water level value, i.e., +8.0 ft NAVD, was computed for the unusually severe northeaster that devastated the mid-Atlantic coastline between the 5th and 8th days of March 1962. Indeed, the history of extreme events that have affected Island Beach demonstrates that in terms of both wave action and surge levels, northeasters have, in the main, been the most intense type of storm affecting the study area. For example, in the case of the 15 hurricanes of record referenced above, the average of the highest significant wave heights amounted to 13.7 ft and the average of the peak water surface elevations was +4.8 ft NAVD. By comparison, the computed values for the 15 severe northeasters that were examined give the average of the highest significant wave heights as 16.9 ft, and the average of peak water surface elevations as +6.3 ft NAVD.

An evaluation of extreme water levels in Barnegat Bay was also performed to determine potential flooding along the back bay shorelines. Several tide gages located throughout Barnegat Bay, including one located at Mantoloking, have been used to assess the potential impact of Barnegat Inlet's south jetty realignment on tidal conditions throughout Barnegat Bay. Mean tidal ranges have increased slightly throughout the Bay. Additional efforts were performed as part of the Seaside Park Reconnaissance Study (USACE, Philadelphia District, 1995) to establish stage frequency curves within the Bay for flood damage analysis. The resulting still water levels ranged from 1.2 ft NAVD to 6.80 ft NAVD for the 2- and 500-year recurrence intervals, respectively.

2.8.3 Sea Level Rise

Relative mean sea level, on statistical average, is rising at the majority of tide gage locations situated on continental coasts around the world (National Research Council, 1987; Barth and Titus, 1984). Although local levels are falling in some areas, sea level is predominantly increasing with rates ranging from 0.04 to 0.20 in./yr (NRC, 1987). Major implications of a rise in sea level are 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. Although there is substantial local variability and statistical uncertainty, average relative sea level over the past century appears to have risen about 1 ft relative to the East Coast of the United States.

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 enormous variability and uncertainty of the climatic factors that affect sea level rise, however, predicting future trends with any certainty is difficult. 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,* be used until more definitive data become available. USACE policy calls for consideration of designs that 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 historical tide gage records at Atlantic City and Ventnor, NJ, sea level has been rising at an approximate average of 0.013 ft/yr (Hicks and Hickman, 1988). Over the 50-year period of analysis, it is assumed that sea level will rise by approximately 0.66 ft. This potential rise in sea level was incorporated into the ocean stage frequency analysis for the Atlantic City gage and in other project design aspects such as nourishment quantities.

2.8.4 Ocean Stage Frequency

The ocean stage frequency curve recommended for the study area was developed from tide gage data obtained at Atlantic City and Ventnor, New Jersey. The observed annual maximum stages were obtained and adjusted to include the effects of sea level rise. The rate of rise applied to adjust the values was 0.013 feet per year, (Hicks and Hickman, 1988). 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 2-15.

Table 2-15 Ocean Stage Frequency Data

Year Event	Annual Probability of Exceedence	Water Surface Elevation (ft NAVD 88)
2	0.50	3.74
5	0.20	5.04
10	0.10	5.54
20	0.05	5.94
50	0.02	6.94
100	0.01	7.94
200	0.005	8.84
500	0.002	10.04

2.8.5 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 longshore transport refers to the difference between volume of material moving in one direction along the coast and that moving in the opposite direction.

A number of studies, beginning in the 1950's, have been conducted by the USACE and other activities in which there was an examination of the magnitude and direction of longshore sediment transport at Island Beach. A summary of the various results of these past sediment transport estimates is presented in Table 2-16.

The values in Table 2-16 indicate that gross longshore sediment transport may vary from as low as 750 thousand to over 2 million cubic yards per year and that, generally, there is a net northward transport which may vary from 30 thousand to about 2 million cubic yards per year. Though there is a trend in the estimates for the net longshore transport to be in the northward direction, the estimated differences between north and south transport quantities are not extremely large with respect to the gross sediment transport values for the most recent studies. Hence, it can be expected that reversals in longshore sediment transport contribute significantly to both the short- and long-term behavioral patterns of the Island Beach shoreline. This is manifestly evident in the reversing patterns of north-side and south-side accretion at and in the vicinity of the individual groins at Lavallette. 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.

The majority of the historic longshore transport analyses performed in the vicinity of the project area have focused on the adjacent inlets, with only one study reported for the central portions of Island Beach. The wide variation in results as shown in Table 2-16 coupled with the lack of data for the main reaches of Island Beach warranted further investigation. A longshore transport analysis as conducted for the study area using the energy flux method- with longshore energy flux and transport rate expressions taken from the Shore Protection Manual Equations 4-39 and 4-49 (USACE, 1984).

Table 2-16 Longshore Sediment Transport Rates from Manasquan Inlet to Barnegat Inlet

Location	Source	Type and Data Base	Gross Transport (cu yd/yr) North	Gross Transport (cu yd/yr) South	Net Transport (cu yd/yr)
Manasquan Inlet	CERC/CENAP 1966 Barnegat Phase 1 GDM	Longshore wave energy @ 30 ft contour before 1954	1.98 M	130,000	1.85 M N
Manasquan Inlet	CEN/A-1954	1930-1931			360,000 N
Manasquan Inlet	Caldwell 1966	survey comparison, 1838-1953			74,000 N
Manasquan Inlet	Douglass and Weggel Drexel 1986	WIS data and energy flux method (1956-1974)	500,000	220,000	280,000 N
Manasquan Inlet	CENAP	LEO data, June 1982 to October 1984	600,000	1.2 M	600,000 S
Manasquan Inlet	PRC Harris	wave data and refraction			301,000 N
Manasquan Inlet	Farrell 1980	shoaling rates; aerial photos (5/65-10/77)			45,070 N
Manasquan Inlet	Bruno 1988	dredging, shoaling rates; surveys			30,000 to 74,000 N
Manasquan Inlet	Bruno 1988	tracer and hindcast			135,550 N
Dover Township	CENAP House Doc #91-160	1955-1963	500,000	500,000	0

Revised WIS data (1956-1995) from Station 71 were used along with average shoreline angles for several communities on Island Beach to briefly examine longshore transport trends. The methodology used is very sensitive to shoreline angle and results should only be examined for general transport trends. Results of this analysis (Table 2-17) determined a potential net transport to the north for all communities with an average net transport rate to the north of approximately 215,000 cu. yd./yr for the entire reach. Potential net transport rates decreased from the southern part of the study area to the north. The large gradient in transport from Island Beach State Park to the adjacent communities implies that more sediment is being supplied to those communities than is exiting, resulting in a relatively stable shoreline as evidenced in shoreline positions observed over the same time period. The results displayed in Table 2-17 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. Actual sediment transport rates for the site may be slightly less when considering the impact of adjacent inlets and coastal structures.

Table 2-17 Potential Longshore Sediment Transport Rates for Island Beach Communities

Community	Shoreline Angle (deg wrt north)	Gross Transport (cu. yd. / yr)		Net Transport (cu. yd. / yr)
		North	South	
Island Beach State Park	7	1,060,000	750,000	310,000 N
Seaside Park to Brick	10	1,030,000	800,000	230,000 N
Mantoloking	12	1,020,000	820,000	200,000 N
Point Pleasant Beach	15	1,000,000	870,000	130,000 N

2.8.6 Bathymetry

An analysis of historic and recent offshore bathymetric data was conducted to identify important geomorphic features which may impact nearshore wave transformation and resulting sediment transport patterns. A search of the NOS bathymetric database for the study area resulted in limited data available, with the most recent survey being performed in 1954. Recent beach profile data were overlaid on the NOS bathymetry and confirmed the overall bathymetric features represented by the NOS data set were accurate. The bathymetry found in the central part of the Island is fairly steep with nearshore parallel contours (Figure 2-11). The 60 ft contour line is approximately 1 mile offshore of the MHW. The nearshore slopes becomes much milder from Island Beach State Park towards Barnegat Inlet. The 60 ft contour in much of the State Park area is approximately 3 miles offshore of the MHW contour, as compared to 1 mile for the central part of the Island. Ebb shoal formations exist at both Manasquan Inlet and Barnegat Inlet. Such features significantly impact wave transformation into the nearshore, sediment bypassing, and adjacent shoreline stability.

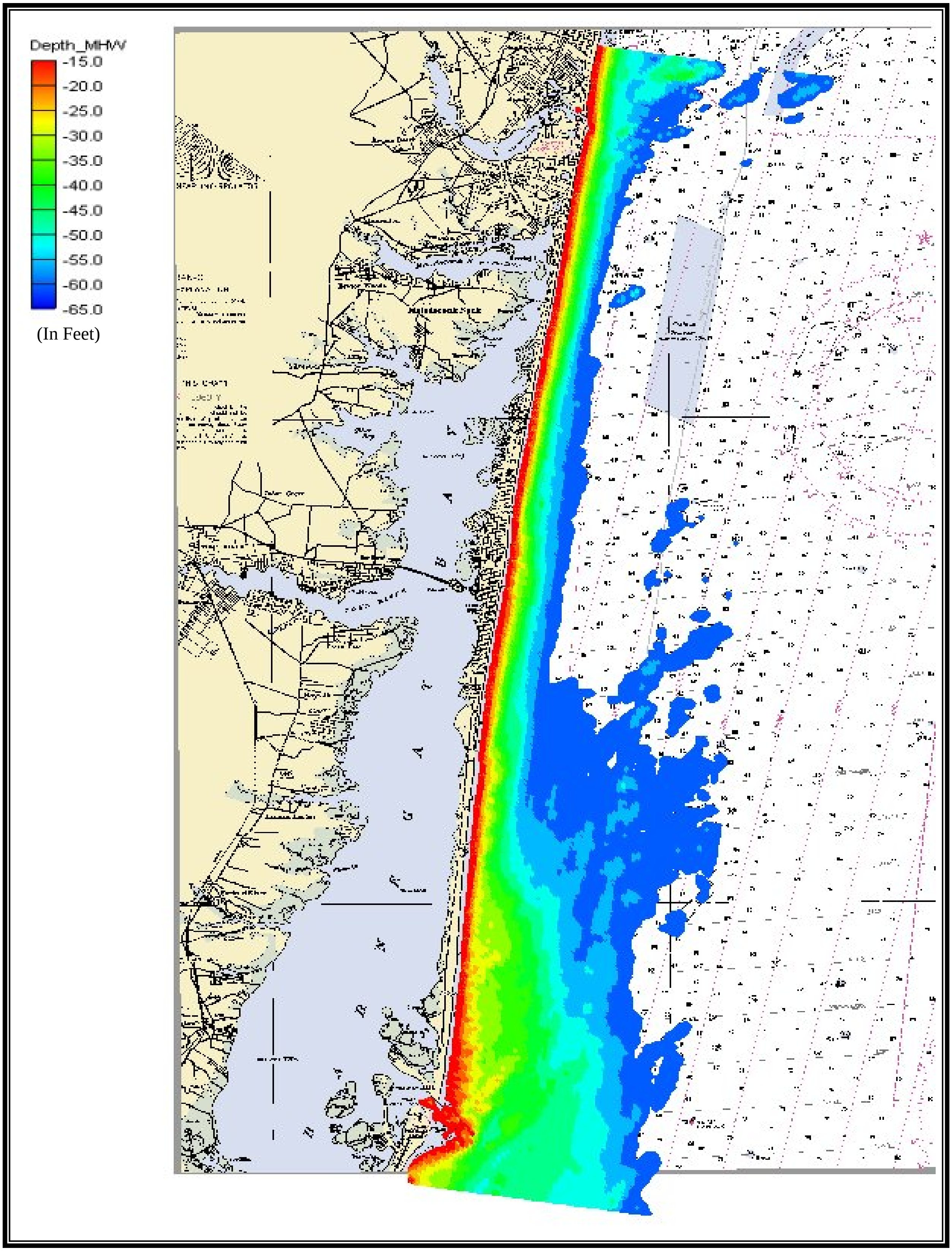


Figure 2-11 Manasquan Inlet to Barnegat Inlet Bathymetry

2.8.7 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. 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 development 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 as described further in Section 2.9.2 and Section 4.6.2. Several sources of beach profile data were assembled and analyzed. Several survey techniques were utilized in collecting the various sources of data. Onshore portions of the surveys were typically surveyed using the standard land surveying techniques. Nearshore and offshore portions of the surveys utilized fathometers and sea sleds. All data sources were adjusted to a common datum, NAVD 1988, and analyzed. Table 2-18 summarizes the various profile data available throughout the communities along the study area. The stationing scheme presented begins at Manasquan Inlet and extends to Barnegat Inlet. Further discussion is presented in Section 2.9.2. 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 NGVD for the 1984 surveys. Several of the LRP profiles were recently re-surveyed by Offshore and Coastal Technologies Inc. - East Coast (OCTI-E) as described below.

2. NJDEP Surveys. Onshore and nearshore profile surveys conducted by the Coastal Research Center, Stockton State College under contract to NJDEP were collected annually, beginning in 1986. Thirteen (13) 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. 156, 155, 154, 153,152, 151, 150, 149, 148, 147, 247, 246, and 146. 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 NGVD. The beach profiles are collected using typical land based surveying techniques with the offshore limits of the surveys extending to wading depth.

Table 2-18 presents the locations of LPR and NJDEP beach profiles located in the study, and Table 2-19 presents average beach profile characteristics for NJDEP profiles. The profiles were analyzed to assess the variability in profile characteristics at each profile and along the entire study area. The overall individual profile characteristics have been relatively stable over the monitoring period. Dune elevations have deviated approximately 1 ft about the mean elevation of + 18 ft NAVD. Berm dimensions as well show small changes, with the berm widths deviating 25 to 50 ft about the average 160 ft width, as measured from the centerline of the dune.

Table 2-18 Location of LRP and NJDEP Beach Profiles in the Study Area

Name of Communities	Stationing (ft x 1000)	Profiles	Station (ft)
Point Pleasant Beach Borough	0 to 9.2	LRP M5	0
		LRP M6	840
		NJDEP 156	1,574
		LRP M7	2,652
		LRP 30	5,645
		NJDEP 155	8,729
Bay Head Borough	9.2 to 15.9	LRP 31	10,400
		NJDEP 154	14,248
		LRP 32	14,493
Mantoloking Borough	15.9 to 27.5	LRP 33	19,500
		NJDEP 153	22,050
		LRP 34	24,700
Brick Township	27.5 to 36.8	LRP 35	29,140
		NJDEP 152	32,240
		LRP 36	33,975
Dover Township	36.8 to 44.6		
Normandy Beach		NJDEP 151	37,717
Chadwick		LRP 37	
Chadwick		LRP 38	43,740
Lavallette Borough	44.6 to 52.2	NJDEP 150	45,825
		LRP 39	49,410
Dover Township	52.2 to 56.3		
Ortley Beach		NJDEP 149	54,196
Ortley Beach		LRP 40	54,310

Table 2-11 (continued) Location of LRP and NJDEP Beach Profiles in the Study Area

Name of Communities	Stationing (Ft X 1000)	Profiles	Station (ft)
Seaside Heights Borough	56.3 to 60.5	LRP 41-a	56,735
		LRP 41	59,525
Seaside Park Borough	60.5 to 69.4	LRP 41-b	62,290
		LRP 42	65,240
		NJDEP 148	66,680
Berkeley Township	69.4 to 72.3	NJDEP 147	70,063
		LRP 43	71,100
Island Beach State Park	72.3 to 123.5	LRP 45	80,870
		NJDEP 247	83,838
		LRP 48	96,630
		NJDEP 246	98,860
		LRP 50	107,470
		NJDEP 146	120,354

Table 2-19 NJDEP Average Beach Profile Characteristics (1986 – 1997)

Profile Type	Community	Average Profile Characteristics			
		Dune Elev. (ft NAVD)	Berm Width (ft, from cl)	Berm Elev. (ft NAVD)	Vol. above MHW ($yd.^3/ft$)
NJDPE 156	Pt. Pleasant Beach	14.44	360.29	6.83	149.97
NJDPE 155	Pt. Pleasant Beach	18.85	181.02	8.58	148.37
NJDPE 154	Bay Head Borough	17.23	108.45	6.77	72.25
NJDPE 153	Mantoloking Borough	18.00	76.20	6.89	104.28
NJDPE 152	Brick Township	16.47	118.26	7.68	151.70
NJDPE 151	Normandy Beach	18.62	114.55	7.68	120.78
NJDPE 150	Lavallette Borough	18.28	130.73	8.65	101.98
NJDPE 149	Ortley Beach	16.30	125.41	7.38	96.32
NJDPE 148	Seaside Park Borough	18.92	179.44	7.88	152.55
NJDPE 147	Midway Beach	19.26	220.34	6.97	216.14
NJDPE 246	Middle IBSP	18.93	132.84	6.09	128.55
NJDPE 146	Southern IBSP	19.82	257.55	5.22	136.53

3. OCTI-E Surveys. Recent onshore and offshore profile data were collected by OCTI-E for the Philadelphia District in October 1997 to document existing conditions. Twenty-five (25) profiles were collected within the communities to be studied in detail. OCTI-E utilized a sea sled beach profiling system that provides a highly accurate depiction of the entire profile from the upper beach to beyond the theoretical closure depth. The locations of the profiles were selected to correspond to locations previously surveyed, allowing comparative analyses. Twenty-one (21) of the profiles re-occupied former LRP survey locations, and the remaining four (4) profiles correspond to NJDEP profile locations. In addition to beach profile data collection, sediment samples were also collected concurrently as described in Section 2.4.8.2 of this report.

Table 2-20 show the locations of OCTI-E beach profiles located in the study area along with beach profile characteristics. Locations of the beach profiles within the study area are shown on Figure 2-12. The profiles were analyzed and used to assess existing conditions. The existing conditions compared well to the NJDEP average profile characteristics. Select profiles were assembled and used as input for numerical modeling of storm-induced damages.

Table 2-20 OCTI-E Beach Profile Characteristics for October 1997 Survey

Profile Type	Profile No.	Community	Dune El (ft NAVD)	Berm Width (ft from cl)	Berm Elev. (ft NAVD)
LRP	M6	Pt. Pleasant Beach	15.0	395	11.7
LRP	M7	Pt. Pleasant Beach	N/A	354	11.6
LRP	30	Pt. Pleasant Beach	15.8	129	8.1
LRP	31	Bay Head	22.8	184	8.4
LRP	32	Bay Head	17.5	123	8.5
LRP	33	Mantoloking	20.7	76	8.3
NJDPE	153	Mantoloking	16.7	88	7.2
LRP	34	Mantoloking	18.5	86	8.8
LRP	35	Brick	17.9	127	9.0
NJDPE	152	Brick Township	23.5	136	9.3
LRP	36	Brick	19.0	118	9.3
NJDPE	151	Normandy Beach	16.7	112	9.2
LRP	37	Chadwick	18.2	125	9.1
LRP	38	Chadwick	22.9	166	9.2
NJDPE	150	Lavallette	18.2	138	8.8
LRP	39	Lavallette	13.5	108	8.3
LRP	40	Ortley Beach	15.3	125	8.3
LRP	41-a	Seaside Heights	N/A	168	8.1
LRP	41	Seaside Heights	N/A	211	8.7
LRP	41-b	Seaside Heights	15.3	89	7.9
LRP	42	Seaside Park	19.0	206	8.5
LRP	43	Berkeley	20.6	176	8.0

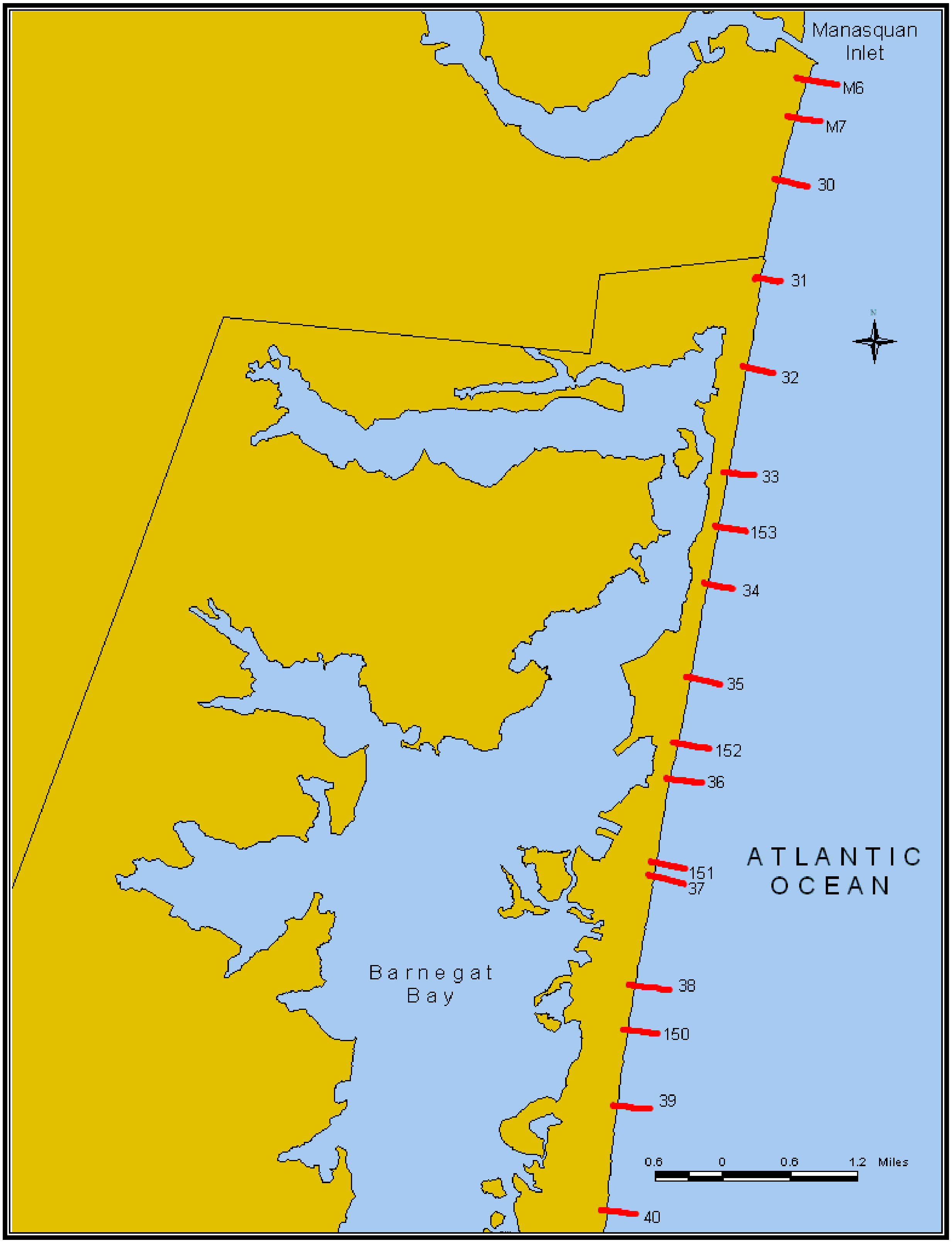


Figure 2-12 OCTI-E Beach Profile Locations

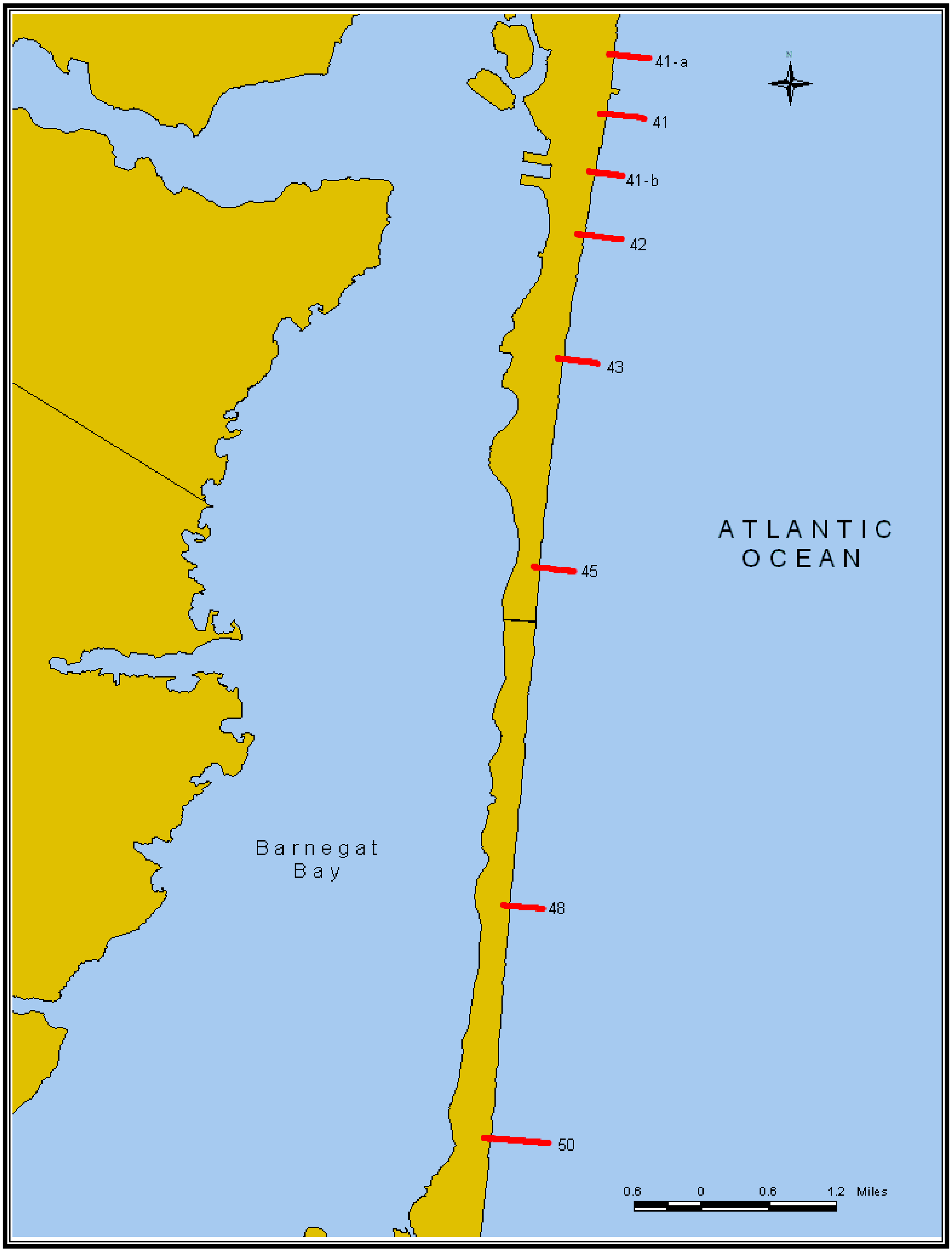


Figure 2-12 (continued) OCTI-E Beach Profile Locations

2.9 Summary of Historical Shoreline Conditions

Reports pertinent to Manasquan Inlet to Barnegat Inlet 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. USACE, New York District. (1954). "Atlantic Coast of New Jersey, Sandy Hook to Barnegat Inlet," Beach Erosion Control Report on Cooperative Study (Survey), serial No. 38.

2. House Document No. 361 (1957). "Shore of New Jersey from Sandy Hook to Barnegat Inlet, Beach Erosion Control Study", 84th Congress, 1957.

3. USACE, Philadelphia District. (1990). "New Jersey Shore Protection Study - Report of Limited Reconnaissance Study."

4. Killam Associates. (1994). "Beach and Dune System Audit for Borough of Mantoloking,Ocean County, New Jersey."

5. Farrell, S. C., Speer, B., Hafner, S., Lepp, T., and Ebersold, S.E. (1997). "New Jersey Beach Profile Network, Analysis of the 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.

6. Farrell, S. C. et al. (1991, 1993, 1994, 1995, 1997). 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. This series of reports analyzes the data for annual volumetric and morphologic changes.

7. 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.

8. USACE, Philadelphia District. (1996). "Manasquan Inlet to Barnegat Inlet Reconnaissance Study."

2.9.1 Prior Studies, Reports, and Projects for Manasquan to Barnegat Inlet

The study area north of Island Beach State Park has been characterized by intermittent dunes fronting boardwalks with a relatively stable to slightly accretional shoreline. Several reports have examined historic shoreline trends in this area as summarized in the following paragraphs.

Killam Associates (1994). The Borough of Mantoloking authorized Killam Associates to conduct a Beach and Dune Audit in 1994. As part of the final report, an analysis of the historical shoreline trends within the borough was conducted. The report analyzed graphically historical shorelines for the following years: 1836-42, 1866-68, 1871-75, 1899, 1932-36, 1951-53, 1977, 1986, 1992, and 1994. The report concluded that the annual loss in the borough is approximately 6.23 feet/year based upon shoreline trends from 1977 to 1994. The long term erosion rate based upon shorelines dating back to 1840 averaged 2 feet/year (Figure 2-13). The reason for the increased erosion rate from 1977 can be attributed to the Northeasters that impacted the island in 1991 and 1992. It was estimated that Mantoloking lost approximately 331,344 cu yds of sand in the December 1992 Northeaster alone.

Farrell et al. (1986-1995). Onshore and nearshore profile surveys conducted by the Coastal Research Center, Stockton State College under contract to NJDEP were collected annually, beginning in 1986. Thirteen (13) 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. 156, 155, 154, 153,152, 151, 150, 149, 148, 147, 247, 246, and 146. Figure 2-14 graphically summarizes the shoreline change calculations for the study area between the years of 1986 to 1995. Table 2-21 shows that slightly more than half of the beach profiles within the study area experienced moderate to high accretion amounts. Areas that eroded during the course of the ten years included: Mantoloking; Brick, Dover, and Berkeley Townships; and Seaside Park.

Table 2-21 Beach Volume and Shoreline Changes From 1986 to 1995

Profile No.	Profile Location	Volume Change (yds.^{3} / ft)	Shoreline Change (ft)
156	Pt. Pleasant Beach	40.43	47.91
155	Pt. Pleasant Beach	-7.91	-10.48
154	Bay Head	24.43	81.89
153	Mantoloking	-10.00	-15.61
152	Brick Township	35.39	9.79
151	Dover Township	-5.70	-28.15
150	Lavallette	13.49	-32.97
149	Ortley Beach	16.50	30.96
148	Seaside Park	18.81	-28.21
147	Berkeley Township	7.74	-33.52
247	Island Beach State Park	8.68	40.36
246	Island Beach State Park	1.97	22.45
146	Island Beach State Park	43.61	22.94

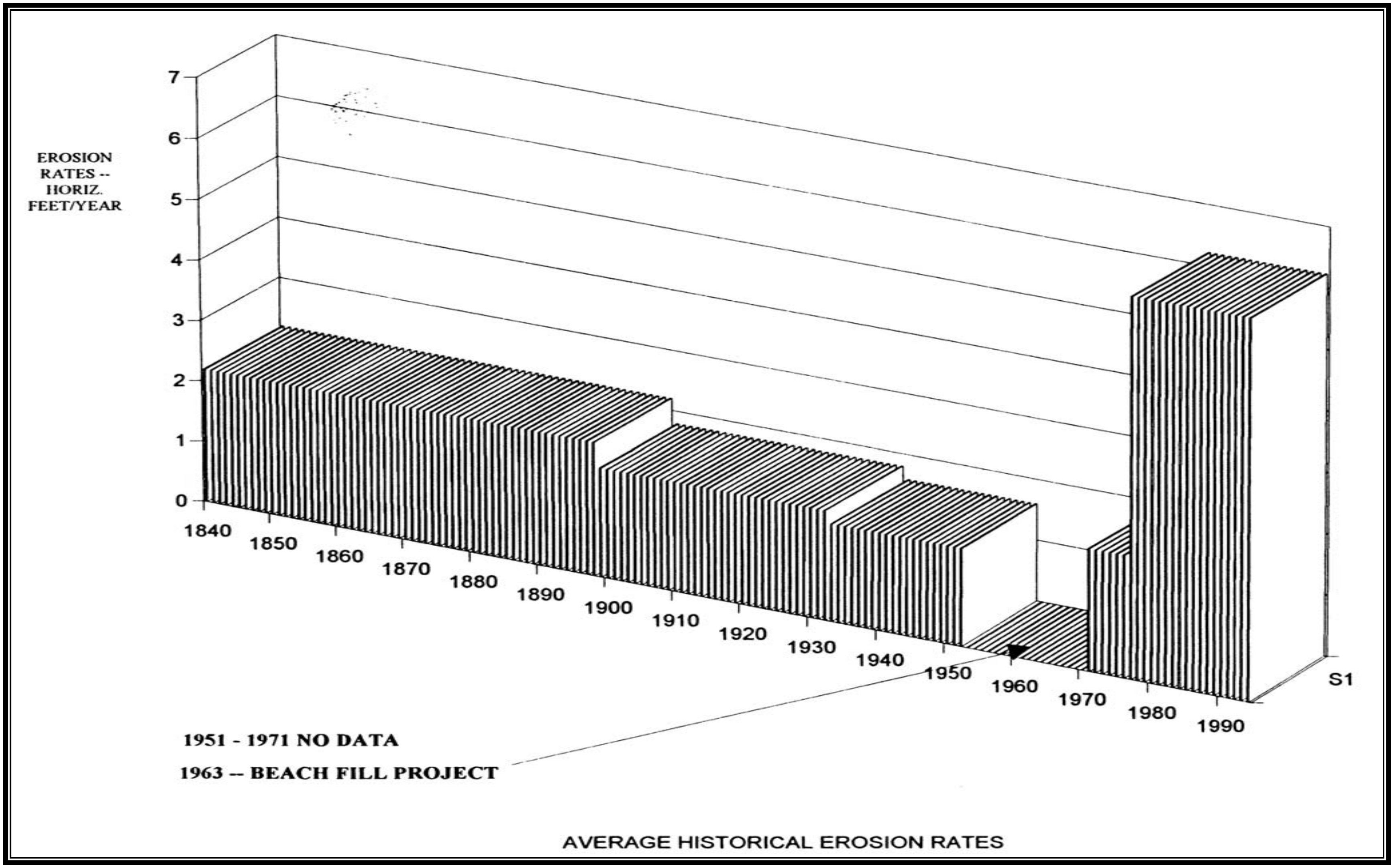


Figure 2-13 Average Historical Erosion Rates for Mantoloking (from Killam Associates, 1994)

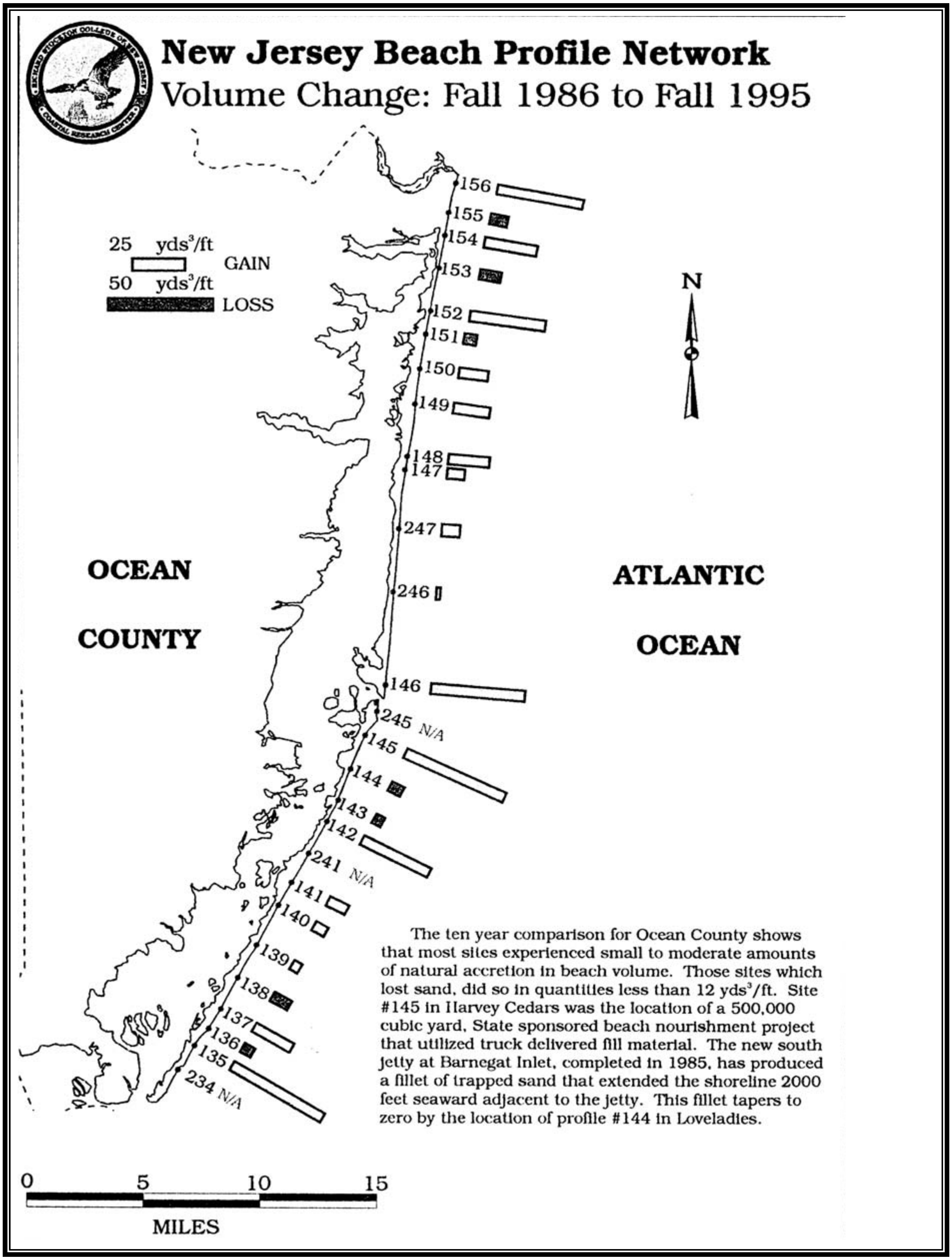


Figure 2-14 NJDEP Beach Profile Volume Changes for Ocean County 1986 – 1995 (from Farrell et al., 1997)

USACE, Philadelphia District (1996). Transects were mapped digitally on historic shorelines obtained as part of the New Jersey Historical Shoreline Map Series (Farrell et al., 1989) and the 1994 digitized ortho-photogrametric shoreline. The communities of Seaside Heights, Lavallette, and Mantoloking were identified as having representative shoreline alignment, beach widths, and historical behavior for the entire study area. Analysis of the data indicated a relatively stable shoreline in these communities from 1840 to 1994, with brief periods of erosion that are followed by a quick recovery. Seaside Heights has been very stable since 1840, showing accretion through every year analyzed and resulting in an average accretion rate of almost 2 feet/year. Lavallette also was stable, with an average accretion rate of 1.2 feet/year. Mantoloking was the most variable, showing periods of accretion and erosion. Accretion occurred from 1952 to 1977 at an average rate of 3.5 feet/year, however from 1977 to 1986, the shoreline eroded an average of over 6 feet/year.

2.9.2 Historical Shoreline Change Analysis for Manasquan Inlet to Barnegat Inlet

As was done in the Reconnaissance Study, 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 1994 MHW shoreline obtained from digital photogrammetry that was obtained as part of the study. All the shorelines can be seen in Figure 2-15, Figure 2-16, and Figure 2-17 for selected areas within the study area. As part of this feasibility study, a detailed quantitative analysis was done to compute shoreline change rates from these maps. Several of the shorelines were missing, incomplete, or invalid for this area, therefore shoreline change rates were computed for the following periods: 1899, 1934, 1952, 1977, 1986, and 1994.

The shoreline change analysis involved rotating and translating each digital shoreline to a user-defined coordinate system grid. The grid ran alongshore for 123,500 ft to Barnegat Inlet from a specified origin near Manasquan Inlet (Figure 2-18). The digital shorelines were segmented into discrete compartments alongshore on the grid that were spaced 1,000 ft apart except in areas where groin compartments were used (Figure 2-18). 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 sequential historic time periods and then relative to 1994 (Table 2-22 and Table 2-23) for specific cells within the study area. Figure 3-6 provides a map that delineates cell boundaries used in the analysis.

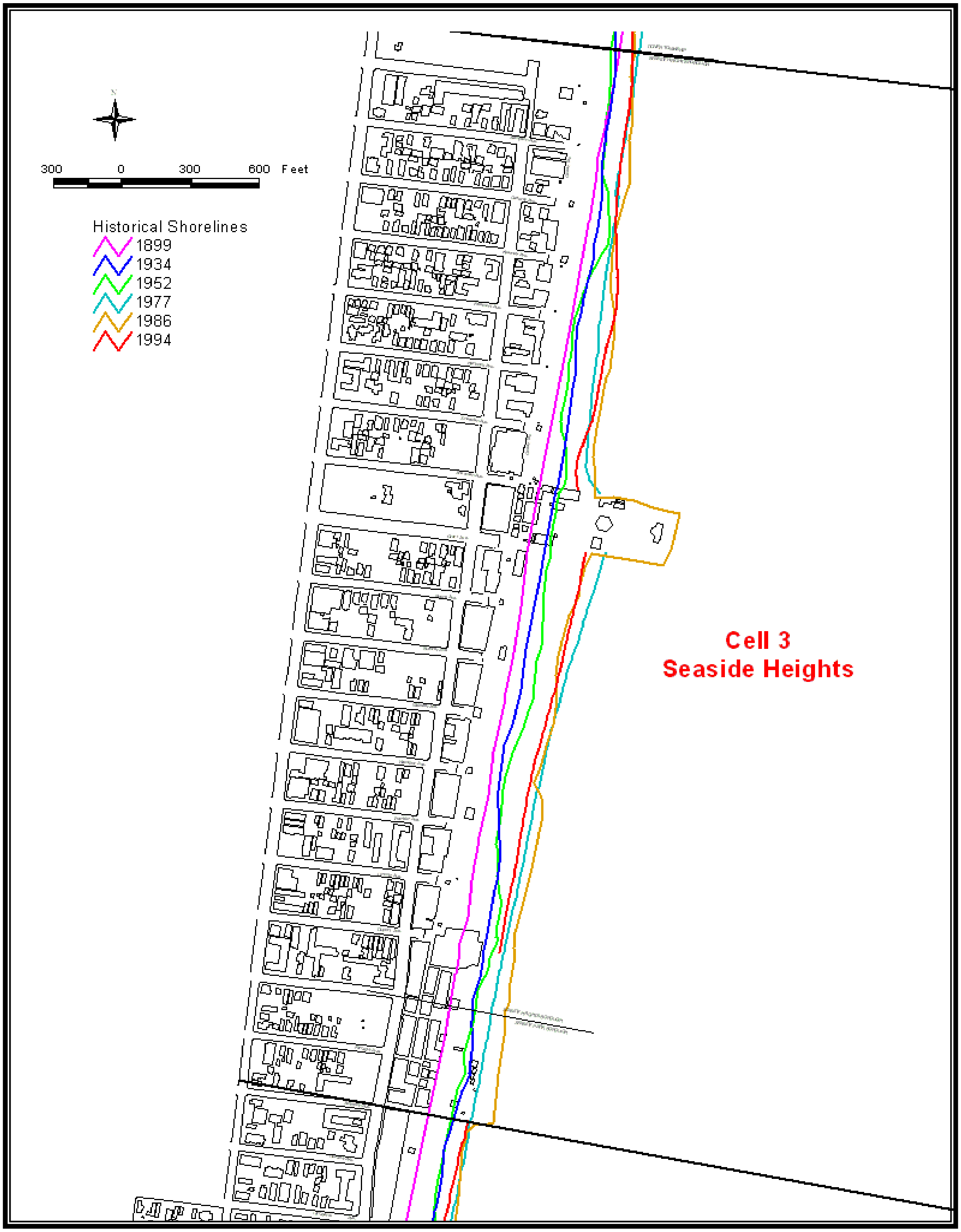


Figure 2-15 Historical Shorelines for Seaside Heights, NJ (data provided by Farrell et al., 1989 and 1994 Digital Photogrammetry)

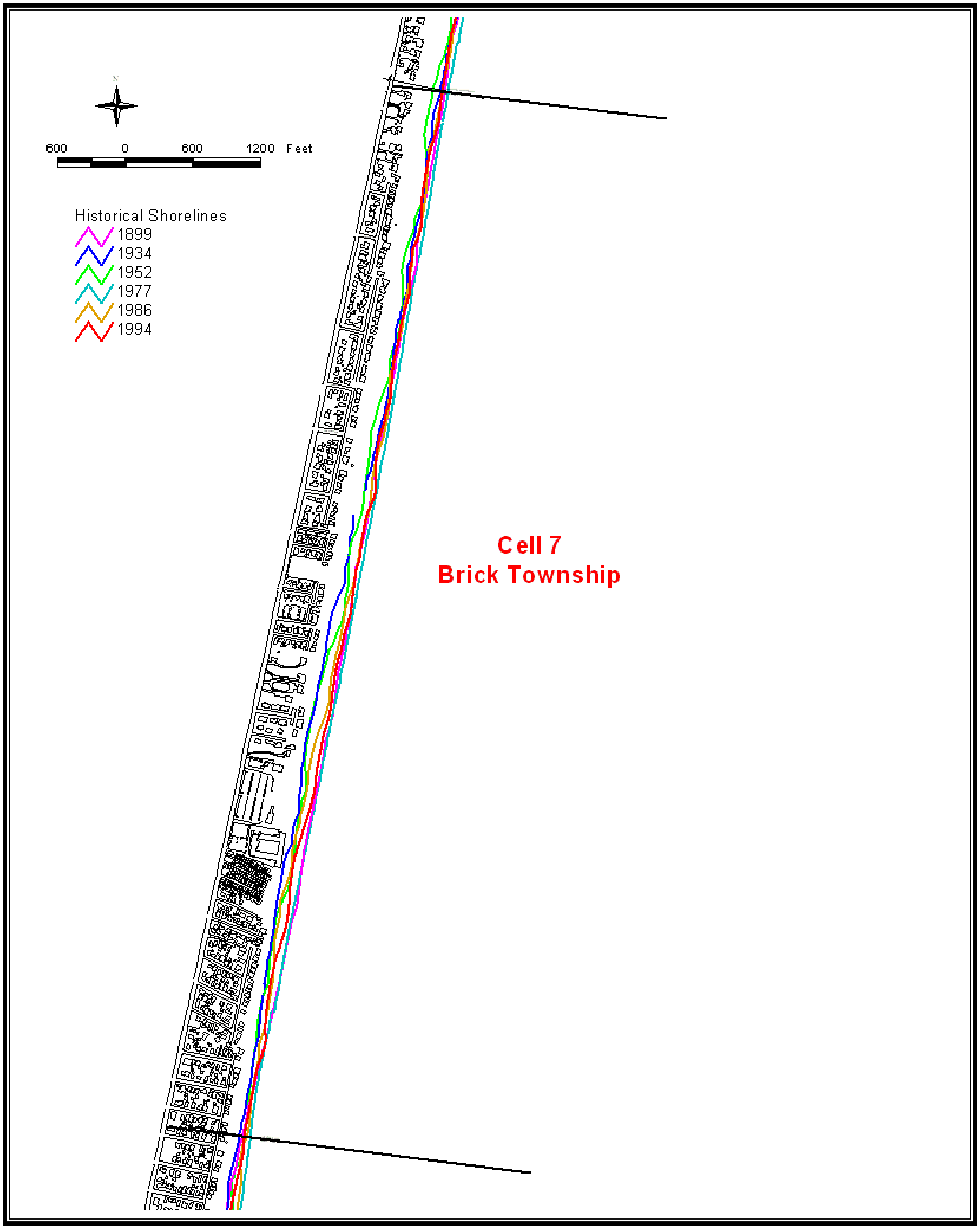


Figure 2-16 Historical Shorelines for Brick Township, NJ (data provided by Farrell et al., 1989 and 1994 Digital Photogrammetry)

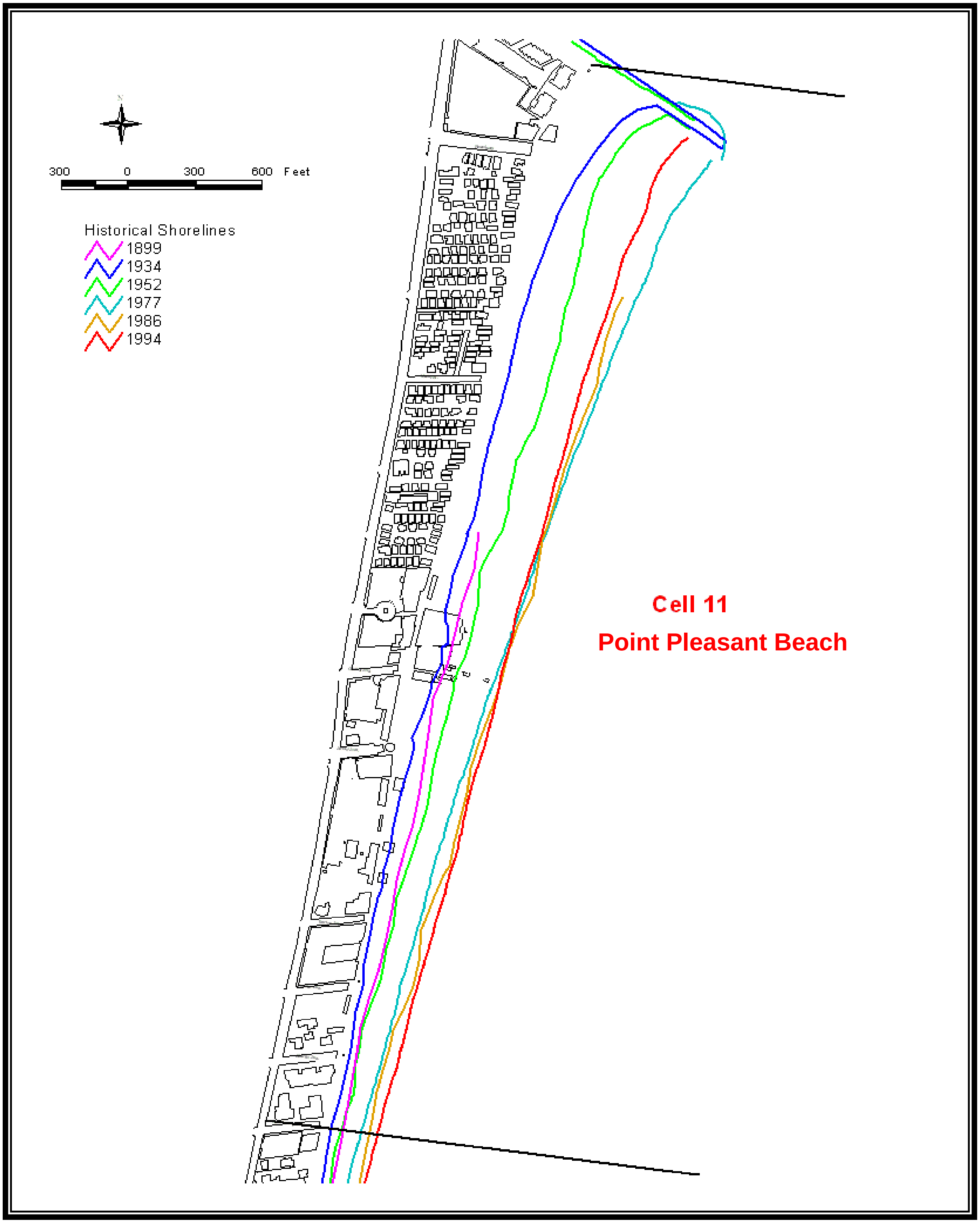


Figure 2-17 Historical Shorelines for Point Pleasant Beach, NJ (data provided by Farrell et al., 1989 and 1994 Digital Photogrammetry)

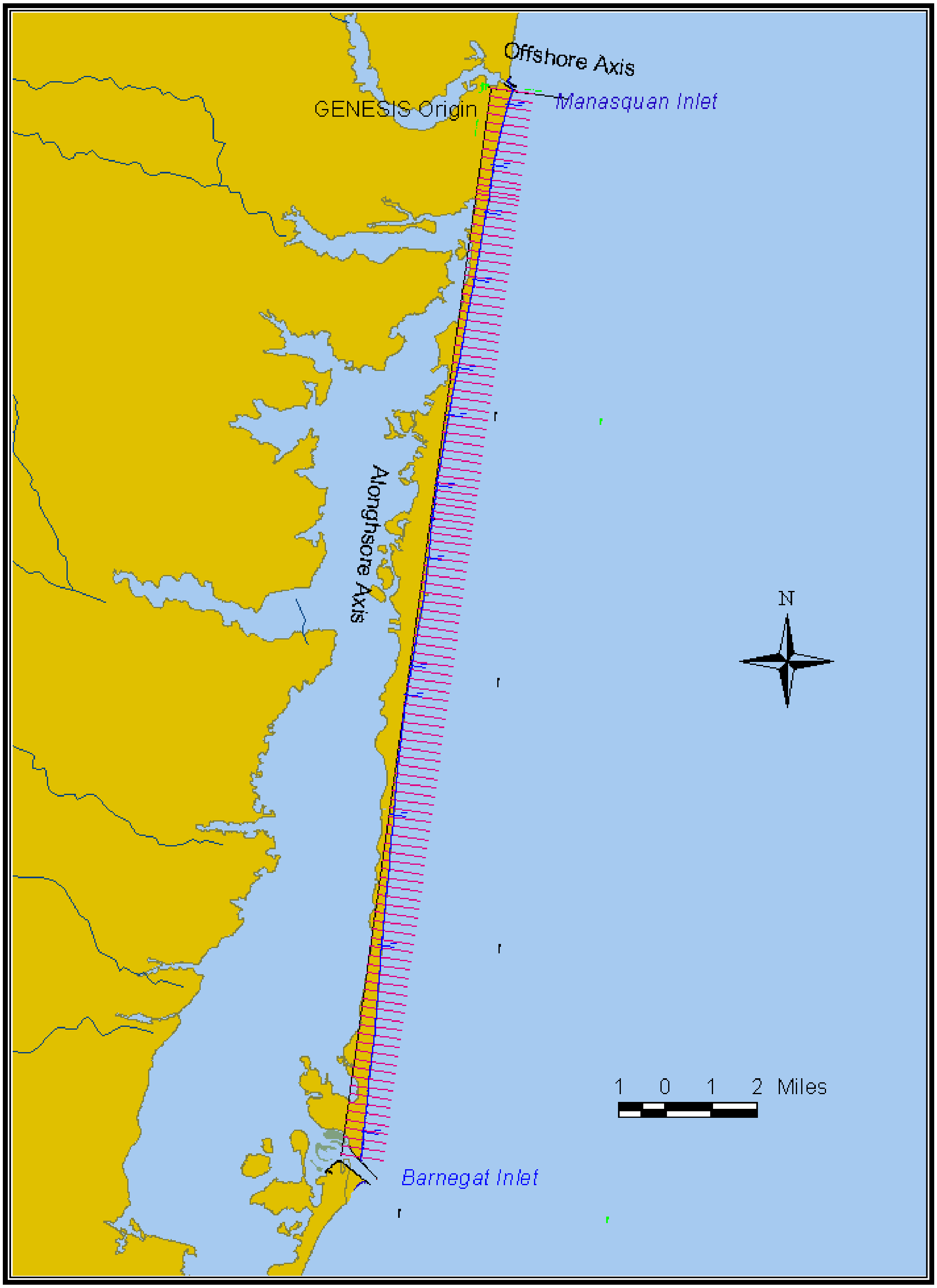


Figure 2-18 Manasquan to Barnegat Inlet Shoreline Analysis Grid

Table 2-22 Shoreline Change Rates (feet/yr) by Epochs

(N/A – Insufficient Data)

Cell No.	Comp No.	Length (ft)	1839-1867	1873-1899	1899-1934	1934-1952	1952-1977	1977-1986	1986-1994
11	1	1000	N/A	N/A	N/A	7.83	22.49	N/A	N/A
11	3	1000	-10.56	N/A	-1.39	5.92	11.51	2.53	-0.43
11	4	1000	-11.62	N/A	-2.07	5.59	7.57	4.78	3.45
11	5	1000	-14.44	N/A	N/A	2.47	6.49	3.53	5.09
10	6	1000	-16.01	N/A	-1.03	1.46	4.93	3.44	4.03
10	7	1000	-16.50	N/A	N/A	1.43	4.59	-0.06	5.96
10	9	1359	-11.61	N/A	-2.26	0.29	6.91	-5.14	-1.59
9	10	1072	-10.62	N/A	-2.45	-0.03	8.81	-3.83	-0.15
9	14	586	-8.60	N/A	-1.61	-0.26	10.37	-3.31	0.54
9	16	885	-4.34	N/A	-1.81	-0.96	6.55	-2.29	-2.25
8	18	1000	-2.31	N/A	-2.64	-0.57	8.56	-8.54	-0.26
8	23	1000	-4.66	N/A	-2.91	-0.26	4.85	-6.31	2.04
8	26	1000	-7.05	N/A	0.11	-2.86	6.15	-6.92	-1.49
8	29	1000	-6.80	N/A	-0.86	-2.35	7.49	-6.00	0.10
7	30	1000	-4.32	N/A	-1.06	-0.95	6.05	-6.11	-0.21
7	33	1000	-5.88	N/A	-2.40	0.68	7.52	-5.48	1.76
7	36	1000	N/A	1.23	-4.12	2.69	6.83	-12.01	6.12
7	38	1000	N/A	3.00	-1.49	0.37	4.82	-4.27	1.45
6	41	1000	N/A	1.26	-1.04	1.37	5.88	-1.11	-5.29
6	44	1000	N/A	0.65	-2.90	4.46	3.57	2.33	-1.90
6	47	847	N/A	N/A	N/A	2.02	4.95	1.42	-5.93
5	48	811	N/A	2.66	-4.17	1.36	7.46	2.53	-1.05
5	51	838	N/A	1.81	-2.61	1.46	5.99	-2.47	-0.62
5	55	838	N/A	-2.58	-2.10	0.98	6.05	-4.20	-0.66
4	56	1000	N/A	N/A	N/A	0.05	6.06	-4.72	0.83
4	58	1000	N/A	0.81	-2.11	0.28	4.41	-0.26	-6.23
3	60	1000	N/A	N/A	0.41	0.46	4.94	1.18	-1.62
3	62	1000	N/A	0.15	2.00	2.06	12.09	-5.43	-1.74
3	64	1000	N/A	0.98	3.16	0.07	4.81	N/A	N/A
2	66	1000	N/A	-0.62	3.48	3.21	2.93	0.00	-2.75
2	68	1000	N/A	-0.78	3.89	-0.84	5.84	3.01	-4.91
2	70	1000	N/A	-0.80	2.75	1.68	-2.03	9.56	1.80
2	72	1000	N/A	-2.28	2.23	1.38	-1.65	6.83	1.35
1	73	1000	N/A	N/A	2.12	0.01	-0.81	10.46	-1.22
1	74	1000	N/A	-1.83	2.85	-0.53	N/A	N/A	-1.10
1	75	1000	N/A	-2.86	2.77	-0.77	2.80	1.34	-0.81

Table 2-23 Shoreline Change Rates (feet/yr) Relative to 1994

(N/A – Insufficient Data)

Cell No.	Comp No.	Length (ft)	1839-1994	1873-1994	1899-1994	1934-1994	1952-1994	1977-1994	1986-1994
11	1	1000	N/A	N/A	N/A	6.99	5.60	-7.58	N/A
11	3	1000	0.81	N/A	3.38	5.38	4.91	1.17	-0.42
11	4	1000	0.18	N/A	2.69	4.75	4.45	4.17	3.45
11	5	1000	N/A	N/A	N/A	3.58	3.97	4.25	5.09
10	6	1000	-0.95	N/A	1.47	2.74	3.21	3.71	4.02
10	7	1000	N/A	N/A	N/A	2.25	2.54	2.72	5.96
10	9	1359	-1.58	N/A	0.19	1.28	1.23	-3.51	-1.59
9	10	1072	-1.36	N/A	0.62	2.10	2.45	-2.14	-0.15
9	14	586	-0.65	N/A	1.21	2.66	3.26	-1.54	0.54
9	16	885	N/A	N/A	N/A	N/A	N/A	-2.27	-2.25
8	18	1000	N/A	N/A	N/A	N/A	N/A	-4.73	-0.26
8	23	1000	-0.91	N/A	-0.49	0.62	0.67	-2.46	2.04
8	26	1000	-0.69	N/A	-0.09	-0.01	0.54	-4.42	-1.49
8	29	1000	-0.77	N/A	0.15	0.80	1.48	-3.19	0.10
7	30	1000	-0.60	N/A	0.09	0.66	0.86	-3.39	-0.21
7	33	1000	-0.23	N/A	0.47	1.78	1.84	-2.14	1.76
7	36	1000	-0.57	-0.26	-0.15	1.42	0.66	-3.65	6.12
7	38	1000	0.20	0.50	0.25	1.04	1.05	-1.63	1.45
6	41	1000	0.36	0.72	0.80	1.55	1.27	-3.04	-5.29
6	44	1000	0.60	0.58	0.93	2.42	1.64	0.38	-1.90
6	47	847	N/A	N/A	N/A	1.77	1.41	-1.96	-5.92
5	48	811	0.76	0.49	0.66	2.95	3.28	0.88	-1.05
5	51	838	0.14	0.37	0.45	1.78	1.63	-1.62	-0.62
5	55	838	0.91	-0.30	0.35	1.41	1.25	-2.57	-0.66
4	56	1000	N/A	N/A	N/A	1.22	1.33	-2.17	0.82
4	58	1000	1.48	-0.09	-0.03	0.88	0.78	-3.01	-6.22
3	60	1000	N/A	N/A	1.24	1.69	1.93	-0.11	-1.62
3	62	1000	N/A	2.41	2.90	3.26	3.11	-3.73	-1.74
3	64	1000	N/A	2.06	2.25	1.78	2.88	0.24	N/A
2	66	1000	N/A	1.99	2.26	1.48	0.75	-1.27	-2.75
2	68	1000	N/A	1.90	2.23	1.66	2.26	-0.64	-4.91
2	70	1000	N/A	1.47	1.78	1.42	1.68	5.98	1.80
2	72	1000	-0.72	0.89	1.36	1.00	1.13	4.31	1.35
1	73	1000	N/A	N/A	1.40	1.27	1.94	5.07	-1.22
1	74	1000	N/A	N/A	N/A	N/A	N/A	N/A	-1.10
1	75	1000	N/A	N/A	N/A	N/A	N/A	0.35	-0.81

The shorelines in the Bay Head (cell 9) and Point Pleasant Beach (cells 10 and 11) communities experienced significant erosional losses in the mid to late 1800's. The trend reversed itself beginning in 1934 where moderate amounts of accretion occurred from 1934 to 1977. From the years 1977 to 1994, the trend was reversed again in Bay Head and the shoreline experienced a period of erosion at approximately 2.5 feet/year. The accretional rates in Point Pleasant Beach reduced significantly with some shoreline segments experiencing erosion in this time period as well. In Mantoloking and Brick Township (cells 8 and 7) the shoreline eroded approximately 2 feet/year between 1899 and 1934. This erosional trend continued for Mantoloking to the 1950's whereas the majority of Brick Township started to experience a period of accretion from 1934 to 1977. Mantoloking also experienced a period of accretion of over 6 feet/year from 1952 to 1977. Again though, the shoreline eroded from 1977 to 1994 for most of Mantoloking and from 1977 to 1984 for Brick Township. Dover Township (cell 6), Lavallette (cell 5), and Ortley Beach (cell 4) have experienced similar shoreline change behavior of moderate erosion between 1899 and 1932 followed by a period of accretion till 1977. From 1977 to 1986, majority of Dover Township and Lavallette continued to accrete at a moderate rate with Ortley Beach starting to erode at a rate of 2.5 feet/year. All three areas eroded from 1986 to 1994 at an average rate of approximately 2 feet/year. The shorelines of Seaside Heights (cell 3), Seaside Park (cell 2), and Berkeley Township (cell 1) went through a period of moderate erosion from 1873 to 1952. Significant accretion occurred over the period of 1952 to 1986 at an average rate of 3.5 feet/year for the majority of the shoreline in these communities. Again though, the trend reversed between 1986 and 1994 with an average rate of erosion of 2 feet/year.

2.9.3 Analysis of Beach Profile Data

An attempt was made to extend the shoreline change analysis to include more recent data through use of beach profile data. NJDEP beach profiles have been conducted yearly since 1986 at selected locations throughout the study area. Analysis of the NJDEP profile data indicates volumetric changes in the profile only through the nearshore zone. The profiles do not extend beyond the surf zone where significant movement of littoral material occurs. Thus, storage of material removed from the nearshore during a significant event may not be accounted for. The lack of established survey controls for the NJDEP surveys prevented direct comparison of recent shoreline positions against historic shoreline positions determined through shoreline change mapping. However, the data identify relative changes in the shoreline position and account for losses and gains to the berm/dune system.

Farrell et al. (1997) summarizes qualitative changes over time for each profile as described above. Additional analyses were performed on the temporal changes in MHW positions for each profile to provide more quantitative shoreline change information. The MHW position, distance along profile corresponding to an elevation of approximately +1.54 ft NAVD, was determined for each profile. Analysis of the positions over time for each profile provides insight into the variability in shoreline positions and estimation of trends in shoreline movement. The MHW positions were plotted for each profile versus the date surveyed and a least squares fit was performed to estimate a shoreline change rate over the corresponding time period. Figure 2-19 to Figure 2-22 display the shoreline positions at profiles NJDEP 148 (Seaside Park), NJDEP 150 (Lavallette), NJDEP 152 (Brick Township), and NJDEP 156 (Point Pleasant Beach) respectively. The figures show the gross changes in the shoreline position from 1986 to 1997 along with erosional/accretional trends over the same time span. Table 2-25 displays the results of the shoreline change rate analysis on the NJDEP profiles.

Analyzing the more recent conditions using the NJDEP profile data from 1986 to present indicates a shoreline, with brief periods of erosion that are followed by a quick recovery (see Figure 2-19). However, the overall shoreline change from 1986 to 1997 shows an accreting shoreline at the northern and southern most extremes within the study area. As Table 2-25 indicates, the beach profile data within all of the communities except for parts of Point Pleasant Beach, Bay Head, and the Island Beach State Park have overall been experiencing low to moderate amounts of erosion on their shorelines from the time period of 1986 to 1997.

2.9.4 Representative Long-Term Shoreline Erosion Rates

Based on analysis of historical shoreline and beach profile data, representative long-term erosion rates were developed to characterize existing conditions along the study reach. Table 2-24 summarizes long-term erosion rates for each analysis cell. The representative erosion rates were determined based on a spatial and temporal weighted average of all data in each cell from the period 1977 to 1994 (see Table 16 in Appendix A, Section 2).

Table 2-24 Representative Long-Term Shoreline Erosion Rates

Cell No.	Community	Average Shoreline Erosion Rate (ft/yr)
1	Berkeley Township	0
2	Seaside Park	-1
3	Seaside Heights	-2
4	Dover Township (Ortley Beach)	-3
5	Lavallette	-1
6	Dover Township	-2
7	Brick Township	-1
8	Mantoloking	-2
9	Bay Head	-2
10	Point Pleasant Beach – South	0
11	Point Pleasant Beach – North	0

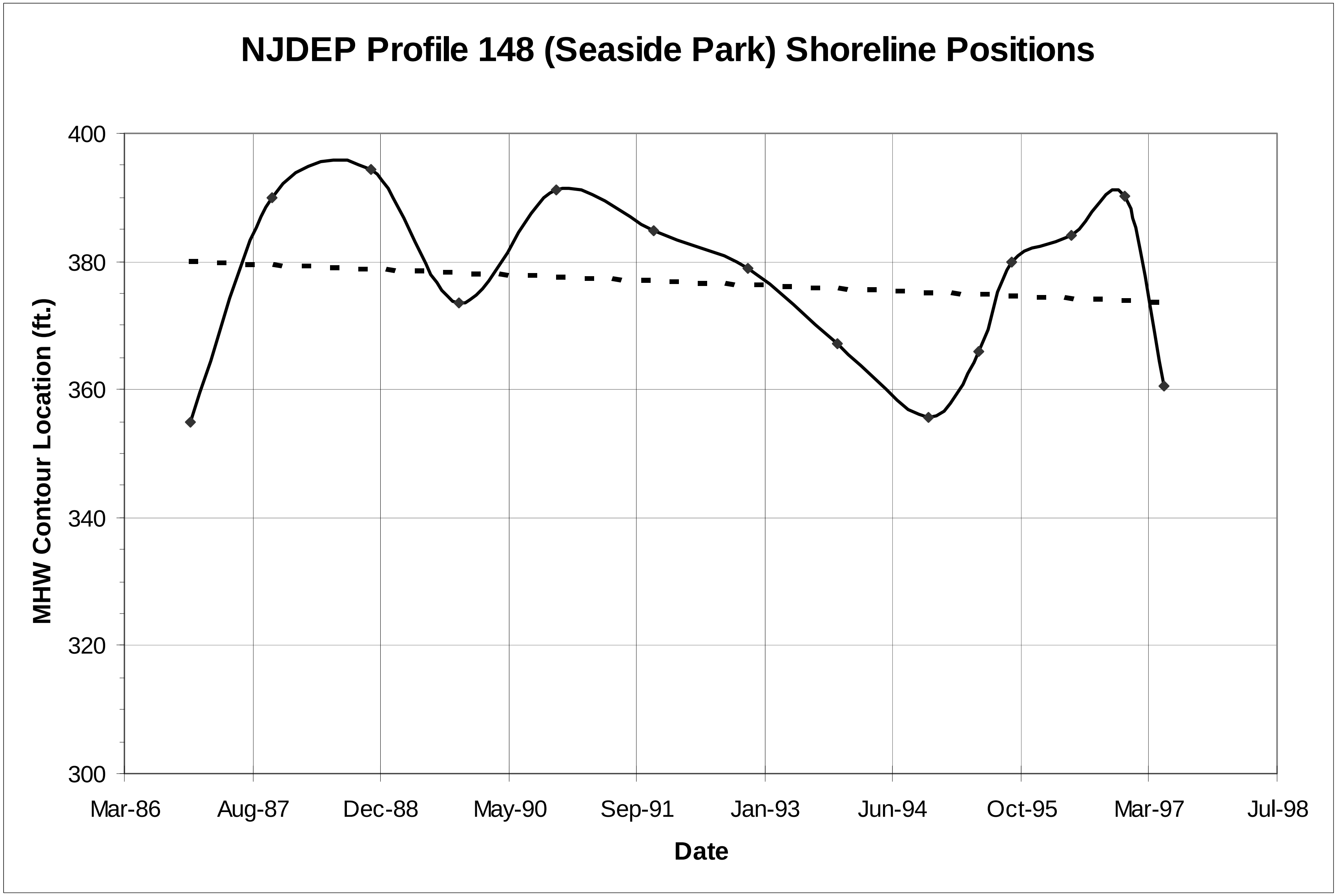


Figure 2-19 NJDEP Profile 148 (Seaside Park) Shoreline Positions

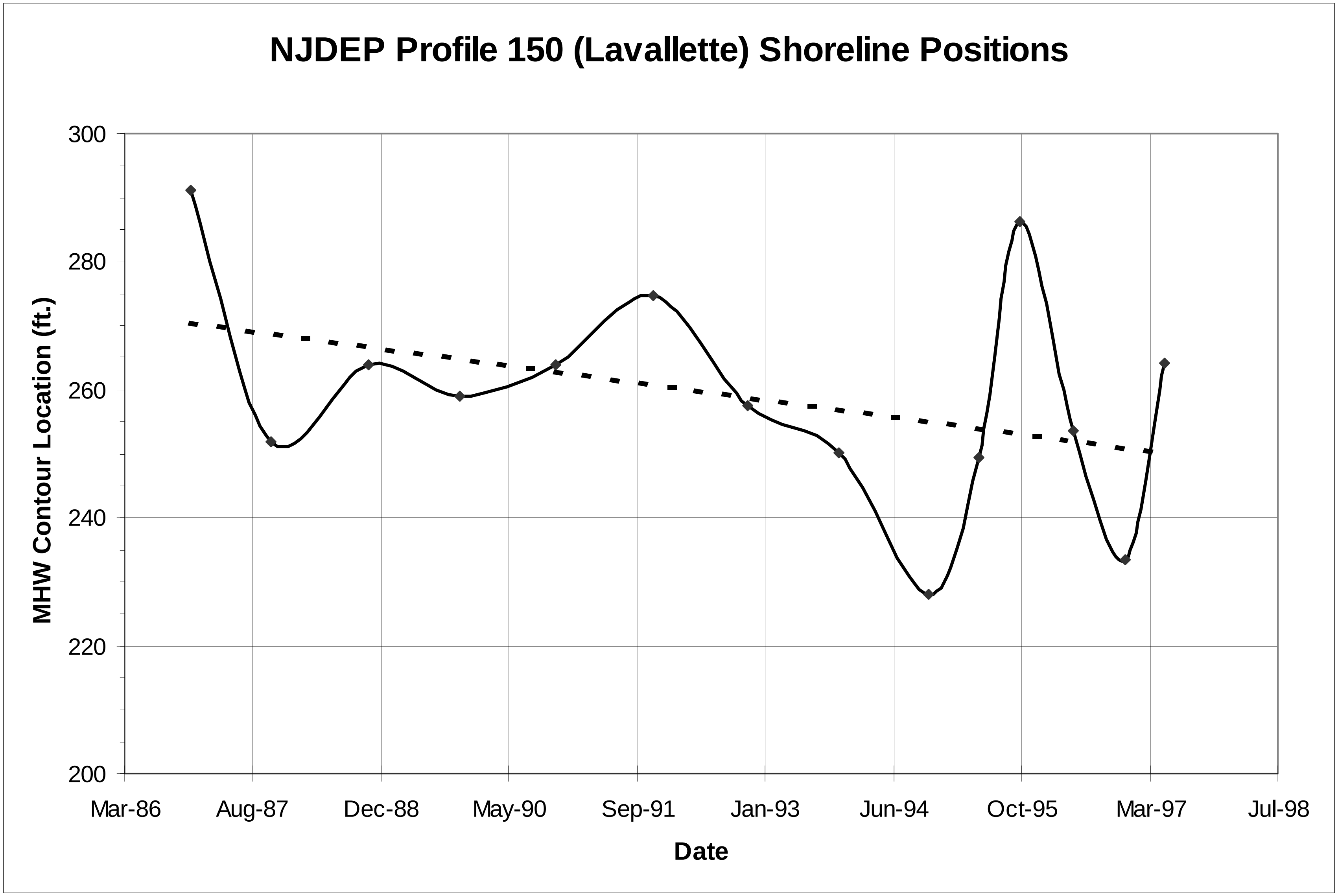


Figure 2-20 NJDEP Profile 150 (Lavallette) Shoreline Positions

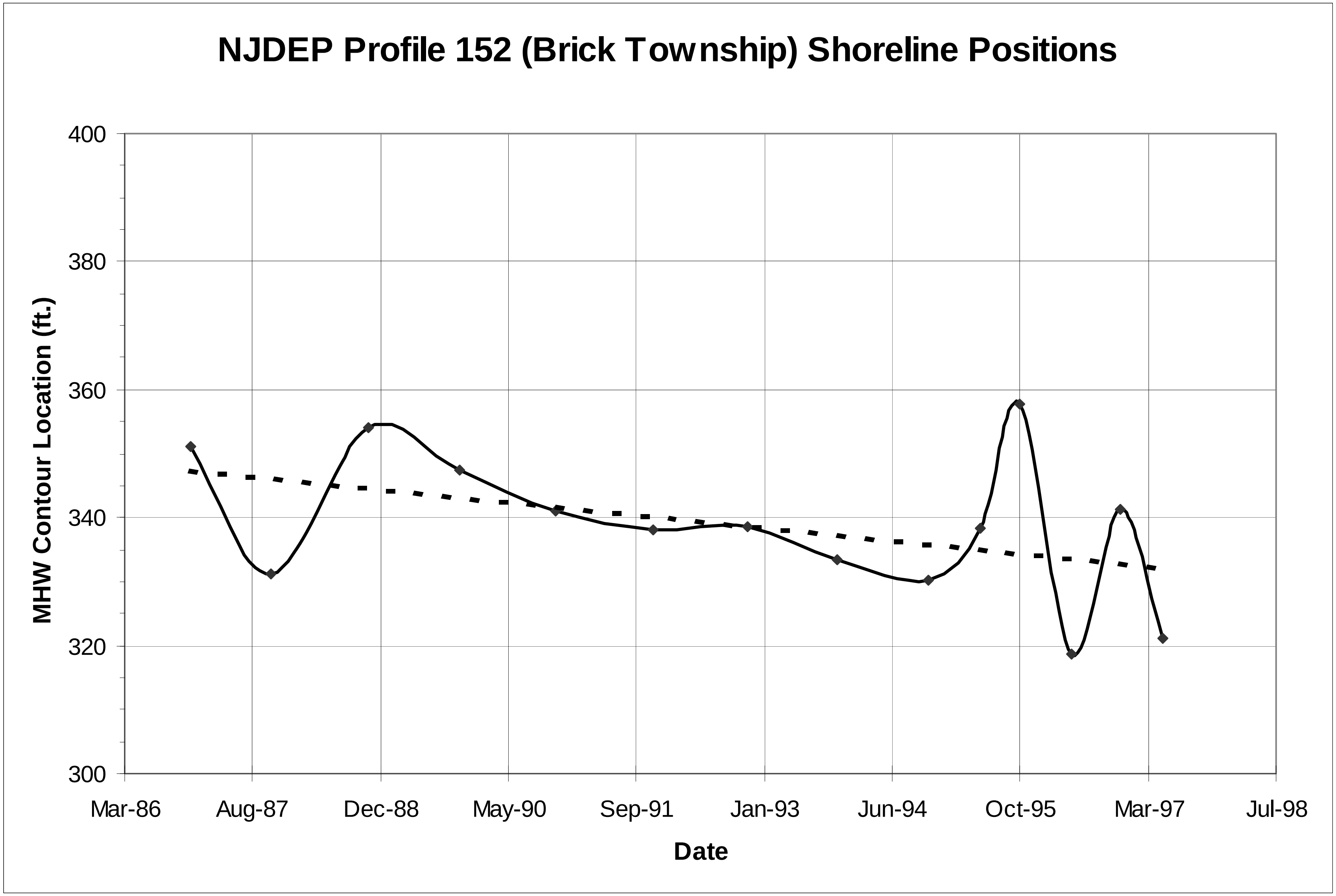


Figure 2-21 NJDEP Profile 152 (Brick Township) Shoreline Positions

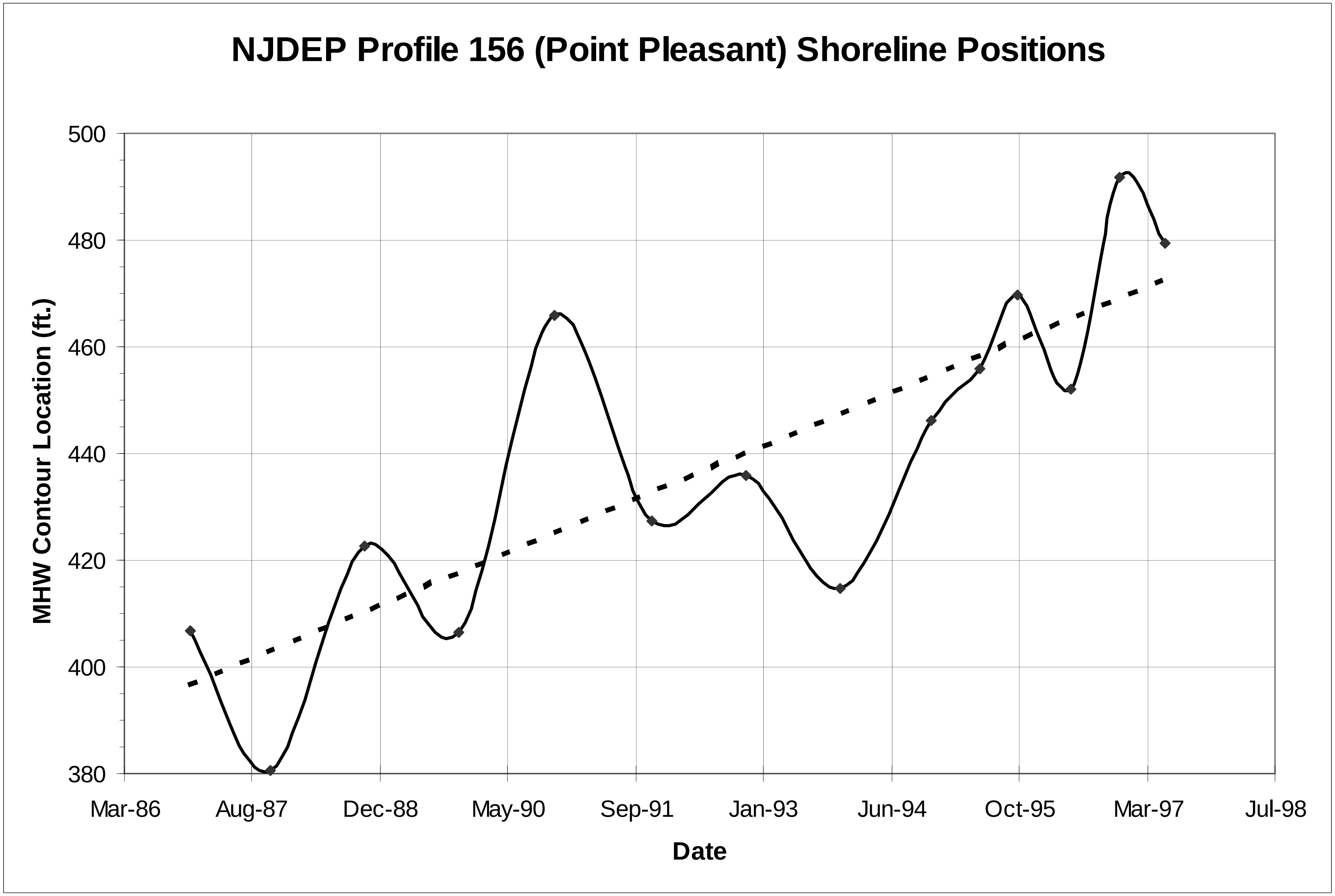


Figure 2-22 NJDEP Profile 156 (Point Pleasant Beach) Shoreline Positions

Table 2-25 Shoreline Change Analysis Results for NJDEP Beach Profiles

NJDEP Profile	SURVEY DATE and SHORELINE POSITION														Shoreline Change Rate (ft/yr)
	Dec-86	*Oct-87*	*Nov-88*	*Oct-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Nov-94*	*Jul-95*	*Nov-95*	*Jun-96*	*Nov-96*	*Jun-97*	
OC146	394.55	377.57	365.10	404.70	388.62	413.80	368.90	398.76	386.61	419.75	428.74	345.01	435.07	459.12	3.7
	Dec-86	*Oct-87*	*Nov-88*	*Oct-89*	*N/A*	*Nov-91*	*Nov-92*	*Nov-93*	*Nov-94*	*Jul-95*	*Nov-95*	*Jun-96*	*Nov-96*	*Jun-97*	
OC246	242.66	220.65	239.21	216.75	N/A	206.96	208.10	189.48	173.08	221.65	254.07	162.56	205.45	194.14	-3.6
	Dec-86	*Oct-87*	*Nov-88*	*Oct-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Nov-94*	*Jul-95*	*Nov-95*	*Jun-96*	*Nov-96*	*Jun-97*	
OC247	319.69	339.60	317.87	352.70	351.89	314.26	346.01	300.26	344.04	350.48	365.39	263.17	325.57	318.13	-1.2
	Dec-86	*Oct-87*	*Nov-88*	*Oct-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Nov-94*	*Jul-95*	*Nov-95*	*Jun-96*	*Nov-96*	*Jun-97*	
OC147	476.55	456.47	456.75	427.20	460.59	460.75	447.85	446.91	432.09	445.86	451.79	444.69	446.19	472.55	-0.9
	Dec-86	*Oct-87*	*Nov-88*	*Oct-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Oct-94*	*May-95*	*Sep-95*	*May-96*	*Dec-96*	*May-97*	
OC148	354.96	389.84	394.44	373.55	391.11	384.72	378.94	367.19	355.59	365.95	379.91	384.14	390.26	360.64	-0.6
	Dec-86	*Oct-87*	*Nov-88*	*Oct-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Oct-94*	*May-95*	*Oct-95*	*May-96*	*Dec-96*	*May-97*	
OC149	270.00	236.32	260.21	244.93	234.12	241.60	262.89	217.53	216.64	243.48	318.93	178.70	232.67	206.87	-2.9
	Dec-86	*Oct-87*	*Nov-88*	*Oct-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Oct-94*	*May-95*	*Oct-95*	*May-96*	*Dec-96*	*May-97*	
OC150	291.23	251.94	263.82	259.05	263.82	274.80	257.52	250.24	228.00	249.34	286.28	253.51	233.40	264.25	-2.0
	Dec-86	*Oct-87*	*Nov-88*	*Oct-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Nov-94*	*May-95*	*Oct-95*	*May-96*	*Dec-96*	*May-97*	
OC151	176.47	155.81	173.63	137.43	148.22	125.59	143.19	129.71	129.13	144.84	152.62	85.25	139.90	121.13	-4.3
	Dec-86	*Oct-87*	*Nov-88*	*Oct-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Nov-94*	*May-95*	*Oct-95*	*May-96*	*Nov-96*	*May-97*	
OC152	351.18	331.30	354.11	347.53	341.00	337.99	338.48	333.42	330.29	338.41	357.68	318.66	341.28	321.09	-1.5
	Dec-86	*Oct-87*	*Oct-88*	*Oct-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Dec-93*	*Nov-94*	*Jul-95*	*Dec-95*	*Jun-96*	*Jan-97*	*May-97*	
OC153	282.81	292.70	282.36	279.13	283.56	247.85	288.31	253.71	282.71	292.85	270.65	291.19	270.61	274.62	-0.6
	Dec-86	*Oct-87*	*Oct-88*	*Oct-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Dec-93*	*Dec-94*	*May-95*	*Dec-95*	*Jul-96*	*Jan-97*	*May-97*	
OC154	151.93	175.85	157.45	170.85	219.51	199.31	187.09	184.37	200.21	234.42	186.27	225.58	215.62	222.24	5.6
	Dec-86	*Oct-87*	*Oct-88*	*Oct-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Nov-94*	*May-95*	*Oct-95*	*May-96*	*Nov-96*	*May-97*	
OC155	357.80	402.41	365.26	347.28	354.67	350.02	356.72	315.90	295.80	331.65	337.03	312.15	319.56	300.08	-6.8
	Dec-86	*Oct-87*	*Oct-88*	*Oct-89*	*Nov-90*	*Nov-91*	*Nov-92*	*Nov-93*	*Nov-94*	*May-95*	*Oct-95*	*May-96*	*Nov-96*	*May-97*	
OC156	406.70	380.62	422.53	406.34	465.86	427.50	435.99	414.68	446.21	455.74	469.64	451.93	491.68	479.37	7.3

3 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 north of Island Beach State Park to determine the potential for erosion 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 alternatives 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, steeper 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 nearshore 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 runup 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. SBEACH is available via a user interface for the personal computer (Rosati et al., 1993). Comprehensive descriptions of development, testing, and application of the model are provided by Larson and Kraus (1989); Larson, Kraus, and Byrnes (1990); and Wise, Smith, and Larson (1996).

3.1.4 Overview of SBEACH Methodology

SBEACH is a geomorphic-based model that simulates two-dimensional beach and dune erosion, including the formation and movement of major morphologic features such as bars and troughs under varying storm waves and water levels (Rosati et al., 1993). The model is intended for predicting short-term profile response to storms.

A fundamental assumption of SBEACH is that profile change is produced solely by cross-shore processes that re-distribute sand across the profile. Longshore processes are assumed to be uniform and neglected in calculating profile change. This assumption is valid when considering storm erosion on open coasts, because, even along shorelines with non-uniform longshore transport, erosion of the upper beach (dune and berm) during storms remains primarily a two-dimensional cross-shore process.

Model input parameters include time histories of water levels as produced by storm surge and tide, time histories of 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 from SBEACH includes beach profile response and cross-shore wave and water level parameters.

3.1.5 SBEACH Calibration

Calibration refers to the procedure of reproducing with SBEACH beach profile erosion produced by an historical storm. Due to the empirical foundation of the SBEACH model and the natural variability in beach erosion that can occur for different beach and storm conditions, optimal use of the model requires calibration and verification using beach profile and storm data from the study site, or data from an adjacent site having similar beach characteristics and experiencing similar hydrodynamic forcing. The calibration procedure involves iterative adjustments of model parameters until agreement is obtained between measured and simulated profiles. In this investigation, model calibration and verification were based on previous SBEACH calibration/verification efforts conducted by CERC at Point Pleasant Beach, NJ (Wise, Smith, and Larson, 1996). The Point Pleasant Beach profile used in calibration has characteristics in terms of nearshore features that are similar to profiles found throughout Island Beach. Storm conditions at Point Pleasant Beach are representative of the entire study area. The conditions selected for calibration were associated with a northeaster that occurred over the period 27 to 29 March 1984 during which the peak water level reached approximately +5.2 feet NAVD, and maximum wave heights of 21.6 feet were recorded in a water depth of 50 feet off of Manasquan Inlet. The selected pre-storm profile surveys were taken on 26 and 27 March. Post-storm profiles were taken on 2 April. Examination of the post-storm profile showed considerable overwash and deposition on the back of the berm. A recovery berm was also evident on the post-storm measured profile, indicating that recovery processes had started prior to collection of the post-storm surveys. The calibrated model reasonably reproduced measured erosion and overwash of the berm. The model did not reproduce the observed post-storm recovery; however, simulation of recovery processes is not critical to evaluating storm erosion damages for this study.

3.1.6 Development of Input Data for Storm Erosion Modeling

Transects were selected to represent the average shoreline, structure, backshore configuration, and upland development conditions for various reaches in the study area. For each cell, 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. In this investigation, the October 1997 most recent survey profiles were selected to represent the onshore and nearshore areas under the without-project base year condition. Each profile extended from the dunes 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 until the profile reached the Bay. These extensions were based on general characteristics of the island's topography as determined by field investigations, USGS topographic sheets, 1994 digital ortho-photogrammetric data, and recent structure inventory surveys. Cross sections of representative beach profile lines can be seen in Figure 3-1 to Figure 3-5 for selective cells. The profile line names correspond to the cells that they represent. The cell limits are shown in Figure 3-6 and described in Table 3-1.

Table 3-1 Cell Descriptions

Cell	Length (ft)	Community
1	2,845	Berkeley Township
2	8,374	Seaside Park
3	4,808	Seaside Heights
4	4,083	Ortley Beach
5	6,624	Lavallette
6	8,803	Dover Township
7	9,362	Brick Township
8	12,716	Mantoloking
9	5,536	Bay Head
10	4,732	Point Pleasant Beach - South
11	4,510	Point Pleasant Beach - North

Potential future damages were also 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 2 to 9 (Seaside Park to Bay Head), with the ends of the Island being historically stable. 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. It was assumed the locals would maintain existing dune conditions, as has been demonstrated historically. Therefore, no modifications were made to the profile above the berm. Figure 3-7 shows both the base year and future (year 15) conditions for cell 8 located in Mantoloking with a long-term erosion rate of -2 ft/yr. Average long-term erosion rates used for all cells to define the future condition are presented in Table 2-24.

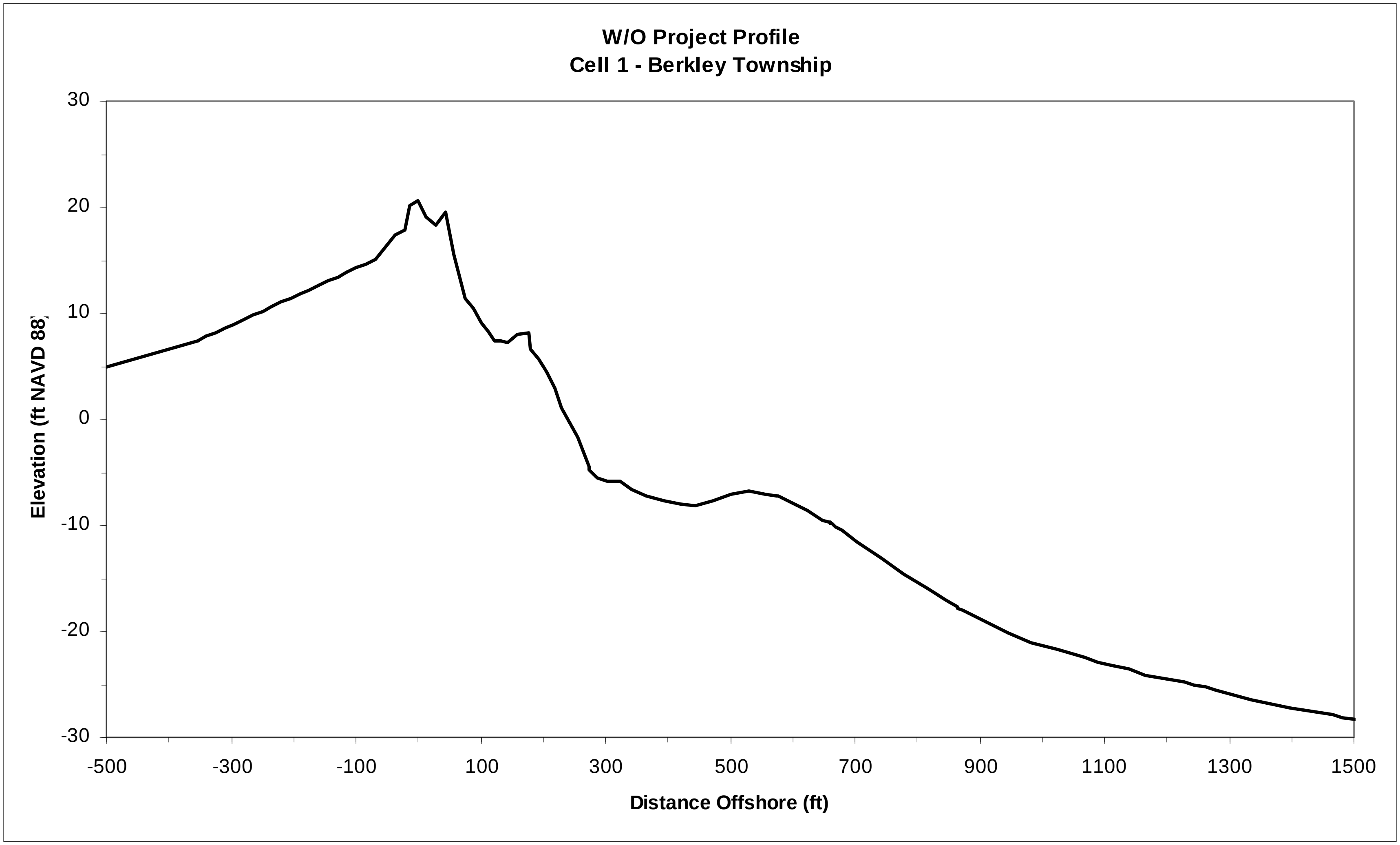


Figure 3-1 Representative Beach Profile for Cell 1 (Berkeley Township)

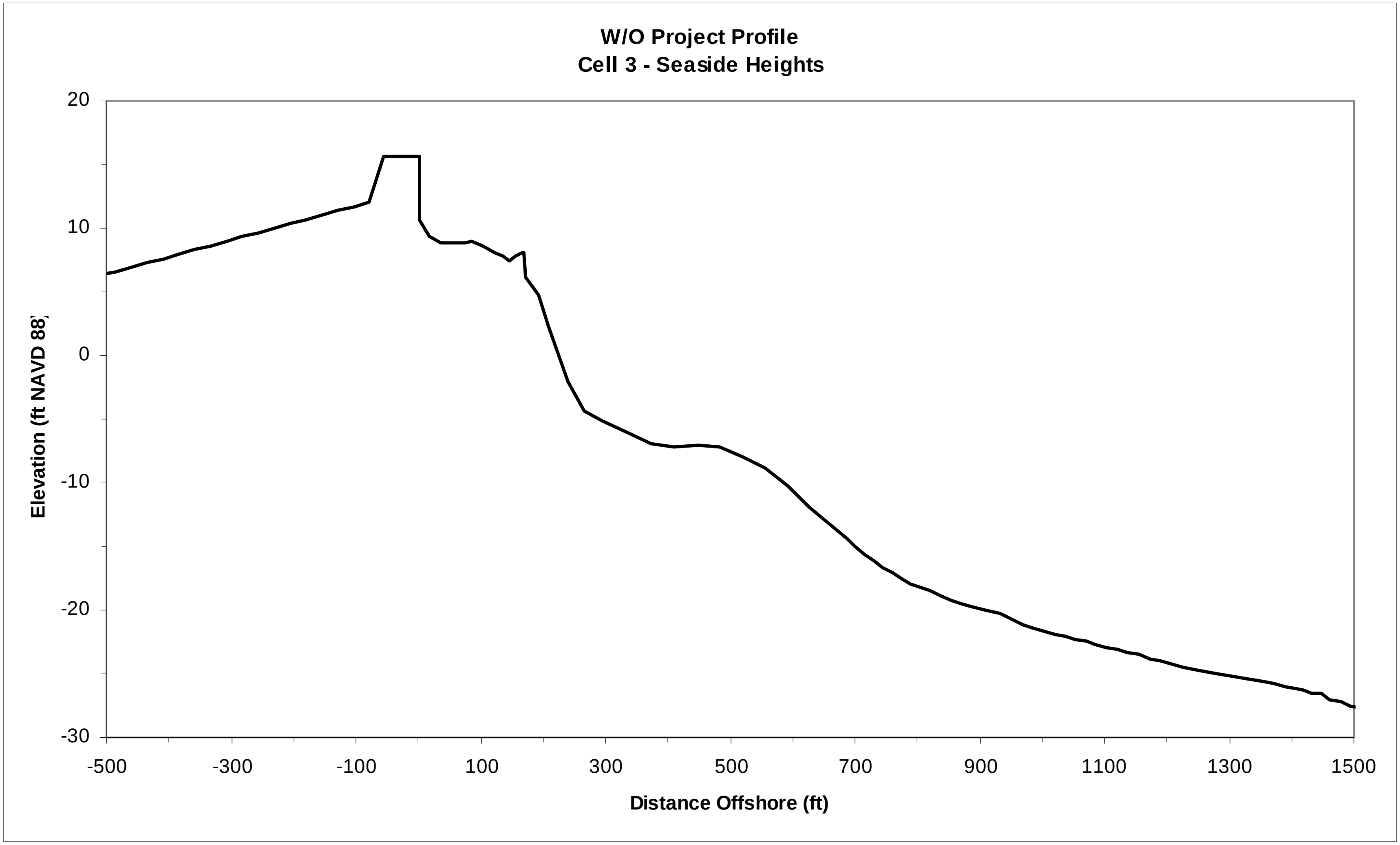


Figure 3-2 Representative Beach Profile for Cell 3 (Seaside Heights)

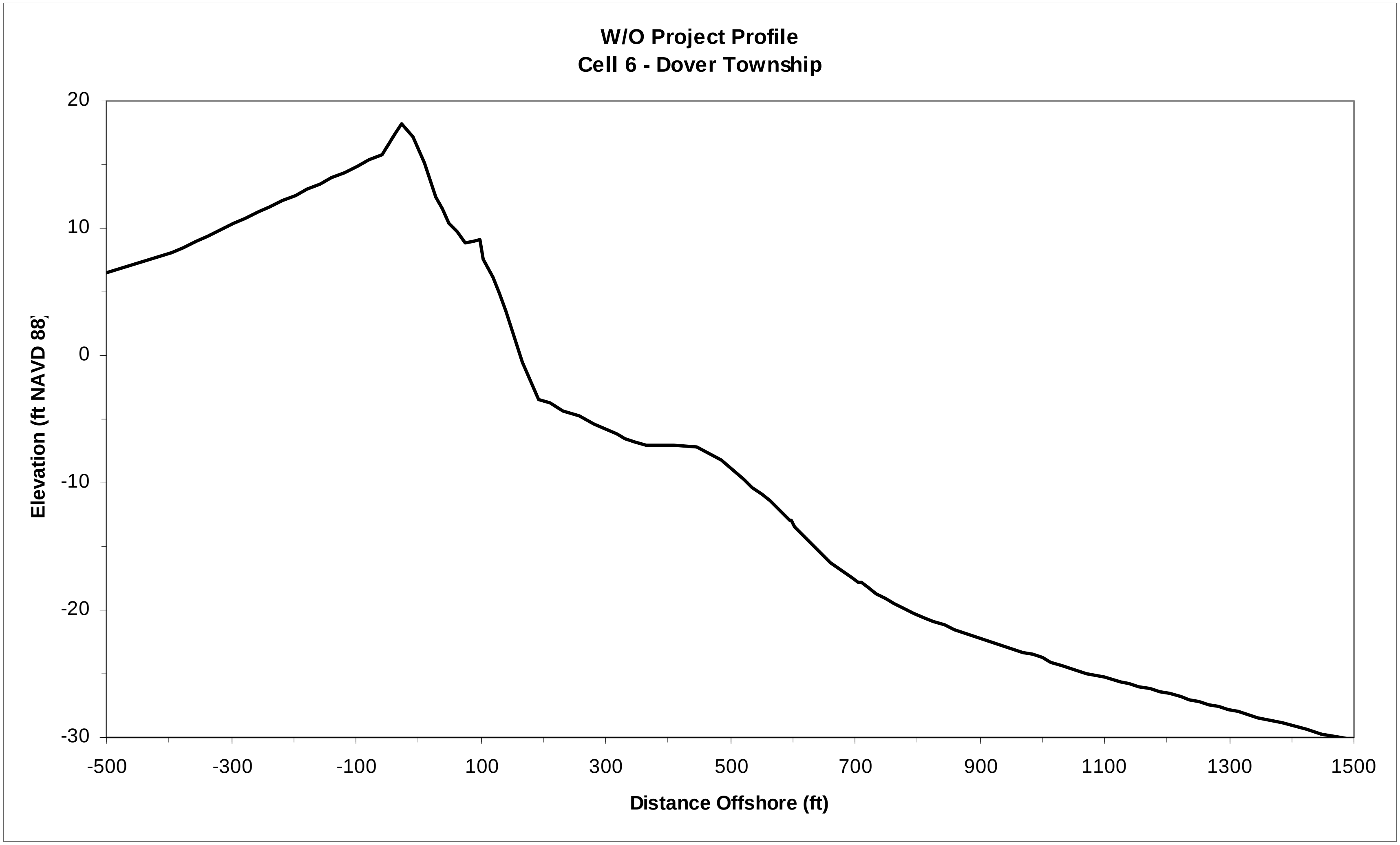


Figure 3-3 Representative Beach Profile for Cell 6 (Dover Township)

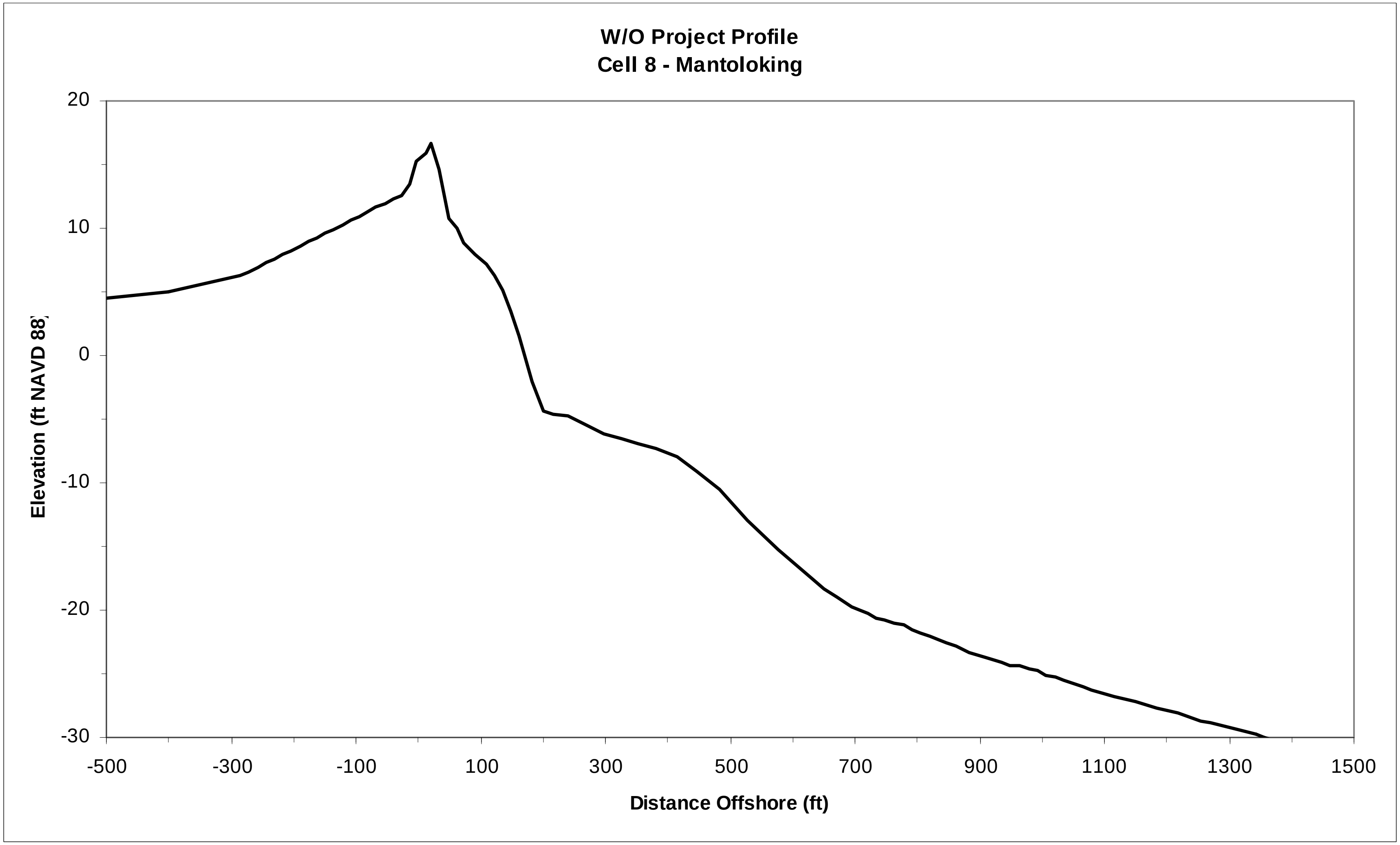


Figure 3-4 Representative Beach Profile for Cell 8 (Mantoloking)

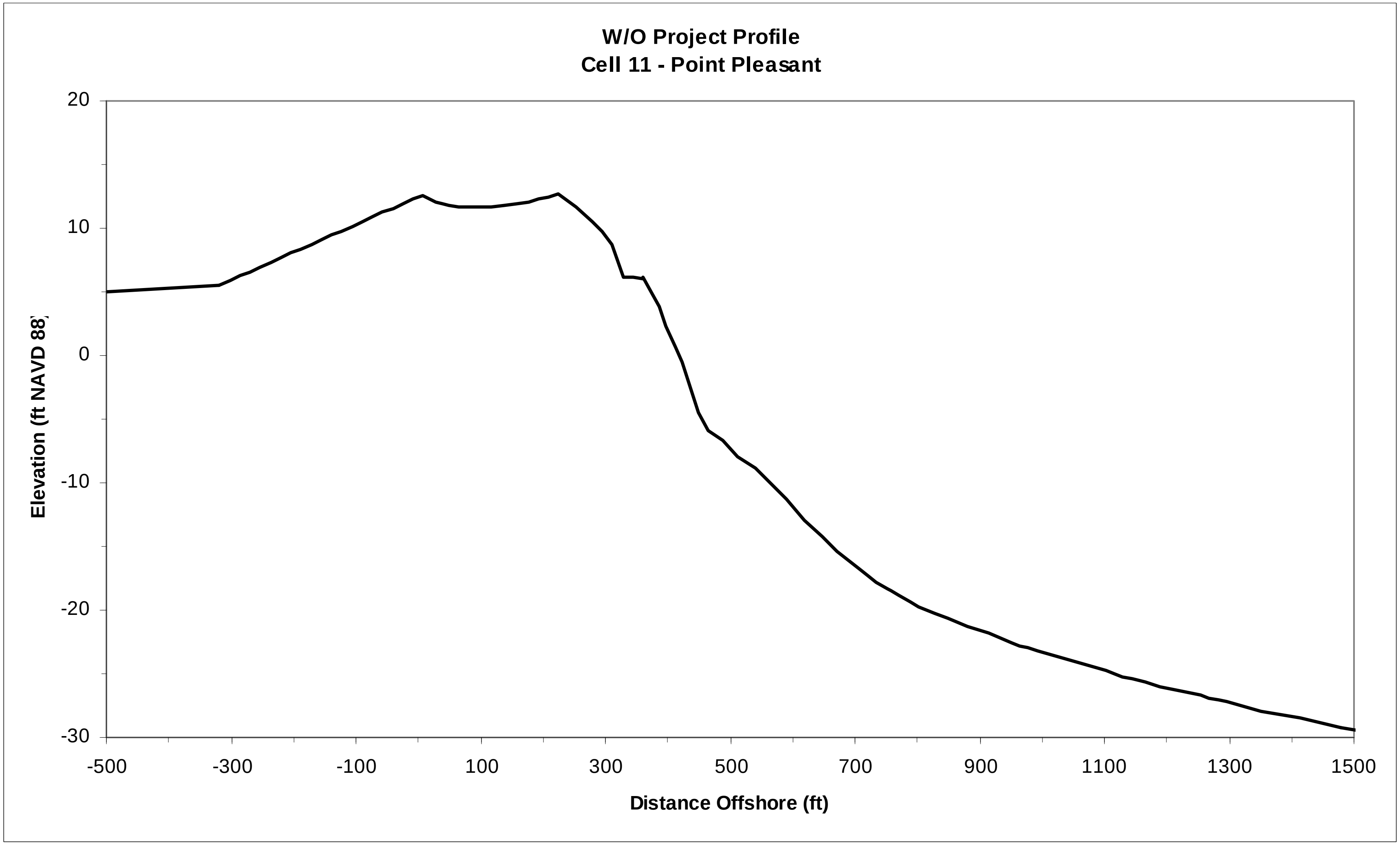


Figure 3-5 Representative Beach Profile for Cell 11 (Point Pleasant Beach)

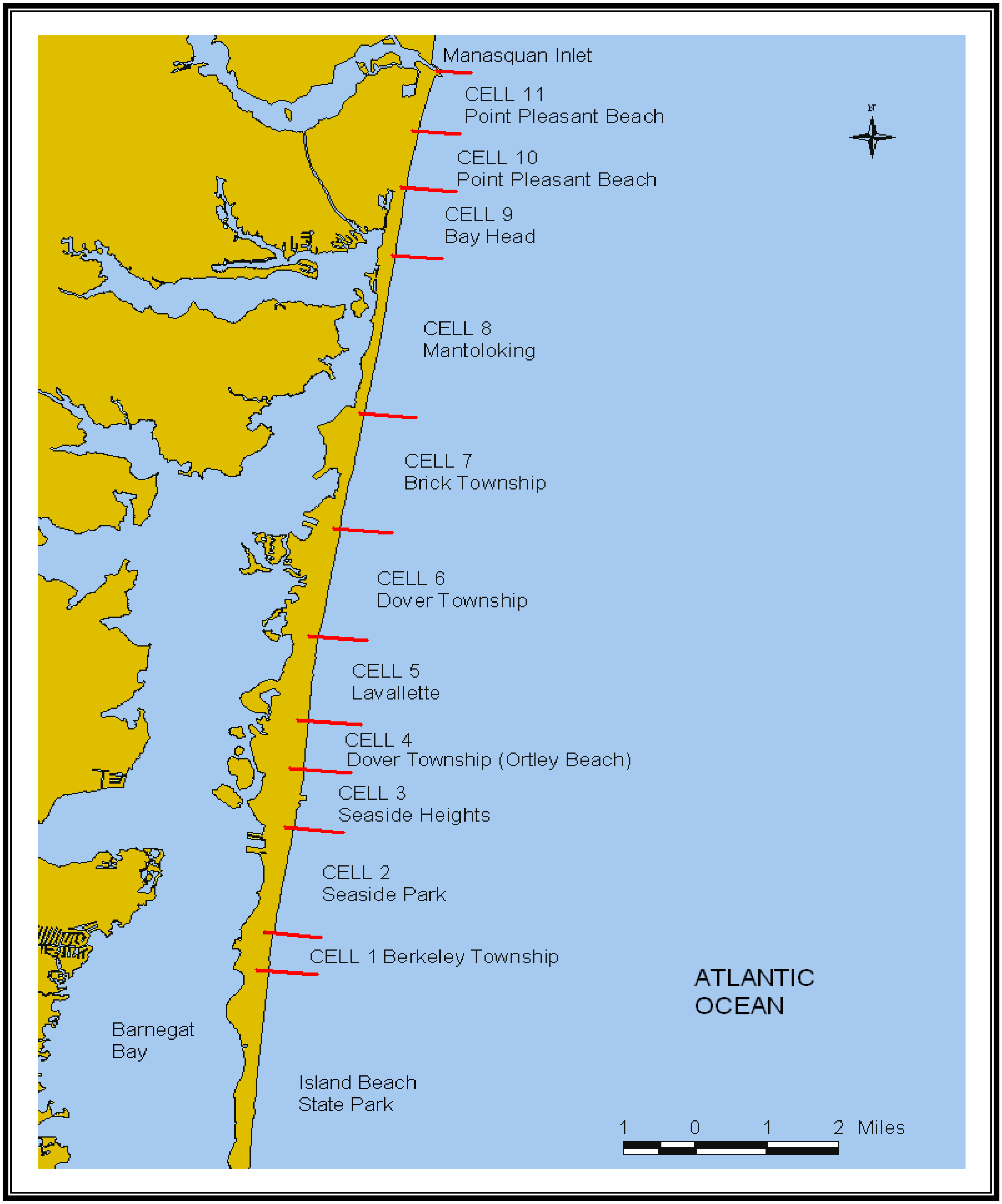


Figure 3-6 Cell Limits

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. Most of Bay Head Borough (cell 9) is fronted with a rubble mound seawall. This structure was accounted for by inputting its location 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 runup; 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.

Water level input data files for representative 2-, 5-, 10-, 20-, 50-, 100-, 200-, and 500-yr events 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 model 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 Section 2.8 of this report. Storm wave heights, as well as water levels (Figure 3-8 to Figure 3-15), were developed by rescaling hindcasted historical storm time series.

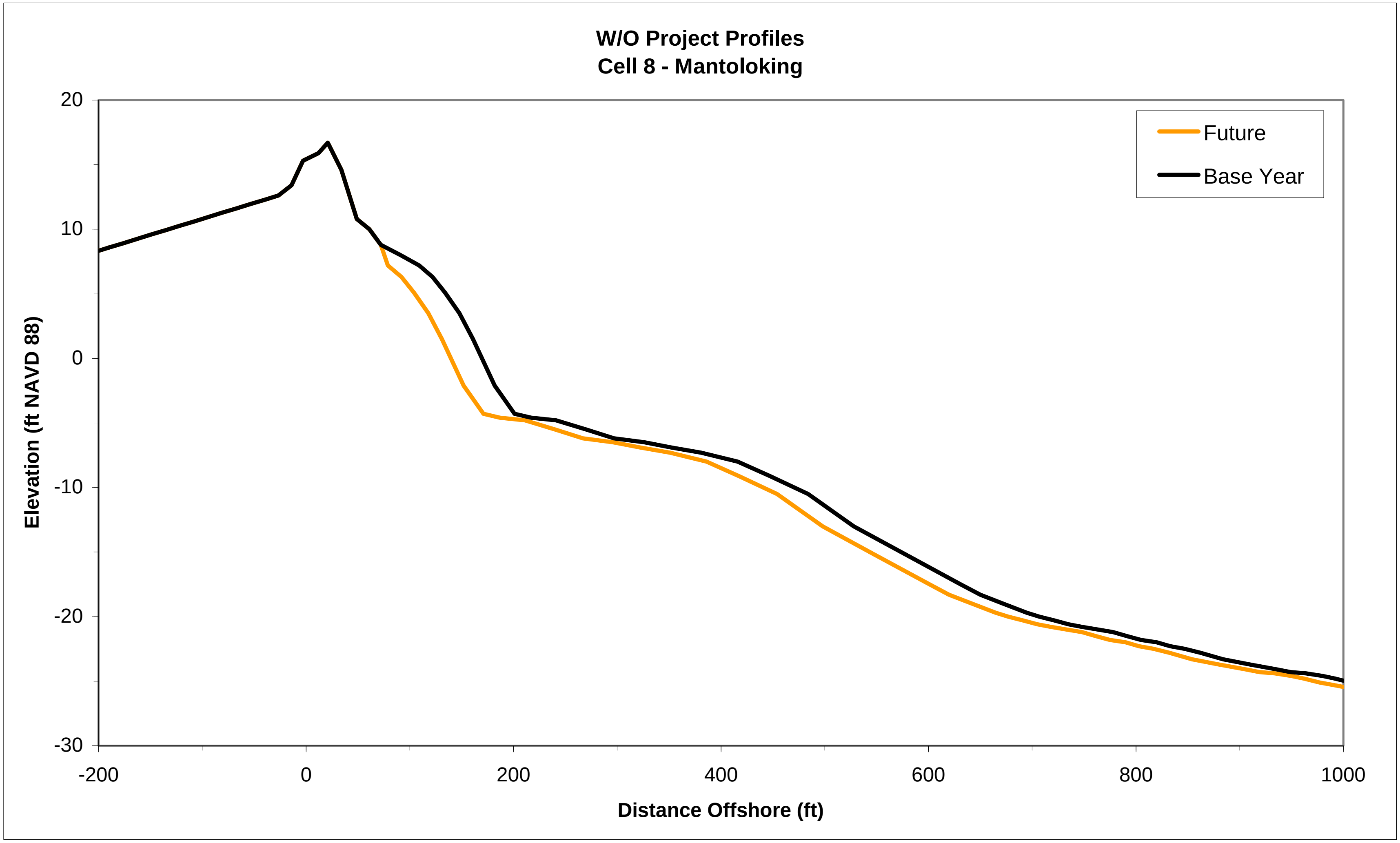


Figure 3-7 Representative Beach Profiles for Base and Future Conditions for Cell 8 (Mantoloking)

3.1.11 Storm Parameters

A variety of data sources were used to characterize the storms used in this analysis. The twenty highest ocean stages recorded at the Atlantic City tide gage between 1912 and 1997 were used in identifying storm events for the study area. For each stage, additional information on the storm type causing the water surface elevation and if possible the actual storm surge hydrograph were obtained. Of the 20 highest events, 12 are northeasters and 8 are hurricanes. 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 both the base year and future 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 landward from the proposed project baseline to the location of the top of the erosion scarp on the beach face. Typical plots of input pre-storm profiles and the resultant post-storm (50-yr event) profiles based on SBEACH predicted retreat are provided in Figure 3-16 to Figure 3-22 for base and future conditions respectively in selective cells. Note that future eroded beach profile simulations were not necessary in cells 1, 10, and 11 because of the zero long-term erosion rate that was computed for these cells.

Portions of the shoreline in Bay Head are structured with a rubble mound seawall. In order for storm erosion to affect the community, the seawall must fail. The SBEACH simulates failure through a number of mechanisms including storm-induced scour at the toe of the structure, direct wave attack, or inundation. Failure criteria for protective structures were developed based on a synthesis of available data, including design and construction information, existing condition typical cross-sections, and field inspection of the structures. 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.

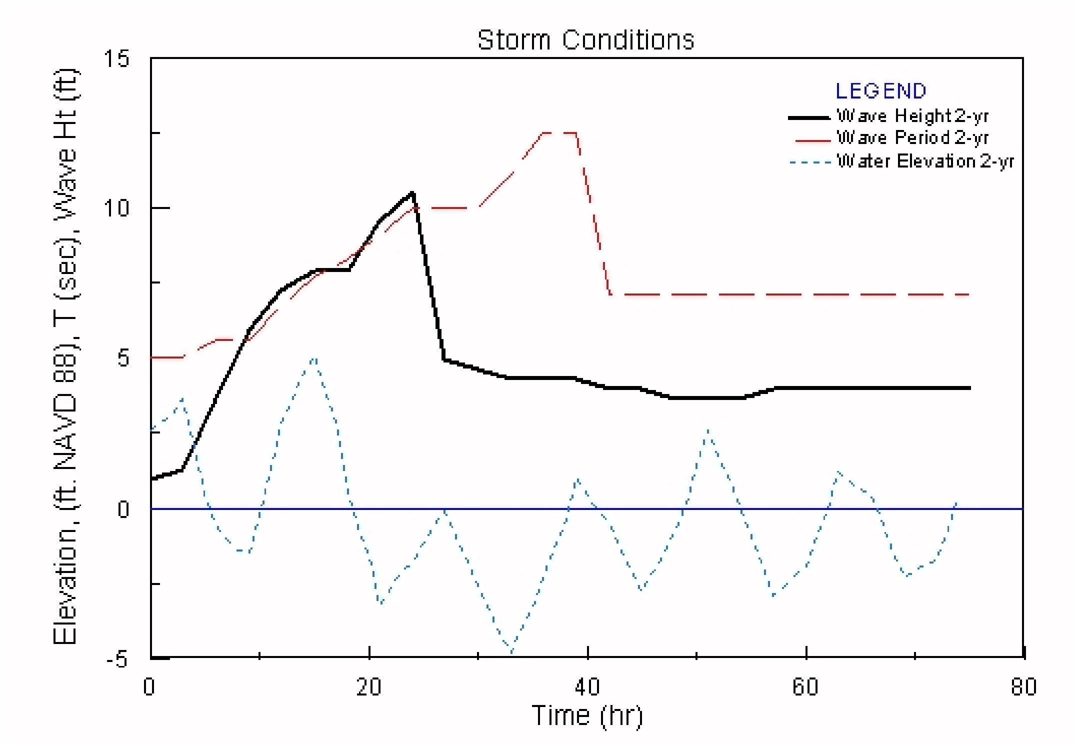


Figure 3-8 2-yr Storm Conditions used in Storm Damage Analysis

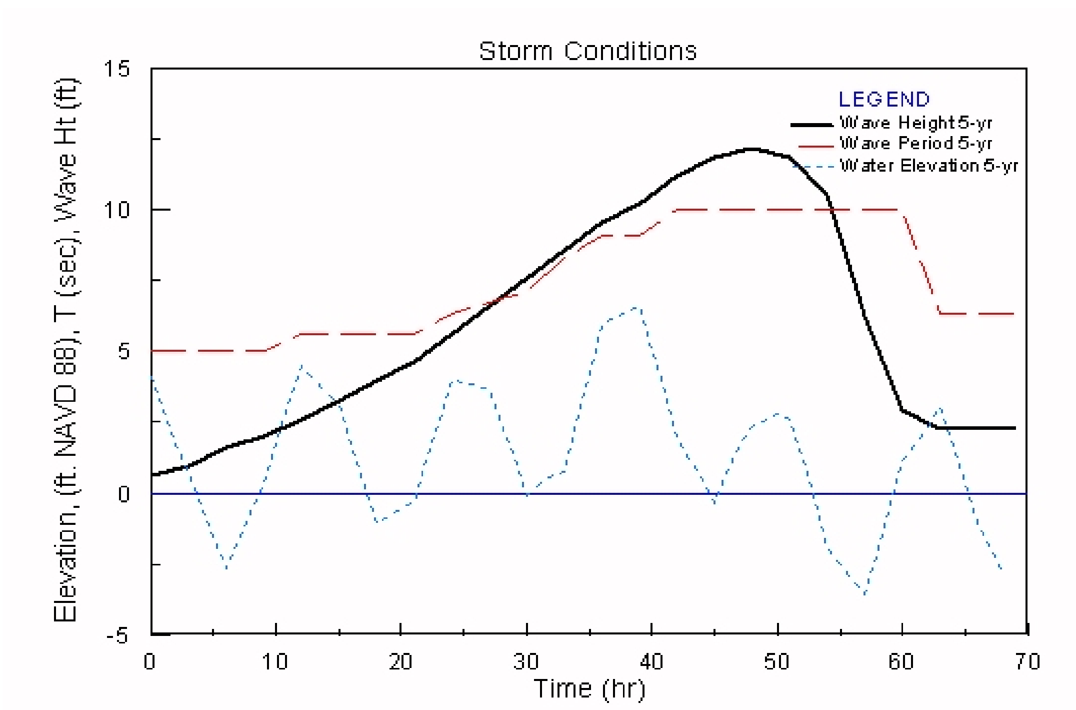


Figure 3-9 5-yr Storm Conditions used in Storm Damage Analysis

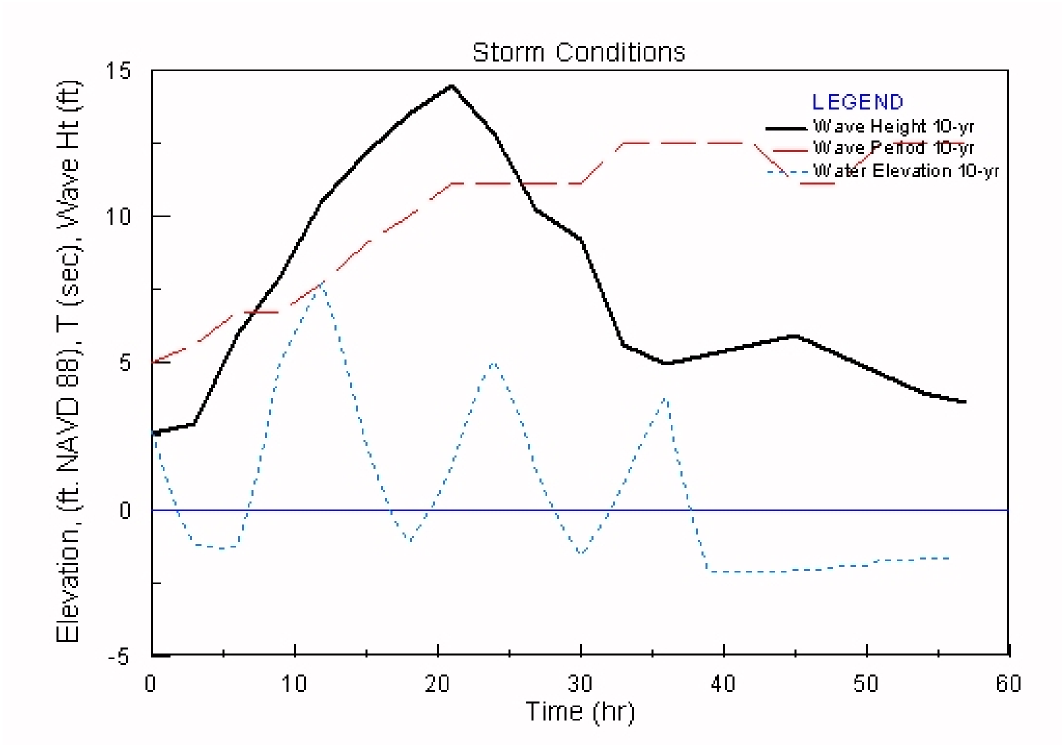


Figure 3-10 10-yr Storm Conditions used in Storm Damage Analysis

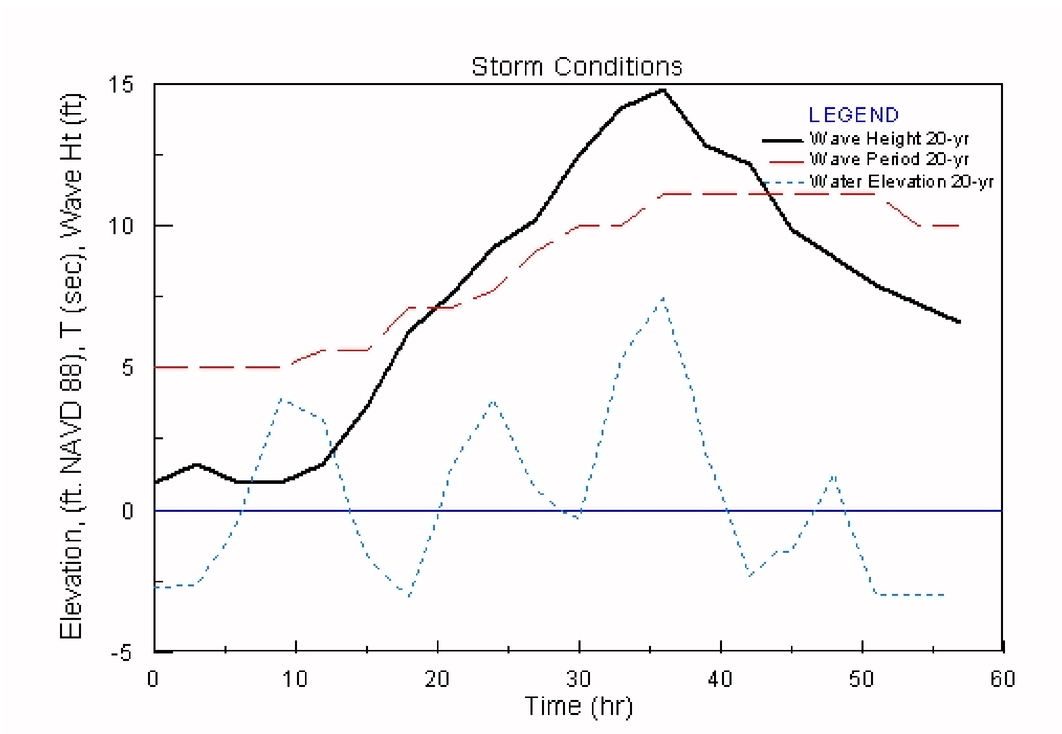


Figure 3-11 20-yr Storm Conditions used in Storm Damage Analysis

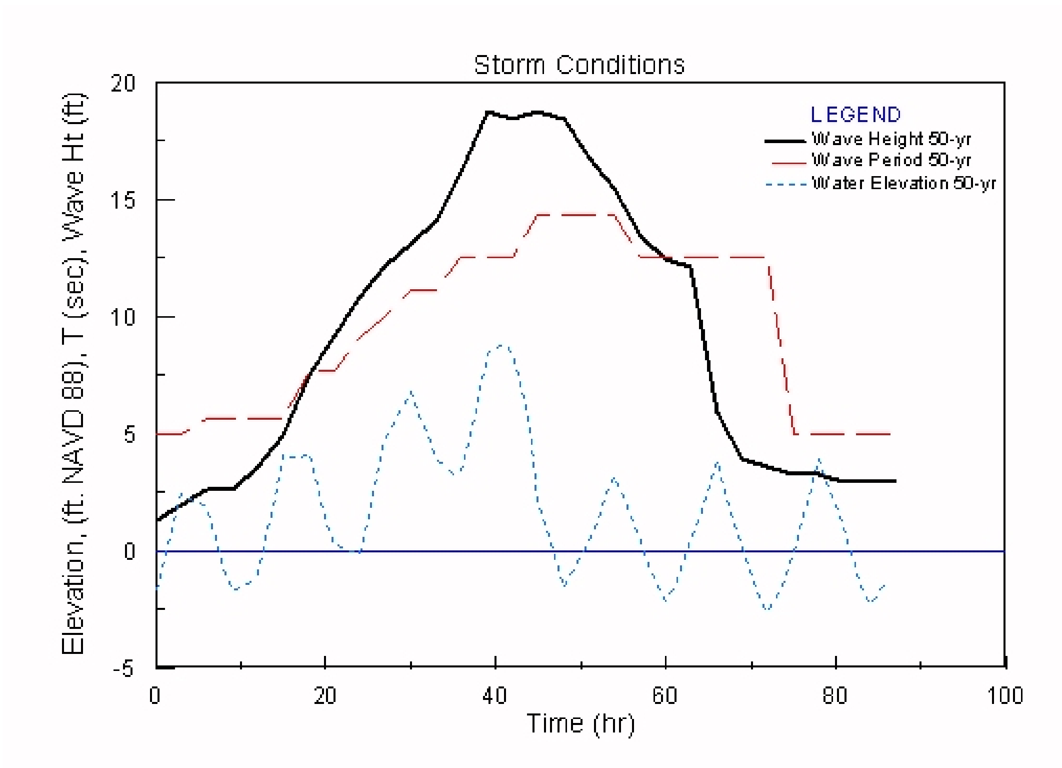


Figure 3-12 50-yr Storm Conditions used in Storm Damage Analysis

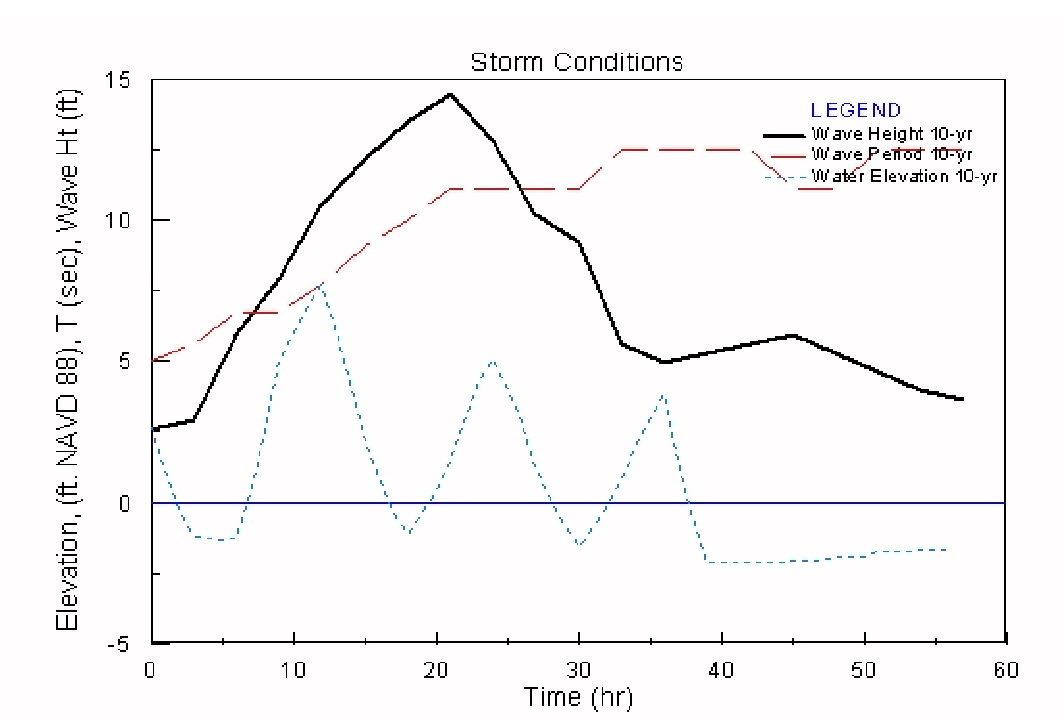


Figure 3-13 100-yr Storm Conditions used in Storm Damage Analysis

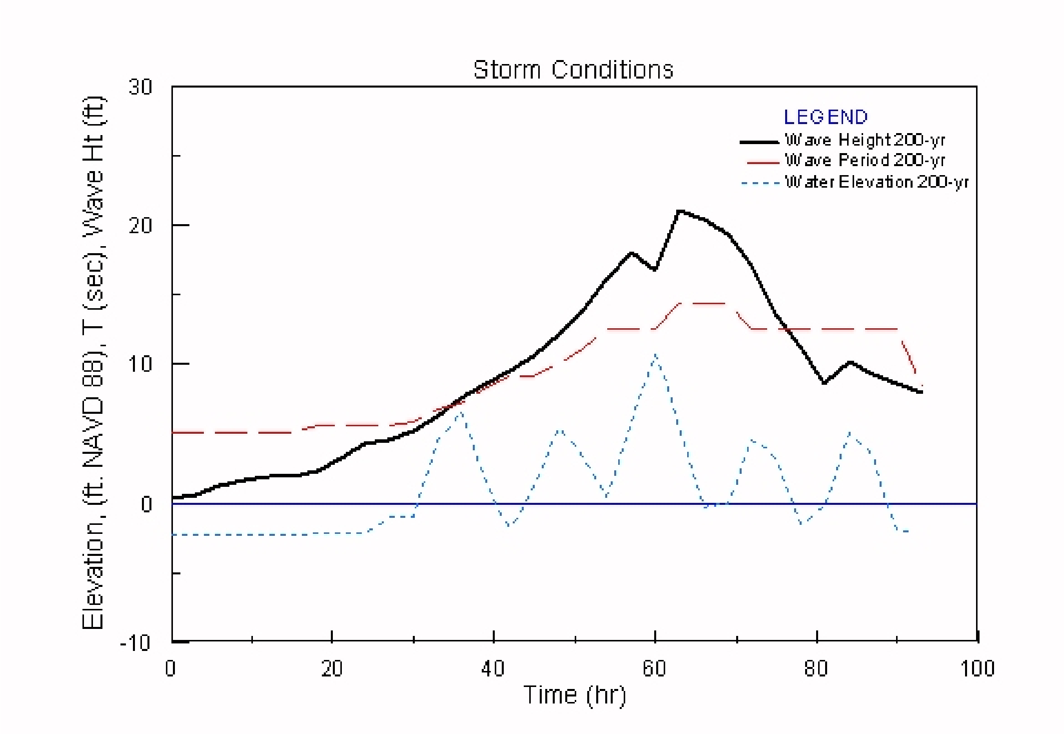


Figure 3-14 200-yr Storm Conditions used in Storm Damage Analysis

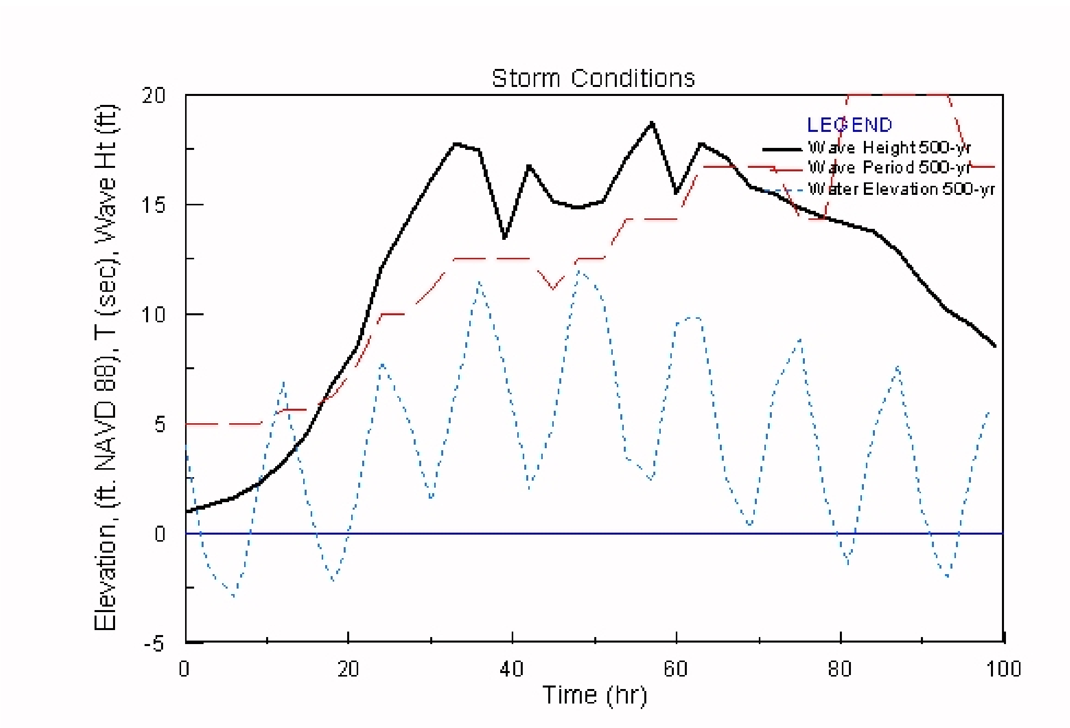


Figure 3-15 500-yr Storm Conditions used in Storm Damage Analysis

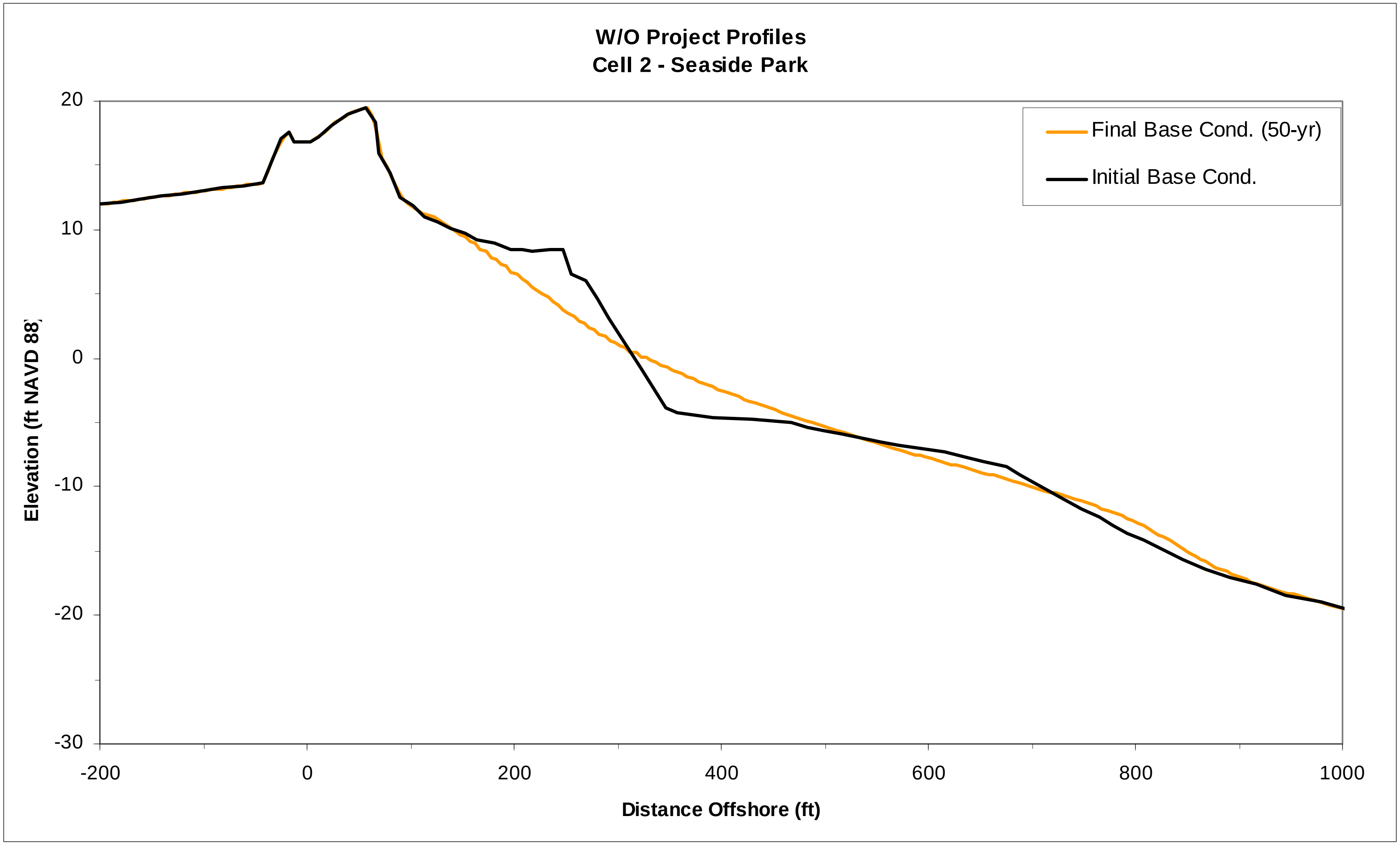


Figure 3-16 Pre- and Post 50-yr Storm Event Beach Profiles for Base Conditions for Cell 2 (Seaside Park)

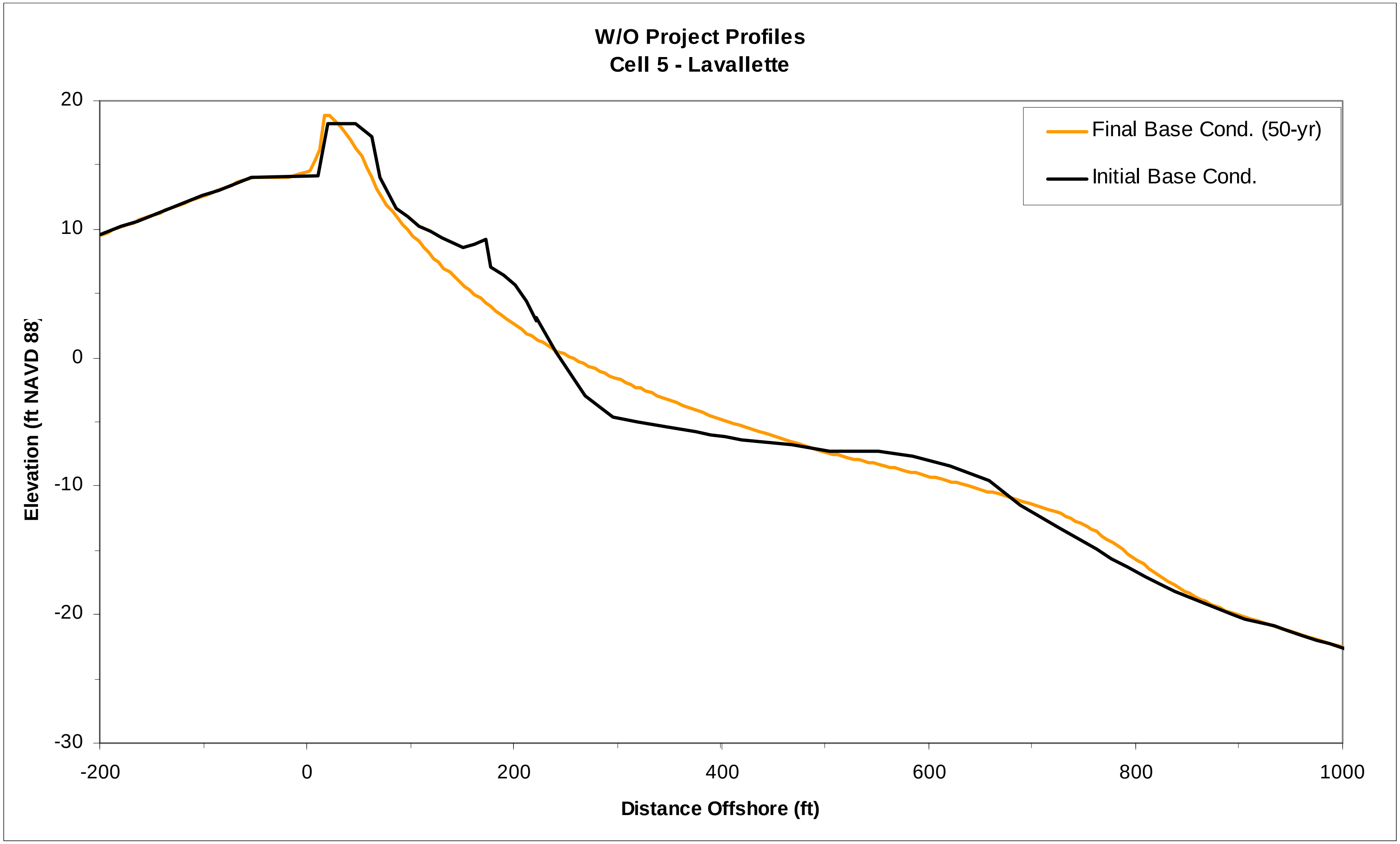


Figure 3-17 Pre- and Post 50-yr Storm Event Beach Profiles for Base Conditions for Cell 5 (Lavallette)

Figure 3-18 Pre- and Post 50-yr Storm Event Beach Profiles for Base Conditions for Cell 8 (Mantoloking)

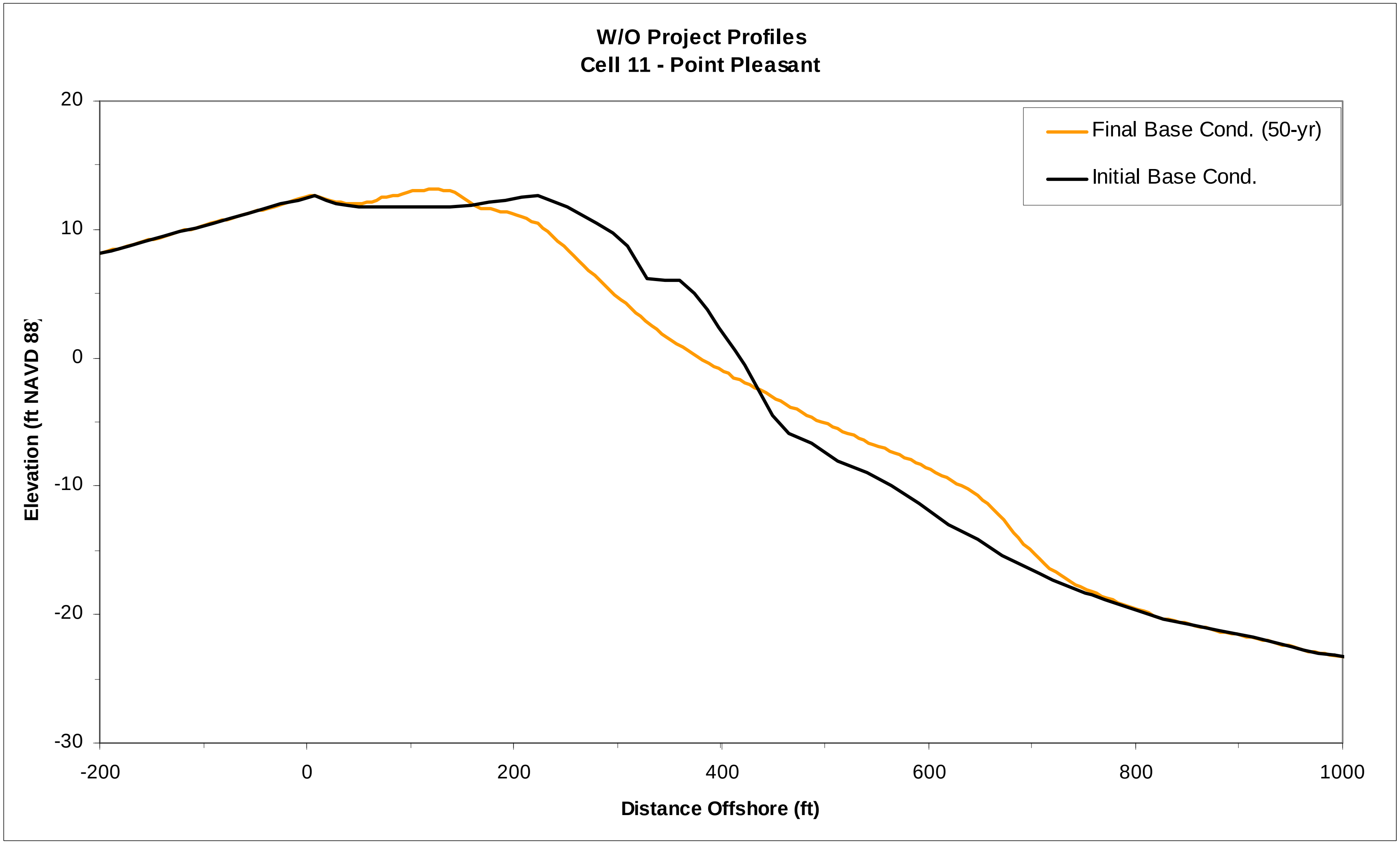


Figure 3-19 Pre- and Post 50-yr Storm Event Beach Profiles for Base Conditions for Cell 11 (Point Pleasant Beach)

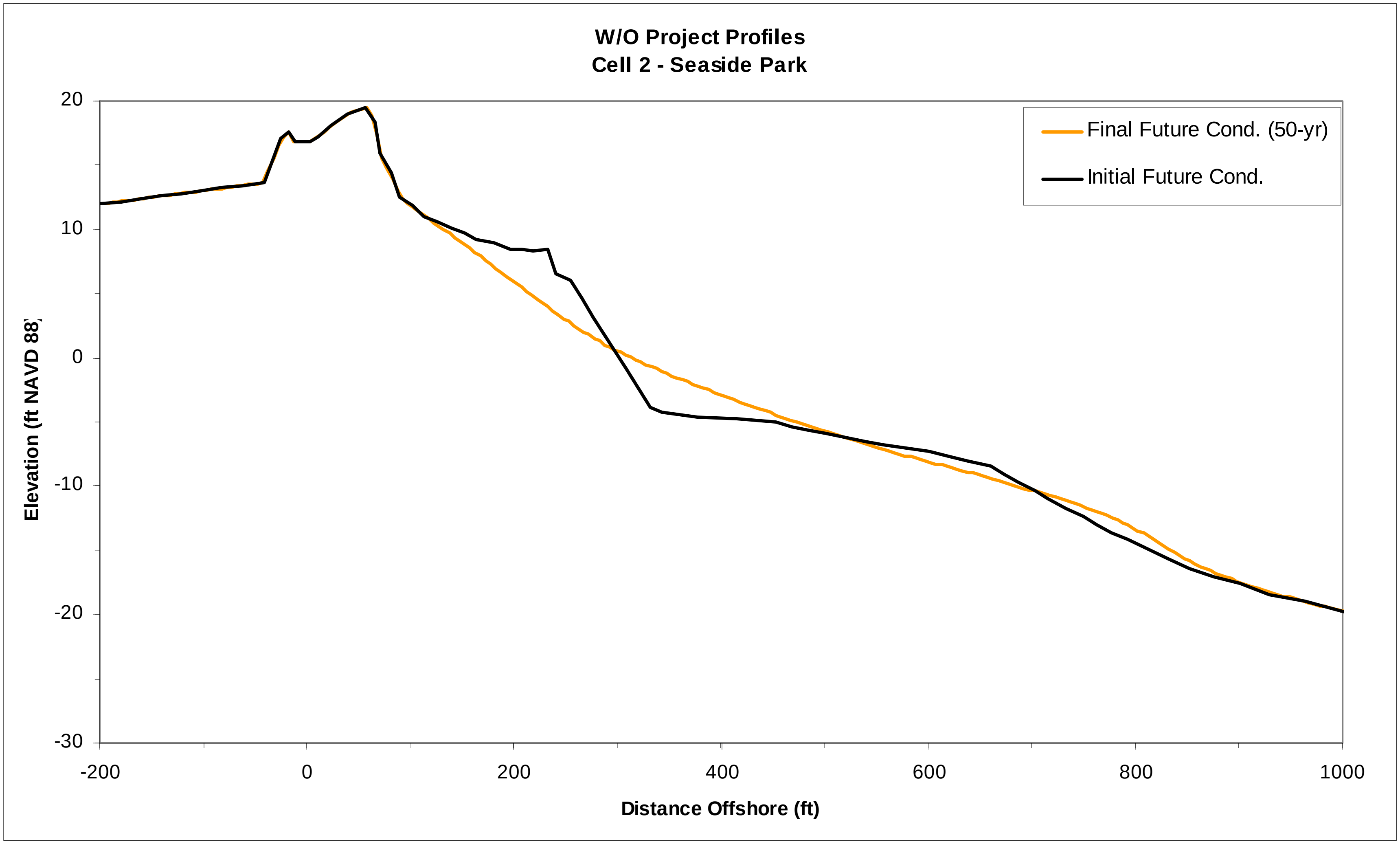


Figure 3-20 Pre- and Post 50-yr Storm Event Beach Profiles for Future Conditions for Cell 2 (Seaside Park)

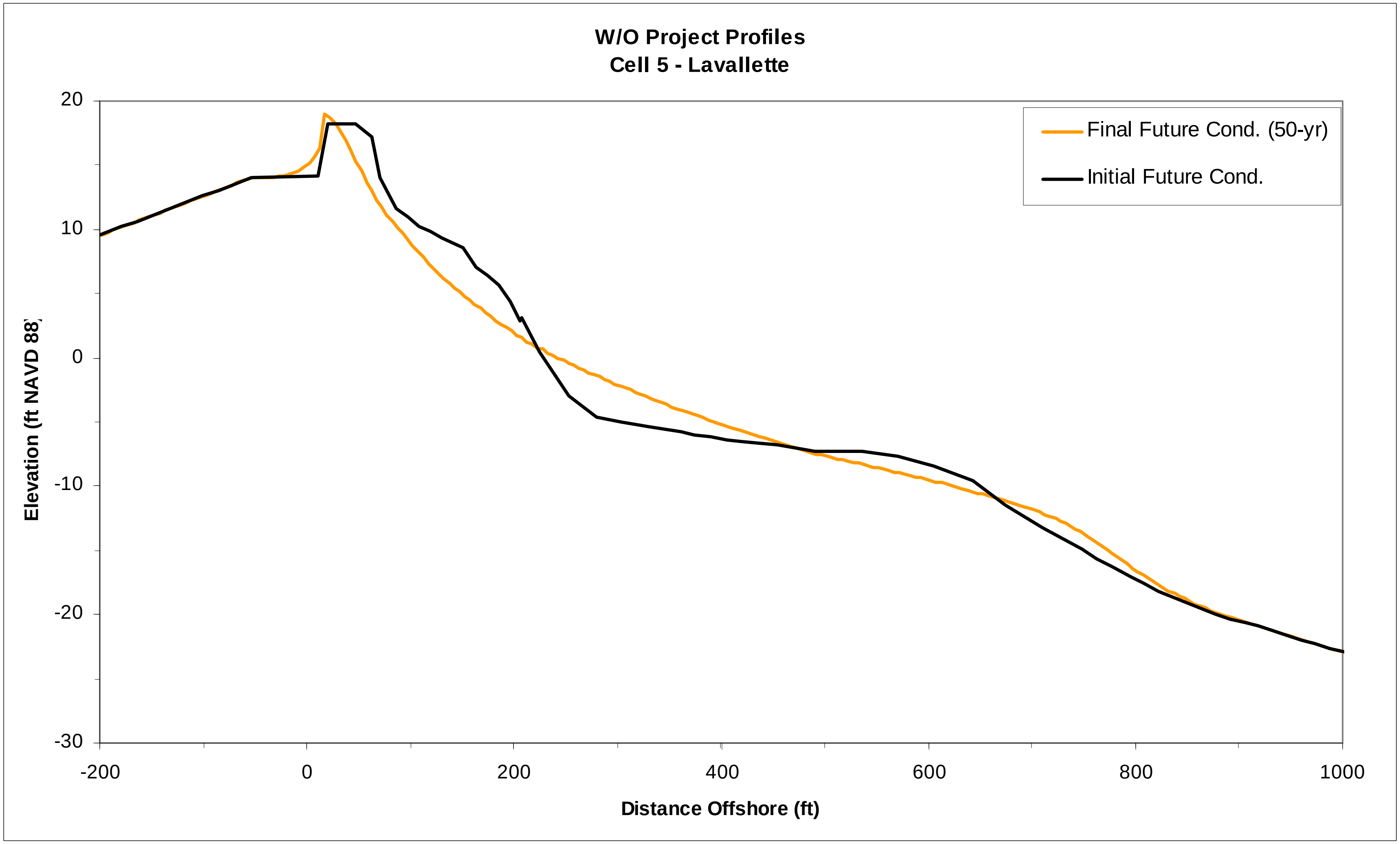


Figure 3-21 Pre- and Post 50-yr Storm Event Beach Profiles for Future Conditions for Cell 5 (Lavallette)

Figure 3-22 Pre- and Post 50-yr Storm Event Beach Profiles for Future Conditions for Cell 8 (Mantoloking)

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. Volumetric erosion into the community per unit length of shoreline can subsequently be computed from the pre- and post-storm profiles.

Results of the without project storm erosion analysis are presented in Table 3-2 and Table 3-3 for base and future conditions, respectively. Predicted shoreline erosion positions are reported relative to the design baseline. The baseline initially was placed at the seaward edge of boardwalks and through the centerline of existing dunes, depending on the condition represented in each cell. In order to satisfy constraints in the economic analyses, the baseline was offset 750 ft seaward to ensure all structures were landward of the economic baseline. The pier mounted structures in Seaside Heights governed the 750 ft offset. For most cells, assuming the majority of structures lie landward of boardwalks and dune lines, zero erosion (not greater than 750 ft) into the community is reported until the 50-yr event for base year conditions. Slightly increased erosion is reported for the future conditions, with erosion typically beginning at the 20-yr event. For Bay Head, zero erosion occurs until the seawall is failed at the 200-yr event. These erosion values are used as input to the economic model that ultimately computes storm damages associated with storm-related erosion.

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 superelevation of the water surfaces surrounding the project area and 2) wave attack, the direct impact of waves and high energy runup on coastal structures.

The model SBEACH calculates nearshore wave characteristics, wave runup, wave setup and elevation of the beach profile for each hindcasted event. The wave runup 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, runup, and minimum dune crest elevation.

Table 3-2 Predicted Shoreline Erosion Positions for Base Conditions

(feet, measured from design baseline)

Storm Event	Cell 1 Berkeley	Cell 2 SS Park	Cell 3 SS Hts	Cell 4 Ortley	Cell 5 Lavallette	Cell 6 Dover	Cell 7 Brick	Cell 8 Mantoloking	Cell 9 Bay Head	Cell 10 PPB South	Cell 11 PPB North
2-yr	-142.5	-222.5	2.5	-102.5	-147.5	-77.5	-82.5	-67.5	-87.5	-122.5	-292.5
5-yr	-87.5	-192.5	2.5	-92.5	-112.5	-32.5	-47.5	-42.5	-37.5	-77.5	-257.5
10-yr	-82.5	-182.5	2.5	-92.5	-100.0	-27.5	-42.5	-37.5	-32.5	-72.5	-242.5
20-yr	-52.5	-182.5	2.5	27.5	-72.5	-2.5	-7.5	2.5	-2.5	-12.5	-207.5
50-yr	-32.5	-167.5	27.5	37.5	-37.5	27.5	17.5	42.5	5.0	7.5	-177.5
100-yr	-2.5	-147.5	62.5	55.0	-17.5	40.0	52.5	47.5	7.5	17.5	-172.5
200-yr	7.5	-52.5	90.0	95.0	0.0	52.5	67.5	57.5	100.0	27.5	-167.5
500-yr	42.5	-12.5	167.0	150.0	67.5	122.5	127.5	232.5	162.0	192.5	77.5

Table 3-3 Predicted Shoreline Erosion Positions for Future Conditions

(feet, measured from design baseline)

Storm Event	Cell 1 Berkeley	Cell 2 SS Park	Cell 3 SS Hts	Cell 4 Ortley	Cell 5 Lavallette	Cell 6 Dover	Cell 7 Brick	Cell 8 Mantoloking	Cell 9 Bay Head	Cell 10 PPB South	Cell 11 PPB North
2-yr	-142.5	-207.5	2.5	-57.5	-127.5	-42.5	-62.5	-47.5	-52.5	-122.5	-292.5
5-yr	-87.5	-177.5	2.5	-27.5	-92.5	-22.5	-32.5	-27.5	-27.5	-77.5	-257.5
10-yr	-82.5	-167.5	2.5	-17.5	-87.5	-12.5	-22.5	-22.5	-17.5	-72.5	-242.5
20-yr	-52.5	-157.5	12.5	32.5	-67.5	12.5	-2.5	12.5	7.5	-12.5	-207.5
50-yr	-32.5	-142.5	37.5	57.5	-32.5	32.5	22.5	47.5	7.5	7.5	-177.5
100-yr	-2.5	-57.5	67.5	62.5	-7.5	47.5	62.5	72.5	7.5	17.5	-172.5
200-yr	7.5	-47.5	97.5	100.0	32.5	62.5	82.5	77.5	105.0	27.5	-167.5
500-yr	42.5	-7.5	192.0	167.5	72.5	142.5	137.5	232.5	212.5	192.5	77.5

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 (FEMA, 1989). The procedure divides possible storm conditions into four cases as follows:

- *Case I* (shown in Figure 3-23): 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* (shown in Figure 3-24): The top of the dune is above the maximum water level, with wave runup greater than (3 ft above the dune crest elevation. In this case, the runup 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* (shown in Figure 3-25): The top of the dune is above the maximum water level, with wave runup exceeding but still less than 3 ft above the dune crest elevation. In this case, the depth at the dune crest is the calculated runup 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* (shown in Figure 3-26): The wave runup does not overtop the dune. In this case, the wave height seaward of the dune is limited to 0.78 times the water depth.

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 Little Egg, Barnegat, and Manasquan Inlets. Figure 3-27 depicts the channels that were modeled. A total of 114 cross-sections or nodes were input to describe the system. Depth soundings for each cross-section were interpolated from the

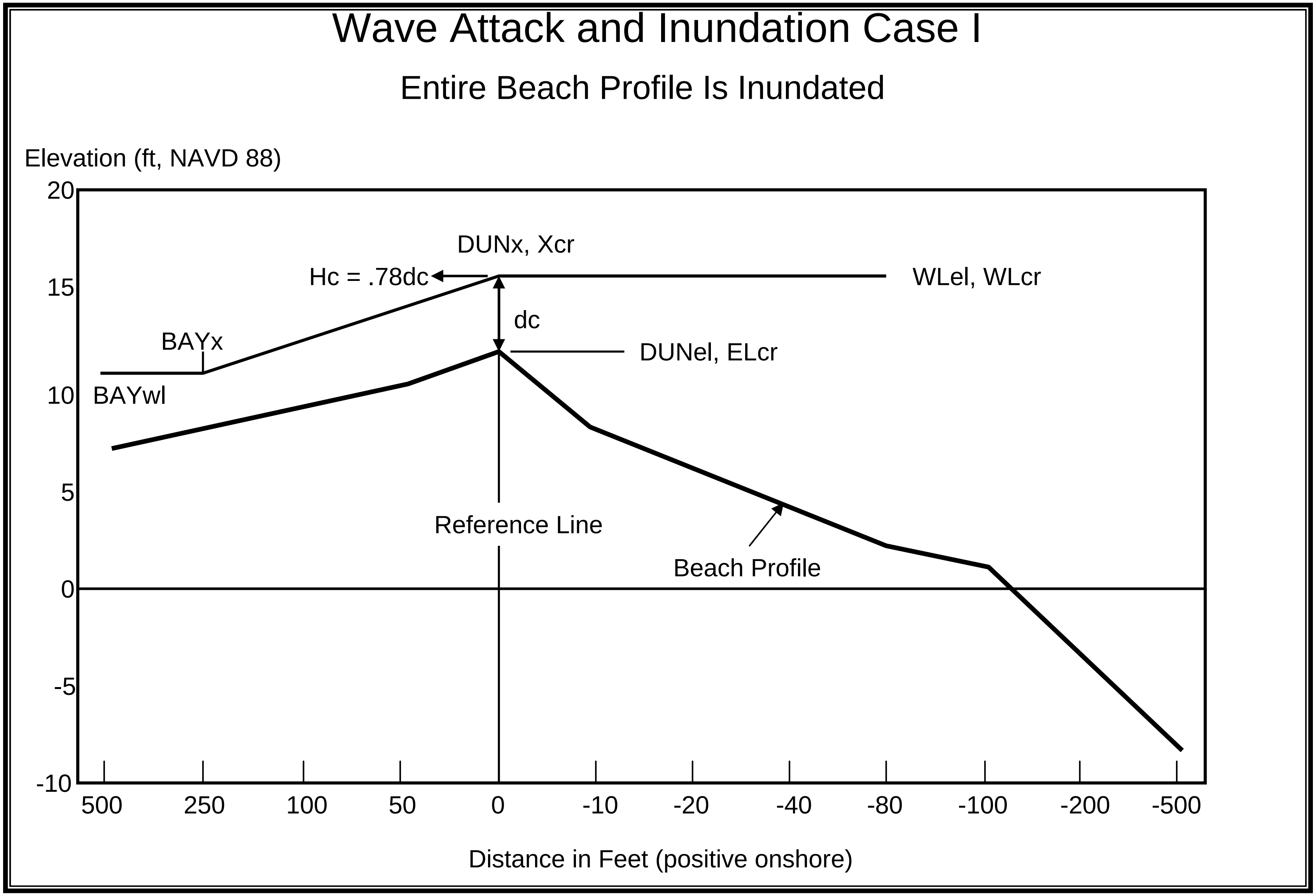


Figure 3-23 Case I: Total Inundation

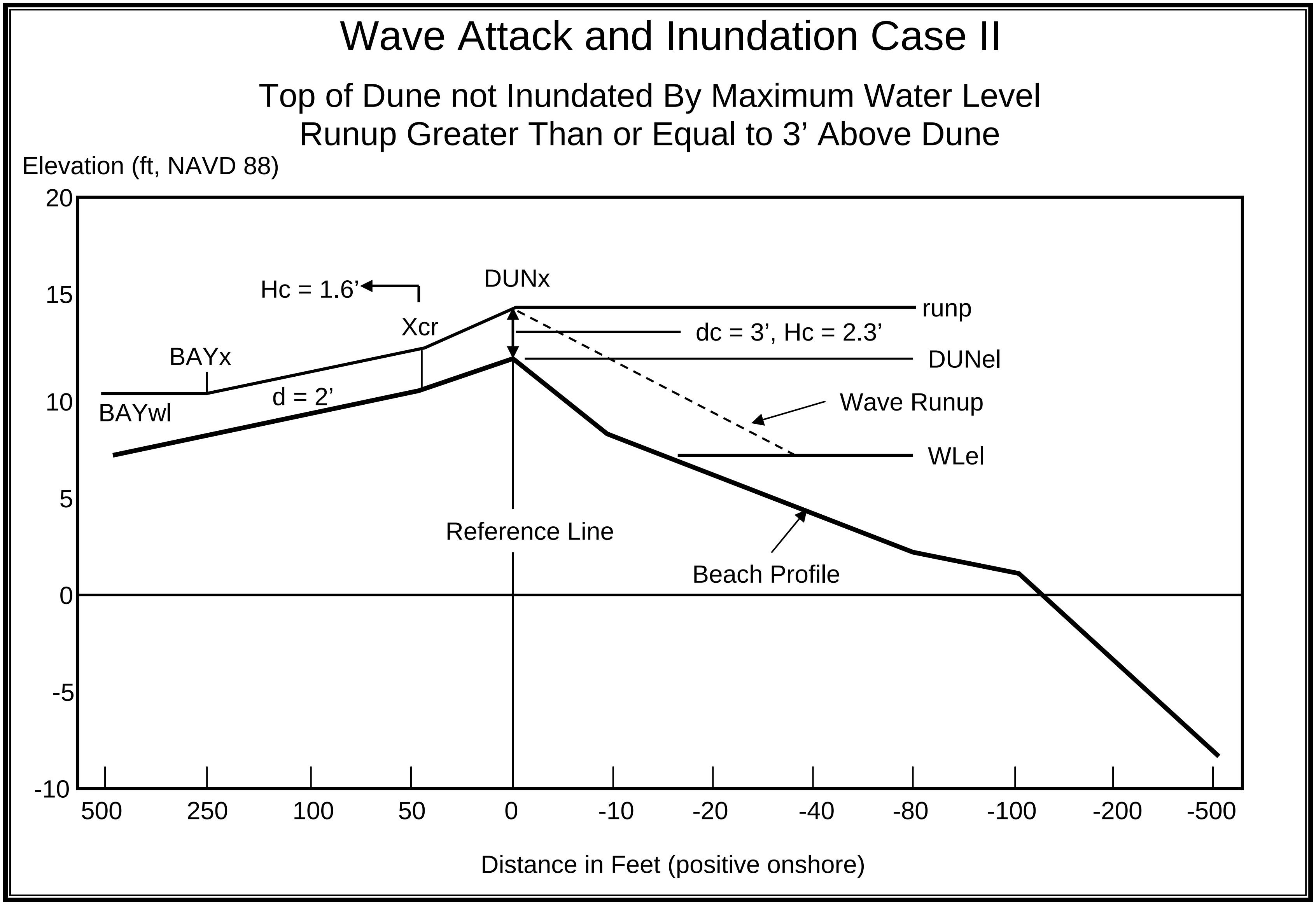


Figure 3-24 Case II: Runup Greater than or Equal to 3 Feet Above Dune

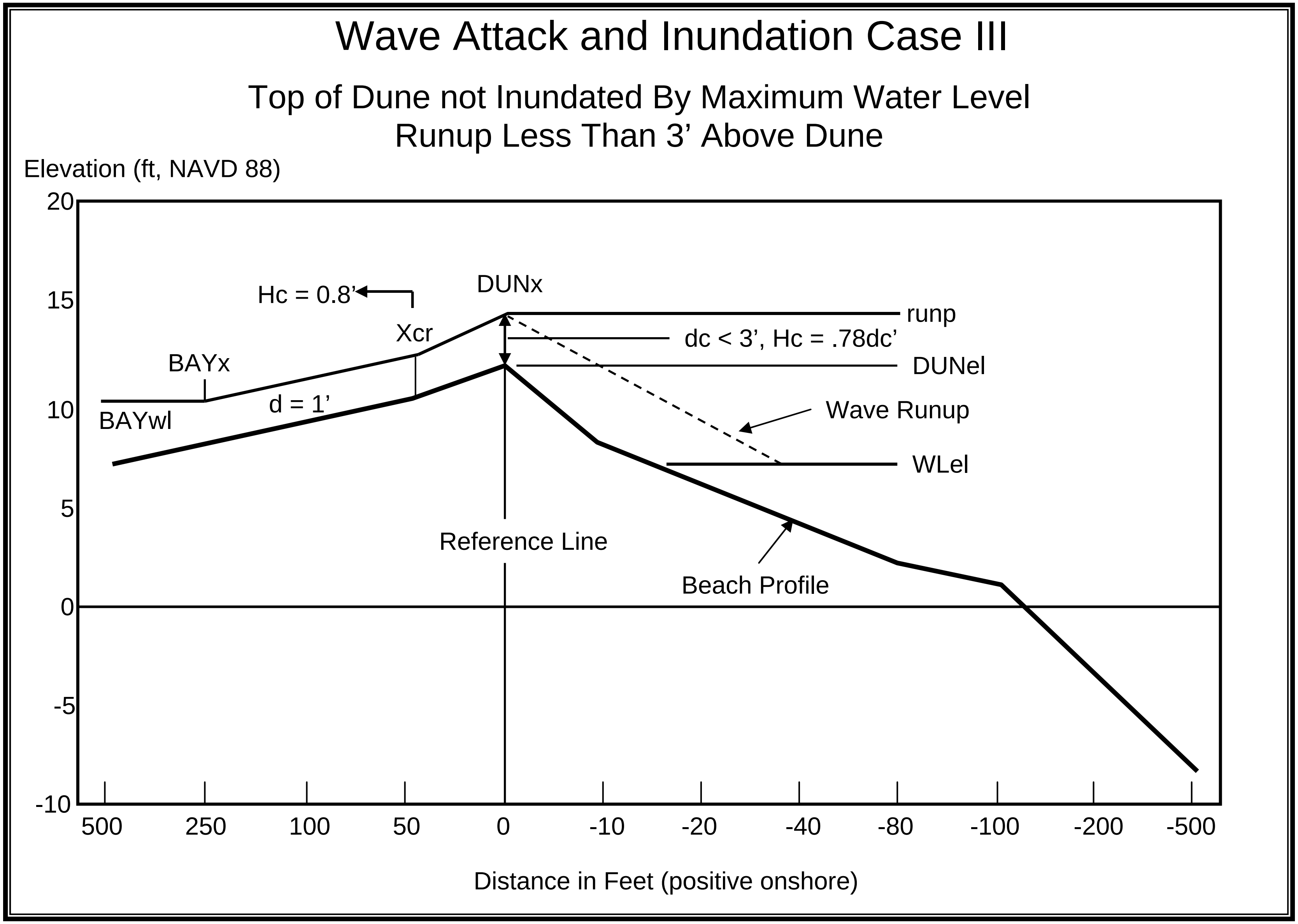


Figure 3-25 Case III: Runup Less than 3 Feet

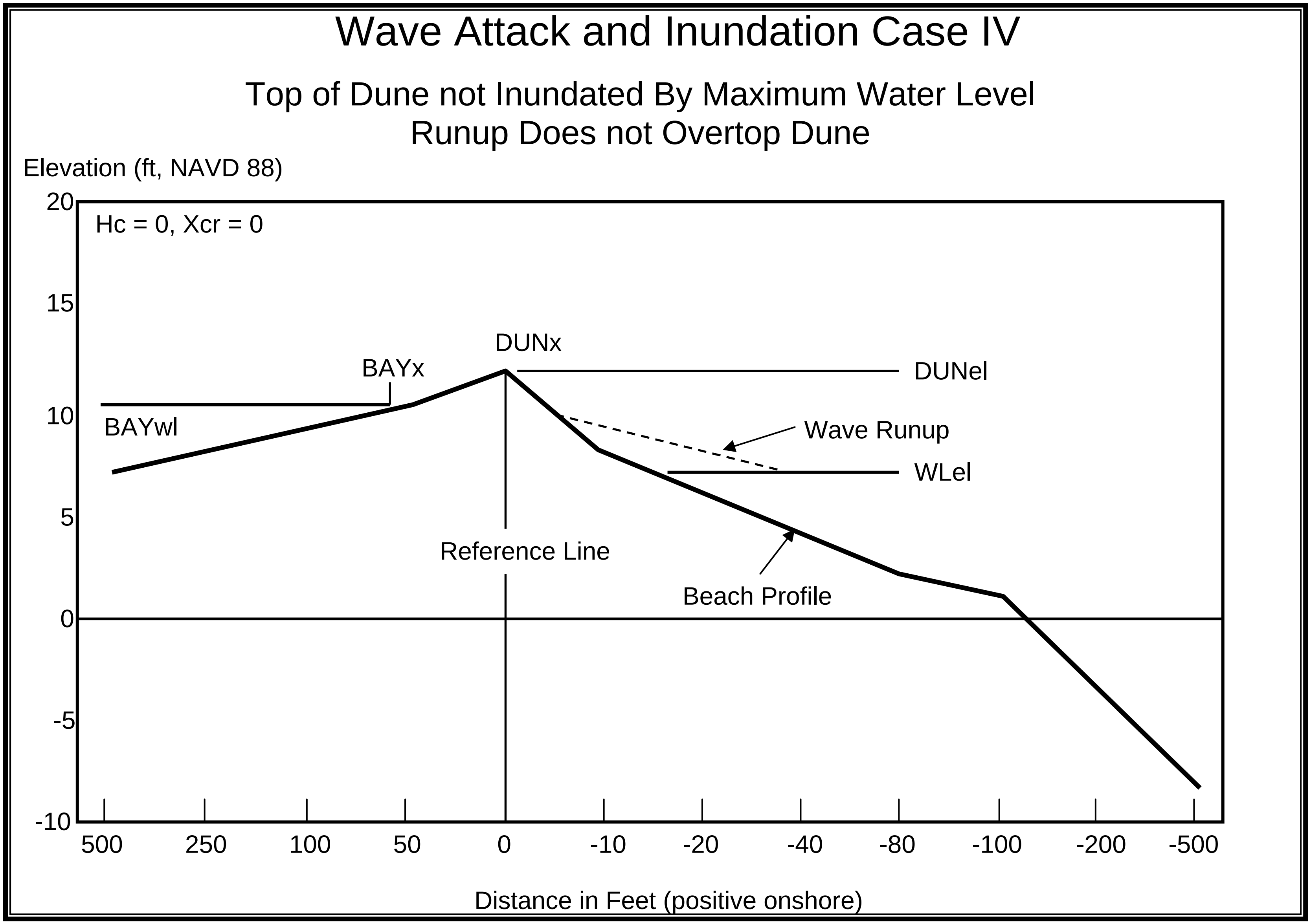


Figure 3-26 Case IV: Runup does not Overtop Dune/No Inundation Over Dune

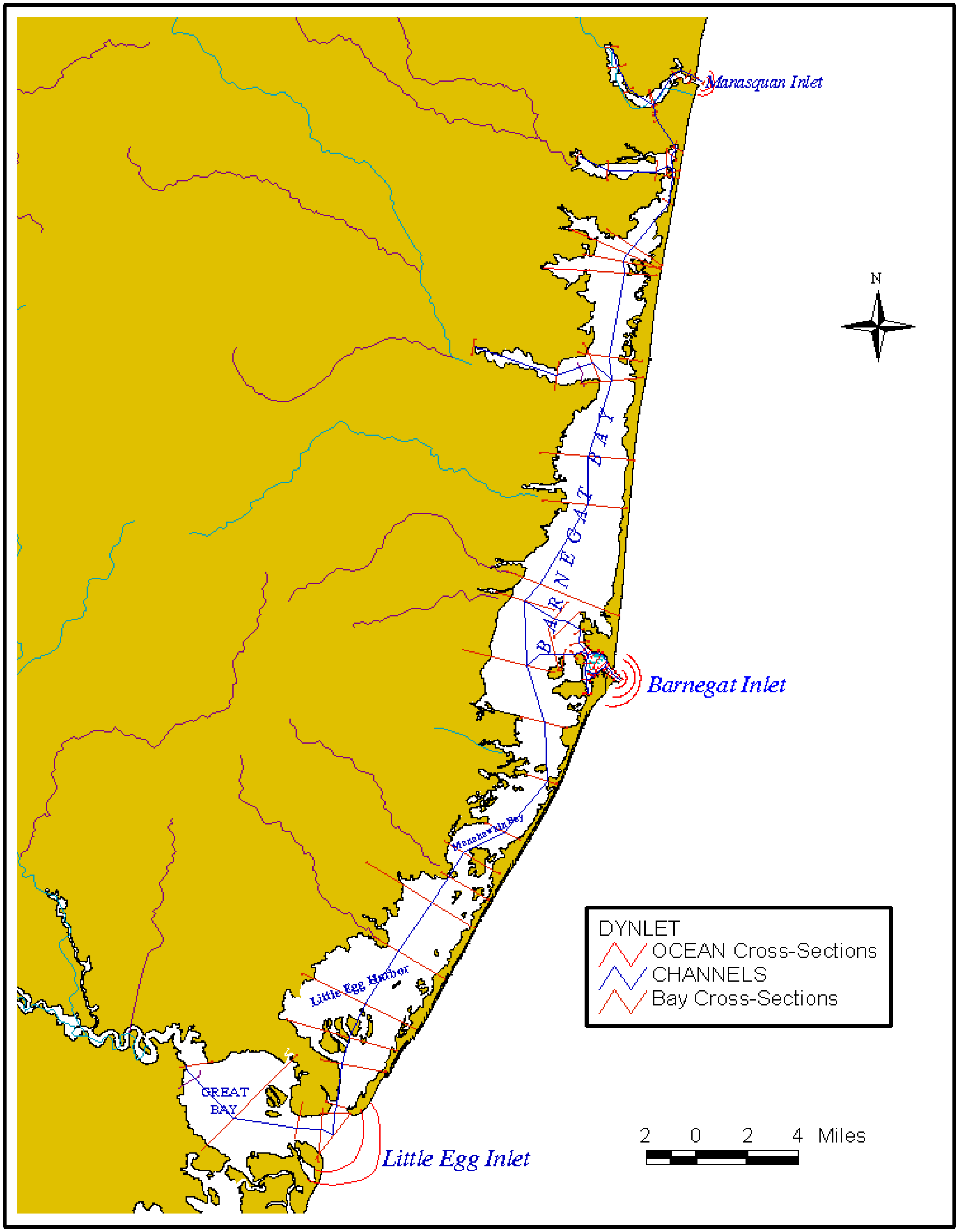


Figure 3-27 DYNLET Layout (Cross-Sections and Channels) used in Back-Bay Water Level Analysis

National Oceanic Atmospheric Administration (NOAA) Nautical Chart for Little Egg Harbor to Cape May. Recent bathymetric data from Barnegat and Manasquan Inlets were incorporated into the model. The model was calibrated to measured currents through Barnegat Inlet and water levels throughout Barnegat Bay. Predicted stages for 5 through 500-year storms were then used to drive the model. The tidal range is rapidly attenuated through the Barnegat Inlet system, with water levels throughout most of Barnegat Bay being fairly uniform. Therefore, it is assumed that Bay water levels for all communities can be represented by predicted water levels for Mantoloking, as described in Section 2.8.2.4 of this report.

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 seawall located in the Bay Head area 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 and Economics Technical Appendices 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 Without Project Economic Analysis

3.2.1 Area of Analysis

For summary damage assessment purposes, the study area was evaluated as a single reach from Berkeley Township to Point Pleasant Beach. For analysis purposes, the reach was divided in cells corresponding to those used for storm damage modeling (see Section 3.1.7) to account for differences in physical characteristics of the beach, shoreline and structure configuration, and upland development.

3.2.2 Conditions

A January 2000 price level, 50-year period of analysis, and a base year of 2004 were used in the economic analysis. Damages were converted to an annual equivalent time basis using a 6.625% discount rate as applicable to public works projects. Damages were calculated for eight frequency storm events (2, 5, 10, 20, 50, 100, 200 and 500 year events) for erosion, wave, and inundation damages. All methodology used was consistent with other recently completed USACE storm damage reduction feasibility studies along the New Jersey coast.

3.2.3 Structure Inventory and Replacement Costs

Approximately 2,700 structures were inventoried during the summer of 1997. These structures were selected based on the assessment of damage susceptibility to oceanfront storm damages. If damageability was only due to bay flooding, the structure was not included in the database. The database also included structures on two piers located in the study area -- one located in Point Pleasant Beach and the other located in Seaside Heights. Storm damages were calculated for these pier structures and included in the summary of total without project damages provided in Table 3-7. However, because the piers extend seaward of any proposed project, no storm damage reduction benefits were calculated or claimed for these structures in the benefit cost analysis.

The Marshall and Swift Residential and Commercial Estimators were used to estimate replacement cost less depreciation using a June 1998 price level and were later updated to a January 2000 price level for the analysis. The associated content value of each residential structure is estimated to be 40% of the structural replacement cost while commercial content values varied based on the activity of the business. Affluence was evaluated and found not to be significant and therefore not claimed.

3.2.4 Long-Term Erosion

For the without project condition, shoreline recession due to long-term erosion is assumed to continue until the shoreline reaches a critical point where locals would intervene to prevent further recession. From an historical perspective, this critical point is when the shoreline reaches the seaward toe of the dune. For this study, the critical point of shoreline recession would occur an average of fifteen years from the base year for those cells experiencing a long-term erosion rate. To account for the changing shoreline, two separate without project conditions were evaluated. The first base condition represented years 1 through 15 of the period of analysis, while the second future condition represented years 16-50. The base condition used existing shoreline and beach profile conditions, while the future condition used the beach profile that is expected to exist after the berm has eroded to the critical point (toe of the dune). If long-term erosion were permitted to continue beyond this critical point many structures would be imminently susceptible to total failure due to erosion, hence the assumption that locals would act to hold the shoreline. Further discussion explaining local costs foregone to maintain the future without project condition is given in Section 5.4.2.

3.2.5 Storm Damage Methodology and Categories

Without project condition damages were calculated for each of the frequency storm events based on erosion, wave and inundation damage to structures, infrastructure and improved property damages.

The calculations for the structural property storm damages were performed using COSTDAM (Coastal Storm Damage Assessment Model), a computer program that computes storm damages for coastal storm processes. COSTDAM reads an ASCII structure file containing the database information of each structure. This data is gathered from a field inventory, photogrammetric mapping and AUTOCAD files. A control file contains the hydraulic profiles used to characterize the wave, erosion, and inundation mechanisms.

COSTDAM first evaluates a structure for damages caused by wave attack, based on the relationship between a structure's first floor elevation and the total water elevation that sustains a wave. COSTDAM then determines if the structure had undergone any erosion damage. Finally, if the water elevation is higher than the first floor elevation (based on Federal Insurance Administration [FIA] depth-damage curves adjusted by increased salt water damageability), the program calculates damages caused by inundation. To avoid double counting, if damage occurs by more than one mechanism, COSTDAM counts the maximum damage of any given mechanism (wave, erosion, inundation) and eliminates the remaining damages from the structure's damage total.

3.2.5.1 Erosion Damages

Erosion damages to structures were evaluated based on storm erosion calculated over the selected range of frequency storm events. In order to estimate the extent of erosion damage produced as a function of horizontal retreat of the shoreline, the position of each structure was determined in relation to a reference line. Critical erosion points for each structure were calculated by measuring the distance between the reference line and the front and back walls of the structure using AUTOCAD. Each structure was then evaluated against storm erosion produced by each event to determine the extent of damage. For slab-on-grade structures and other structures without a pile foundation, total damage was assumed to occur at the point that erosion extended halfway through the structure footprint. For structures on piles, total damage was not claimed until erosion extended entirely through the structure footprint. In the absence of total failure, partial damages for both foundation types were calculated by assuming the percent damage claimed was equal to the proportion of erosion under the structure's footprint relative to the extent of erosion that would cause total failure.

3.2.5.2 Wave Damages

A structure was considered damaged by waves only when then there was sufficient wave force to completely destroy a structure. Partial wave damages were not calculated; instead the structure was subjected to inundation damages. In this study area, wave damages only occurred during the 500-year event in cell 4, and only for the future condition control file.

3.2.5.3 Inundation Damages

Flooding can potentially cause damages to property and its contents through several mechanisms. The predominant damage-inducing mechanisms, as typical to riverine flooding, are depth and duration of flooding. However, ocean and bay flooding has been shown to cause more damages than inundation in fresh water for the same depth. Also, the depth and velocity of the floodwater may be sufficient to result in structural damage and ultimately failure.

Inundation damages to structures were estimated using depth-damage curves derived from previous studies of saltwater areas and FIA (Federal Insurance Administration) curves. The depth-damage curves display the percent of damage at various depths relative to the first floor elevation. Distinguishing characteristics of these curves are construction type (frame, concrete block, or masonry) and the number of stories in a structure as well as the presence of a basement. For commercial structures, the business activity is also a distinguishing factor.

3.2.6 Without Project Condition Structure Damages Summary

Expected average annual erosion, wave, and inundation damages to structures are displayed in Table 3-4 and Table 3-5 for the existing and future without project conditions. Combined average annual damages to structures for the full 50-year period of analysis are summarized in Table 3-6. Erosion damages accounted for 27% of total structure damage, while inundation damages accounted for 73%, and wave damages accounted for less than 1%.

Table 3-4 Average Annual Damages to Structures – Existing Condition (Years 1 – 15)

Cell	Erosion	Wave	Inundation	Total
1 (Berkeley Township)	$0	$0	$108,000	**$108,000**
2 (Seaside Park)	$0	$0	$43,000	**$43,000**
3 (Seaside Heights)	$95,000	$0	$316,000	**$411,000**
4 (Ortley Beach)	$166,000	$0	$319,000	**$485,000**
5 (Lavallette)	$5,000	$0	$249,000	**$254,000**
6 (Dover Township)	$93,000	$0	$691,000	**$784,000**
7 (Brick Township)	$189,000	$0	$370,000	**$559,000**
8 (Mantoloking)	$595,000	$0	$625,000	**$1,220,000**
9 (Bay Head)	$228,000	$0	$131,000	**$359,000**
10 (Point Pleasant Beach - South)	$73,000	$0	$214,000	**$287,000**
11 (Point Pleasant Beach - North)	$29,000	$0	$945,000	**$974,000**
Total	**$1,473,000**	**$0**	**$4,011,000**	**$5,484,000**
% of Damages	**27%**	**0%**	**73%**	

Table 3-5 Average Annual Damages to Structures – Future Condition (Years 16 – 50)

Cell	Erosion	Wave	Inundation	Total
1 (Berkeley Township)	$0	$0	$60,000	**$60,000**
2 (Seaside Park)	$0	$0	$69,000	**$69,000**
3 (Seaside Heights)	$60,000	$0	$365,000	**$425,000**
4 (Ortley Beach)	$87,000	$29,000	$349,000	**$465,000**
5 (Lavallette)	$4,000	$0	$152,000	**$156,000**
6 (Dover Township)	$75,000	$0	$394,000	**$469,000**
7 (Brick Township)	$134,000	$0	$213,000	**$347,000**
8 (Mantoloking)	$486,000	$0	$520,000	**$1,006,000**
9 (Bay Head)	$163,000	$0	$114,000	**$277,000**
10 (Point Pleasant Beach - South)	$40,000	$0	$118,000	**$158,000**
11 (Point Pleasant Beach - North)	$16,000	$0	$523,000	**$539,000**
Total	**$1,065,000**	**$29,000**	**$2,877,000**	**$3,971,000**
% of Damages	**27%**	**1%**	**72%**	

Table 3-6 Average Annual Damages to Structures – Combined (Years 1 – 50)

Cell	Erosion	Wave	Inundation	Total
1 (Berkeley Township)	$0	$0	$168,000	**$168,000**
2 (Seaside Park)	$0	$0	$112,000	**$112,000**
3 (Seaside Heights)	$155,000	$0	$681,000	**$836,000**
4 (Ortley Beach)	$253,000	$29,000	$668,000	**$950,000**
5 (Lavallette)	$9,000	$0	$401,000	**$410,000**
6 (Dover Township)	$168,000	$0	$1,085,000	**$1,253,000**
7 (Brick Township)	$323,000	$0	$583,000	**$906,000**
8 (Mantoloking)	$1,081,000	$0	$1,145,000	**$2,226,000**
9 (Bay Head)	$391,000	$0	$245,000	**$636,000**
10 (Point Pleasant Beach - South)	$113,000	$0	$332,000	**$445,000**
11 (Point Pleasant Beach - North)	$45,000	$0	$1,468,000	**$1,513,000**
Total	**$2,538,000**	**$29,000**	**$6,888,000**	**$9,455,000**
% of Damages	**27%**	**<1%**	**73%**	

3.2.7 Loss of Improved Property and Infrastructure

Loss of improved property and infrastructure damage, due to erosion, was also calculated for each cell. The EAD model was used to calculate the damages to both land and infrastructure. The land value was determined by first determining the market value of near shore land in accordance with ER 1165-2-130. That value was then compared to the cost of filling in the eroded land for reutilization. The cost of filling/restoring the land is based on a typical 100' x 50' lot for the different depths, widths and cubic yards of erosion produced by the storms. The cost of filling/restoring the eroded developed land was determined to be the cheaper of the two, and was prorated for the width of each cell to estimate total damages for the area. The cost of fill was not a fixed value. It decreased with greater quantities eroded, therefore reflecting economies of scale. Infrastructure damage calculations included damages to existing boardwalks and seawalls along the study reach.

Table 3-7 displays the total without project damages with the inclusion of infrastructure and private land erosion. Without project expected average annual damages are approximately $12,105,000 (including damages to the two piers). Total potential benefits, excluding pier damages, are $10,018,000.

Table 3-7 Summary of Average Annual Without Project Damages

Cell	Structural Damage	Infrastructure	Improved Property	Total
1 (Berkeley Township)	$168,000	$0	$2,000	**$170,000**
2 (Seaside Park)	$112,000	$15,000	$0	**$127,000**
3 (Seaside Heights)	$836,000	$75,000	$14,000	**$925,000**
4 (Ortley Beach)	$950,000	$70,000	$10,000	**$1,030,000**
5 (Lavallette)	$410,000	$38,000	$2,000	**$450,000**
6 (Dover Township)	$1,253,000	$6,000	$16,000	**$1,275,000**
7 (Brick Township)	$906,000	$13,000	$20,000	**$939,000**
8 (Mantoloking)	$2,226,000	$22,000	$93,000	**$2,341,000**
9 (Bay Head)	$636,000	$98,000	$10,000	**$744,000**
10 (Point Pleasant Beach - South)	$445,000	$5,000	$17,000	**$467,000**
11 (Point Pleasant Beach - North)	$1,513,000	$36,000	$1,000	**$1,550,000**
Seaside Heights Pier*	$1,869,000	$0	$0	**$1,869,000**
Point Pleasant Beach Pier*	$218,000	$0	$0	**$218,000**
Total Without Project Damages	**$11,542,000**	**$378,000**	**$185,000**	**$12,105,000**
Potential Benefits (Excluding Pier Damages)*	**$9,455,000**	**$378,000**	**$185,000**	**$10,018,000**
***Structures located on piers remain unprotected under with project conditions; therefore these are residual damages and will not be claimed as potential benefits.**				

3.2.8 Historical Damages

Actual storm damages for seven of the ten communities were obtained from the National Flood Insurance Claims Database that was provided by the Federal Insurance Administration. Based on these records, the study area received approximately $10 million worth of damage during the December 1992 storm (which was estimated to be approximately a 20 year event), while the models calculated $7 million for those same towns. Given that the models calculate oceanside damages only and neglect flooding damages to bayside structures, the models are expected to under-represent total actual damages as reported by the Federal Insurance Administration, which include both oceanside and bayside damages. Considering oceanside damages only, model calculations provide a reasonable representation of historical damages for this event.

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4 PLAN FORMULATION

4.1 General

This section describes the formulation procedure and results for the Manasquan Inlet to Barnegat Inlet Feasibility Study. The plan formulation process involved establishment of plan formulation rationale, identification and screening of potential solutions, and evaluation of detailed plans to address identified problems and needs.

The purpose of the formulation analysis was to identify plans which are publicly acceptable, implementable, and feasible from environmental, engineering, economic and social standpoints. The formulation was undertaken in three phases, or cycles:

Cycle 1 - Initial Screening of Solutions
Cycle 2 - Secondary Screening of Solutions
Cycle 3 - Final Screening and Optimization of the Selected Alternative Solution

Coordination for plan formulation mostly included the New Jersey Department of Environmental Protection (NJDEP) and the U.S. Fish and Wildlife Service (USFWS). Information from the following recent Philadelphia District reports was also used, as these studies addressed similar hurricane and storm damage problems along the Atlantic Coast of New Jersey:

- *New Jersey Shore Protection Study, Great Egg Harbor Inlet to Townsends Inlet Feasibility Study, Final Feasibility Report, September 2001*

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

4.2 Planning Objectives

The Federal objective of water and related land resources project planning is to contribute to national economic development (NED) consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements as 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. Plans developed will be evaluated based on NED benefits.

The objective of the Manasquan Inlet to Barnegat Inlet study is to formulate an effective solution to hurricane and storm damage problems that is consistent with Federal objectives and is acceptable to the project sponsor. The shore protection plans considered were developed to address the following specific objectives:

1. Reduce hurricane and storm damages to development and infrastructure along the study reach to maximize benefits over a fifty year period of time,

2. Minimize negative impacts of shore protection measures on the natural environment,

3. Provide a plan that satisfies the needs of project sponsors and the local community.

4.3 Planning Constraints

Planning constraints are policy, technical, or institutional considerations that must be considered when meeting the planning objectives. The formulation of all alternatives were conducted in accordance with Federal laws and guidelines established for water resources planning.

4.3.1 Technical Constraints

These constraints include physical or operational limitations. The following criteria, within a planning framework, were used in plan formulation:

a) 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.

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

c) Plans must represent sound, safe, acceptable engineering solutions.

d) Plans must comply with USACE regulations.

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

f) The design tide and wave data are based on calculations and investigations as detailed in Section 2.8 of this report.

4.3.2 Economic Constraints

Economic constraints also limit the range of alternatives. The following items constitute the economic constraints foreseen to impact analysis of the plans considered in this study and any subsequent formulation of alternatives.

a) 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.

b) To be recommended for project implementation, tangible benefits must exceed project economic costs. Measurement shall be based on the NED benefit/cost ratio being greater than 1.0.

c) The benefits and costs are expressed in comparable quantitative economic terms to the maximum practicable extent.

4.3.3 General Environmental Constraints

Appropriate measures must be taken to ensure that any resulting projects are consistent with local, regional and state plans, and that 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.

a) Consideration should be given to public health, safety and social well-being, including possible loss of life.

b) Wherever possible, provide an aesthetically balanced and consistent appearance.

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

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

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

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

4.3.4 Institutional Constraints

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

b) 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.

c) Reasonable public access must be furnished to comply with the planned recreational use of the area.

d) 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.

e) 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.

4.3.5 Regional and Social Constraints

The needs of other regions must be considered and one area cannot be favored to the unacceptable detriment of another.

a) Consideration should be given to public health, safety and social well-being, including possible loss of life.

b) Plans should minimize the displacement of people, businesses and livelihoods of residents in the project area.

c) Plans should minimize the disruption of normal and anticipated community and regional growth.

4.4 Cycle 1 - Initial Screening of Solutions

In Cycle 1, alternatives were identified and evaluated on the basis of their suitability, applicability, and merit in meeting the planning objectives and engineering criteria for the study. The goal of the Cycle 1 analysis was to screen out those alternatives that obviously 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 researching past reports, the professional experience of study team members and other Philadelphia District personnel. In addition, input from the Non-Federal Sponsor, the New Jersey Department of

Environmental Protection, concerning the effectiveness of alternatives was considered as well as input from local officials and organizations.

Initial screening of alternatives addressed both non-structural measures 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 abandonment of the study area. These latter options are typically not feasible due to the level of development or economic base 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 alternatives include seawalls, bulkheads, revetments, breakwaters, groins and beach fill. In general, seawalls, bulkheads, and revetments are shore parallel structures used to retain fill and reduce direct wave attack on the backshore. Breakwaters are shore parallel structures typically constructed of stone/rubble and placed offshore to reduce incident wave energy. Groins (sometimes incorrectly referred to as "jetties[1]" by locals) are shore perpendicular structures used to modify long shore sediment transport to hold sand on the beach. Beach fill is the placement of sand from a borrow source onto the beach to provide a larger berm and dune. Of these structural alternatives, seawalls, bulkheads, revetments, breakwaters, and groins are typically expensive to construct. Because such "hard" structures may act as permanent barriers to natural processes, they may conflict with the ecosystem and are not usually favored by environmental or regulatory agencies. The beach fill alternative is typically less expensive and is more environmentally favorable since it is most closely related to the natural beach environment. However, because beach fills erode similar to natural beaches, long-term periodic nourishment is normally required to maintain the design template over the project life. It is noted that the beach fill alternative has been the main feature of selected plans for all recent Philadelphia District storm damage reduction feasibility studies in both New Jersey and Delaware.

The following alternatives were considered in Cycle 1 screening. Each alternative is discussed and evaluated according to technical appropriateness and relative cost in providing hurricane and storm damage reduction. A summary of results from the Cycle 1 screening is given in Table 4-1.

<u>Non-Structural Measures</u>

- No Action
- Regulation of Future Development
- Permanent Evacuation

[1] Jetties are shore perpendicular structures located at the mouth of coastal inlets and are typically longer and higher than groins. Jetties are primarily navigation structures that act to "jet" the tidal flow through the inlet to maintain inlet and navigation channel geometry. In beach fill design, an existing jetty may function as a terminal structure to retain sand at the end of a project.

Structural Measures

- Berm Restoration
- Dune Restoration
- Berm and Dune Restoration
- Berm and Dune Restoration with Groin Field
- Berm and Dune Restoration with Offshore Detached Breakwater
- Berm and Dune Restoration with Submerged Reef
- Berm and Dune Restoration with Perched Beach
- Berm and Dune Restoration with Geotextile Tube Core
- Seawall/Bulkhead
- Offshore Submerged Feeder Berm
- Beach Dewatering

No Action. This alternative involves no measures to prevent storm damage and is used as a basis to evaluate benefits of alternative plans. In the absence of Federal involvement, the potential without-project damages discussed in Section 3 of this report would most likely be realized.

Regulation of Future Development. Land use controls could be 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 behind existing dune or bulkhead lines as well as other restrictions. Regulation of future development lends itself more to relatively large, continuous, undeveloped areas rather than heavily developed areas. There is virtually no oceanfront that is not developed in the reach that extends from Berkeley Township to Point Pleasant Beach. Future development is precluded along the reach of Island Beach State Park. Therefore additional regulation to prevent new development would have little to no impact on the study area. This alternative was not considered in Cycle 2.

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 prohibitively expensive. The study area contains many structures that house year-round residents, and permanent evacuation would meet with strong opposition from these locals. This alternative was not considered in Cycle 2.

Berm Restoration. This alternative involves the placement of beach fill material (sand), directly onto the existing beach in order to widen the existing beach profile. The sand is normally pumped from an offshore borrow source onto the existing shoreline using a dredge. The restored beach is graded to a certain design elevation and width to provide the optimal restoration and protection levels. The berm translates the wave breaker zone and inundation profile seaward and provides sacrificial material during storms. Berm restoration can be effective in countering long-term erosion problems and storm damages for minor events. A berm only plan is less effective against major storms during which high waves and water levels may overwhelm the relatively low berm crest. Typically, the beach berm restoration requires future additional sand placement on a periodic basis to maintain the required design. This alternative was considered in Cycle 2.

Dune Restoration. This involves construction of sand dunes to a desired height and width. Dunes can provide significant protection against flooding and wave attack during storms. However, a dune that is not fronted by a berm can erode and fail during even average (non-storm) wave conditions due to continual exposure of waves at the base of the steep foreslope. During storms, a dune-only plan would quickly become ineffective without a fronting berm to reduce wave energy and to provide an erosion buffer. A dune-only plan is not feasible and was not considered in Cycle 2.

Berm and Dune Restoration. This alternative combines features described above. 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 alternative in terms of providing protection from storms. Of all alternatives considered, a combined berm and dune system most closely replicates conditions typically found along natural undisturbed barrier island shorelines. This alternative was included in Cycle 2 formulation.

Berm and Dune Restoration with Groin Field. 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 and reduce periodic nourishment requirements. To function effectively and reduce negative impacts to downdrift shorelines, groin compartments must be filled with sand. Therefore, groins are typically used in conjunction with berm restoration. Groins provide no protection from storm surge, and must be combined with a dune or other structure designed to provide storm wave and flood damage reduction. This alternative was considered in Cycle 2.

Berm and Dune Restoration with Offshore Detached Breakwater. An offshore detached breakwater is designed to reduce wave energy impacting the shoreline thereby reducing erosion. Because offshore breakwaters do not protect against inundation or provide a protective berm, they must be evaluated in conjunction with beach and dune restoration. Typically an offshore detached breakwater is constructed as a series of rubble-mound structures parallel to the shoreline with crest elevation at or above mean water level. Breakwaters are often applied to reduce wave energy at harbors, or to reduce shoreline erosion in low-energy wave environments. Depending on placement, breakwaters can be used to reduce storm erosion and wave damages. The magnitude of wave and erosion reduction is a function of breakwater spacing, permeability, crest width, and crest height. To provide significant wave reduction on the open coast during major storms, breakwaters must be relatively massive with a crest elevation well above mean water level. However, if the breakwater is improperly designed and blocks too much wave energy during ambient (non-storm) conditions, a tombolo[2] may form that completely interrupts littoral drift and starves downdrift beaches. Offshore breakwaters are costly, because they require placement of a large volume of stone in a multi-layer design section that must be constructed entirely from the ocean. Due to high cost of construction and potential design problems in achieving adequate storm damage reduction while still allowing sufficient littoral drift, this alternative was not considered in Cycle 2.

Berm and Dune Restoration with Submerged Reef. A submerged reef is a continuous underwater offshore structure placed parallel to the shoreline that is designed to reduce wave energy and retain sand on the beach by preventing offshore losses during storms. Submerged reefs would need to be combined with berm and dune restoration to provide upland protection against storm waves and flooding damage. A potential benefit of submerged reefs would be to reduce renourishment requirements for the beach.

An assessment of offshore reefs along the coast of New Jersey (Bruno et al., 1996) indicates that such structures do not perform well on an open coast due to scour and flanking at the exposed ends of the reef. Greater effectiveness is obtained when the reefs are constructed within existing groin compartments. Because no existing groin field extends along the study reach, a submerged reef would be expected to perform poorly, and this alternative was not considered in Cycle 2.

Berm and Dune Restoration with Perched Beach. This alternative is similar to the submerged reef alternative except that a perched beach is designed only for sand retention and is not intended to provide any substantial reduction of wave energy. This alternative involves constructing a continuous submerged sill parallel to the shoreline at a depth within the active surf zone. The sill is designed to support the sand on the upper beach profile and eliminate the need for sand on the outer part of the beach profile near its closure with the ocean bottom, thereby reducing the total quantity of sand required to maintain the design beach width. The submerged sill would act in the same way as a natural bar formed offshore during storm events creating a "perched beach" with a wider berm. Perched beaches are not usually designed for high-energy open ocean coastlines due to potential for scour problems and loss of sand over the structure during major storm events. Because of the dynamic wave, current, and tidal conditions that exist in the study area, a perched beach is not expected to perform well and was not considered in Cycle 2.

Berm and Dune Restoration with Geotextile Tube Core. This alternative 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 erosion 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

[2] A tombolo is a feature that forms when the shoreline advances seaward to the point that it attaches to the breakwater.

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 alternative was included in the Cycle 2 formulation.

Berm Restoration with Seawall/Bulkhead. Seawalls and bulkheads are shore-parallel structures usually built at or above the mean high water line to prevent wave, inundation, and/or erosion damages. In general, seawalls are more massive structures with a vertical, curved, or stepped face designed to withstand direct impact of storm waves. Bulkheads are typically narrower structures with a vertical face intended to retain fill behind the structure and prevent overtopping and flooding. Crest elevation is the primary design parameter controlling the effectiveness in reducing wave and flooding damages. Under normal conditions, seawalls and bulkheads have no impact on littoral drift. However, if the beach erodes to the point where waves are frequently impacting the structure, further erosion may be accelerated due to scour at the base of the structure. This may eventually lead to permanent loss of dry beach in the absence of nourishment. Berm placement and periodic nourishment in front of the structure can prevent such failures, but combined costs may be prohibitive. Seawalls and bulkheads are costly but can be very effective in preventing wave and flood damages. Therefore this alternative was considered in Cycle 2.

Offshore Submerged Feeder Berm. Potentially high costs associated with direct placement of sand on the beach berm have led to the development of alternate less expensive methods of beach nourishment. One such method is offshore berm placement. With this method, sand is placed in shore-parallel mounds, comparable to large sand bars. These feeder berms can provide a source of sand to gradually build up the beach through onshore transport, similar to beach recovery that occurs after storms when sand in the offshore bar is slowly returned to the beach. The offshore berm can also reduce incident wave energy by causing waves to break further offshore. However, the berm would have little impact in reducing wave and flooding damages during major storms when the water level is much higher than normal due to storm surge.

Prototype experience with berms is limited, and proper design techniques are still being researched and developed. For the berm to function successfully as a beach nourishment technique, several factors such as berm depth, wavelength, wave height, wave velocity, must be within proper ratios (Hands and Allison, 1991). Presently there are no methods available to accurately predict the rate at which beach nourishment would occur, making it difficult to quantify reduction in future erosion damages. Because this method is not yet proven for controlling erosion, and is not effective in reducing wave and flooding damages to upland structures, this alternative was not considered in Cycle 2.

Beach Dewatering. The concept of beachface drainage as a method to increase beach stability has been tried in Florida and Denmark. Sand in the swash zone is typically in a buoyant state due to local saturation of the sediment. Beach dewatering diminishes erosion by drawing down the local water table, enhancing drainage of wave uprush, and depositing sand on the beach face.

This alternative requires initial beach fill placement along with the installation of a network of drainage pipe underneath the beach, which is operated by a pumping system.

Frequent system maintenance is required. Costs would have to be offset by reduced future nourishment requirements. Life cycle costs for large-scale implementation are unknown. Technology and performance is still unproven for an open ocean coast location. Therefore, this alternative was not considered in the Cycle 2 formulation.

Table 4-1 Summary of Cycle 1 Screening Results

Objective: Hurricane and Storm Damage Reduction

Alternative	Technically Appropriate?	Meet Objective?			Relative Cost	Further Consideration in Cycle 2
		Erosion Protection	Inundation Protection	Wave Attack Protection		
No Action	Yes[1]	No	No	No		Yes
Regulation of Future Development	No[2]	No	No	No	Low	No
Permanent Evacuation	Yes	No	No	No	Very High	No
Berm Restoration	Yes	Yes	Partial	Partial	Moderate	Yes
Dune Restoration	No[3]	Partial	Partial	Partial	Low	No
Berm and Dune Restoration	Yes	Yes	Yes	Yes	Moderate	Yes
Berm and Dune Restoration with Groin Field	Yes	Yes[4]	Yes	Yes	High	Yes
Berm and Dune Restoration with Offshore Detached Breakwater	Yes[5]	Yes[4]	Yes	Yes[6]	Very High	No
Berm and Dune Restoration with Submerged Reef	No[7]	Yes[4]	Yes	Yes	High	No
Berm and Dune Restoration with Perched Beach	No	Yes[4]	Yes	Yes	Moderate to High	No
Berm and Dune Restoration with Geotextile Tube Core	Yes	Yes[8]	Yes	Yes	Moderate	Yes
Seawall/Bulkhead	Yes	Partial	Yes	Yes	High	Yes
Offshore Submerged Feeder Berm	No	Partial	No	No	Moderate	No
Beach Dewatering	No	Partial	No	No	High	No

Notes:

1. Appropriate for undeveloped reaches.
2. Development already regulated.
3. Requires berm.
4. May provide additional erosion protection and reduced periodic nourishment requirements compared to the Berm and Dune Restoration alternative.
5. Optimal breakwater design could be difficult to determine.
6. May provide additional wave damage protection compared to the Berm and Dune Restoration alternative.
7. Requires groin field.
8. May provide additional erosion protection compared to the Berm and Dune Restoration alternative.

Table 4-2 briefly summarizes environmental impacts of all of the alternatives considered in Cycle 1 analysis. Since a number of alternatives involve impacts on shoreline and offshore resources, two evaluations were done for each resource category (if applicable). For each resource category and the corresponding alternative, the first abbreviation represents the impact evaluation for shoreline and nearshore resources and the second abbreviation represents the impact evaluation for offshore resources. The abbreviations describe the degree (significant, intermediate, or minor), nature (adverse or beneficial), and duration (temporary or permanent) of the impact. Some impact designations contain more than one impact. For instance, berm restoration may involve a minor adverse temporary effect (MAT) on terrestrial ecology during construction, however, the long-term effect may be beneficial (MBP) by providing a stable beach, which is more favorable to terrestrial organisms. Another example is for the groin field alternative, where the construction of groins would have permanent adverse impacts (MAP) on shellfish such as surfclams, which require sandy bottoms that would be permanently lost within the footprint, however, there may be beneficial impacts (MBP) on shellfish, by providing a suitable substrate for blue mussels to inhabit. Some of the designations may be subjective based on the perspective of the resources affected. One example of this would be aesthetics where an impact could be perceived as adverse or beneficial, depending on the perspectives involved. Actions determined to have potential effects (*) on resources may involve whether a certain resource is present at the time of the action. This applies to a number of actions where endangered species could be involved.

Table 4-2 Comparative Environmental Impact Analysis of Cycle 1 Alternatives

Alternative	Affected Area(s)	Resource Categories													
		Air Quality	Topography and Soils	Ground -water	Hydrody-namics	Water Quality	Wet-lands	Terrestrial Ecology	Aquatic Ecology			Endangered Species	Cultural Resources	Socio-economics	Aesthetics
									Soft-Bottom Benthic Organisms	Fisheries					
										Shellfish	Finfish				
No Action	Beach/Nearshore	NE	SAP	NE	NE	NE	NE	MAP	NE	NE	NE	NE	NE	SAP	NE
	Offshore	NE	NE	NE	NE	NE	N/A	N/A	NE	NE	NE	NE	NE		NE
Regulation of Future Development	Beach/Nearshore	NE	SAP	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE
	Offshore	NE	NE	NE	NE	NE	N/A	N/A	NE	NE	NE	NE	NE		NE
Permanent Evacuation	Beach/Nearshore	MBP	SAP	NE	NE	NE	NE	BP	NE	NE	NE	BP	NE	SAP	BP
	Offshore	NE	NE	NE	NE	NE	N/A	N/A	NE	NE	NE	NE	NE		NE
Berm Restoration	Beach/Nearshore	MAT	SBP	NE	NE	MAT	NE	MAT/MBP	AT	AT	AT	NE*	NE	SBP	MAT/BP
	Offshore	MAT	MAP	NE	NE	MAT	N/A	N/A	AT	AT	AT	NE*	NE		NE
Dune Restoration	Beach/Nearshore	MAT	SBP	NE	NE	MAT	NE	MAT/MBP	AT	AT	AT	NE*	NE	SBP	MAT/BP
	Offshore	MAT	MAP	NE	NE	MAT	N/A	N/A	AT	AT	AT	NE*	NE		NE
Berm and Dune Restoration	Beach/Nearshore	MAT	SBP	NE	NE	MAT	NE	MAT/BP	AT	AT	AT	NE*	NE	SBP	MAT/BP
	Offshore	MAT	MAP	NE	NE	MAT	N/A	N/A	AT	AT	AT	NE*	NE		NE
Berm and Dune Restoration w/Groin Field	Beach/Nearshore	MAT	SBP	NE	BP	MAT	NE	MAT/BP	MAP	MAP/MBP	BP	NE*	NE	SBP	MAT/BP
	Offshore	MAT	MAP	NE	NE	MAT	N/A	N/A	AT	AT	AT	NE*	NE		NE
Berm and Dune Restoration w/Offshore Detached Breakwater	Beach/Nearshore	MAT	SBP	NE	BP	MAT	NE	MAT/BP	AT/MAP	AT/MBP	AT/MBP	NE*	NE	BP	MAT/BP/AP
	Offshore	MAT	MAP	NE	NE	MAT	N/A	N/A	AT	AT	AT	NE*	NE		NE
Berm and Dune Restoration w/Perched Beach	Beach/Nearshore	MAT	AP	NE	U	MAT	NE	MAT/BP	AT	AT	AT	NE*	NE	BP	MAT/BP
	Offshore	MAT	MAP	NE	NE	MAT	N/A	N/A	AT	AT	AT	NE*	NE		NE
Berm and Dune Restoration With Geotextile Tube Core	Beach/Nearshore	MAT	SBP	NE	NE	MAT	NE	MAT/BP	AT	AT	AT	NE*	NE	SBP	MAT/BP
	Offshore	MAT	MAP	NE	NE	MAT	N/A	N/A	AT	AT	AT	NE*	NE		NE
Seawall/Bulkhead	Beach/Nearshore	MAT	AP	NE	AP*	MAT	NE	AT	AT	AT	AT	NE*	NE	BP	AP
	Offshore	MAT	MAP	NE	NE	MAT	N/A	AT	AT	AT	AT	NE*	NE		NE
Offshore Submerged Feeder Berm	Beach/Nearshore	MAT	BP	NE	BP	MAT	NE	BP	AT	AT	AT	NE	NE	BP	MAT/BP
	Offshore	MAT	MAP	NE	NE	MAT	N/A	NE	AT	AT	AT	NE*	NE		NE
Beach Dewatering	Beach/Nearshore	MAT	U	U	U	U	U	U	U	U	U	U	U	U	U
	Offshore	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE	NE		NE

Definitions for Abbreviations of the Impacts Assessed for the Alternatives Considered in Cycle 1

SAP (Significant Adverse Permanent) - Effect(s) are significantly adverse to affected resource, and are a long-lasting condition
SBP(Significant Beneficial Permanent) - Effect(s) are significantly beneficial to affected resource, and are a long-lasting condition
SAT (Significant Adverse Temporary) - Effect(s) are significantly adverse to affected resource, but are a temporary condition
SBT (Significant Beneficial Temporary) - Effect(s) are significantly beneficial to affected resource, but are a temporary condition
AP (Adverse Permanent) - Action has long-term adverse effect(s) on affected resource
BP (Beneficial Permanent) - Action has long-term beneficial effect(s) on affected resource
AT (Adverse Temporary) - Action has short-term adverse effect(s) on affected resource
BT (Beneficial Temporary) - Action has short-term beneficial effect(s) on affected resource
MAP (Minor Adverse Permanent) - Action has long-term, but minor adverse effect(s) on affected resource
MBP (Minor Beneficial Permanent) - Action has long-term, but minor beneficial effect(s) on affected resource
MAT (Minor Adverse Temporary) - Action has short-term, but minor adverse effect(s) on affected resource
MBT (Minor Beneficial Temporary) - Action has short-term, but minor beneficial effect(s) on affected resource
NE (No Effect) - Action has no effect(s) on resource
U (Unknown) - degree and duration of effect(s) on affected resource is unknown
*****Action has potential adverse effect(s) on resource

4.5 Cycle 2 – Second Level Screening of Solutions

The purpose of Cycle 2 was to further narrow down the number of alternatives for detailed consideration in Cycle 3. Cycle 2 screening was based on an assessment of the engineering, environmental, social and economic impacts of each alternative. The following alternatives were considered in Cycle 2:

- No Action
- Berm Restoration
- Berm and Dune Restoration
- Berm and Dune Restoration with Groin Field
- Berm and Dune Restoration with Geotextile Tube Core
- Seawall/Bulkhead

Of these alternatives, the seawall/bulkhead option was eliminated based on negative environmental and social impacts and high cost of implementation. The no-action alternative is appropriate for undeveloped reaches. The remaining alternatives had moderate to high potential for meeting objectives with acceptable environmental and social impacts, and were considered in Cycle 3. Table 4-3 summarizes results of Cycle 2 screening. Table 4-4 provides a brief comparative environmental impact analysis of Cycle 2 alternatives.

Table 4-3 Summary of Cycle 2 Screening Results

OBJECTIVE: HURRICANE AND STORM DAMAGE REDUCTION							
Alternative	**Primary Design Parameters**	**Environmental Considerations**	**Social Considerations**	**Relative Costs**	**Potential to Meet Objective**	**Further Consideration in Cycle 3?**	**Remarks**
No Action	--	Generally preferred. However, in some cases may result in loss of existing habitat.	Acceptable in undeveloped reaches. Not acceptable in developed reaches.	--	No	Yes	Ultimate cost of the no-action alternative is that potential without-project storm damages are likely to be fully realized.
Berm Restoration	Berm width	Temporary loss of benthic habitat in borrow areas. Burial of benthic organisms in placement area. Provides piping plover habitat.	Acceptable. Provides additional recreational beach area.	Moderate	Moderate	Yes	Adverse environmental impacts can be minimized through coordination with agencies. This applies to all beach fill alternatives.
Berm and Dune Restoration	Berm width and dune height	Same as previous. Added habitat from dune planting. Berm and dune system replicates natural beach condition.	Same as previous. Excessive dune height may impair view of beach/ocean.	Moderate	High	Yes	Proved most cost-effective in other recent District studies along NJ coast.
Berm and Dune Restoration with Groin Field	Groin spacing and length	Same as previous. Gain rocky habitat. Potential negative impact on downdrift beaches.	Same as previous. Probably acceptable. Groins used as fishing areas.	Moderate	High	Yes	Groin construction costs would have to be offset by savings from reduced periodic nourishment. No additional wave and flood damage reduction expected.
Berm & Dune Restoration with Geotextile Tube Core	Tube diameter and elevation of placement	Same as berm/dune. Concerns over use of non-biodegradeable material.	Same as berm/dune. Possible aesthetic concerns if tube is exposed or damaged.	Moderate	High	Yes	Added erosion damage reduction benefits would need to be cost-effective. No significant additional wave and flood damage reduction benefits expected.
Seawall/Bulkhead	Crest elevation	Hard shoreline structures not favored. No added habitat. Potential scour problems and loss of dry beach a problem.	Massive seawalls usually not favored for aesthetic reasons. Access may be a problem. Any acceleration of erosion would be viewed very negatively.	High	High	No	Combination with berm to prevent long-term loss of beach would likely be cost prohibitive.

Table 4-4 Comparative Environmental Impact Analysis of Cycle 2 Alternatives

Resource Categories	Berm Restoration	Berm and Dune Restoration	Berm and Dune Restoration w/Groin Field	Berm and Dune Restoration w/ Geotextile Tube Core	Seawall/Bulkhead
Air Quality	Emissions discharges from dredge and construction equipment would be minor and temporary during the duration of construction activities.	Same as berm restoration.	Same as berm and dune restoration with a minor incremental increase in emissions to build groins.	Same as berm restoration.	Emissions discharges from construction equipment would be minor and temporary during the duration of construction activities.
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. **Offshore:** Long-term changes in borrow site bathymetry are expected from impacts associated with deepening through dredging.	**Beach/Nearshore**: Same as berm restoration except greater topographic relief would be present with a dune, which would rise several feet above beach berm. **Offshore:** Same as berm restoration	**Beach/Nearshore**: Same as berm and dune restoration except groins would retain sand longer, which would be expected to provide a more stable beach profile. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** Geotextile 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.	**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 bulkhead/seawall interface with intertidal or subtidal areas. **Offshore:** No effect.
Ground-water	**Beach/Nearshore**: Beachfill placement activities are not expected to have any impacts on groundwater resources. **Offshore:** Dredging within the borrow site is not expected to have any impacts on groundwater resources.	**Beach/Nearshore**: Same as berm restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore**: Same as berm restoration **Offshore:** Same as berm restoration.	**Beach/Nearshore:** Same as berm restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore**: No effect. **Offshore:** No effect.
Hydrodynamics	**Beach/Nearshore**: Only negligible effects are expected on nearshore transport and beach run up. Intertidal zone would be displaced seaward. **Offshore:** Only negligible effects are expected on wave climate.	**Beach/Nearshore**: Same as berm restoration. **Offshore:** Same as berm restoration.	**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.	**Beach/Nearshore:** No effect. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** It is generally believed that hardened structures such as bulkheads and seawalls without beach nourishment could exacerbate erosion to adjacent unprotected areas. Sand nourishment could mitigate this effect. **Offshore:** No effect.
Water Quality	**Beach/Nearshore**: 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**: Same as berm restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore**: Same as berm restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** No effect. **Offshore:** No effect.
Wetlands	**Beach/Nearshore**: No vegetated wetlands would be affected within the project impact area. **Offshore:** Not applicable.	**Beach/Nearshore**: Same as berm restoration. **Offshore:** Not applicable.	**Beach/Nearshore**: Same as berm restoration. **Offshore:** Not applicable.	**Beach/Nearshore**: Same as berm restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** No effect. **Offshore:** No effect.
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. **Offshore:** Not applicable	**Beach/Nearshore**: Same as berm restoration except that a dune would provide greater terrestrial habitat diversity for flora and fauna that would typically inhabit dunes. **Offshore:** Not applicable	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Not applicable.	**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	**Beach/Nearshore:** Bulkhead or seawall may reduce terrestrial habitat diversity for the upper beach and dune area. **Offshore:** Not applicable.

Resource Categories	Berm Restoration	Berm and Dune Restoration	Berm and Dune Restoration w/Groin Field	Berm and Dune Restoration w/ Geotextile Tube Core	Seawall/Bulkhead
Soft-bottom Benthic Organisms	**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. **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.	**Beach/Nearshore**: Same as berm restoration. **Offshore:** Same as berm restoration, except that additional quantities of sand required for dune construction and maintenance may incur an incremental increase in benthic habitat affected by dredging.	**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. **Offshore:** Same as berm and dune restoration.	**Beach/Nearshore:** Impacts would be minimal since most of the fill placement and construction would occur on the upper beach. **Offshore**: Same as berm and dune restoration, but on a smaller scale.	**Beach/Nearshore:** No effect. **Offshore:** No effect.
Rocky Hard Bottom Organisms	**Beach/Nearshore:** Existing man-made groins would be permanently covered within the design template resulting in a loss of rocky habitat, which affects a specialized benthic community consisting of barnacles (*Balanus balanoides*), polychaetes, molluscs (*Donax sp.*), small crustaceans such as, mysid shrimp (*Heteromysis formosa*), amphipods (*Gammarus sp.*), uropods (*Idotea baltica*), and mollusks such as blue mussel (*Mytilus edulis)*, which is a dominant member of this community. Loss of this habitat would also impact reef-dwelling finfish such as tautog and black sea bass. Recolonization is expected to a lesser degree as this habitat would become partially exposed between nourishment cycles. **Offshore:** No rocky hard bottom habitats were identified in offshore portions of the project area.	**Beach/Nearshore:** Same as berm restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** The construction of new groins and rehabilitating or supplementing existing groins to be covered with beachfill from berm and dune restoration would still allow for rocky habitat to persist seaward of the berm design template, therefore, this alternative would most likely result in no change over existing conditions or a minor increase in this type of habitat. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** No effect. **Offshore:** No effect.	**Beach/Nearshore:** No effect. **Offshore:** No effect.
Shellfish and Essential Fish Habitat Resources	**Beach/Nearshore**: Shellfish resources in the nearshore such as surfclams would become buried during beachfill placement. Recruitment and recolonization is expected shortly after construction is completed. **Offshore:** Temporary loss of commercial surfclams and other shellfish and reproductive stocks within offshore borrow site. Areas would be left for recolonization/recruitment after dredging ceases.	**Beach/Nearshore**: Same as berm restoration. **Offshore:** Same as berm restoration, except that additional quantities of sand required for dune construction and maintenance may incur an incremental increase in benthic habitat affected by dredging.	**Beach/Nearshore**: Same as berm and dune restoration except that groin substrates would be attractive to blue mussels (*Mytilus edulis*). **Offshore:** Same as berm and dune restoration.	**Beach/Nearshore:** Impacts would be minimal since most of the fill placement and construction would occur on the upper beach. **Offshore:** Same as berm and dune restoration, but on a smaller scale.	**Beach/Nearshore:** No effect. **Offshore:** No effect.

Resource Categories	Berm Restoration	Berm and Dune Restoration	Berm and Dune Restoration w/Groin Field	Berm and Dune Restoration w/ Geotextile Tube Core	Seawall/Bulkhead
Finfish and Essential Fish Habitat Resources	**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**: Same as berm restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore**: Same as berm and dune restoration, except groins would become attractive habitat for rocky reef-oriented fish such as tautog. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** Impacts would be minimal since most of the fill placement and construction would occur on the upper beach. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** No effect. **Offshore:** No effect.
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**: Same as berm restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** Same as berm restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** Same as berm and dune restoration. **Offshore:** No effect.
Cultural Resources	**Beach/Nearshore**: Potential to cover shipwreck sites with beachfill. **Offshore:** Potential to impact offshore shipwreck sites. Sites would be avoided based on remote sensing investigations.	**Beach/Nearshore**: Same as berm restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** No effect. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** No effect. **Offshore:** No effect.
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:** Dredge equipment working offshore may appear unsightly during construction and periodic nourishment.	**Beach/Nearshore**: Same as berm restoration except that a dune may inhibit some ocean views. **Offshore:** Same as berm restoration.	**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. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** A dune with a geotextile tube core may inhibit ocean views of some properties. Potential for exposure of geotextile tube core, which may be considered unsightly. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** Hardened structures such as bulkheads and seawalls would have adverse aesthetic impacts because of their unnatural appearance. **Offshore:** No effect.

4.6 Cycle 3 - Final Screening and Optimization

The Cycle 1 and Cycle 2 screening process eliminated many of the potential alternative measures. Alternatives recommended for further consideration in Cycle 3 are listed below.

- No Action
- Berm Restoration
- Berm and Dune Restoration
- Berm and Dune Restoration with Groin Field
- Berm and Dune Restoration with Geotextile Tube Core

These alternatives were evaluated based on detailed 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 January 2000 price level, and a 6.625% discount rate.

The selected plan is determined solely on cost-effectiveness by comparing expected benefits and estimated costs for a matrix of design alternatives. 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., 50-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 (2-year event through 500-year event).

4.6.1 Incremental Analysis

To formulate the NED plan, two separate reaches were delineated within the study area. Reach delineation was based on existing economic and physical conditions with a specific focus on the level of development within each reach.

The first reach extends from Barnegat Inlet northward to Berkeley Township. This reach encompasses Island Beach State Park and is different from the remaining study area in that it is primarily a natural beach setting with very limited existing development and infrastructure. Because existing development is limited and future development is precluded based on land use policies, any with-project storm damage reduction benefits would be very low and not expected to outweigh project costs. Furthermore, State agencies desire to preserve Island Beach State Park as a natural setting with no direct intervention to control natural beach processes. Therefore, this reach was eliminated from further analysis with a recommendation of no action.

The second reach extends from Berkeley Township northward to Point Pleasant Beach at the Manasquan Inlet south jetty. The total length of this reach is essentially fully developed with ocean front residential, commercial, and municipal properties and structures. For calculation purposes, this reach was broken into cells based on municipal boundaries. However, differences in the level of development from cell to cell are insufficient to warrant incremental analysis of each cell. Furthermore, the cells are of a length scale and proximity such that it would not be feasible to construct a project on a cell-by-cell basis because of project end losses and flanking that would occur at any gaps in the selected plan.

4.6.2 Design Parameters

All of the Cycle 3 design alternatives include beach fill. Therefore, the Cycle 3 analysis focused on determining the optimal beach fill design template. There are several parameters that define a specific beach fill design template. A range of values for these parameters was identified based on existing conditions in the study area and accepted coastal engineering practices. The following parameters and associated constraints were utilized to develop a matrix of alternative beach fill designs from which the optimal plan was determined.

Berm Width. In this report, berm width is defined as the distance from the seaward toe of the dune to the berm crest. Berm width is a primary design parameter controlling the amount of storm damage reduction provided by a beach fill. Wider beach berms provide increased protection against erosion, and to a lesser extent, increased protection from waves and flooding. However, to achieve a given level of storm damage reduction, incremental costs to widen the berm are typically much higher than costs to increase dune height. Therefore, plans with very wide berms are usually not the most cost-effective solution, particularly where waves or inundation are the principle damage mechanisms.

For cells that have an existing dune (cells 1, 2 and 4-10), the average existing berm width (75 ft) was the minimum design width considered in the analysis. This existing berm width is sufficient to support dunes by preventing dune degradation during non-storm conditions and allowing for seasonal variations in shoreline position without impacting the design dune template. Also, this berm width together with a foreshore slope distance (berm crest to MHW) of 70 ft is approximately equal to the mimimum acceptable total beach width (150 ft) required to support nesting of piping plovers. In addition to the existing berm width of 75 ft, alternatives with a 100-ft berm width were considered for these cells to determine whether widening the beach beyond the average existing condition would be cost effective.

Cells 3 and 11 include commercial recreation areas located in Seaside Heights and northern Point Pleasant Beach, respectively. These areas include boardwalks and pier structures with no existing dune. The representative existing condition at Seaside Heights includes a 150-ft berm. At northern Point Pleasant Beach, the existing berm is approximately 250 ft. The berm is much wider at northern Point Pleasant Beach than throughout the remainder of the study area because of the influence of the Manasquan Inlet jetty that traps northbound sand transport. A minimum design berm width of 100 ft was identified for cells 3 and 11 based on the smallest berm width that presently exists in these cells. In addition to the minimum berm width of 100 ft, berm widths of 125 ft and 150 ft were considered for these cells. Design berm widths of greater than 150 ft would not likely be feasible because of cost and would introduce problems related to maintaining transitions from wide design berms to narrower design berms in adjacent cells. Additionally, based on the selected plan chosen in Cells 1, 2 and 4-10, the berm width of 75 feet was evaluated for comparative purposes and to ensure the NED plan was thoroughly evaluated and determined.

Berm Elevation. The design berm elevation should match the average existing natural berm elevation. Elevation of the natural berm is controlled by the average tide range, wave conditions, and foreshore beach slope at the study area. If the design berm is higher than the existing natural berm height, a persistent vertical scarp may form at the limit of wave runup, creating environmental issues and safety problems for beachgoers. A design berm that is too low allows frequent overtopping by wave runup. This overtopping can gradually create a ridge at the berm crest and cause flooding and ponding of water on the back berm during high tides. Based on analysis of beach profile data, the average existing berm elevation in the study area is +8.5 ft NAVD except along northern Point Pleasant Beach (cell 11), where the berm transitions to +11.5 ft NAVD due to the influence of the Manasquan jetty. These existing berm elevations were used in all design alternatives.

Beach Fill Slope. The slope of the design berm face is based on the average existing foreshore slope as determined from historical profiles. The existing foreshore slope averages 1:10, therefore the foreshore slope for all alternatives was set to match this value from the berm crest down to the mean high water line. Below the mean high water line down to the depth of closure, the design slope was determined by translation of the existing beach profile within each cell.

Depth of Closure. Depth of closure refers the depth on the beach profile to which significant cross-shore sand transport occurs. Depth of closure enters beach fill design in determining sand quantities required to construct the design berm width. Depth of closure varies as a function of storm wave height. As a first approximation for initial screening of beach fill alternatives, a maximum depth of closure of -30 ft NAVD was used to compute fill quantities. Current guidance recommends that the design depth of closure be determined for a time period consistent with the periodic nourishment interval. Therefore, after selection of the optimized design template and nourishment interval, further analysis was performed to calculate a design of depth of closure for the selected plan. The design depth of closure was determined to be -26 ft NAVD, based on calculations for a 10-yr frequency storm. This value is consistent with available profile data, and provides a somewhat conservative design assuming an expected nourishment cycle of around 5 years. Final quantities determined for the selected plan (Section 5) were calculated using the -26 ft NAVD depth of closure.

Design Baseline. A design baseline was established along the ocean frontage of the project study area to reference design beach templates for each alternative to the structure database for computing storm damages.

Dune Height. As with berm width, dune height is a primary parameter controlling potential storm damage reduction. Higher dunes provide effective protection against wave attack and flooding during a storm. However, excessive dune heights can create problems by blocking views and making beach access more difficult.

Existing dune heights vary along the reach. Excluding cells 3 and 11 that presently have no dune, the average existing dune height is +18 ft NAVD. This height was the minimum design height considered in cells that have an existing dune (cells 1,2 and 4-10). Higher dune heights were considered at a 2-ft interval up to +22 ft NAVD. A dune height of +22 ft NAVD is slightly higher than the highest dunes that presently exist along the reach and is considered the maximum acceptable dune height for these areas.

Cells 3 and 11 have no existing dunes. For these areas the minimum dune height considered was +14 ft NAVD. This value was determined as the minimum height expected to provide any effective storm damage reduction to the boardwalk and backing structures. Higher dune heights were considered at a 2-ft interval up the maximum of +18 ft NAVD. This height is approximately 2 ft above the existing boardwalk deck. Additionally, based on the selected plan chosen in Cells 1, 2 and 4-10, the dune height of 22 feet was evaluated for comparative purposes and to ensure the NED plan was thoroughly evaluated and determined. Greater dune heights are not locally acceptable as they would significantly restrict view of the ocean from the boardwalk, which is an integral part of the recreation experience provided by the Seaside Heights and Point Pleasant Beach boardwalks. Cells 3 and 11 are inherently different than the other cells of the project area due to their physical structures. Both cells contain large amusement piers, which are at elevations between 15 and 16 feet NAVD and are perpendicular to the shoreline. There are two amusement piers in Cell 3 and one amusement pier in Cell 11, each of which would incur a significant cost to elevate above a dune height greater than 18 feet NAVD.

Dune Width and Slope. The dune width and slope design were that of a "Caldwell Section", and are typical of many Corps shore protection designs, especially along the New Jersey coast. This dune configuration was patterned after designs by Joseph M. Caldwell, a USACE engineer. The "Caldwell Section" was developed based on results of experiments performed in response to the March 1962 northeaster that devastated much of the East Coast shorefront areas. Side slopes were set at 1V:5H, which was determined to be the optimum condition base on native sand grain size, and the grain size of sand to be obtained from offshore borrow areas. Dune crest width was set at 25 ft.

Design Beach Fill Quantities. Required sand volumes were calculated for each alternative. Volumes were separated into "above berm" estimates of dune quantities, and "below berm" estimates of berm quantities. Dune volume was computed using the difference between the design dune template and existing dune condition for each cell and multiplying the unit volume by the appropriate cell length. To determine berm quantities, a representative design MHW line was established by cell for each alternative. Berm volume was computed by multiplying the difference between existing and design MHW shoreline positions by the active profile depth (the design berm elevation to the depth of closure).

Periodic Nourishment. Periodic sand nourishment is typically included as part of a beach fill project. The nourishment volume is considered sacrificial and protects the design template from long-term erosion. At the end of the nourishment cycle, the design beach template remains. The nourishment quantity is placed at the time of initial construction (termed "advanced fill") and at regular intervals throughout the 50-year period of Federal participation.

A longer nourishment cycle brings a corresponding decrease in the annualized cost of beach fill material, dredge mobilization and demobilization, etc. However, this economic analysis does not take into account the risk of a large storm occurring during the interval between nourishment cycles or the risk of greater than normal wave action in a given year. These risks grow with every year the nourishment cycle is increased. Everts et al. (1974) found that the rate of loss of fill material is proportional to the quantity placed at one time, and thus recommend placing smaller volumes on a more frequent basis to maximize overall residence time. Sorenson, Weggel and Douglas (1989) also recommend frequent placement of small volumes, with the nourishment cycle in the two to four year range.

In the formulation analysis, nourishment quantities were calculated on an individual cell basis (i.e., assuming no transitions between cells) for each alternative using the *Planform Evolution Model,* a numerical tool that estimates shoreline change produced by long-term erosion and beach fill diffusion. The diffusion component accounts for “spreading out” losses that occur because the design beach is wider than adjacent beaches. A 5-year periodic sand nourishment cycle was assumed for initial screening of beach fill alternatives. After selection of the optimal template, the periodic nourishment cycle was optimized by considering a 4-year and 3-year interval. An overfill factor of 1.5 was used in estimating nourishment quantities to account for difference in grain size between the native beach and fill material taken from borrow source areas A and B (see Figure 2-7).

4.6.3 Berm Restoration

Initial screening model runs of the berm-only alternative indicated that this option was not likely to be the most cost-effective solution for hurricane and storm damage reduction. Because a high percentage of potential damages for this study reach are attributed to inundation rather than erosion, the berm-only alternative provides relatively little potential storm damage reduction benefits relative to costs. This trend is consistent with recent Philadelphia District studies that have shown a berm-only plan is not as cost-effective as a combined berm and dune plan in providing hurricane and storm damage reduction. Based on these initial screening results, the berm-only option was eliminated from further consideration, and the formulation analysis focused on berm and dune restoration.

4.6.4 Berm and Dune Restoration

The optimal berm and dune restoration plan was determined through analysis of costs and benefits of a range of alternatives. Costs used in formulation were based on design and construction costs required for sand placement. Other costs which were essentially constant for all plans (such as real estate costs) or relatively low-cost items (sand fence, dune grass) were not included in the formulation, as they would not have controlled determination of the selected plan. Likewise, only benefits obtained through storm damage reduction to structures were counted in the formulation process, as these benefits represent the primary intended output of hurricane and storm damage reduction projects. All costs and benefits were included in analysis of the final selected plan, as presented in Section 5.

The formulation process first included optimization of the beach fill design template (assuming a 5-year nourishment cycle). After the optimal design template was determined, the periodic nourishment cycle was then optimized.

4.6.4.1 Optimization of Beach Fill Design Template

A matrix of berm and dune alternatives was developed for analysis based on design parameters and constraints discussed in Section 4.6.2. One set of alternatives applied to the majority of the reach (cells 1,2, and 4-10), as given in Table 4-5. A second set of alternatives, given in Table 4-6, was used for cells 3 and 11 (Seaside Heights and Point Pleasant Beach boardwalk areas) to account for different existing conditions and constraints. The two sets of alternatives were not formulated as separate projects, but as different design dimensions for specified areas that together form a single project plan for the reach. Figure 4-1 and Figure 4-2 show the range of beach fill alternatives for the representative cells of Mantoloking (cell 8) and Seaside Heights (cell 3), respectively.

Table 4-5 Beach Fill Alternatives (Cells 1,2, 4-10)

Alternative	Dune Height, ft NAVD	Berm Width, ft
D18B075	18	75
D18B100	18	100
D20B075	20	75
D20B100	20	100
D22B075	22	75
D22B100	22	100

Table 4-6 Beach Fill Alternatives (Cells 3 and 11)

Alternative	Dune Height, ft NAVD	Berm Width, ft
D14B100	14	100
D14B125	14	125
D14B150	14	150
D16B100	16	100
D16B125	16	125
D16B150	16	150
D18B100	18	100
D18B125	18	125
D18B150	18	150

Required beach fill volumes were computed as described in Section 4.6.2. Design template and nourishment quantities are presented in Table 4-7 and Table 4-8 for all alternatives. It is noted that quantities required to incrementally widen the berm are much higher than quantities needed to increase dune height.

Each alternative was analyzed for erosion, wave attack and inundation damage using the same methodologies applied in the without-project analyses (beach profile and hydraulic response were computed using SBEACH, and structure damages were calculated using COSTDAM). Storm damages were computed for each alternative and compared to without project damages as presented in Table 4-9 and Table 4-10.

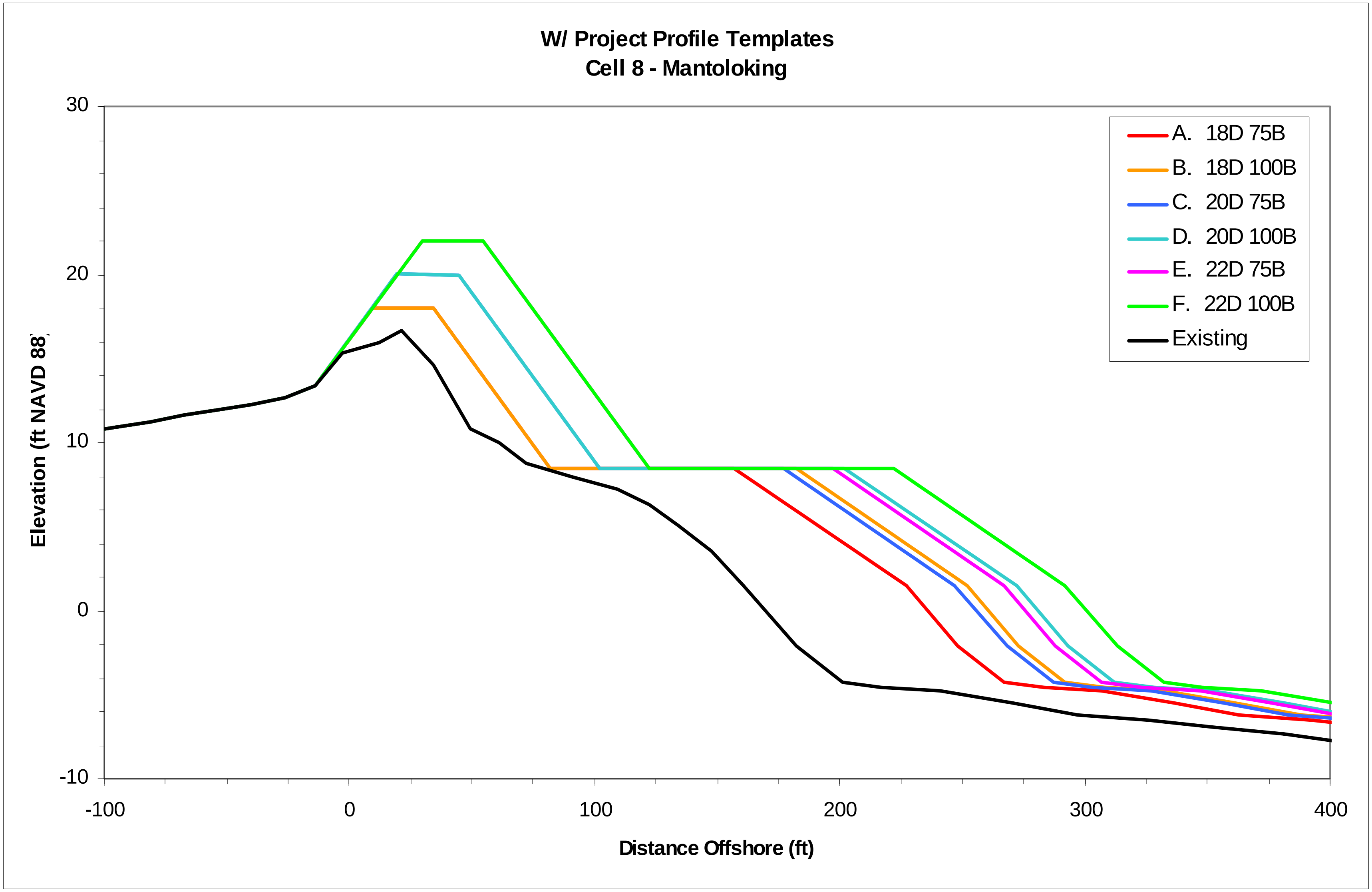

Figure 4-1 Typical Beach Fill Alternative Templates for Cells 1, 2, and 4-10

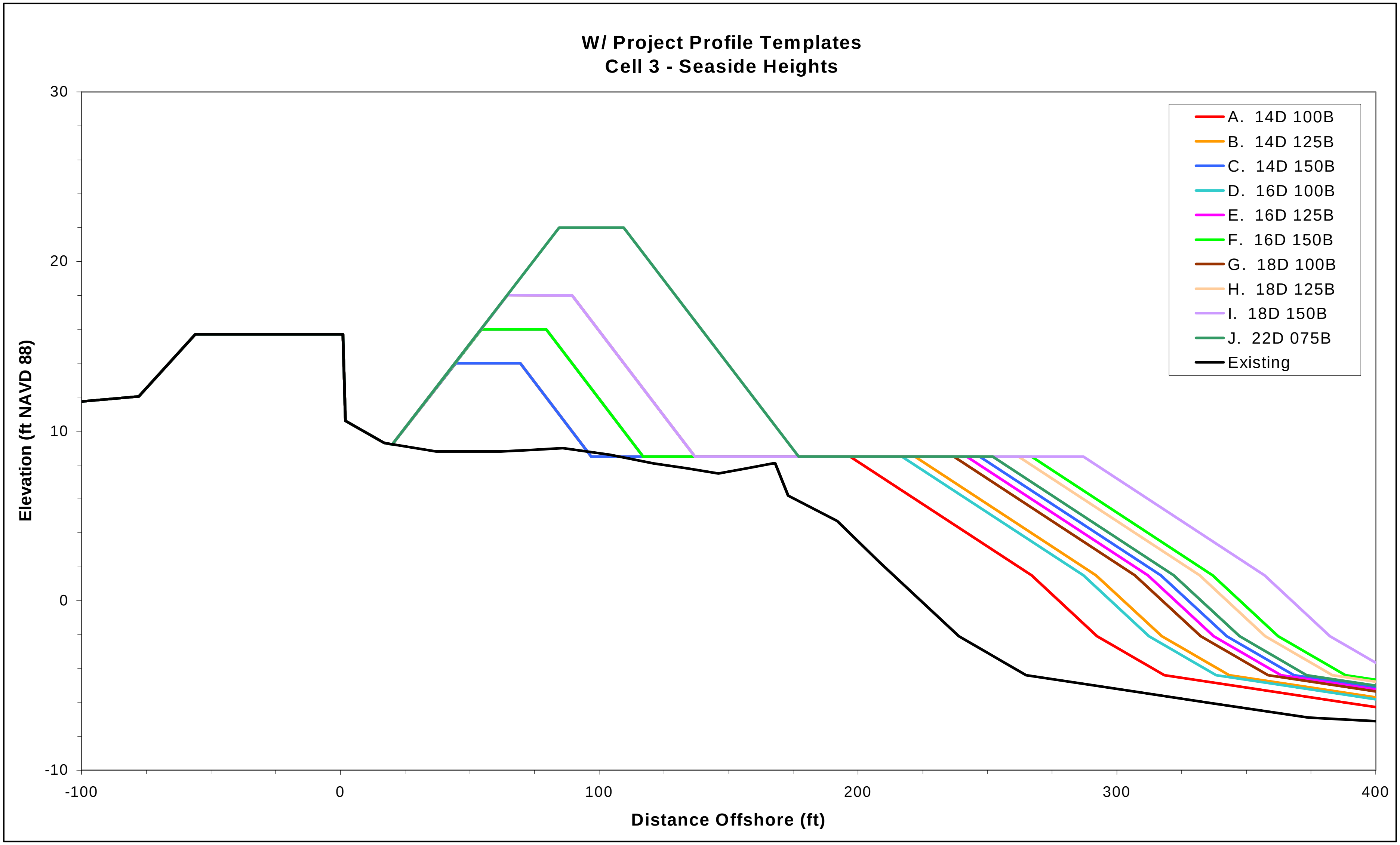

Figure 4-2 Typical Beach Fill Alternative Templates for Cells 3 and 11

Table 4-7 Required Sand Quantities for Beach Fill Alternatives (Cells 1,2, and 4-10)

Alternative	Design Dune (cu yds)	Design Berm (cu yds)	Total Design (cu yds)	Nourishment* (cu yds)
D18B075	257,000	2,472,000	2,729,000	1,109,000
D18B100	257,000	4,141,000	4,398,000	1,814,000
D20B075	682,000	3,769,000	4,451,000	1,641,000
D20B100	682,000	5,774,000	6,456,000	2,584,000
D22B075	1,305,000	5,347,000	6,652,000	2,398,000
D22B100	1,305,000	7,524,000	8,829,000	3,162,000
* Includes Overfill				

Table 4-8 Required Sand Quantities for Beach Fill Alternatives (Cells 3 and 11)

Alternative	Design Dune (cu yds)	Design Berm (cu yds)	Total Design (cu yds)	Nourishment* (cu yds)
D14B100	59,000	224,000	283,000	98,000
D14B125	59,000	389,000	448,000	173,000
D14B150	59,000	592,000	651,000	265,000
D16B100	110,000	353,000	463,000	161,000
D16B125	110,000	546,000	656,000	242,000
D16B150	110,000	781,000	891,000	354,000
D18B100	176,000	505,000	681,000	236,000
D18B125	176,000	732,000	908,000	335,000
D18B150	176,000	991,000	1,167,000	449,000
* Includes Overfill				

Table 4-9 Storm Damage to Structures (Cells 1,2, and 4-10)

Alternative	Average Annual Damages			Total	% Reduction
	Erosion	Inundation	Wave		
Without Project	*$2,338,000*	*$4,738,000*	*$29,000*	*$7,105,000*	--
D18B075	$1,819,000	$5,112,000	$0	$6,931,000	2 %
D18B100	$1,231,000	$3,998,000	$0	$5,229,000	26 %
D20B075	$670,000	$2,853,000	$0	$3,523,000	50 %
D20B100	$480,000	$1,695,000	$0	$2,175,000	69 %
D22B075	$53,000	$640,000	$0	$693,000	90 %
D22B100	$25,000	$483,000	$0	$508,000	93 %

Table 4-10 Storm Damage to Structures (Cells 3 and 11)

Alternative	Average Annual Damages			Total	% Reduction
	Erosion	Inundation	Wave		
Without Project	*$200,000*	*$2,149,000*	*$0*	*$2,349,000*	--
D14B100	$670,000	$1,330,000	$0	$2,000,000	15%
D14B125	$690,000	$1,106,000	$0	$1,796,000	24%
D14B150	$481,000	$1,116,000	$0	$1,597,000	32%
D16B100	$417,000	$1,116,000	$0	$1,533,000	35%
D16B125	$391,000	$1,055,000	$0	$1,446,000	38%
D16B150	$348,000	$826,000	$0	$1,174,000	50%
D18B100	$325,000	$715,000	$0	$1,040,000	56%
D18B125	$323,000	$665,000	$0	$988,000	58%
D18B150	$309,000	$566,000	$0	$875,000	63%

General trends observed in Table 4-9 and Table 4-10 are that erosion and inundation damages decreased with increase in dune height and berm width. No wave damages were counted for any of the with-project alternatives. Apparent anomalies in trends for specific damage categories are explained by the fact that only one damage mechanism (that which produces the greatest damage) is counted for each individual structure. For example, in Table 4-10, each of the with-project alternatives produced more erosion damages than the without-project condition. This is because structures that were originally damaged by inundation in the without-project condition were shifted into the erosion damage category for the with-project alternatives. In this case, increases in erosion damages were more than offset by the decreases in inundation damages, producing a net decrease in total damages.

Also presented in Table 4-9 and Table 4-10 is the total percent damage reduction of each alternative relative to without-project damages. The formulation alternatives provide a wide range in potential damage reduction (from 2% to 93% reduction for cells 1,2, and 4-10; and from 15% to 63% reduction for cells 3 and 11). Damage reduction trends are evident by examining the increase in percent damage reduction relative to incremental change in dune or berm dimension. For cells 1,2, and 4-10, an incremental increase in dune height (berm width held constant) produced an average increase in storm damage reduction of 39%. On the other hand, increase in berm width (dune height held constant) produced an average additional 15% in damage reduction. For cells 3 and 11, a similar comparison shows an 18% average increase in damage reduction with dune height and a 7% average increase with berm width. Therefore, both groups show that, for this reach, a 2-ft increase in dune height is more effective in reducing storm damage in comparison to a 25-ft increase in berm width.

Table 4-11 and Table 4-12 show average annual damage reduction benefits, costs, and net benefits for each alternative. Based on these formulation results, the optimal plan that maximizes net storm damage reduction benefits is a 22-ft dune with 75-ft berm for cells 1,2, and 4-10 and an 18-ft dune with 100-ft berm for cells 3 and 11. Average annual net benefits provided by the combined plan are $2,198,000 with a benefit-to-cost ratio (BCR) of 1.40.

*Alternative D22B75 for Cells 3 and 11 was evaluated subsequent to the plan formulation of the alternatives to ascertain whether the NED plan selected in Cells 1,2 and 4-10 would also be an appropriate plan for Cells 3 and 11. Constraints were placed on the elevation of the dune in Cells 3 and 11 because they are inherently different than the other cells due to their physical structures. Both cells contain large amusement piers, which are at elevations between 15 and 16 feet NAVD and are perpendicular to the shoreline. There are two amusement piers in Cell 3 and one amusement pier in Cell 11, each of which would incur a significant cost to elevate above a dune height greater than 18 feet NAVD. Additionally, the impact to businesses on each of the piers would be considerable during the pier re-construction, but was not factored into the cost estimate for this alternative. It was determined that the taper of the dune required beneath the piers would be excessive for any dune elevation above the 18 ft dune. The total cost to elevate the piers for higher dune elevations between 19 and 22 ft NAVD dune is estimated to be approximately $25,000,000. The cost to elevate the piers would be comparable cost estimates and relatively the same magnitude regardless of the elevation to which the piers are raised. The final cost of elevating the piers was added to the increased quantities of sand and the average annual costs were determined. Increased costs result in a plan with a BCR less than 1.

It is noted that, for formulation purposes, the benefit analysis was based on structure damage reduction only and did not include infrastructure and improved property damage reduction. Although infrastructure and improved property damage reduction are NED benefits, these categories represent only a small percentage (< 5%) of total NED benefits for this study and would not have controlled the outcome of the formulation. Also, because recreation benefits are considered incidental, they were not counted in the formulation analysis. All benefits and costs were included in the final economic analysis of the NED plan, presented in Section 5.

It is also noted that quantities presented in Table 4-11 and Table 4-12 are preliminary estimates developed for formulation. Final design quantities were calculated based on detailed analysis of the selected plan as presented in Section 5.

Table 4-11 Storm Damage Reductions Benefits (Cells 1, 2, and 4-10)

Alternative	Average Annual Damages	Average Annual Damage Reduction Benefits	% Damage Reduction	Sand Quantity (cu yds)		Average Annual Costs	Net Storm Damage Reduction Benefits	BCR
				Design Template	Periodic Nourishment (with Overfill)			
Without Project	*$7,105,000*	--	--	--	--	--	--	--
D18B075	$6,931,000	$174,000	2 %	2,729,000	1,109,000	$2,495,000	($2,321,000)	0.07
D18B100	$5,229,000	$1,876,000	26 %	4,398,000	1,814,000	$3,754,000	($1,878,000)	0.50
D20B075	$3,523,000	$3,582,000	50 %	4,451,000	1,641,000	$3,508,000	$74,000	1.02
D20B100	$2,175,000	$4,930,000	69 %	6,456,000	2,584,000	$5,184,000	($254,000)	0.95
D22B075	$693,000	$6,412,000	90 %	6,652,000	2,398,000	$4,944,000	$1,468,000	1.30
D22B100	$508,000	$6,597,000	93 %	8,829,000	3,162,000	$6,312,000	$285,000	1.05

Table 4-12 Storm Damage Reductions Benefits (Cells 3 and 11)

Alternative	Average Annual Damages	Average Annual Damage Reduction Benefits	% Damage Reduction	Sand Quantity (cu yds)		Average Annual Costs	Net Storm Damage Reduction Benefits	BCR
				Design Template	Periodic Nourishment (with Overfill)			
Without Project	*$2,349,000*	--	--	--	--	--	--	--
D14B100	$2,000,000	$349,000	15 %	283,000	98,000	$316,000	$33,000	1.10
D14B125	$1,796,000	$553,000	24 %	448,000	173,000	$456,000	$97,000	1.21
D14B150	$1,597,000	$752,000	32 %	651,000	265,000	$643,000	$109,000	1.17
D16B100	$1,533,000	$816,000	35 %	463,000	161,000	$438,000	$378,000	1.86
D16B125	$1,446,000	$903,000	38 %	656,000	242,000	$598,000	$305,000	1.51
D16B150	$1,174,000	$1,175,000	50 %	891,000	354,000	$802,000	$373,000	1.47
D18B100	$1,040,000	$1,309,000	56 %	681,000	234,000	$579,000	$730,000	2.26
D18B125	$988,000	$1,361,000	58 %	908,000	335,000	$753,000	$608,000	1.81
D18B150	$875,000	$1,474,000	63 %	1,167,000	449,000	$953,000	$521,000	1.55
***D22B75**	$534,000	$1,815,000	77 %	1,235,145	288,366	$2,447,000	-$632,000	0.74

4.6.4.2 Optimization of Nourishment Cycle

After determining the NED design template, the nourishment cycle was optimized by considering 5-year, 4-year, and 3-year intervals. Because the nourishment cycle doesn't affect storm damage reduction benefits, optimization was performed on the basis of cost. Longer nourishment cycles can be more cost-effective by reducing the number of construction activities (e.g., mob and demob, engineering and design, supervision and administration) during the life of the project. However, longer nourishment cycles also require placement of a greater quantity of sand to create a wider beach at the beginning of each cycle. Because longshore spreading losses increase with increase in initial beach width, cost-effectiveness of a reduced number of construction cycles may be offset by increased sand volume requirements.

Table 4-13 shows results of the nourishment cycle optimization, with a 4-year cycle producing the least total average annual cost. The cost of the 5-year cycle alternative in Table 4-13 is slightly less than the cost calculated during formulation of the design template, because of refined pumping efficiency assumptions used for the selected plan. These assumptions were applied uniformly to each nourishment cycle alternative in the optimization procedure.

Table 4-13 Periodic Nourishment Cycle Costs

Nourishment Alternative	Periodic Nourishment Quantity with Overfill (cu yds)	Average Annual Cost of Nourishment	Total Average Annual Costs
5-year cycle	2,631,000	$2,340,000	$5,491,000
4-year cycle	1,935,000	$2,388,000	$5,338,000
3-year cycle	1,450,000	$2,644,000	$5,402,000

4.6.5 Berm and Dune Restoration with Groin Field

Following development of the optimal beach fill template and nourishment cycle, further consideration was given to construction of a groin field along the project reach from Berkeley Township to Point Pleasant Beach. Because groin fields provide no added storm damage protection, purposes for consideration in this study are to stabilize the beach and reduce nourishment requirements. Normally, a groin field must extend along the entire length of a beach fill project to function properly in reducing nourishment quantities. Partial groin fields within a project often create accelerated erosion in the downdrift direction. Also, groins can cause negative impact to adjacent areas outside the project, unless appropriate steps are taken to taper the groin field at project ends.

A limited number of existing groins are located along the reach at Lavallette and Bay Head. Based on their existing condition and their lengths relative to the selected plan dimensions, these groins would be mostly covered and expected to have little impact on the project. In order to function as part of a larger groin field, these groins would need to be modified and extended.

A preliminary screening analysis was performed to evaluate whether potential benefits of including a groin field would outweigh costs of construction. Groins require a specific alongshore spacing to function optimally. This spacing is typically around 500 to 1000 ft. As an estimate of minimum potential costs, it was assumed that groins would be placed at a maximum spacing of 1500 ft, which would require 50 groins along the entire project reach. Assuming groins of 500-ft length at a cost of $2,500 per foot, the cost per groin would be $1,250,000. Total initial construction cost for the entire groin field would be $62,500,000. This cost translates to an average annual cost of $4,315,000 over the life of the project. Based on the formulation analysis, the average annual cost of periodic nourishment at a 4-year cycle is $2,388,000. Because the average annual cost of the groin field exceeds that of periodic nourishment, no cost savings would be gained even if the groins totally eliminated the need for future nourishments. Therefore, groins were not considered further in the plan formulation.

4.6.6 Berm and Dune Restoration with Geotextile Tube Core

Consideration was given to the use of a geotextile tube (geotube) core to provide added storm damage reduction benefits. Geotubes are relatively inexpensive, costing around $100 per linear foot. Their primary function on open coast projects is to provide added dune stability by acting as a barrier to erosion upon exposure. Exposed geotubes can provide some protection against low waves, but provide little protection against waves and flooding when fully uncovered and overtopped. In the process of modeling storm damages and benefits for alternative beach fill plans, it became apparent that a geotube core was not likely to be an effective solution.

Examination of storm damages in Table 4-9 and Table 4-10 shows that inundation accounts for 78% of residual structure damages for the selected plan. Because the optimized dune heights are relatively high, the dune remains largely intact for all but the most extreme storm events (100-yr return period and higher) at which most of the residual damages are realized. Geotubes would be ineffective in providing any additional protection against inundation for these extreme events. Some limited additional erosion protection may be provided by a geotube during such events, but stability of the geotube would be questionable due to exposure to high waves and overtopping. Therefore, a geotube core would provide few additional damage reduction benefits to the selected plan and was not considered further.

4.7 Summary of Optimized NED Plan

The study area was divided into two reaches based on the level of existing development. The first reach extends from Barnegat Inlet northward to Berkeley Township and encompasses Island Beach State Park. No action is recommended for this reach based on minimal potential storm damage reduction benefits and existing land use policies.

The second reach extends from Berkeley Township at the northern boundary of Island Beach State Park northward to Point Pleasant Beach at the Manasquan Inlet south jetty. The optimized NED plan for this reach includes beach and dune restoration with a +22-ft NAVD dune fronted by a 75-ft berm along the entire length of the reach, except at Seaside Height and Point Pleasant Beach where the plan includes a +18-ft NAVD dune fronted by a 100-ft berm. The beach fill design template was optimized to provide maximum net storm damage reduction benefits to structures. The plan includes a periodic nourishment cycle of 4 years, optimized based on minimum average annual cost. Detailed project design, environmental impacts, and full costs and benefits of the NED plan are presented in Section 5.

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5 SELECTED PLAN

5.1 Identification of the Selected Plan

The National Economic Development (NED) Plan is defined as the plan that maximizes net beneficial contributions to the Nation while maintaining planning objectives. Specifically, the selected NED plan for this study maximizes net storm damage reduction benefits. The design of the selected plan is consistent with accepted coastal engineering practice and Corps criteria described in the Coastal Engineering Manual. Because design of the selected plan is not technically complex and is essentially complete, additional design work (i.e., General Design Memorandum) is not needed except for development of plans and specifications. The following sections describe the selected plan.

5.1.1 Description of the Selected Plan

The selected plan consists of a berm and dune constructed using sand obtained from offshore borrow sources. The plan extends approximately 13.7 miles from Berkeley Township at boundary of Island Beach State Park northward to Point Pleasant Beach at the Manasquan Inlet south jetty. Design dune dimensions include a crest width of 25 ft and side slopes of 1V:5H. The design dune crest elevation is +22 ft NAVD along the entire reach except at Seaside Heights and northern Point Pleasant Beach where the design elevation is +18 ft NAVD. The plan includes approximately 175 acres of dune grass planted on the newly constructed dune. Pedestrian dune crossovers (247) are provided at existing access locations, including handicap access at regular intervals. Eleven vehicle crossovers are also provided. Sand fence is included along the perimeter of the dune base and at each crossover to protect the dune.

The design berm extends 75 ft from the seaward toe of the dune to the berm crest along the entire reach except at Seaside Heights and northern Point Pleasant Beach, where the design berm extends 100 ft. The design beach slope is 1V:10H from the berm crest down to Mean High Water (MHW). Below MHW, the design beach slope parallels the existing beach slope down to the depth of closure (-26 ft NAVD).

Design cross-sections for the selected plan are shown in Figure 5-1 and Figure 5-2. The design cross-sections were applied in each cell along the project reach to develop the selected plan layout as shown in Figure 5-3 to Figure 5-27. In developing the selected plan layout, planform adjustments were made as needed to maintain design cross-section dimensions, ensure adequate spacing between the dune and backing structures, and provide smooth transitions from cell to cell.

Final design quantities were estimated based on the design layout of the selected plan using procedures detailed in Section 4.6.2. Initial sand quantity is estimated at 10,689,000 cu yds, which includes a design fill quantity of 9,728,000 cu yds and advanced nourishment of 961,000 cu yds. Table summarizes dimensions and quantities for the selected plan.

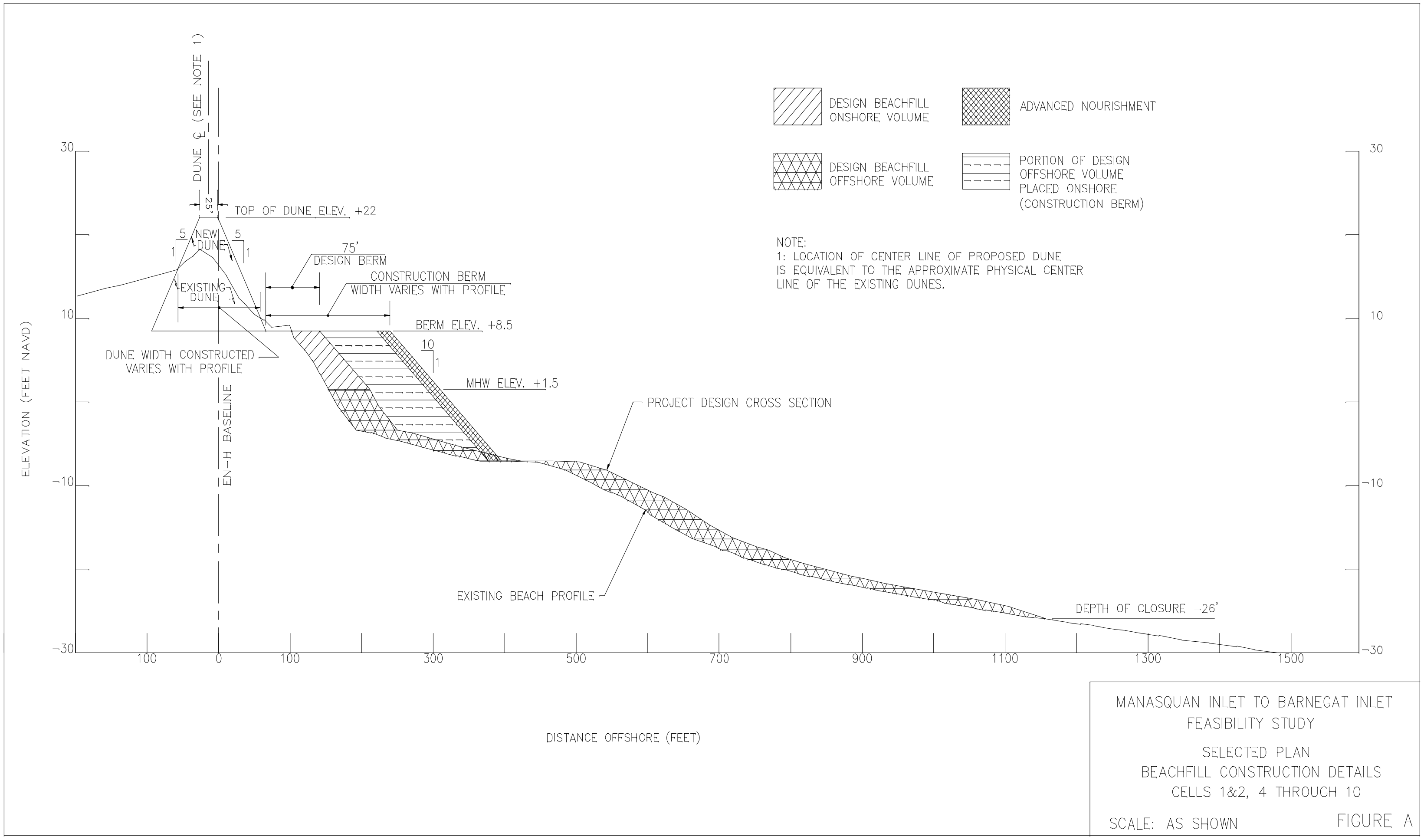

Figure 5-1 Selected Plan – Typical Design Cross-Section with 22-ft NAVD Dune (All Communities except Seaside Heights and northern Point Pleasant Beach)

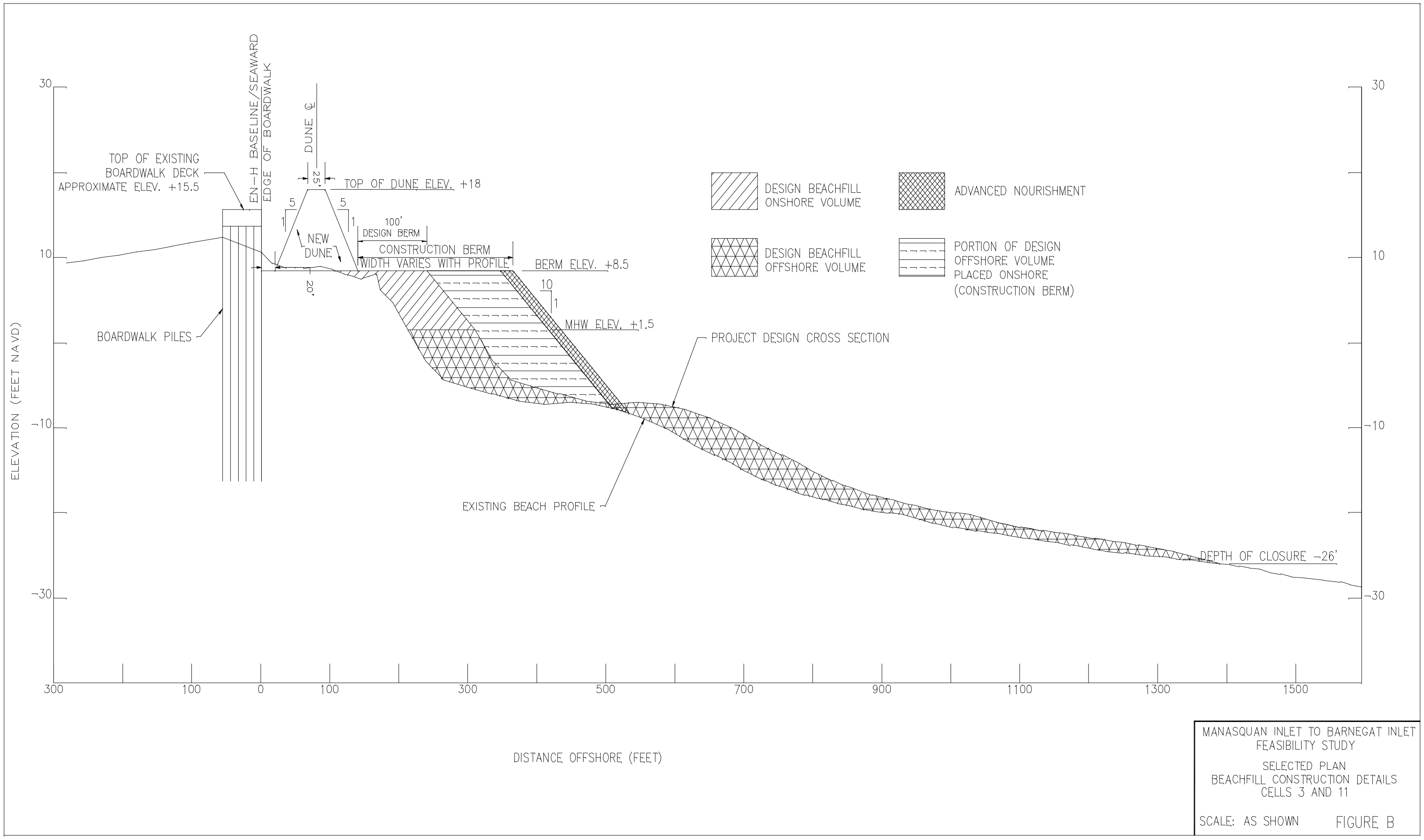

Figure 5-2 Selected Plan - Typical Design Cross-Section with 18-ft NAVD Dune (Seaside Heights and northern Point Pleasant Beach)

Table 5-1 Summary of Selected Plan Dimension and Quantities

Design Component	Dimension/Quantity	Remarks
Berm Elevation	+8.5 ft NAVD; +11.5 ft NAVD at northern Point Pleasant Beach	Same as average existing condition
Berm Width	75 ft; 100 ft at Seaside Heights and northern Point Pleasant Beach	Berm width measured from seaward base of dune to berm crest
Seaward Berm Slope	1:10	Same as average existing condition
Dune Elevation	+22 ft NAVD; +18 ft NAVD at Seaside Heights and northern Point Pleasant Beach	
Dune Width at Crest	25 ft	Standard Caldwell section
Dune Side Slopes	1:5	Standard Caldwell section
Dune Offset for Maintenance of Existing Structures	20 ft (as required)	Required dune offsets are reflected in selected plan layout
Length of Fill	13.7 miles	
Initial Sand Quantity	10,689,000 cu yds	Includes advanced nourishment with overfill
Periodic Nourishment Quantity	961,000 cu yds / 4 year cycle	Includes overfill
Major Replacement Quantity	1,788,000 cu yds	Includes periodic nourishment with overfill; same dune grass and sand fence quantities as initial fill
Taper Section	Tapers to existing within project reach at southern end; no taper at northern end	Manasquan Inlet south jetty functions as terminal structure at northern end
Borrow Source Location	Area A – approximately 2 miles offshore of Island Beach State Park; Area B – approximately 2 miles offshore of Mantoloking	Overfill factor of 1.5 for borrow material
Dune Grass	175 acres	18” spacing
Sand Fence	206,000 feet	Along base of dune and at crossovers
Outfall Extensions	None	
Pedestrian Dune Crossovers	247	Includes handicap access ramps
Vehicle Dune Crossovers	11	

5.1.2 Periodic Nourishment Requirements

Periodic sand nourishment is included in project design to maintain the integrity of the design beach template over the project life. Without periodic nourishment, ongoing erosion would compromise the design template and reduce storm protection.

Nourishment requirements were determined by considering losses resulting from diffusion of the design beach fill planform and natural background erosion. The diffusion component refers to "spreading out" losses that occur because the design beach is wider than adjacent beach areas. Background erosion refers to the average long-term rate of shoreline erosion that occurs along the project reach. Background erosion rates were determined through analysis of recent historical shoreline erosion rates, which implicitly include effects of sea-level rise and storm losses.

A periodic nourishment quantity of 961,000 cu yds 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. Advanced and periodic nourishment quantities include an overfill factor of 1.5 based on use of sand from borrow areas A and B (see Figure 2-7).

5.1.3 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 5-1 and Figure 5-2. 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.

5.1.4 Major Replacement Requirements

Major replacement quantities were developed in accordance with ER 1110-2-1407 to identify additional erosional losses from the project due to higher intensity (low frequency) storm events. The nourishment rates developed for the project alternatives 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 project life. 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 subaerial beach to regain the design cross-section and insure the predicted level of storm damage reduction. It is estimated that a volume of approximately 827,000 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 1,788,000 cu yds. Because a high intensity storm would likely impact dune grass, crossovers, and sand fence, these items were included in the total major replacement costs.

5.1.5 Project Transitions and Tapers

At the southern end, the project will taper to the existing beach within cell 1 (Berkeley Township). This taper will avoid the need for any construction activity within Island Beach State Park. At the northern end, the project terminates at the Manasquan Inlet south jetty with no requirement for a taper. 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.

5.1.6 Storm Water Outfall Extensions

Two existing drainage structures are located in the proposed beach fill area. One is a large reinforced concrete outfall structure located at Sea Avenue in Bay Head. Drainage of this structure will be maintained by grading of the design beach, and no extension is required. The second structure is an inactive cast iron storm water outfall pipe on piles located at 9th Avenue in Ortley Beach (Dover Township). Because this outfall is no longer functioning, the structure will be removed at the time of beach construction, and no extension is required.

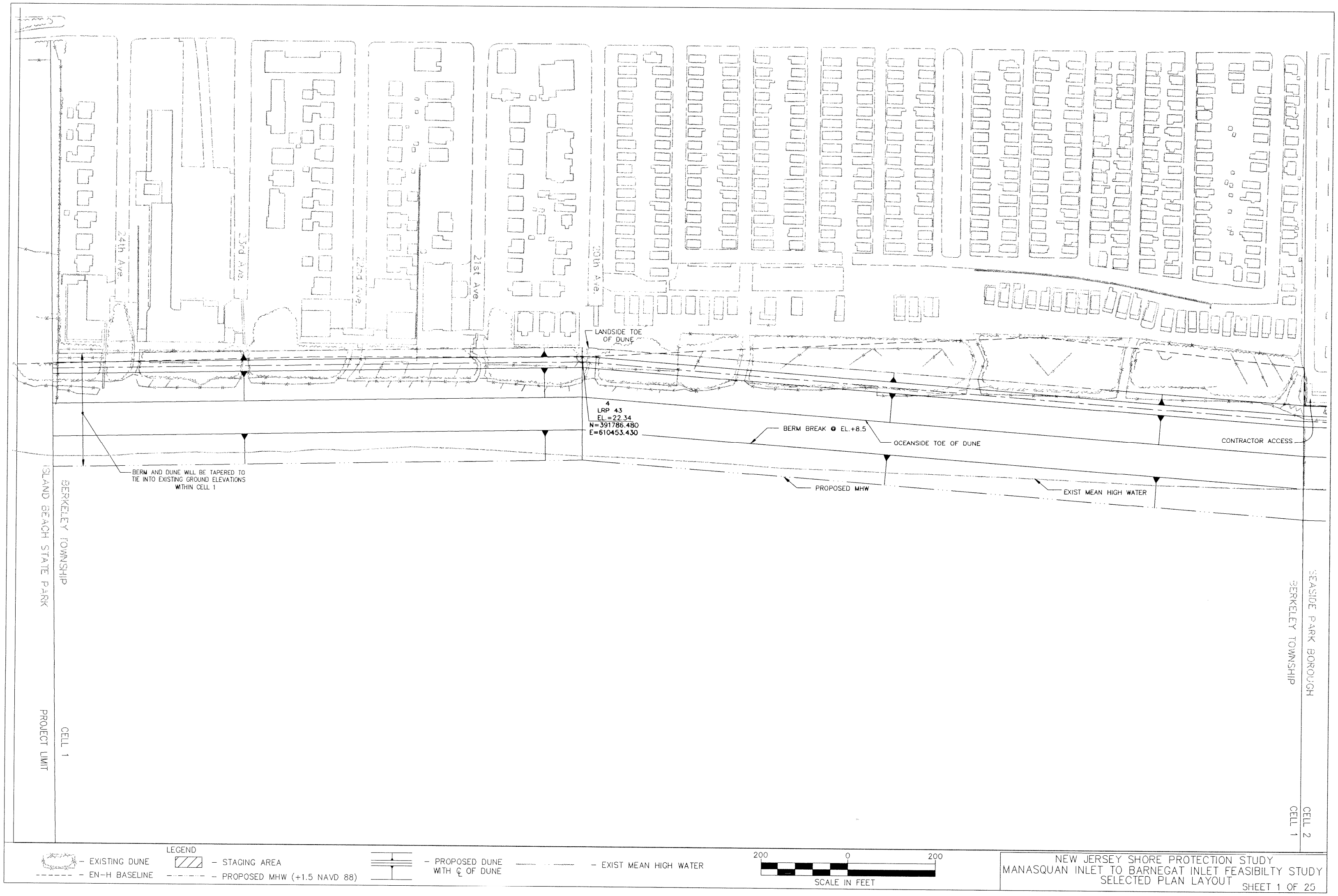

Figure 5-3 Selected Plan Layout – Berkeley Township, South Seaside Park

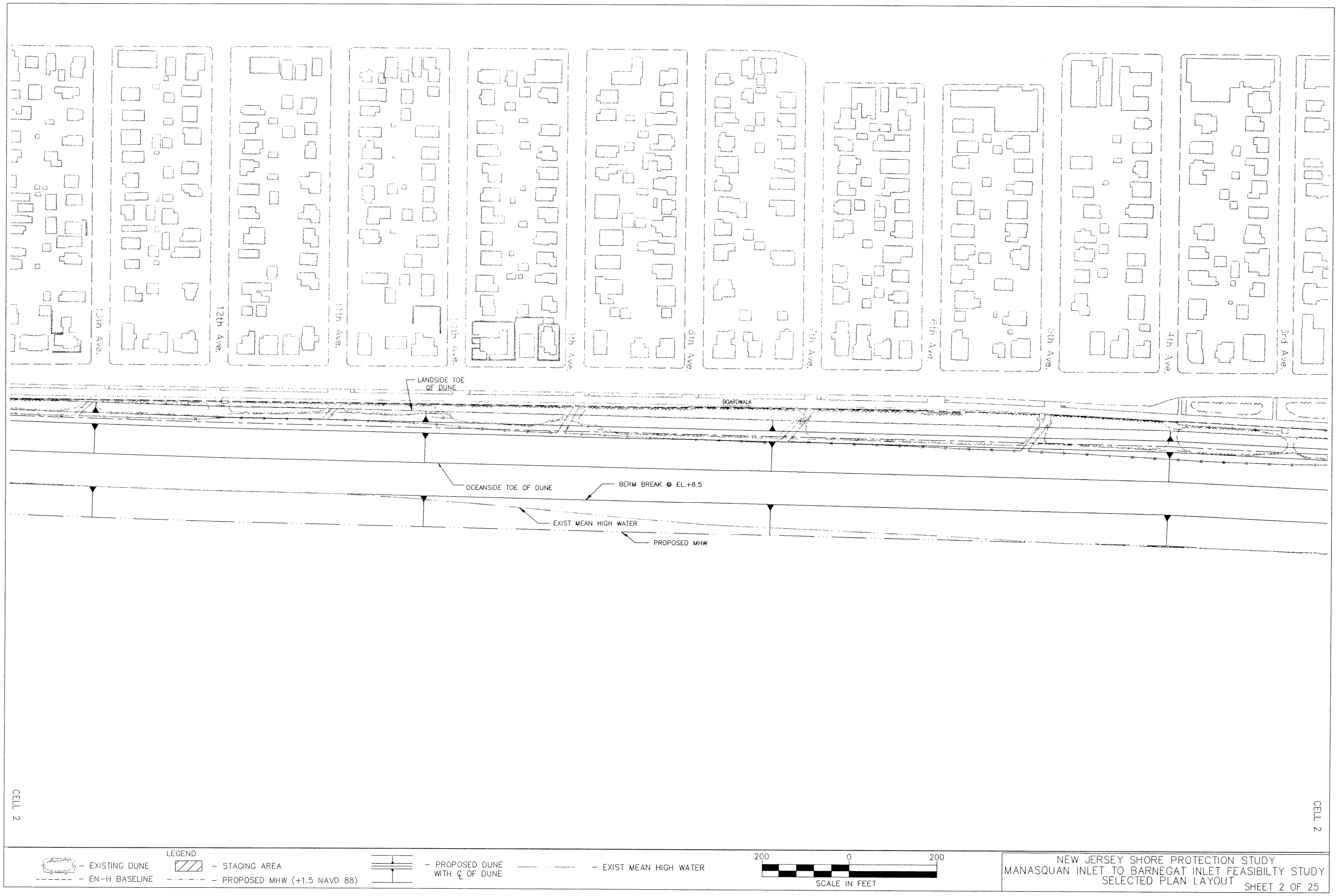

Figure 5-4 Selected Plan Layout – Seaside Park Borough, 13th Avenue to 3rd Avenue

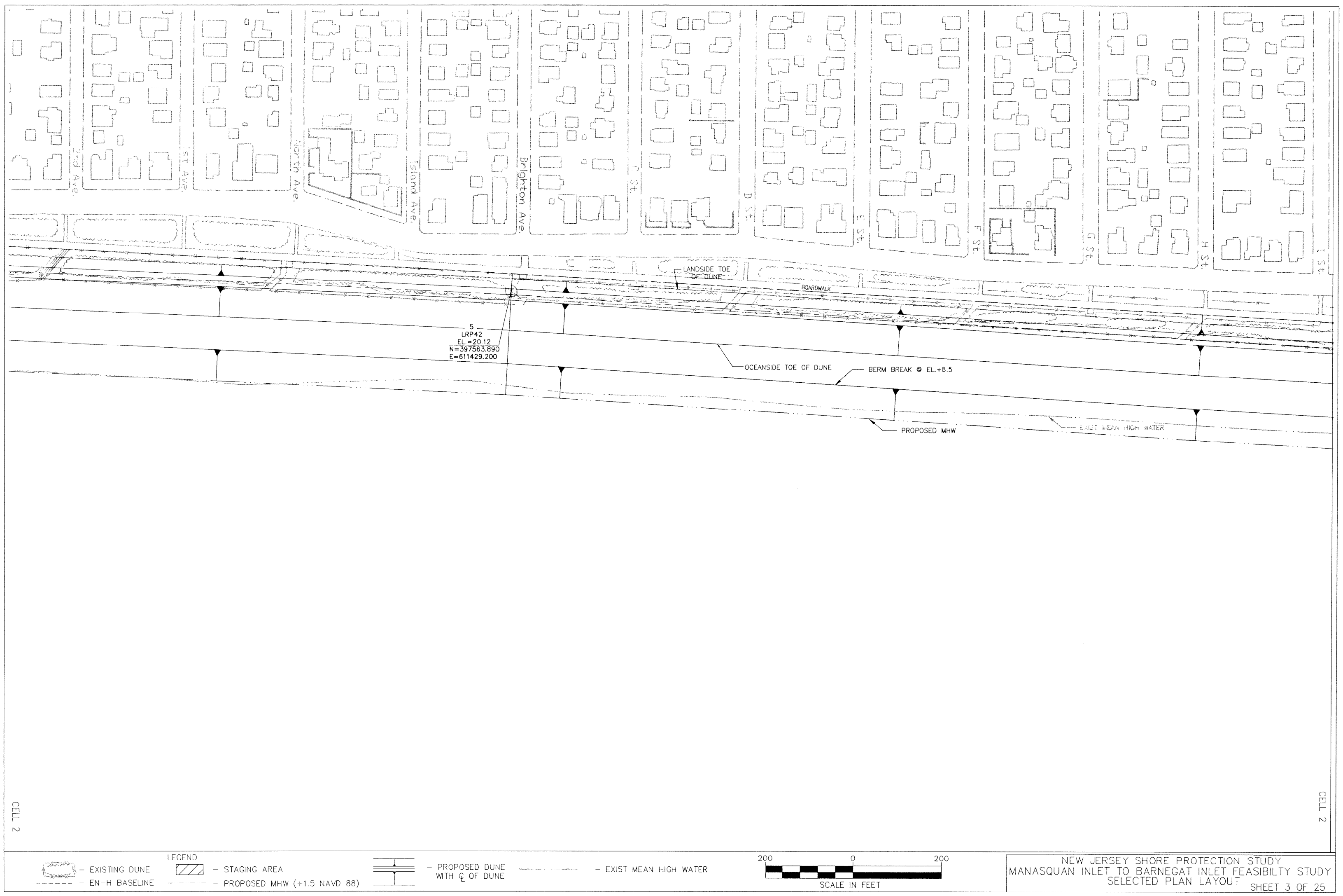

Figure 5-5 Selected Plan Layout – Seaside Park Borough, 2nd Avenue to I Street

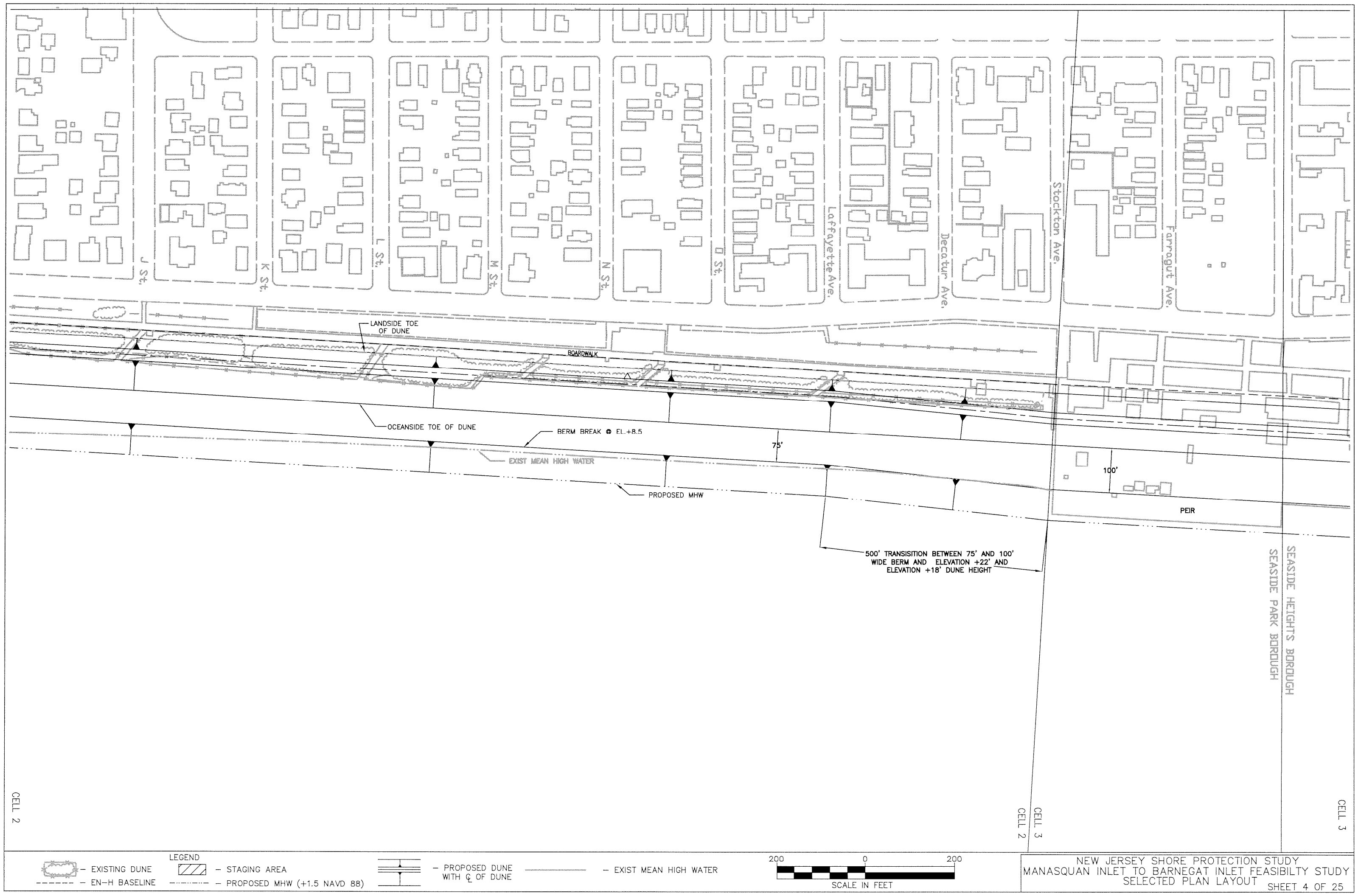

Figure 5-6 Selected Plan Layout – Seaside Park Borough, J Street to Farragut Avenue

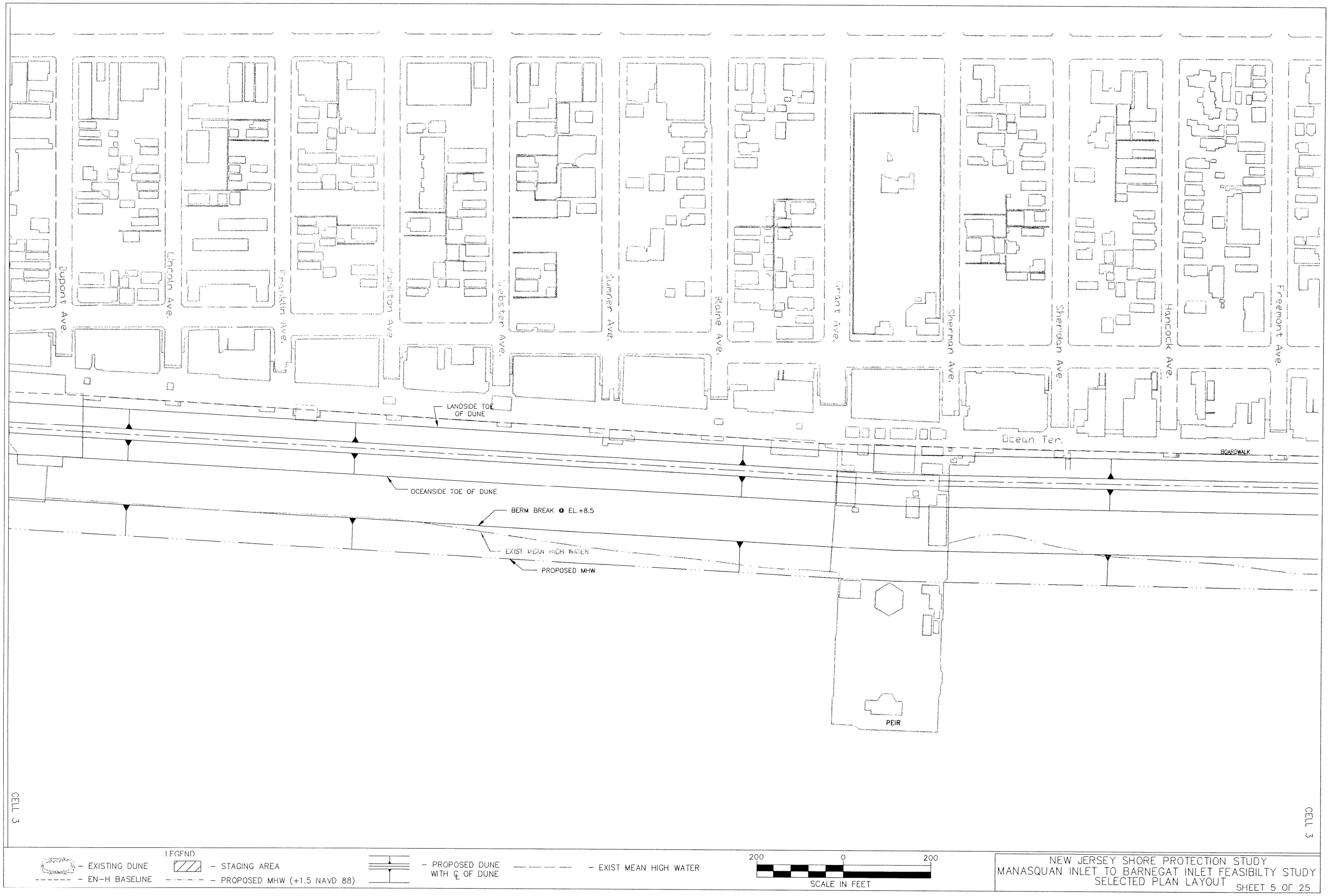

Figure 5-7 Selected Plan Layout – Seaside Heights Borough, Dupont Avenue to Freemont Avenue

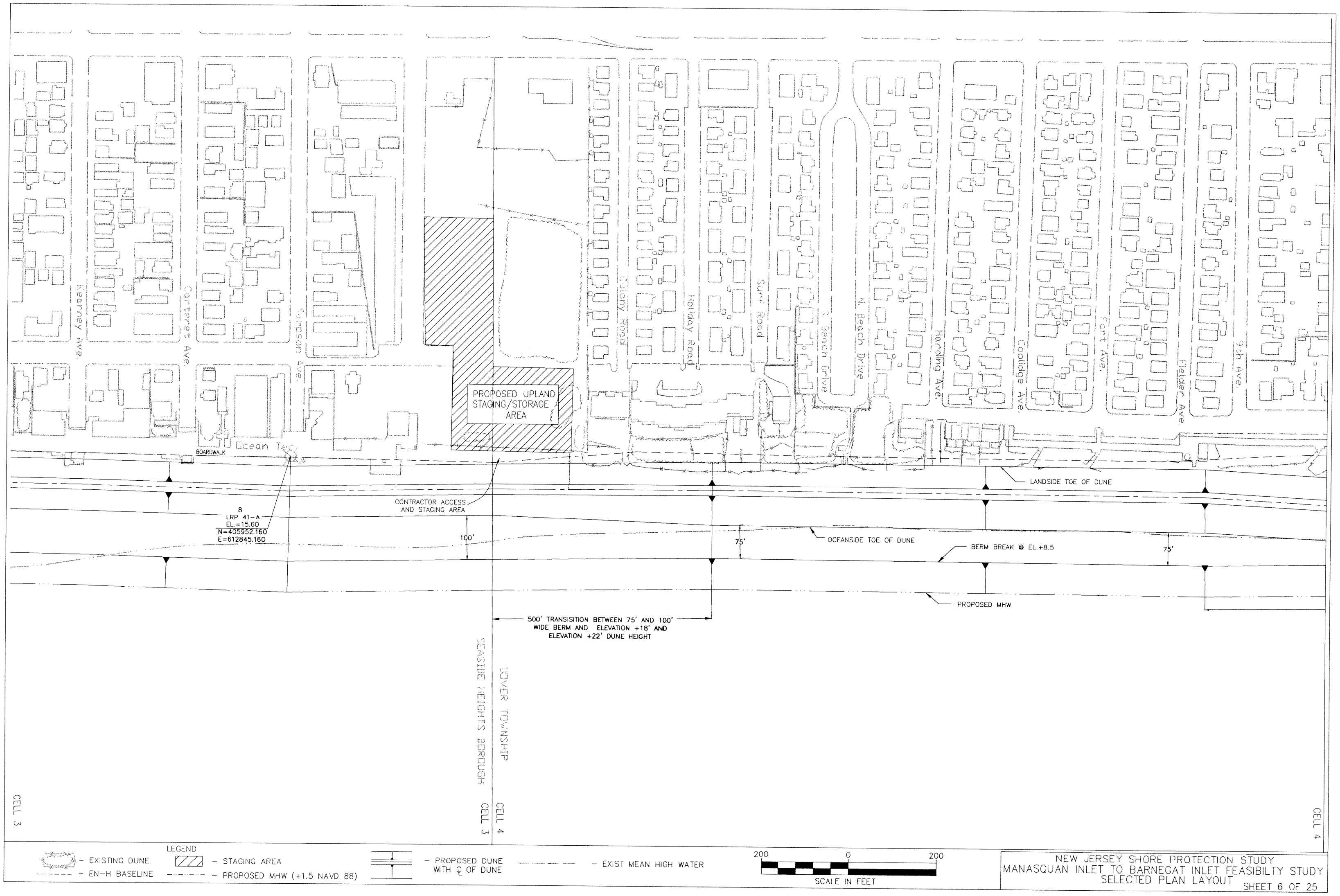

Figure 5-8 Selected Plan Layout – Seaside Heights, Kearney Avenue to Dover Township, Ortley Beach

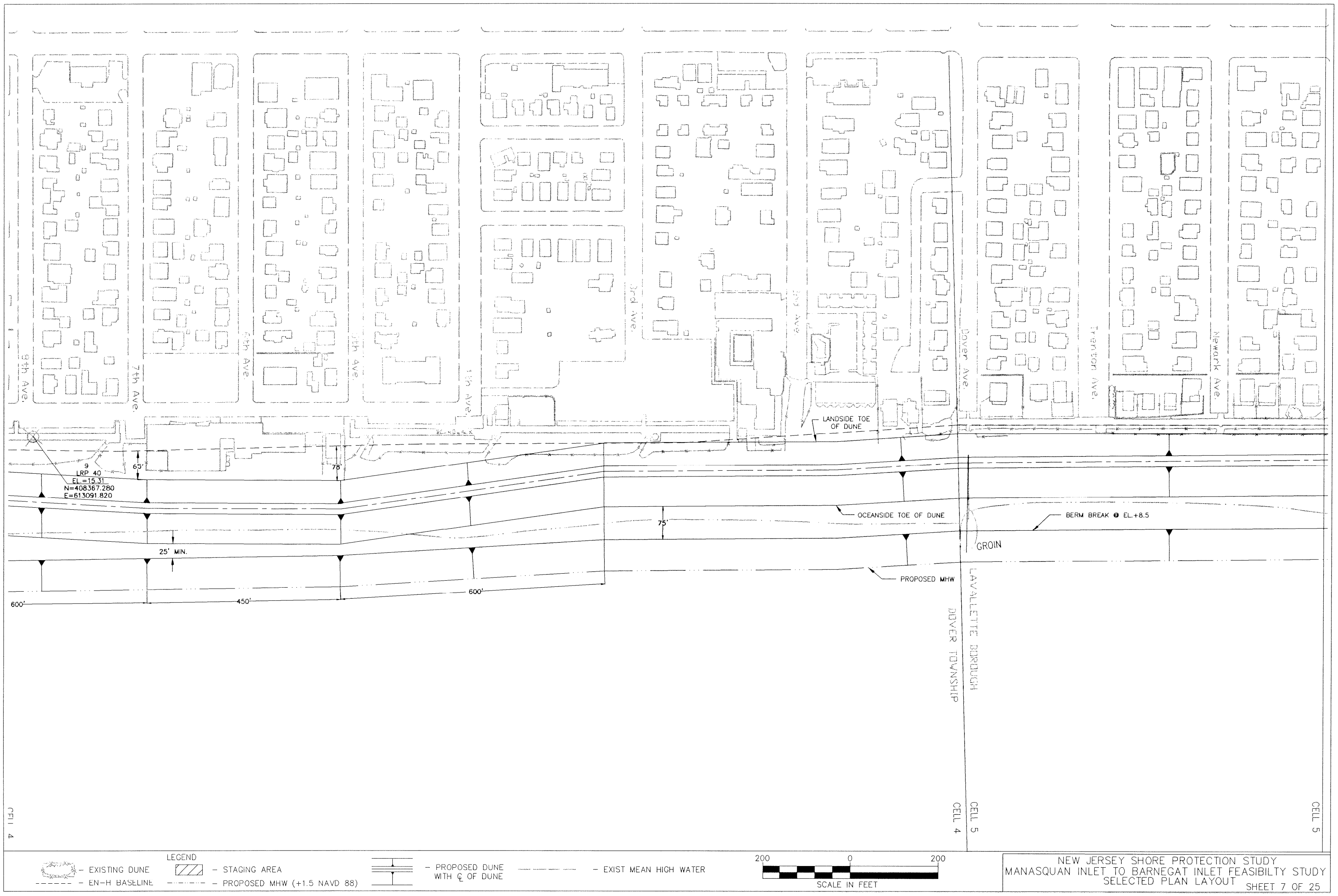

Figure 5-9 Selected Plan Layout – Dover Township, Ortley Beach to Lavallette Borough, Newark Avenue

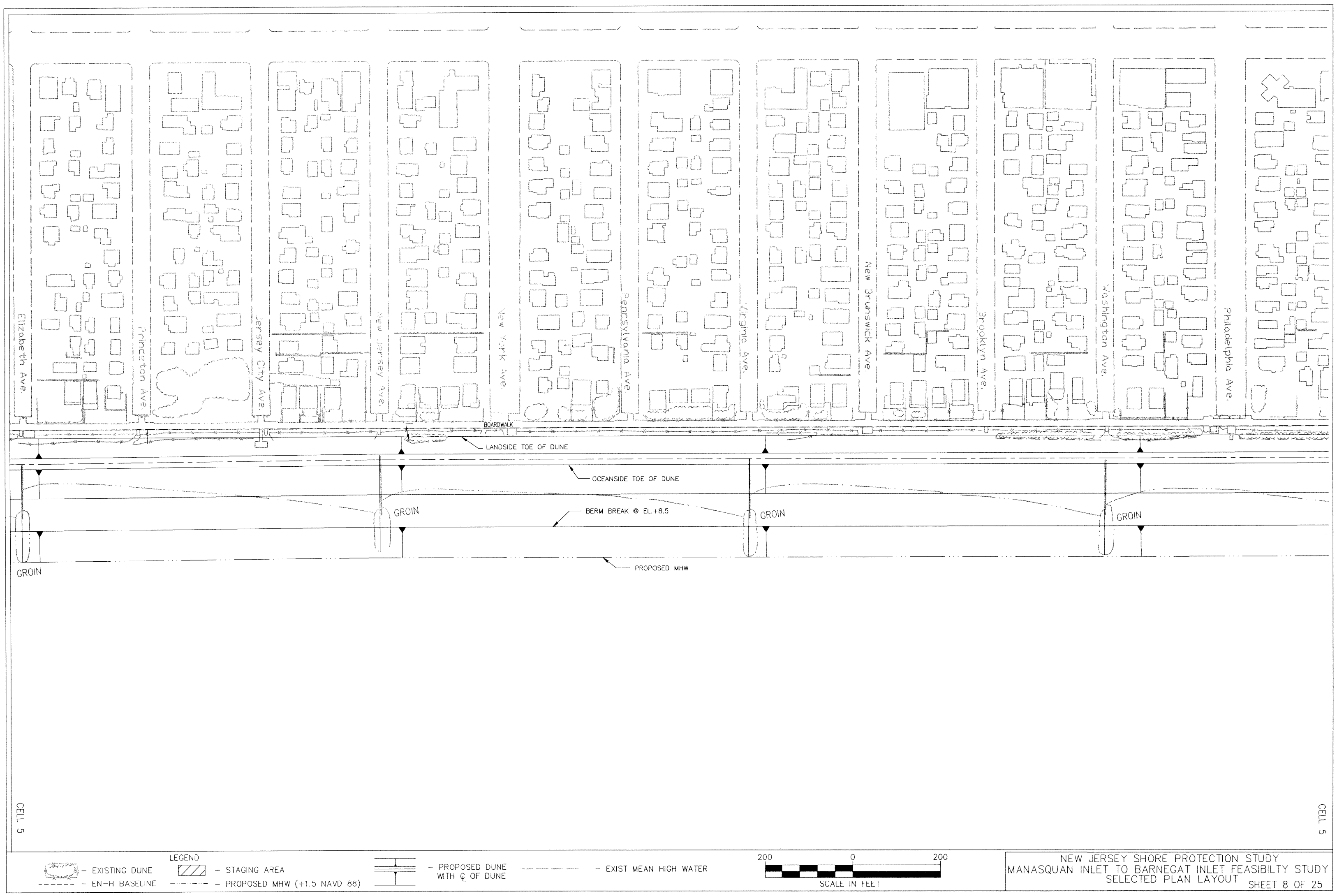

Figure 5-10 Selected Plan Layout – Lavallette Borough, Elizabeth Avenue to Philadelphia Avenue

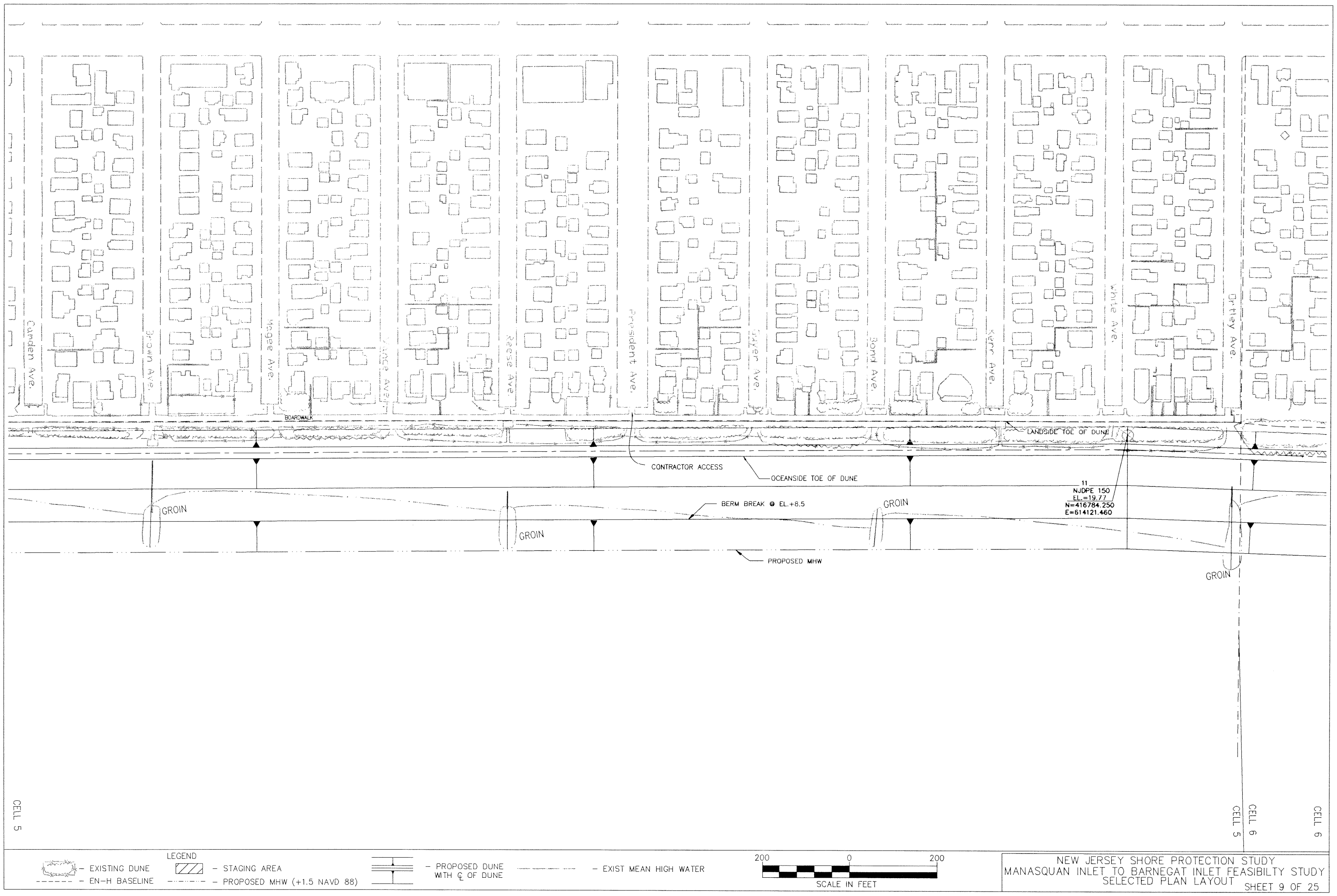

Figure 5-11 Selected Plan Layout – Lavallette Borough, Camden Avenue to Ortley Avenue

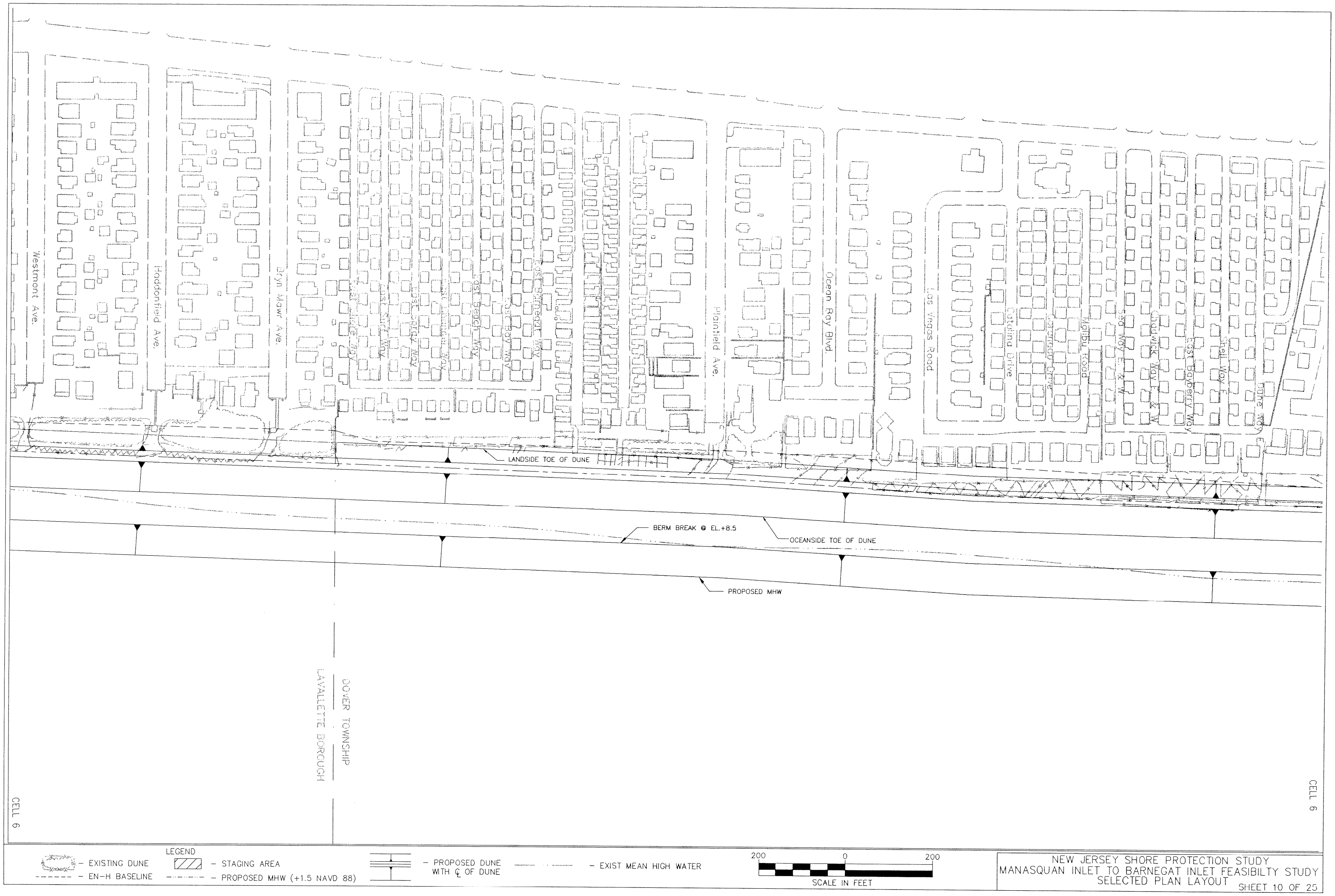

Figure 5-12 Selected Plan Layout – Lavallette Borough, Westmont Avenue to Dover Township, Ocean Beach

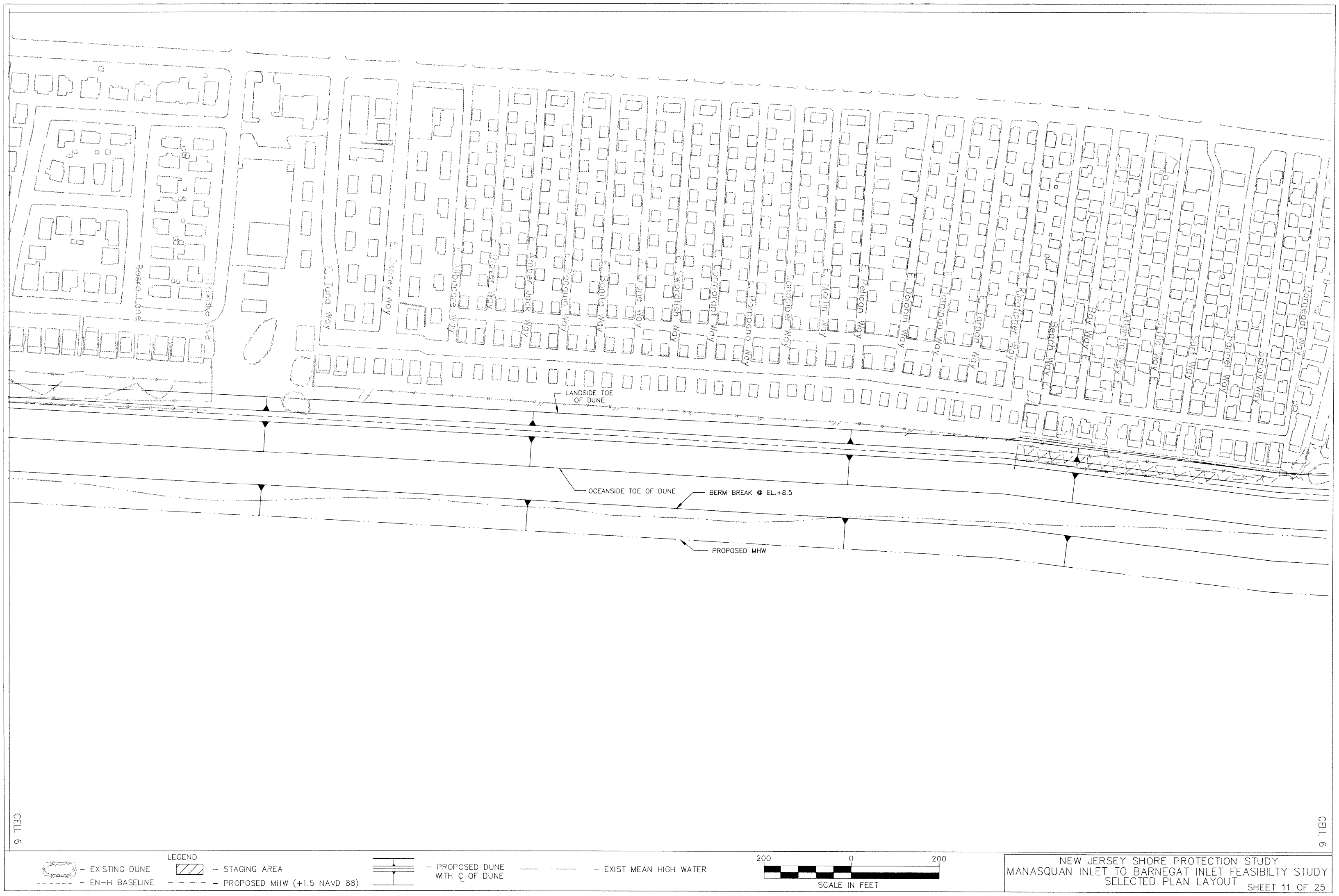

Figure 5-13 Selected Plan Layout – Dover Township, Ocean Beach to Chadwick Beach

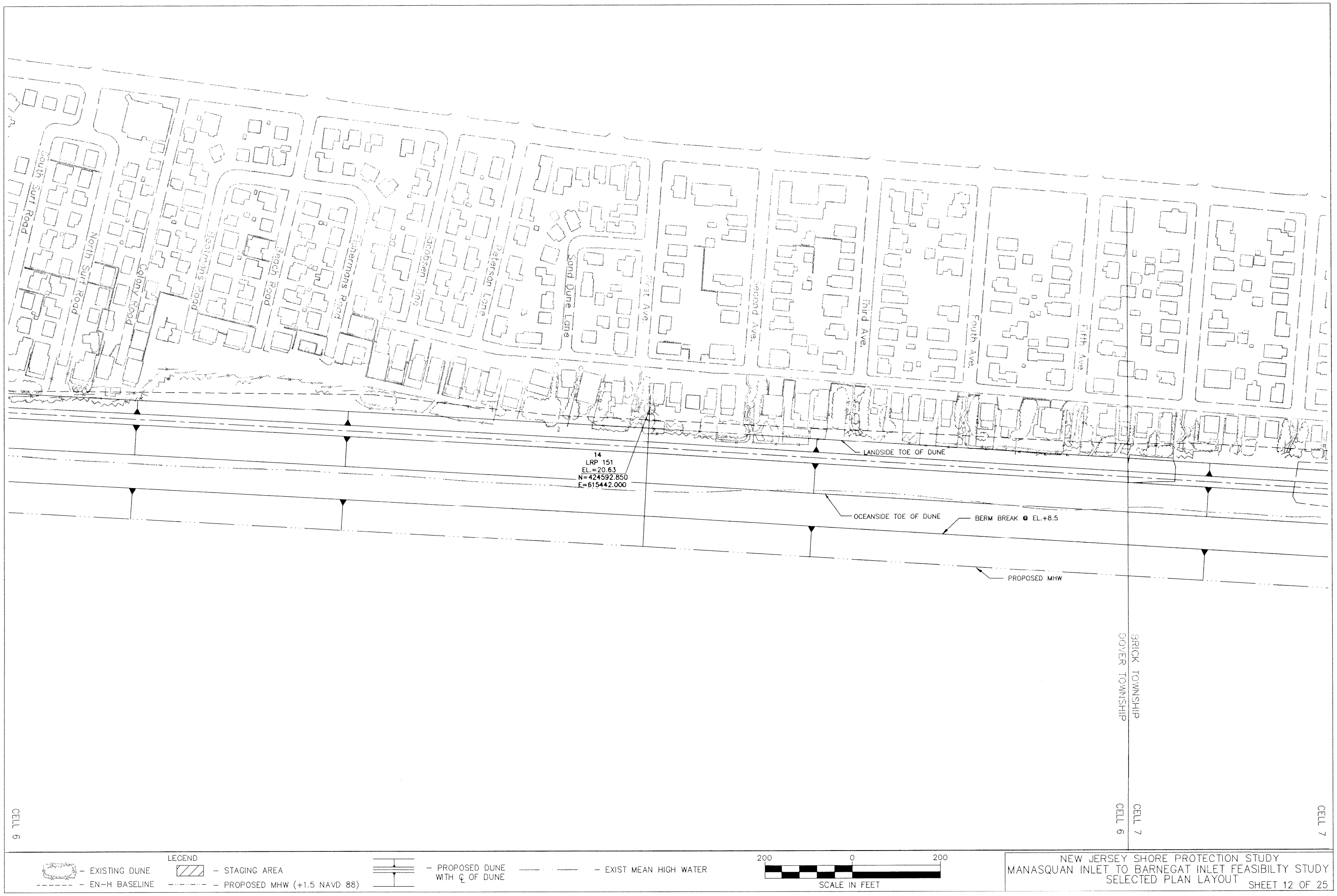

Figure 5-14 Selected Plan Layout – Dover Township, Silver Beach to Brick Township, Normandy Beach

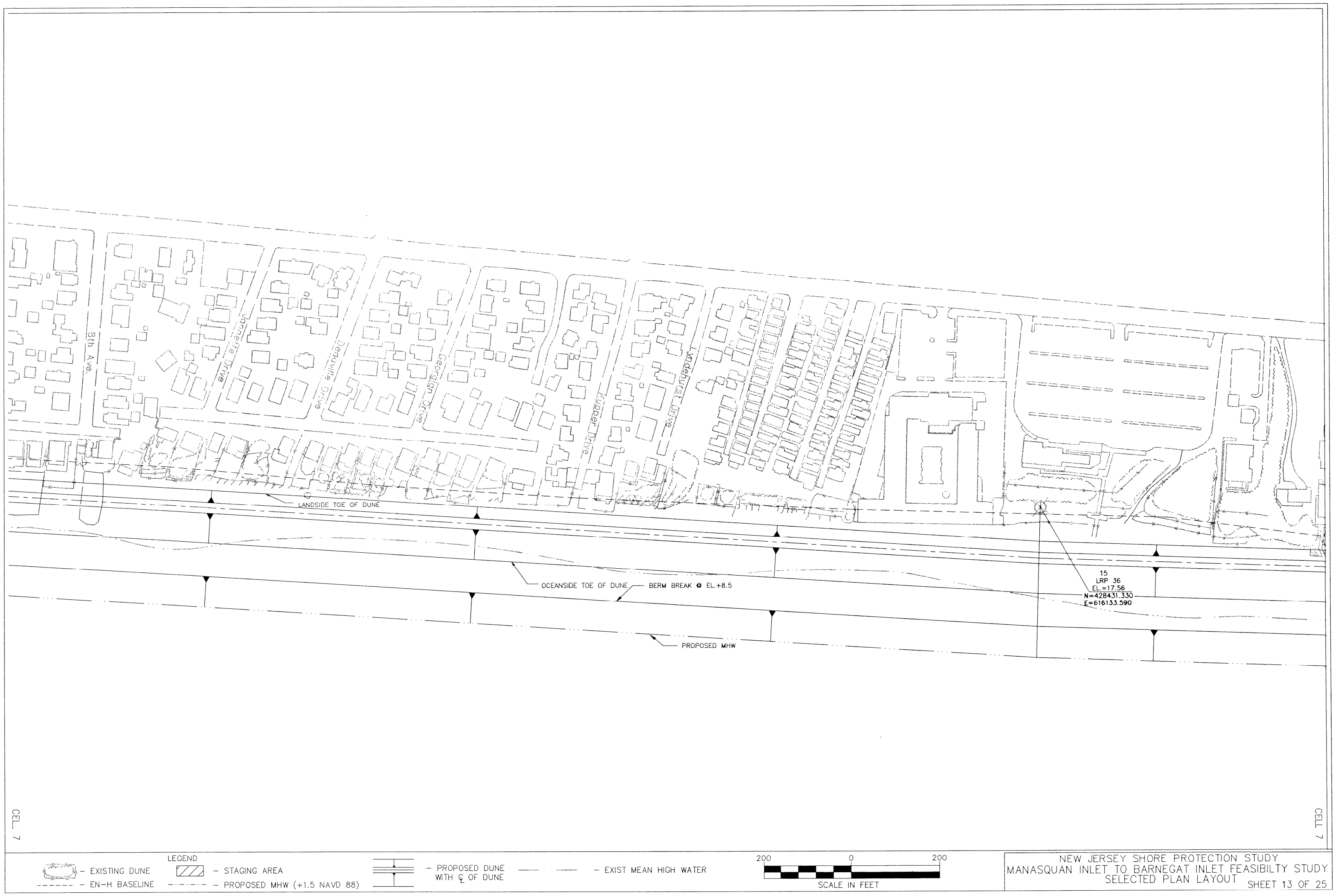

Figure 5-15 Selected Plan Layout – Brick Township, Normandy Beach to Mantoloking Estates

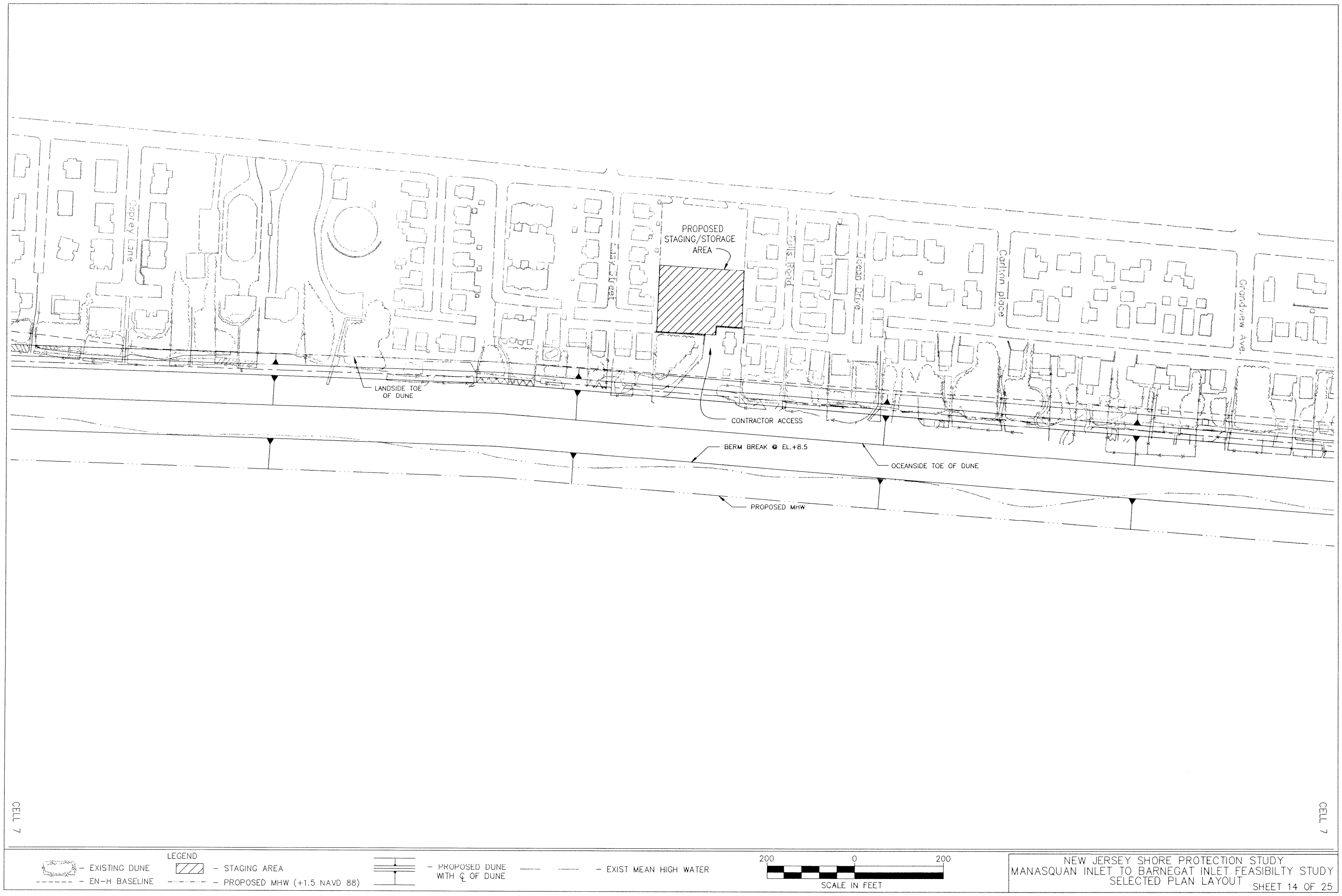

Figure 5-16 Selected Plan Layout – Brick Township, Mantoloking Estates to South Mantoloking Beach

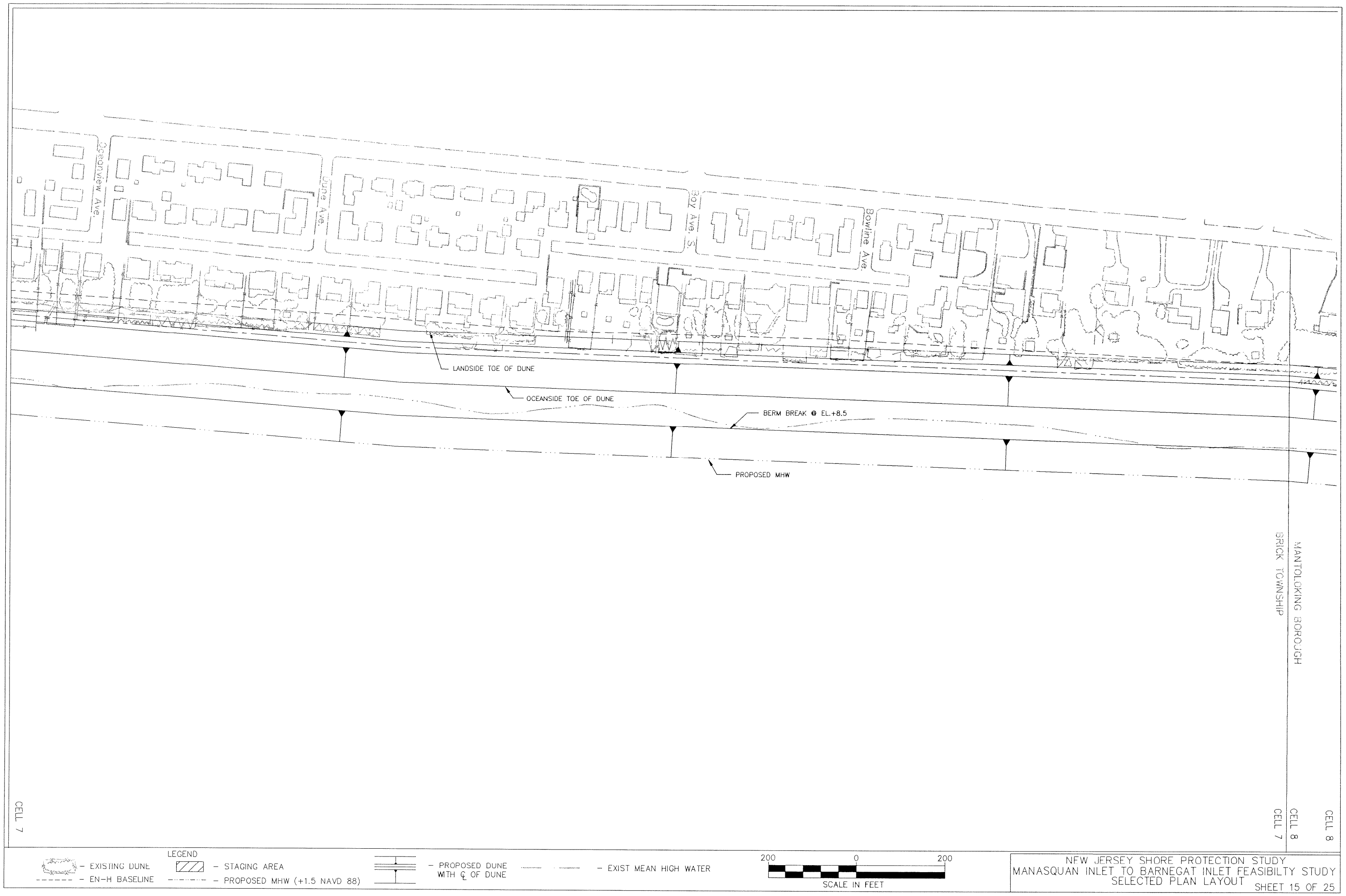

Figure 5-17 Selected Plan Layout – Brick Township, South Mantoloking Beach to Mantoloking Borough

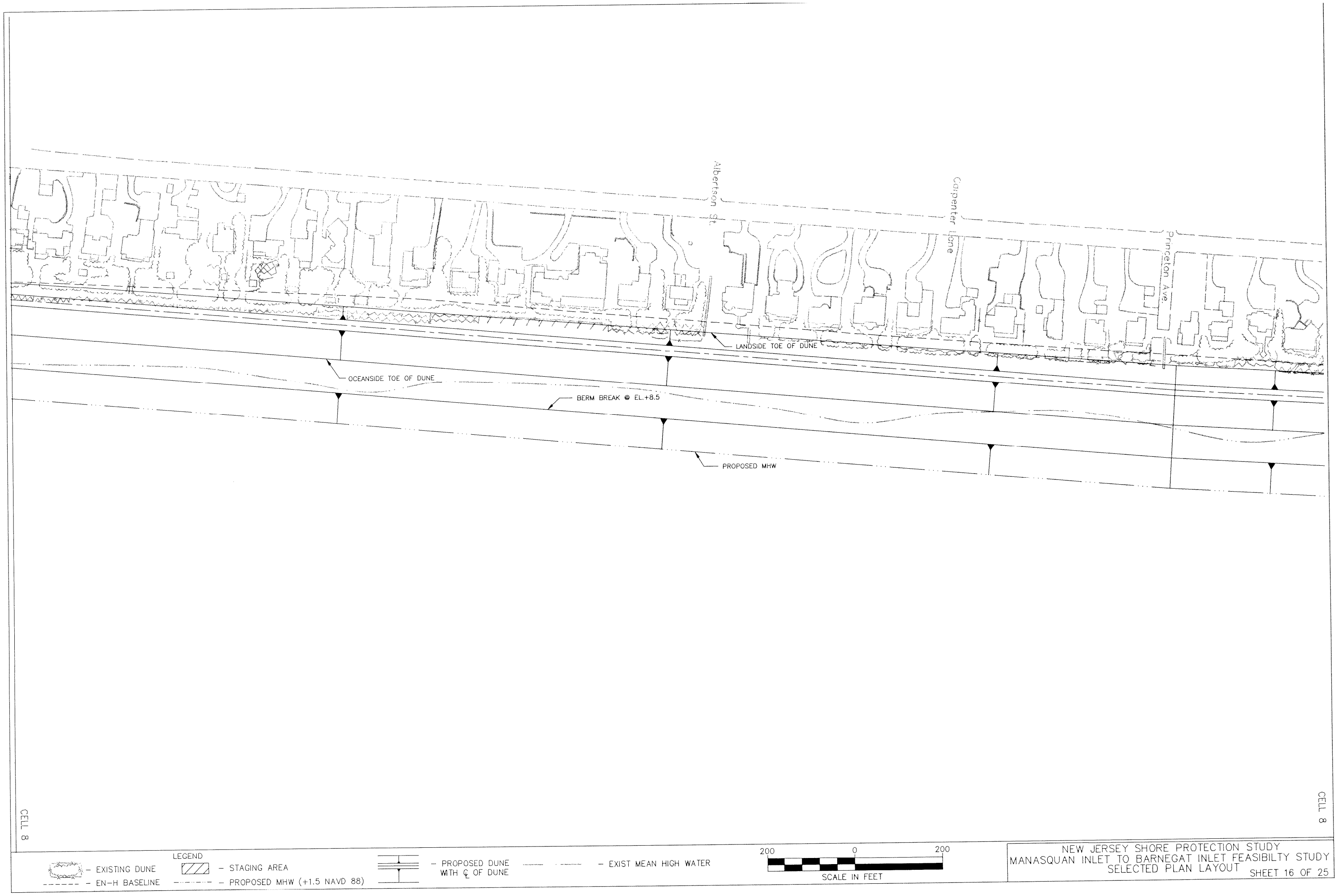

Figure 5-18 Selected Plan Layout – Mantoloking Borough, South of Princeton Avenue

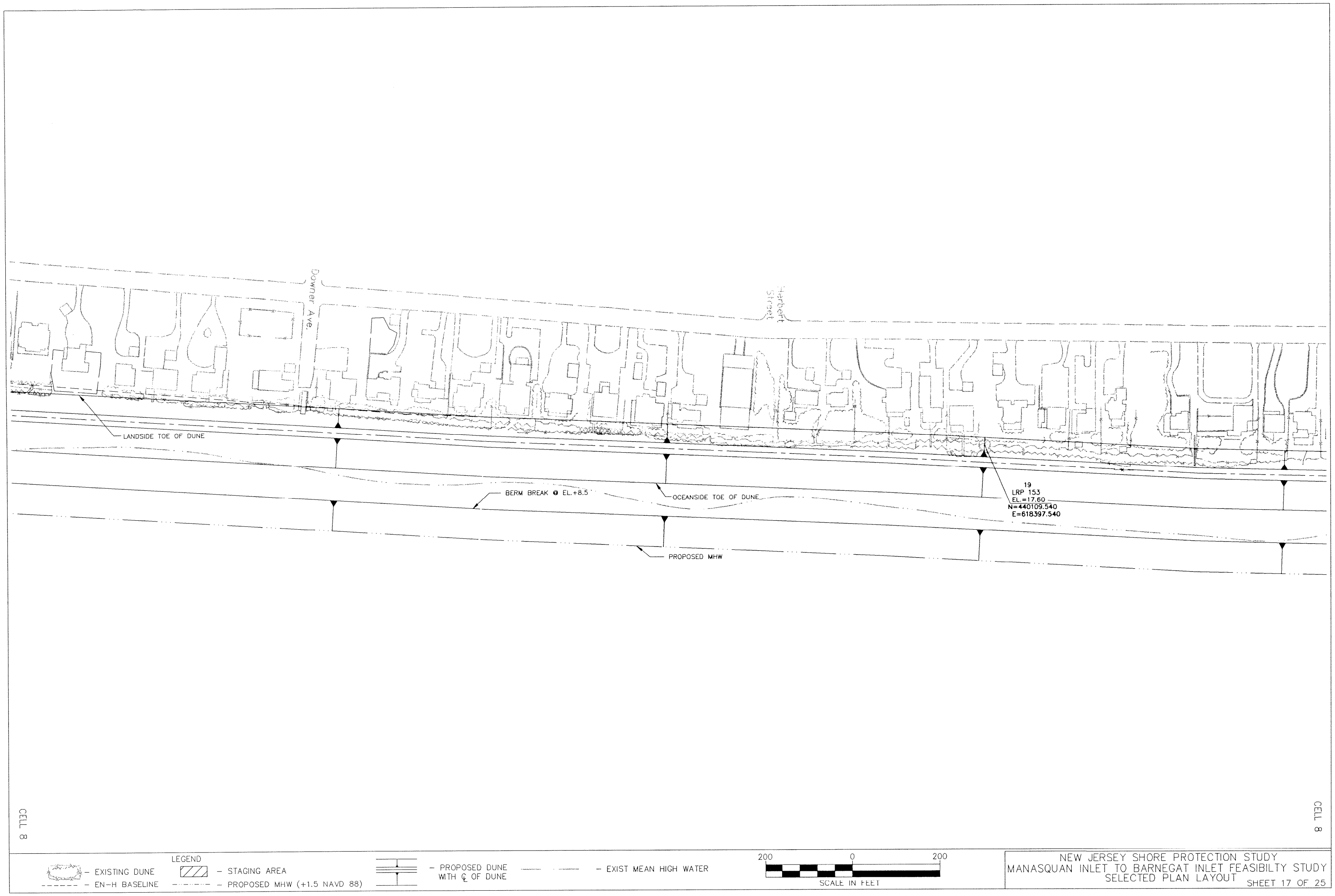

Figure 5-19 Selected Plan Layout – Mantoloking Borough, South of Downer Avenue to North of Herbert Street

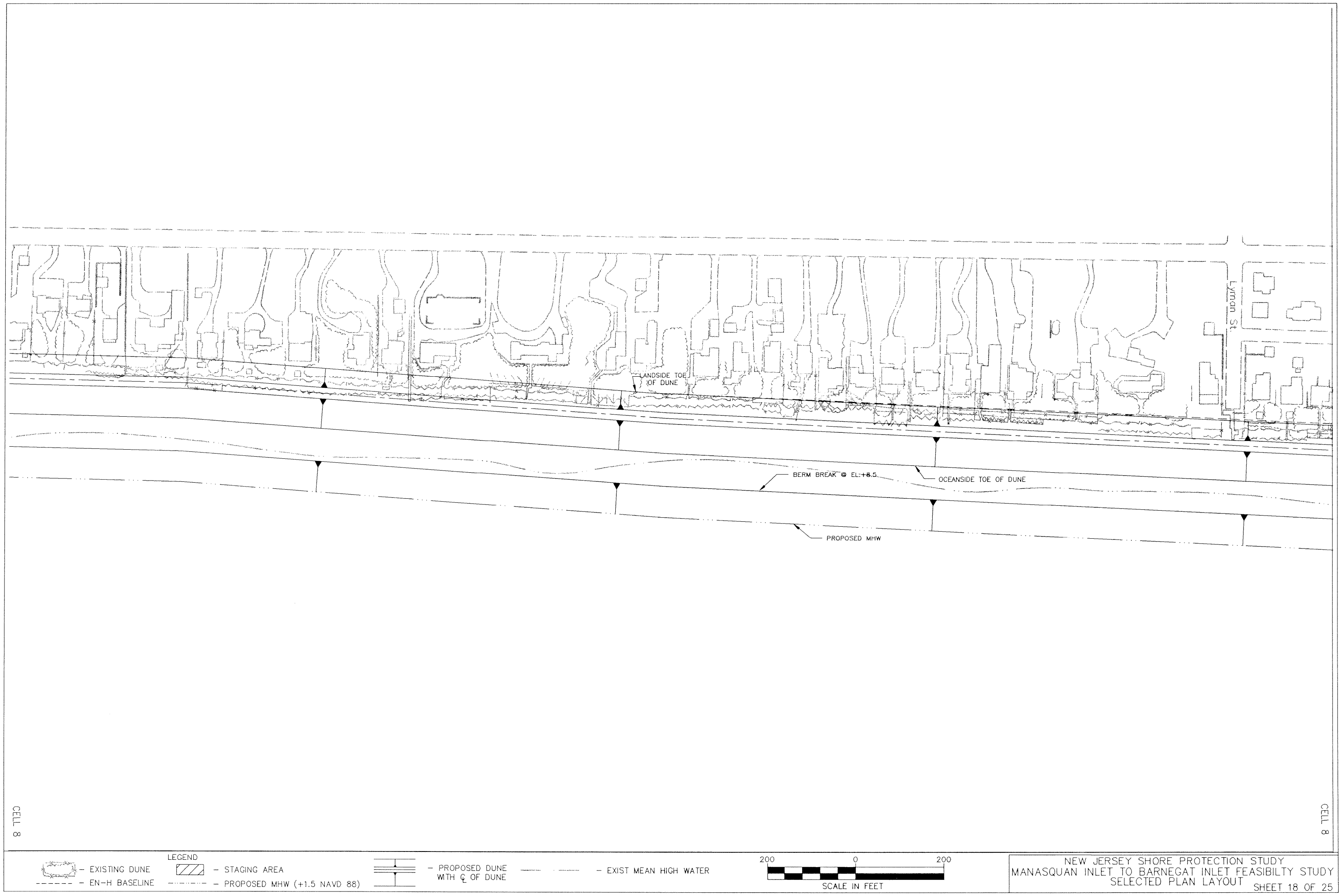

Figure 5-20 Selected Plan Layout – Mantoloking Borough, South of Lyman Street

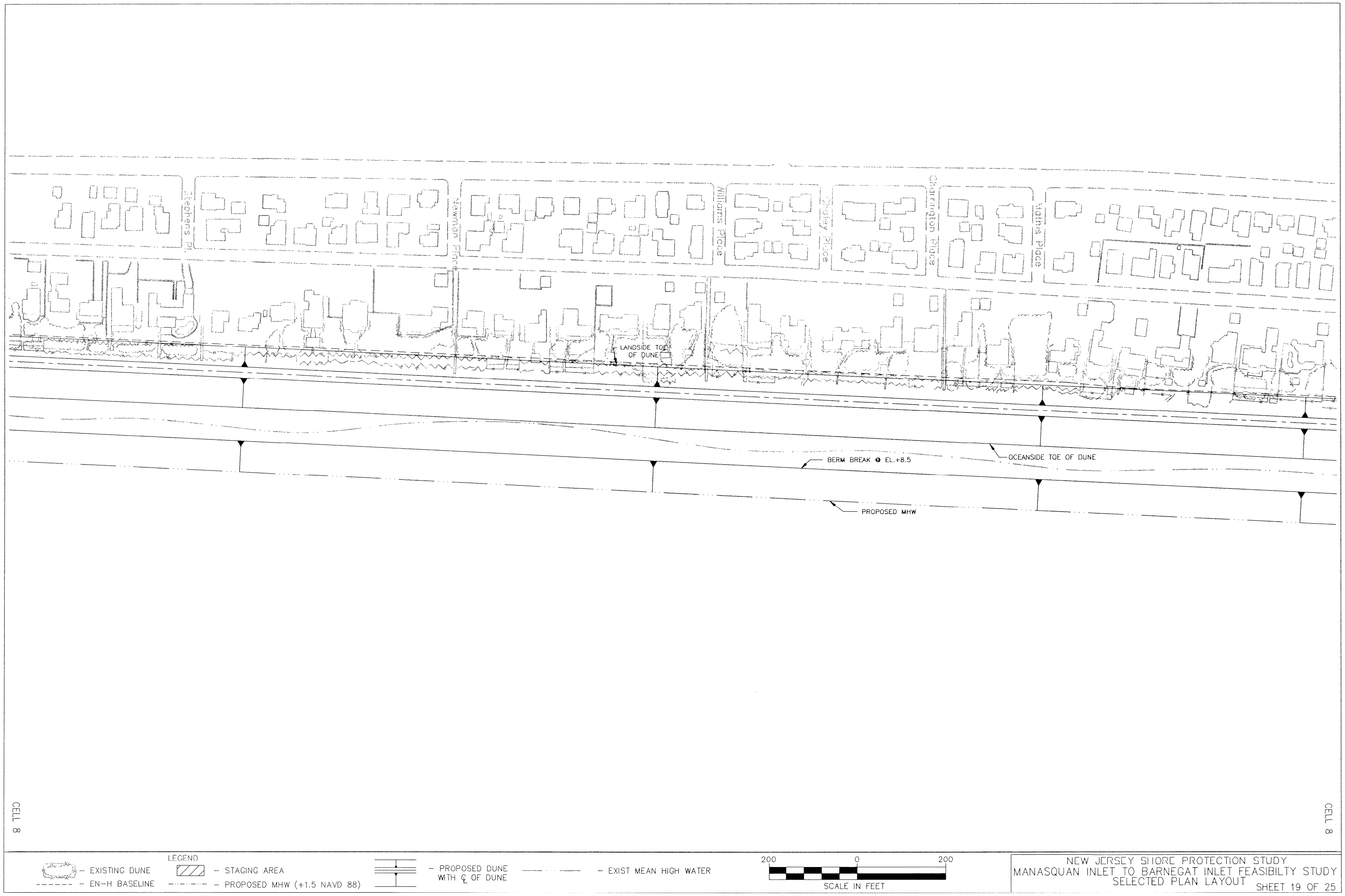

Figure 5-21 Selected Plan Layout – Mantoloking Borough, South of Stephens Place to North of Mathis Place

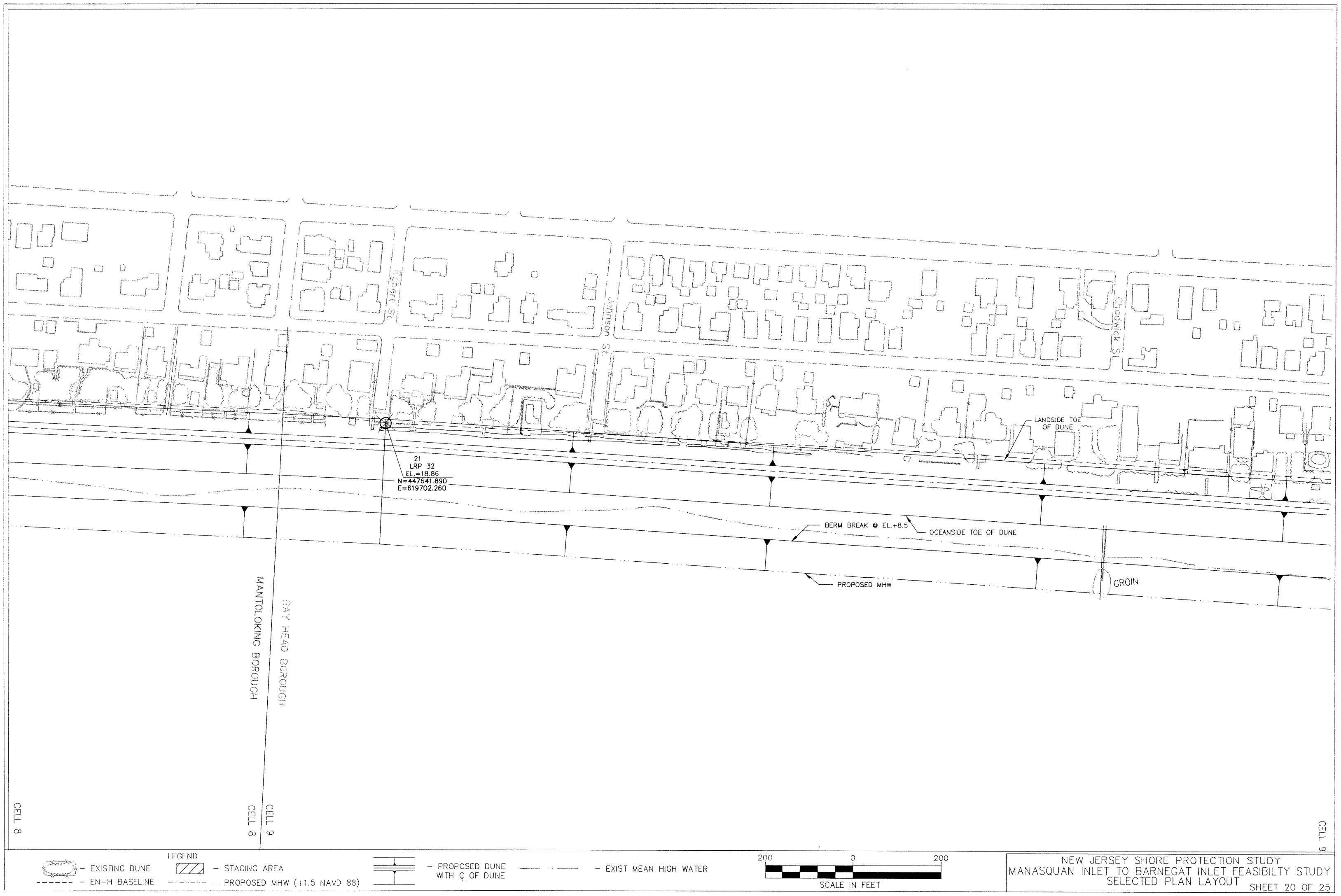

Figure 5-22 Selected Plan Layout – Mantoloking Borough to Bay Head Borough

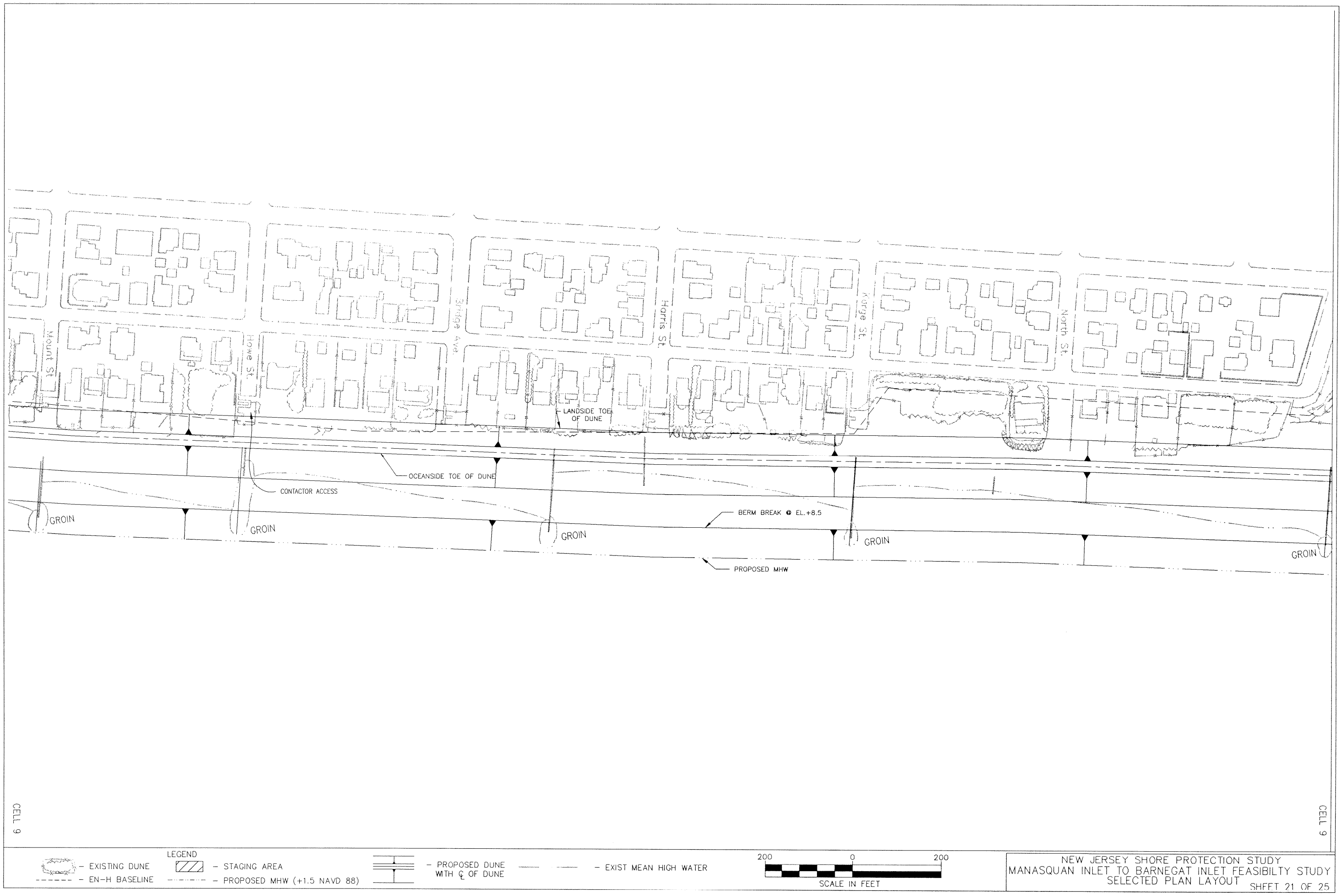

Figure 5-23 Selected Plan Layout – Bay Head Borough, Mount Street to North Street

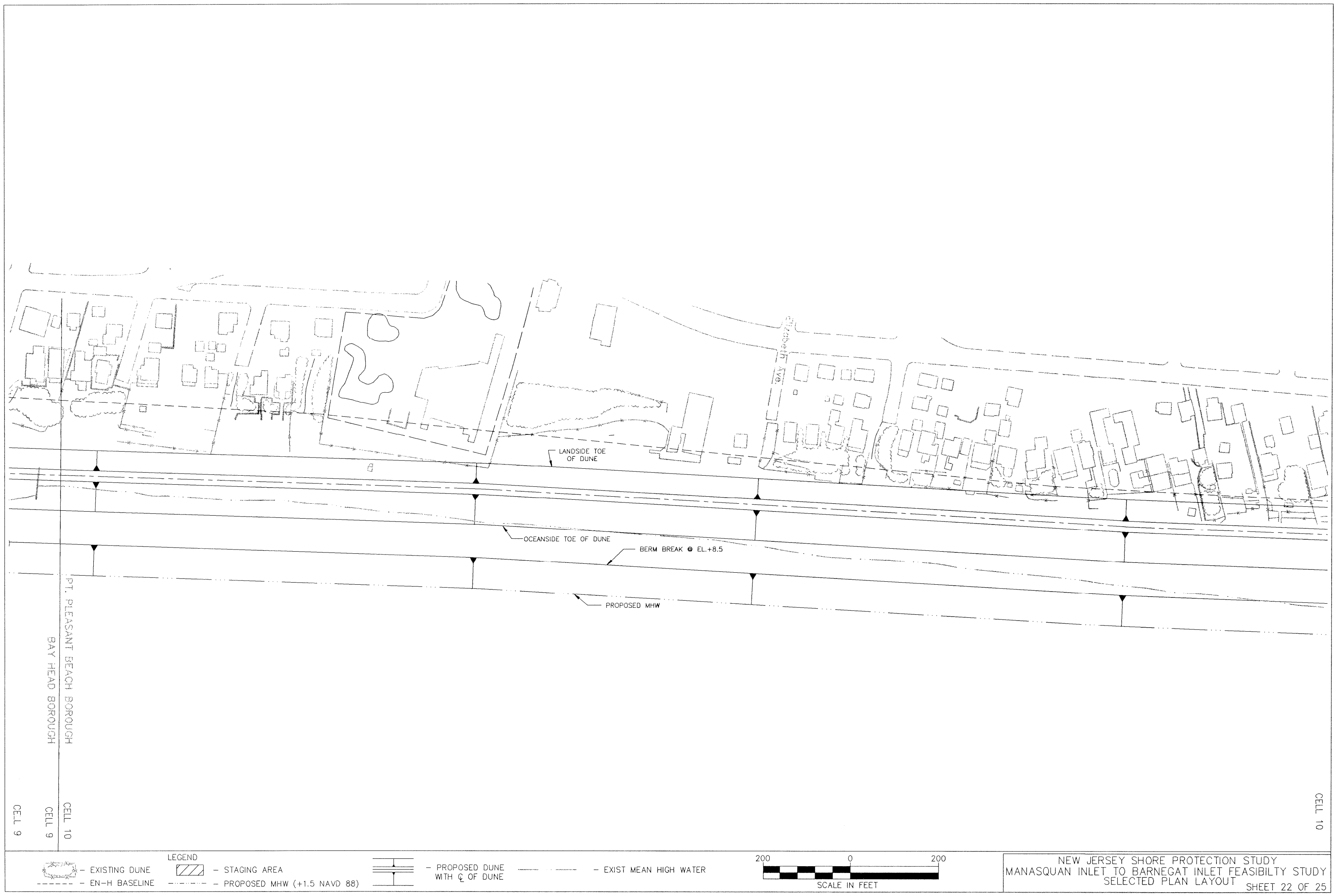

Figure 5-24 Selected Plan Layout – Point Pleasant Beach Borough

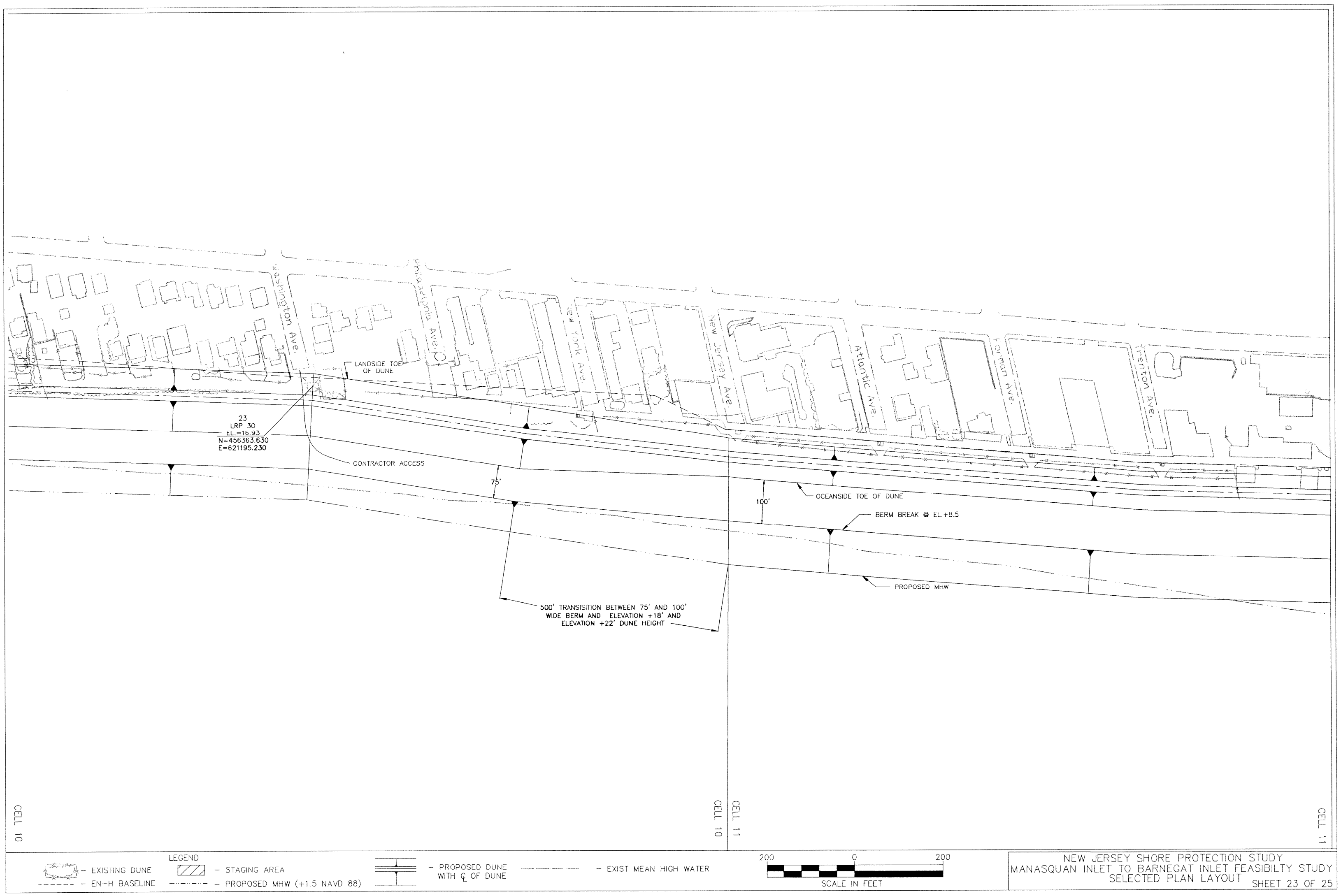

Figure 5-25 Selected Plan Layout – Point Pleasant Beach Borough, South of Washington Avenue to Trenton Avenue

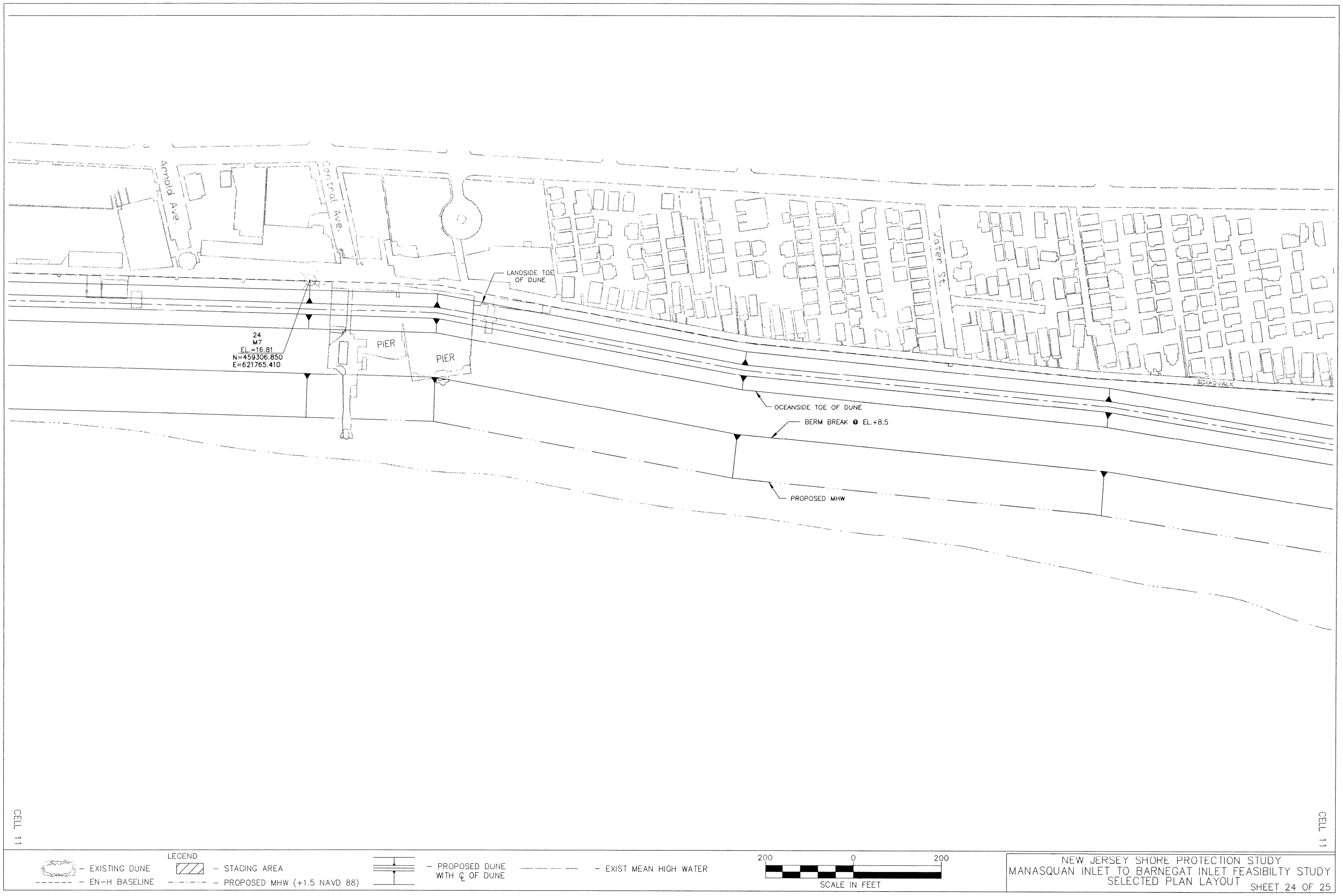

Figure 5-26 Selected Plan Layout – Point Pleasant Beach Borough, Arnold Avenue to North of Water Street

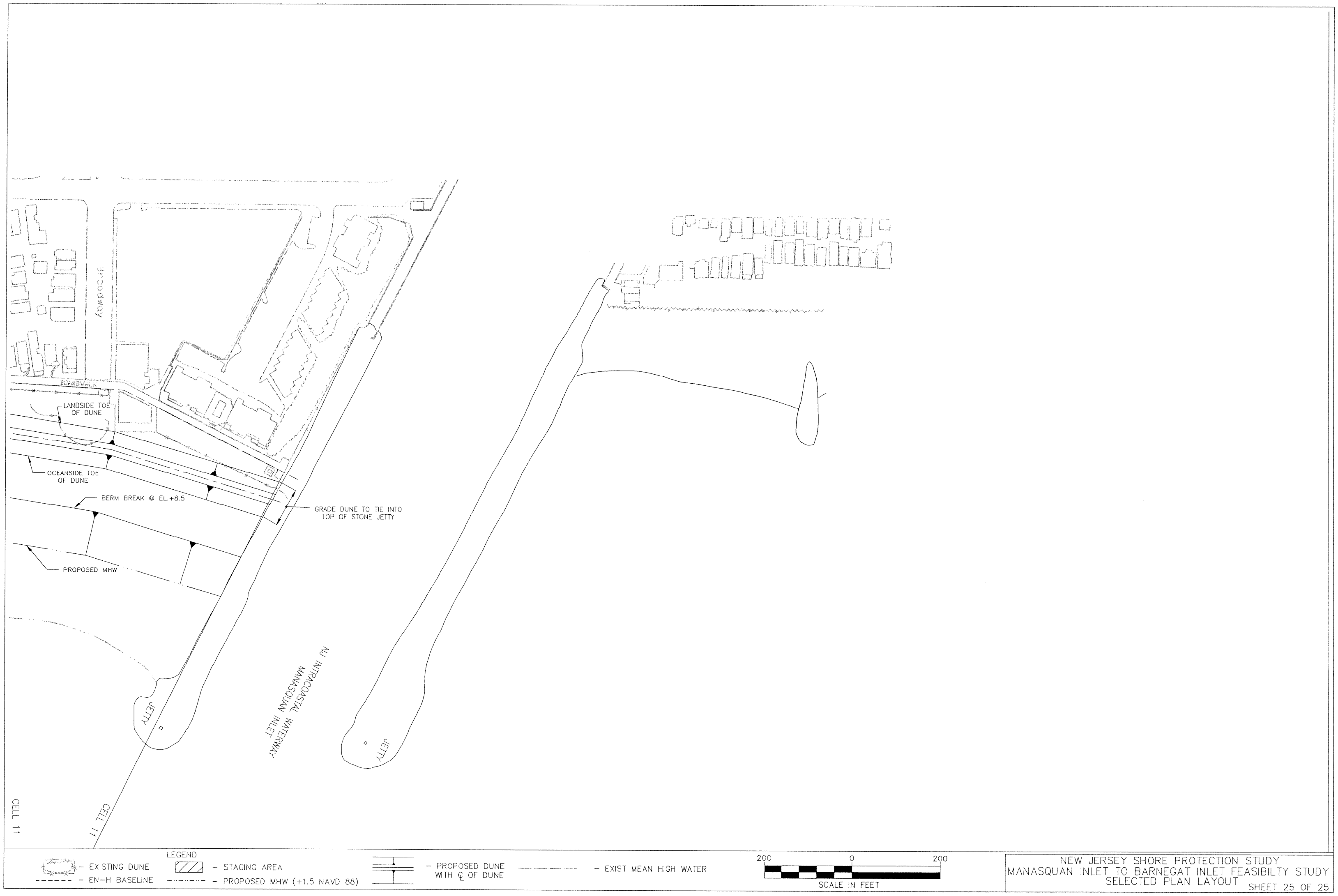

Figure 5-27 Selected Plan Layout – Point Pleasant Beach Borough at Manasquan Inlet

5.2 Project Impacts

5.2.1 Comparative Effects of Alternatives

All of the alternatives considered result in some form of a beneficial or adverse socio-economic or environmental impact. The no action alternative will allow for the continuation of existing conditions as well as the existing processes, which currently modify those conditions. The following discussion will focus on the impacts of the berm and dune restoration with periodic beach nourishment alternative; however, the impacts associated with the no action alternative will be discussed when appropriate. A brief summary comparing the effects of all of the alternatives that were considered during plan formulation is presented in Section 4 of this report.

5.2.2 Soils

Existing soils within the affected area are composed of unconsolidated sands deposited on the beach from wave action and previous beach fill activities. Although the proposed fill material has a finer sand grain size than existing sands on the beach, composition and soil properties are similar and no expected adverse impacts to soils are anticipated.

5.2.3 Topography and Bathymetry

5.2.3.1 Affected Beaches and Nearshore Area

Based on the typical cross section of the design and construction templates, including advanced nourishment, for the entire project area except Seaside Heights and northern Point Pleasant Beach (see Figure 5-1), significant topographical changes will occur after initial placement. Width of the beach and foreshore slope will vary between nourishment cycles as the sacrificial portion of the beach is redistributed by waves and littoral drift. After initial construction, the upland portion of the beach (above Mean High Water (MHW)) will be extended seaward approximately 165 feet. A range of 0 – 7 feet of vertical fill may initially cover the existing beach above MHW to produce a berm (flat portion of beach extending from the seaward edge of the dune to the foreshore slope) at a design elevation of +8.5 feet North American Vertical Datum (NAVD). The berm will initially extend seaward from the seaward base of the dune distance of approximately 180 feet. This includes the sacrificial advanced nourishment. The base design template (w/o advanced nourishment) will have a berm that extends 75 feet from the seaward base of the dune. The base design template will have a beach that extends 150 feet from the seaward base of the dune to the MHW line. This zone will constitute the "towel" portion of the beach. For the dune construction, vertical fill, with dimensions that vary with existing dune elevation, will be placed over the existing beach to reach a standard project dune crest height of +22 feet NAVD. The base of the proposed dune will be approximately 130 feet wide with a 25-foot wide dune crest. The dune side slopes will be 1V:5H. The foreshore zone (portion of the beach that slopes to the water) will be sloped 1V:10H, which is similar to current conditions.

Significant bathymetric changes are expected in the intertidal and subtidal portions of the beach and nearshore. Approximately 5 feet of vertical sand fill would initially be placed within the intertidal zone, which would displace the intertidal zone seaward approximately 150 feet from the current intertidal zone. Below the MLW line, vertical fill thickness of the design template will diminish offshore to the depth of closure. These changes would result in offshore beach fill slopes that are similar to existing slopes except displaced seaward. Offshore thickness and widths of the design fill would develop gradually after initial construction and between periodic nourishment cycles as the sandy material becomes sorted and redeposited by wave action.

The selected plan for Seaside Heights and northern Point Pleasant Beach includes dimensions that are slightly different from the plan for the rest of the study area due to a difference in dune height and berm width. However, significant topographical changes will similarly occur after initial placement. Based on a typical cross-section (see Figure 5-2), the upland portion of the beach (above Mean High Water (MHW)) will be extended seaward approximately 220 feet. A range of 0 – 7 feet of vertical fill above MHW may initially cover the existing beach to produce at berm at the design elevation of +8.5 ft NAVD (Seaside Heights) and elevation +11.5 ft NAVD (Point Pleasant Beach). The berm will initially extend seaward from the seaward base of the dune a distance of 225 feet. This includes the sacrificial advanced nourishment. The base design template (w/o advanced nourishment) will have a berm that extends 100 feet from the seaward base of the dune. The base design template will have a beach that extends approximately 170 feet from the seaward base of the dune to the MHW line. This zone will constitute the "towel" portion of the beach. For the dune construction, approximately 10 feet of vertical fill may be placed over the existing beach to reach the design project dune crest height of +18 feet NAVD. The dune base will vary depending on the existing dune base width and height, but will generally be 120 feet with a 25-foot wide dune crest. The dune side slopes will be 1V:5H. The foreshore zone (portion of the beach that slopes to the water) will be sloped 1V:10H, which is similar to current conditions.

Significant bathymetric changes are also expected in the intertidal and subtidal portions of the beach and nearshore along Seaside Heights and northern Point Pleasant Beach. Approximately 5 feet of vertical sand fill would initially be placed within the intertidal zone, which would displace the intertidal zone seaward approximately 225 feet from the current intertidal zone. Below the MLW line, vertical fill thickness of the design template will diminish offshore to the depth of closure. These changes would result in offshore beach fill slopes that are similar to existing slopes except displaced seaward. Offshore thickness and widths of the design fill would develop gradually after initial construction and between periodic nourishment cycles as the sandy material becomes sorted and redeposited by wave action.

5.2.3.2 Offshore Areas

The beach nourishment alternative would result in bathymetric changes in the proposed borrow areas. The current elevations of Borrow Area A and Borrow Area B are approximately -72 NAVD (-69 feet MLW) and -68 NAVD (-65 feet MLW), respectively. Dredging would increase the depth by a total of approximately 9 feet in Borrow Area A and 13 feet in Borrow Area B over the life of the project. The resulting cross-sectional configuration would be designed to approximate natural ridge slopes, and therefore promote free exchange of water with the overlying and adjacent waters and avoid the creation of deep pits. The excavation would also be designed to ensure that all of the bottom substrate would not be removed, and therefore the bottom would retain its existing substrate character. In addition, due to the dynamic offshore location of the borrow areas, it is anticipated that the sand source will be replenished to some extent throughout the life of the project. The intent of excavating a broad basin with depth, contours, and substrate consistent with the adjacent areas was to simulate the character of these nearby environments.

No prominent offshore shoals with depths of 30 feet or less will be impacted within these sites. Use of a hopper dredge may result initially in a number of distinct furrow features. These furrows are expected to become less prominent over time as ocean currents rework the remaining bottom sediments.

Based on the quantities of existing material available (11.2 million cy in Borrow Area A and 6.3 million cy in Borrow Area B) and assuming no future infilling, it is estimated that the 820 acres which make up the two borrow areas (Borrow Area A - 460 acres; Borrow Area B – 360 acres) will provide enough sand for the initial construction plus approximately 6 nourishment cycles (through year 24). It is anticipated that 6.3 million cy of material will be removed from Borrow Area A for initial construction and 620,000 cy of material will be removed for each nourishment cycle. Borrow Area B will provide 4.4 million cy of material for initial construction and an additional 340,000 cy for each nourishment cycle.

5.2.4 Air Quality

Internal combustion engines in heavy equipment such as hydraulic and hopper dredges, pumps, bulldozers, trucks, small construction vehicles, and workboats will produce pollutants emitted during dredging and sand placement activities. Air pollutants emitted, which include nitrogen oxides (NO_x) and smaller amounts of sulfur dioxide (SO_2), volatile organic carbons (VOC), carbon monoxide (CO) and particulate matter (PM) would be limited to discharges during construction hours, which in some cases may be continuous until project completion. Threshold levels are established in areas of non-attainment, which is required to conform to the State Implementation Plan for the purpose of eliminating or reducing the severity and number of violations of the National Ambient Air Quality Standards (NAAQS). No threshold levels are established for Ocean County because it is within attainment of the NAAQS for NO_x, therefore, further conformity analysis is not required. However, a project of this size may exceed the threshold for Prevention of Significant Deterioration (PSD) for attainment areas. This is based on an estimate of maximum dredging volumes (in cubic yards/year) that would meet a PSD threshold of 100 tons/year of NO_x emitted. Estimated maximum dredging volumes to meet the PSD for NO_x are approximately 830,000 cubic yards per year for a hopper dredge or approximately 1.17 million cubic yards per year for a hydraulic dredge (Louis Berger Group, 1999). Therefore, the volumes required for initial construction exceeds the projected maximum dredging volumes to meet the PSD of 100 tons/year. Projects similar to this have not historically required air quality permits from the NJDEP. This document will be submitted to the NJDEP for air quality review. Based on NJDEP and EPA review, a determination will be made as to the status of Clean Air Act conformity. A statement of conformity with the State Implementation

Plan is provided in Section 9 of this document, however, it will not be final until State and Federal review is completed.

5.2.5 Water Quality

5.2.5.1 Affected Beaches and Nearshore Area

The discharges associated with offshore dredging for the berm and dune restoration alternative would result in short-term minor adverse impacts to water quality in the immediate vicinity of the beach fill placement. The direct impacts on water quality result from the associated dredging and discharge of a sand slurry material mixed with water as it is pumped on the beach and nearshore area. The amount of turbidity and its associated plume is mainly dependent on the grain size of the material. Generally, the area of impact decreases with increase in grain size. The period of turbidity is also less with larger grain-sized material. Most of the sediments are greater than 90% sands and gravels; therefore, suspended particles should settle-out quickly after discharge. However, as the beach fill undergoes dewatering, turbidity in the nearshore within the immediate vicinity is expected to be elevated. A temporary plume of higher turbid water would be noticeable during the duration of pump-out; however, this effect will not be significant, as turbidity levels are naturally high in the high-energy surf zone. Wave action and currents would sort the sands and other particles within the beach fill. Hurme and Pullen (1988) found that fine sediments winnowed from the deposited material are transported by waves and currents into the nearshore with varying impacts on benthos from a few months to at least seven years. 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. Material utilized for the berm and dune restoration alternative is more closely matched to the beach material, therefore, the amount of fine-grained particles being suspended and redeposited in the nearshore is expected to be minor. Dredging and deposition of dredged material is associated with changes in dissolved oxygen and oxygen demand (biological or chemical) based on a potential for release of nutrients and other constituents. However, this effect is expected to be minor due to the overall lower levels of organic and fine-grained particles present in the beach fill material coupled with the deposition in a turbulent, well-oxygenated surf zone and nearshore environment.

There are several areas within the study area that have shellfish restrictions based on the potential for contamination from sanitary sewer lines and stormwater outfalls. None of the proposed borrow sites occur within the restricted areas. However, increases in bacteria levels may be observed during beach fill operations, as bacteria are fairly ubiquitous in the ocean environment. Since there are no known sources of chemical contaminants within the affected areas such as dumpsites or industrial outfalls, it is expected that the material to be placed on the beaches and nearshore area will consist of clean sand. This is confirmed through vibracore analysis that has determined that the offshore borrow area contains sand that closely matches the existing beach sand. The dredged material-testing manual for ocean dumping assumes that dredged material composed of beach fill quality sand that is not suspected to have any source of contamination nearby will not exceed the limiting permissible concentration (LPC). The LPC is defined as the concentration (after allowance for initial mixing) that does not exceed applicable marine water-quality criteria or a toxicity threshold of 0.01 of the acutely toxic concentration. The LPC of the suspended particulate and solid phases is the concentration that will not cause unreasonable toxicity or bioaccumulation (U.S. Environmental Protection Agency and U.S. Army Corps of Engineers, 1991).

Indirect impacts of beach fill placement on water quality in the surf and nearshore zones are expected to be short-term and minor. However, short-term increased turbidity can affect organisms in several ways. Primary production in phytoplankton and/or benthic algae may become temporarily inhibited from turbidity. Suspended particulate matter can clog gills and inhibit filter-feeding species, and inhibit sight-dependent 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. Since turbidity is expected to be minor and localized, based on the coarse nature of the beach fill material, these indirect effects on organisms are expected to be minor and temporary.

5.2.5.2 Offshore Area

Dredging in the proposed borrow areas will also generate turbidity resulting in minor sedimentation impacts within the immediate vicinity of the dredging. Turbidity generation would be limited to the point of dredging and immediate vicinity. Turbidity could also be generated offshore if a barge or a hopper dredge is allowed to overflow. Since the material is beach fill quality sand with little amounts of fines present, these impacts are also expected to be minor. Utilization of a dredge with a pipeline delivery system would help minimize the impact offshore.

Dredging deep pits in a sand borrow site can have indirect adverse effects on water quality by significantly altering circulation patterns in the borrow area. Deep pits can minimize circulation where fine-grained particles could settle out and become deposited on the bottom. The lack of circulation and increased oxygen demand can result in decreased dissolved oxygen (DO) levels or increased hydrogen sulfide levels (Murawski, 1969; Saloman, 1974; National Research Council, 1995). Imposing restrictions on dredging depths can minimize this impact. Shallow pits would be created, but they would be no greater than 13 feet deeper than surrounding existing depths. It is expected that based on the coarse nature of the material and the high energy in the oceanic environment, the walls of the dredging cuts would slump, thereby allowing a transition between the surrounding bathymetry and the shallow pit. In an already well-mixed oceanic environment, this would allow for greater circulation within the impacted area. Monitoring of DO would be performed before, during and after the initial dredging operations to determine if dredging depths should be adjusted to avoid creating anoxic zones in the post-dredging environment of the borrow area.

5.2.6 Terrestrial Ecology

Construction of the berm and dune restoration alternative would result in the initial placement of approximately 10.7 million cubic yards of sand on the beach, with subsequent periodic nourishments of approximately 960,000 cubic yards every 4 years over the 50-year period of Federal participation. This construction will greatly disturb the impacted beach and dune area during construction and periodic nourishment phases, however, impacts to terrestrial species are expected to be minor and temporary. Since there is little vegetation on the beach area, the direct impacts on vegetation will mainly be limited to the existing constructed dune areas that require the dunes to be built-up to specified elevations. Existing vegetation would initially be disturbed, however, the newly constructed dune will be replanted with similar beach-dwelling species such as American beachgrass and seaside panicum. Approximately 175 acres of dune habitat will be planted with new vegetation. Periodic disturbance to vegetation on the constructed dune may be necessary if damages or erosion from future storms require maintenance or reconstruction of the dune.

It is expected that construction of a higher, wider, and more protective dune would provide conditions suitable for the recolonization of voluntary primary and secondary dune type vegetation. This may especially be true for the lee-side of the constructed dune, which would provide a more protected environment suitable for some of the secondary dune plant species previously mentioned. Recolonization and establishment of a stable dune community would be contingent on the amount of storm damage and reconstruction of the dune required over the project life.

The existing animal species inhabiting the beach are generally capable of surviving adverse conditions, and most are capable of migrating out of the impacted area. Therefore, impacts are not expected to be significant. It would be reasonable to expect recolonization from adjacent areas shortly after the end of construction, and a rapid return to pre-construction conditions. Considering the current condition of the existing beach, the proposed project would actually create additional habitat.

5.2.7 Wetlands

There are no vegetated wetlands within the affected areas along the shoreline, therefore, no direct impacts on vegetated wetlands are anticipated. Based on the construction template of the selected plan, however, a total of approximately 214 acres of intertidal and subtidal shallow water marine habitat would be impacted (below MHW) from Manasquan Inlet to Island Beach State Park. This habitat will not be lost, however, since this habitat will simply be recreated seaward of the existing intertidal zone.

5.2.8 Benthos

5.2.8.1 Affected Beaches and Nearshore Area

The majority of the impacts of beach fill placement will be felt on organisms in the intertidal zone and nearshore zones where these organisms could become buried and smothered by several feet of sand. The nearshore 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 nearshore (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. In addition, Maurer et al. (1978) observed in a laboratory experiment that some benthic animals are able to migrate vertically through more than 12 inches of sediment. However, their survival depends not only on the sediment depth, but also on length of burial time, season, particle size distribution, and other habitat requirements of the animal.

Beach nourishment may also inhibit the return of adult intertidal organisms from their nearshore-offshore overwintering refuges, cause reductions in organism densities on adjacent unnourished beaches, and inhibit pelagic larval recruitment efforts. Parr et al. (1978) noted that the nearshore community is highly resilient to this type of disturbance, however, the offshore community is more susceptible to damage by receiving high sediment loads from fines sorting-out from a beach fill. 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). Reilly et al. (1978) concluded that nourishment initially destroys existing macrofauna, however, recovery is usually rapid after pumping operations cease. Recovery of the macrofaunal component may occur within one or two seasons if borrow material grain sizes are compatible with the natural beach sediments. However, the benthic community may be somewhat different from the original community. Hurme et. al. (1988) concluded, "Macrofauna recover quickly because of short life cycles, high reproductive potential, and planktonic recruitment from unaffected areas. However, the recolonization community may differ considerably from the original community. Recolonization depends on the availability of larvae, suitable conditions for settlement, and mortality. Once established, it may be difficult for the original community species to displace the new colonizers."

Benthic recovery on the beach/intertidal zone may become hampered by the four-year periodic nourishments. Based on the above-mentioned studies, the benthic community may take 1-2 years to recover. With a four-year renourishment cycle, the benthic community may be in a higher than normal state of flux due to periodic disturbances from nourishment. It is conceivable that the benthic community may attain a recovered state for a period of 1-2 years before being disturbed again by a nourishment cycle. It is noted however that although the selected plan includes periodic nourishment on a four-year cycle, actual nourishment activities will be based on current survey information and limited only to those areas where sand is needed, therefore minimizing nourishment activities and impacts. Based on this, there may be a greater amount of adult recruitment into the affected areas from adjacent unaffected areas during periodic nourishment than is expected with initial construction, which affects the entire area.

Studies on the effects of beach nourishment on intertidal and subtidal benthic macrofauna are limited in the Mid-Atlantic coast beaches. Scott and Bruce (1999) made comparisons between the sand-filled area of Ocean City (existing Federal shore protection project) and the remaining undisturbed (unnourished) areas throughout the study area. Scott and Bruce (1999) found that the mean number of taxa, total abundance, and total biomass were higher in the samples obtained in the intertidal zone of the sand-filled area, however, total biomass was significantly lower in the sand-filled area of the nearshore subtidal zone.

The impacts of sand placement on meiofaunal communities is less understood. However, there is evidence suggesting that meiofaunal communities are sensitive to sediment disturbance, but their ecological importance to higher organisms is uncertain (Hurme and Pullen, 1988).

Grain size compatibility analyses conducted on suitable sediments within the borrow site indicate that there will be relatively low levels of fine sediments placed on the beach. Parr et al. (1978) recommend that to minimize biological impacts, the percentage of fine sediments (smaller than 125 micrometers) should be low to minimize siltation and consequent deposition offshore, which could create anoxic conditions in the sediment. The berm restoration would be conducted in a manner that approximates the existing beach profile. The approximate area of intertidal and shallow nearshore habitat lost resulting from the beach fill would be likewise created seaward. Therefore, no significant loss of intertidal or shallow nearshore benthic habitat is expected.

Groins, which represent artificial rocky intertidal habitat, will be subject to sand burial from beach nourishment. There are 16 groins within the study area (9 in Cell 5, Lavallette, and 7 in Cell 9, Bay Head) that are composed of timber and stone. Most of the hard bottom substrate associated with these groins would be impacted below the mean high water line by initial sand placement activities. This type of habitat is rather unique to the area, which is predominantly composed of soft-bottom sandy beach and nearshore habitat. Specialized fauna (such as blue mussels, barnacles, starfish and uropods) that normally inhabit hard bottom intertidal and nearshore hard substrates will likely be impacted since the landward ends of some of the groins could be permanently covered with sand. Once covered, the landward ends of the groins would not be available for fishermen to use nor to provide habitat for invertebrates, finfish, and shorebirds. Non-mobile organisms and intertidal dwellers would be affected by burial from the placement of sand. However, it is difficult to measure the loss of this habitat due to variations in depths and rock exposure due to variable erosion and deposition cycles observed (either long-term or seasonally) within the project area. At the completion of initial construction and/or each nourishment cycle, this habitat may be reduced by more than 50% within the affected areas, however, subsequent erosion and loss of sand would allow for some recruitment between nourishment cycles. The fill placement over the affected groins would be expected to re-establish sandy bottomed intertidal habitat.

Additional hard bottom, nearshore substrate may also exist within the project area in the form of shipwrecks or other nearshore debris. Preliminary cultural resources investigations have identified the presence of 19 “high probability underwater remote sensing targets” within 1,000 feet of the existing MHW line (Dolan Research, 2001). Seven of these targets have been tentatively identified as potential shipwreck sites that are currently utilized by local divers. Based on this information, it appears that at least some of these targets have exposed surfaces that could be utilized as hard bottom substrate. Since the characteristics, including size, exact location, and amount of exposed surface area are not currently known, it is not possible to determine the extent of potential impacts to these targets. It is possible, however, that some of the targets (or portions of the targets) may become buried with sand over time as the construction template equilibrates to the design profile. This may result in a reduction of exposed hardened surface area within the nearshore zone. Further investigations will be conducted on these targets to determine their habitat characteristics and cultural significance in order to determine potential impacts. This additional information will be coordinated with NJDEP, NJSHPO, and other appropriate agencies.

5.2.8.2 Offshore Areas

The primary ecological impact of dredging the sand borrow sites will be the complete removal of the existing benthic community through entrainment into the dredge. It is estimated that a total of approximately 820 acres of benthic habitat will be impacted by dredging Borrow Areas A and B during the initial construction and approximately six nourishment cycles. If no future infilling occurs in these areas over the course of the project, additional potential borrow areas will need to be identified for use for the remaining nourishment cycles. These investigations will take place in the PED phase of the project and will most likely be concentrated outside of the State Territorial Waters (i.e., greater than 3 nautical mile offshore). A potential area for these future investigations has been delineated in Figure 2-7. Investigations during the PED phase will be conducted within this area to determine what portion will be an acceptable source of the additional material that may be required for this project. While source of New Jersey's sport and recreational fishing areas occur withinthis delineation, coordination will be done with NJDEP and other applicable agencies to determine the best location/alignment of any additional areas so as to avoid sensitive fisheries habitat. The smaller box depicted on Figure 2-7 simply represents the estimated quantity/area needed to supplement the sand requirements of the project.

Initially, 460 acres in Borrow Area A were surveyed for benthic and cultural resources. The proposed area for this borrow area was initially much larger in the early phases of the Feasibility Study but was reduced to 460 acres based on concerns raised by NJDEP, Division of Fish and Wildlife. Due to the length of the study area and the large distance between the two borrow areas, it was necessary to enlarge Borrow Area B from 130 acres to 360 acres in order to supply enough sand to the northern portions of the study area. Benthic and cultural investigations have been completed for both.

Based on the expanded acreage of Borrow Area B, it is estimated that approximately 6.3 million cy of sand is available for dredging, assuming that approximately 13 feet of sand is removed from the area over the course of the project. It is estimated that 4.4 million cy of material will be removed from Borrow Area B during initial construction and 340,000 cy of material will be removed for each nourishment cycle. Similarly, it is estimated that 11.2 million cy of material is available in Borrow Area A, assuming that approximately 9 feet of sand is removed from the area over the course of the project. Initial construction will require the removal of 6.3 million cy of material from Borrow Area A and each nourishment cycle will require an additional 620,000 cy. These quantities will result in a cumulative impact of 820 acres of offshore benthic habitat within the borrow areas.

Dredging will primarily involve the immediate loss of infaunal and some of the less mobile epifaunal organisms. These may include polychaetes (worms), mollusks (clams and snails), and crustaceans (amphipods and crabs). Some of the more noticeable and larger benthos that would be impacted include horseshoe crabs and whelks. Mortality of these organisms will occur as they pass through the dredge device and/or as a result of being transplanted into an unsuitable habitat. A secondary disturbance would be the generation of turbidity and deposition of sediments on the benthic community adjacent to the dredging. Despite the initial effects of dredging on the benthic community, recolonization is anticipated to occur within one year. Saloman et al. 1982 determined that short-term effects of dredging lasted about one year resulting in minor sedimentological changes, and a small decline in diversity and abundance within the benthic community. The recovery of a borrow area is dependent upon abiotic factors such as the depth of the borrow pits, and the rate of sedimentation in the borrow pits following the dredging. Dredging a borrow pit can result in changes that affect circulation patterns resulting in pits where fine sediments can become deposited, which may lead to hypoxia or anoxia in the pit. Accumulations of fine sediment may also shift a benthic community from predominantly a filter-feeding community to a deposit-feeding community. It is important that for recovery, the bottom sediments are composed of the same grain sizes as the pre-dredge bottom.

Cutler et al. (1982) investigated long-term effects of dredging on the benthic community and noted that faunal composition was different than the pre-dredge community; however, the difference was attributed more to normal seasonal and spatial variations. In this study, it was determined that there were no significant differences in the benthic communities and sediment parameters between borrow sites and surrounding areas. It can be expected that after sand is removed from the borrow sites, the affected areas would first be colonized by surface-dwelling opportunistic species. This may gradually change within a few years to a more-deeper burrowing community composed of larger-sized organisms.

Periodic disturbances from maintenance of the project may favor the development of benthic communities composed primarily of colonizers. Assuming that the same location is dredged every nourishment cycle, the secondary benthic community may be in a higher state of flux than the original community. This may, in effect, favor more r-selected (rapid reproduction, short life span) benthic species in the sand borrow impact area over the 50-year period of Federal participation. In addition, benthic organism abundances may be lower than normal. However, this may not be the case if subsequent dredging cycles are conducted at different locations within the borrow areas. This would allow disturbed areas from previous dredging disturbances to become recolonized.

Benthic investigations in and around the selected borrow sites reveal benthic communities with relatively high infaunal abundance and low species diversity (Versar, Inc., 2000). The majority of the dominant taxa in the borrow areas were small, common organisms that could easily recolonize after dredging operations. Additionally, the investigations did not find any rare or unique benthic assemblages within the vicinity of the sand borrow areas. In fact, the community composition of the borrow area were similar to the nearby reference areas, suggesting that recruitment after dredging activities should result in similar community patterns. However, shifts in benthic community composition can be expected if the physical habitat is significantly different than the pre-dredging habitat. Since the offshore borrow areas are in a less dynamic area (as opposed to a high-energy ebb shoal or inlet area), little replenishment of new sand into theses areas is expected after dredging ceases. Therefore, the recruitment of benthic species similar to the existing community requires the exposure of a similar substrate after dredging operations terminate. Vibracore data confirm that surficial sand deposits of variable thickness exist within the area. These deposits should be correlated with vibracore data to expose similar sand strata during dredging. These areas would be deepened by 9 - 13 feet, which would modify the bathymetry in the affected areas. Dredging this depth of material is expected to result in leaving similar substrate material to remain, and would not produce a deep pit. Once impacted, the affected portions of the offshore sites would be left alone for benthic recruitment. Recolonization of the benthic community may occur within 1-2 years following dredging, however, the effects of the four-year periodic project maintenance over the 50-year period of Federal participation may have more profound adverse effects if conducted at the same locations. Hurme et al. (1988) recommend that borrow materials be obtained from broad, shallow pits in nearshore waters with actively shifting bottoms, which would allow for a sufficient surficial layer of similar sediments for recolonization.

In order to minimize adverse effects on the benthic community within the borrow area, several mitigative measures would be considered. These measures include dredging shallow well-flushed pits, avoiding previously dredged areas to allow for recruitment and recolonization, dredging during times of the lowest biological activity and the utilization of a pipeline delivery system to help minimize turbidity.

5.2.9 Fisheries

5.2.9.1 Finfish

With the exception of some small finfish, such as sand lances and larval/early juvenile forms, most bottom and pelagic fishes 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 borrow site or surf zone of the project area (Grosslein and Azarovitz, 1982). However, dredging and beach fill placement in the spring and summer months may have greater adverse impacts on finfish spawning than during the fall and winter.

Another impact is the potential for removal of prominent sandy shoal habitat. Sandy shoals or “lumps” are believed to be attractive to resident and migratory finfish. It is not well understood the mechanisms that make these areas attractive. However, it is reasonable to expect that the increased habitat complexity at the shoals and adjacent bottom would be more attractive to fish than the flat featureless bottom that characterizes much of the mid-Atlantic coastal region (USFWS, 1999a). Several potential borrow areas were either eliminated or modified to avoid adversely impacting prominent shoal habitat. The placement of beach fill in the nearshore along the shoreline would offset shallow water habitat. Most finfish are capable of migrating outside of the impacted area until the construction ceases.

The primary impact to fisheries will be felt from the immediate loss of a food source by the disturbance of benthic and epibenthic communities. Demersal finfish feed heavily on bottom dwelling species. Thus, the loss of benthos and epibenthos 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 infaunal and epifaunal macroinvertebrates. Approximately 510 acres of offshore benthic forage habitat could be impacted with initial construction. However, this area would be left for benthic recruitment and recolonization, which could take several months to several years for recovery. After initial beach fill placement, periodic beach nourishments could disrupt approximately 45 acres of benthic forage habitat at a time. However, each portion of the borrow areas utilized for periodic nourishment would also be left to recolonization after use, and would most likely not be disturbed again.

5.2.9.2 Shellfish

The existing benthic communities at the two proposed sand borrow sites were sampled and analyzed by Versar, Inc. in August of 1999 and October 2001. These areas are designated Borrow Area A (offshore and south of Seaside Park) and Borrow Area B (offshore of Manasquan Inlet). These areas are depicted in Figure 2-7. The only species of commercial or recreational value that was collected during the macroinvertebrate survey was the Atlantic surf clam (*Spisula solidissima*).

According to Versar, Inc. (2000), juvenile and small adult surf clams were collected in approximately 70% of the stations sampled with the Young grab sampler within the two borrow areas. Mean abundance of juvenile surf clams collected was low, ranging from 119/m^2 at Borrow Area A to 221/m^2 at Borrow Area B. Mean abundance of juvenile clams at the two borrow areas were, in general, significantly lower than the clam abundances at the LBI regional areas. No juveniles or small surf clams were collected from the nearby reference area.

In addition to the grab samples taken, adult surf clam dredge tows were also conducted within the two borrow areas by Versar, Inc. in August 1999 and in the expanded Borrow Area B in October 2001. Adult surf clams were collected in 87% of the 15 dredge tows conducted in Borrow Area A. The estimated number of surf clams collected per tow averaged 130 and ranged as high as 703. Overall, the standing stock of adult surf clams within Borrow Area A was estimated to be 1.2 million clams. No adult surf clams were collected in the five tows conducted within Borrow Area B in 1999. Subequent to this survey, the size of Borrow Area B was increased to accommodate sand quantities required for the project so additional surf clam tows were conducted within the entire borrow area in October, 2001. During this study, adult surf clams were taken in 72% of the dredge tows coducted in Borrow Area B. Among the 25 tows conducted, approximately 6,400 surf clams were collected. The estimated number of clams collected per tow averaged 256 and ranged as high as 1,050 clams. Density estimates for the borrow area averaged 11.9 clams/100 sq. ft. and ranged to 69.6 clams/100 sq. feet. Overall, the standing stock of adult surf clams of Borrow Area B was estimated to be 1.86 million clams. The distribution of clams within the borrow area is patchy, however. No clams were collected in the 1999 survey of Borrow Area B and the five Borrow Area B stations that were sampled in 1999 and repeated in 2001 also produced no clams.

The mean density of clams collected per 100 square feet from Borrow Area A was 6.1. This density is comparable to the regional reference area LBI Area D that had a density of 4.1

clams per 100 square feet. Regional reference areas LBI Area A and E had approximately 5 to 10 times more clams per square feet than Manasquan Borrow Area A (Figure 5-28).

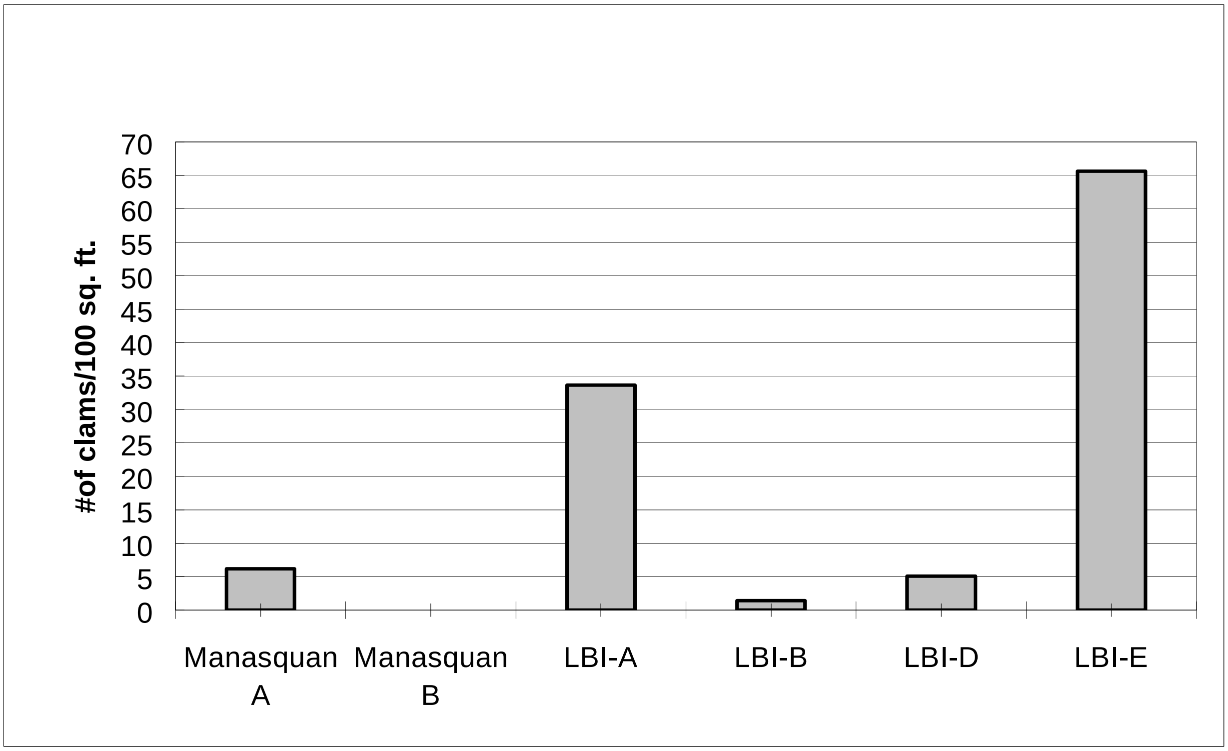

Figure 5-28 Comparison of Mean Surf Clam Density at Borrow Areas and Regional Reference Areas (1999)

As stated in Section 2.2.14.3, the Atlantic surf clam fishery supports the largest molluscan fishery in New Jersey and New Jersey's 1999 harvest accounts for 84% of the total mid-Atlantic catch (NJDEP 1995). Annual commercial surf clam surveys conducted by the New Jersey Department of Environmental Protection, Division of Fish and Wildlife indicates that the vast majority of commercial surf clam beds in New Jersey waters are located between Atlantic City and Shrewsbury Rocks, including the Manasquan borrow areas. Dredging sand for beach replenishment has the potential to impact these resources. Overall, however, the catch per tow was lower in Borrow Area A than in previous NJDEP surveys. Five-minute tows conducted by NJDEP in 2000 between Shark River to Barnegat Inlet averaged about 9.02 bushels per 5-minute tow while catches at Borrow Area A averaged only 6.1 bushels. As such, the use of the proposed sand borrow areas for beach restoration and periodic renourishment is not expected to have any significant impact on the surf clam population or the commercial fishery along the New Jersey Coast.

To minimize the impacts of the proposed project on the surf clam population, periodic monitoring of the benthic communities in the borrow areas will be conducted prior ro each dredging cycle to provide information for selecting dredging locations within these borrow areas that minimize surf clam impacts. In addition, a sand substrate will be maintained within the borrow area to encourage surf clam recruitment after dredging. If commercial populations of clams are found in an area prior to dredging, the Corps will coordinate with NJDEPBureau of Shellfisheries to develop a plan to try to avoid portions of any site that supports productive surf clam habitat.

5.2.9.3 Essential Fish Habitat

As discussed in the Section 2.2.14.5, 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 impact areas. Fish occupation of waters within the project impact areas is highly variable spatially and temporally. Some of the species are strictly offshore, while others may occupy both nearshore 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 result from dredging offshore in the borrow sites and beach fill placement in the intertidal zone and nearshore. EFH can 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. More long-term impacts to EFH involve physical changes to the bottom habitat, which involve changes to bathymetry, sediment substrate, and benthic community as a food source.

One major concern with respect to physical changes involves the potential loss of prominent offshore sandy shoal habitat within borrow sites due to sand mining for the beach replenishment. It is generally regarded that prominent offshore shoals are areas that are attractive to fish including the Federally managed species, and are frequently targeted by recreational and commercial fishermen. Despite this, there is little specific information to determine whether shoals of this type have any enhanced value for fish. However, it is reasonable to expect that the increased habitat complexity at the shoals and adjacent bottom would be more attractive to fish than the flat featureless bottom that characterizes much of the mid-Atlantic coastal region (USFWS, 1999a).

Since mining of sand in shoals may result in a significant habitat alteration, it is proposed that these areas be avoided or the flatter areas surrounding the prominent shoals be mined. Prominent shoal habitat was avoided as part of the borrow site screening process. This was accomplished by avoiding sites with prominent shoal habitat such as the “Seaside Lumps” and “Fish Heaven”, which are considered important sport and commercial fishing grounds (Long and Figley, 1982). Other physical alterations to EFH involve substrate modifications. An example would be the conversion of a soft sandy bottom into a hard clay bottom through the removal of overlying sand strata. This could result in a significant change in the benthic community composition after recolonization, or it could provide unsuitable habitat required for surf clam recruitment or spawning of some finfish species. This could be avoided by correlating vibracore strata data with sand thickness to restrict dredging depths to avoid exposing a different substrate. Based on vibracore data, dredging depths would be considered to minimize the exposure of dissimilar substrates.

Biological impacts on EFH are more indirect involving the temporary loss of benthic food prey items or food chain disruptions. Table 5-2 provides a brief description of direct or indirect impacts on the designated Federally managed species and their EFH with respect to their life stage within the designated EFH squares (#'s 14, 19, and 20) that encompasses the entire project impact area.

Table 5-2 Direct and Indirect Impacts on Identified EFH Species for Representative Life Stages

MANAGED SPECIES	EGGS	LARVAE	JUVENILES	ADULTS
1. Atlantic cod *(Gadus morhua)*				**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. **Indirect:** Temporary disruption of benthic food prey organisms.
2. Whiting (Merluccius bilinearis)	Eggs are pelagic and are concentrated in depth of 50 –150 meters, therefore no direct or indirect effects are expected.	Larvae are pelagic and are concentrated in depth of 50 –150 meters, therefore no direct or indirect effects are expected.	**Direct:** Occur near bottom. Physical habitat in borrow site should remain basically similar to pre-dredge conditions. However, some mortality of juveniles could be expected from entrainment into the dredge. **Indirect:** Temporary disruption of benthic food prey organisms.	**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. **Indirect:** Temporary disruption of benthic food prey organisms.
3. Red hake *(Urophycis chuss)*	Eggs occur in surface waters; therefore, no direct or indirect effects are expected.	Larvae occur in surface waters; therefore, no direct or indirect effects are expected.	**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. However, some mortality of juveniles could be expected from entrainment into the dredge. **Indirect:** Temporary disruption of benthic food prey organisms.	
4. Redfish (*Sebastes fasciatus*)	n/a			
5. Witch flounder (*Glyptocephalus cynoglossus*)	Eggs are pelagic, generally over deep water, therefore no direct or indirect effects are expected.			
6. Winter flounder (Pseudo*pleuronectes americanus*)	Eggs are demersal in very shallow waters of coves and inlets in	Larvae are initially planktonic, but become more bottom-oriented as they develop. Potential	**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge	**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge

MANAGED SPECIES	EGGS	LARVAE	JUVENILES	ADULTS
	Spring. Dredging may have some effect on eggs if construction occurs during Spring.	for some to become entrained during dredging in borrow areas.	conditions. However, some mortality of juveniles could be expected from entrainment into the dredge. **Indirect:** Temporary disruption of benthic food prey organisms	conditions. **Indirect:** Temporary disruption of benthic food prey organisms.
7. Yellowtail flounder (*Pleuronectes ferruginea*)	Eggs are pelagic, generally over deep water, therefore no direct or indirect effects are expected.	Larvae occur in pelagic waters; therefore, no direct or indirect effects are expected.		
8. Windowpane flounder *(Scopthalmus aquosus)*	Eggs occur in surface waters; therefore, no direct or indirect effects are expected.	Larvae occur in pelagic waters; therefore, no direct or indirect effects are expected.	**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. However, some mortality of juveniles could be expected from entrainment into the dredge. **Indirect:** Temporary disruption of benthic food prey organisms.	**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. **Indirect:** Temporary disruption of benthic food prey organisms.
9. Ocean Pout (*Macrozoarces americanus*)	Eggs are demersal, laid in masses on the bottom. Dredging may impact eggs if construction occurs when eggs are present.	Larvae generally stay at or near bottom, possibly near nesting site. Dredging may impact larvae if present. Impacts will be minimized due to short duration of larval stage.		**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. **Indirect:** Temporary disruption of benthic food prey organisms.
10. Atlantic sea herring *(Clupea harengus)*			**Direct:** Occur in pelagic and near bottom. Physical habitat in borrow site should remain basically similar to pre-dredge conditions. However, some mortality of juveniles could be expected from entrainment into the dredge. **Indirect:** None, prey items are planktonic	**Direct:** Occur in pelagic and near bottom. Physical habitat in borrow site should remain basically similar to pre-dredge conditions. **Indirect:** None, prey items are primarily planktonic
11. Monkfish *(Lophius americanus)*	Eggs occur in surface waters with depths greater than 75 ft; therefore, no direct or indirect effects are expected.	Larvae occur in pelagic waters with depths greater than 75 ft; therefore, no direct or indirect effects are expected.		
12. Bluefish *(Pomatomus saltatrix)*			**Direct:** Juvenile bluefish are pelagic species. No significant direct effects anticipated. **Indirect:** Temporary disruption of benthic food prey organisms.	**Direct:** Adult bluefish are pelagic species. No significant direct effects anticipated. **Indirect:** Temporary disruption of benthic food prey organisms.

MANAGED SPECIES	EGGS	LARVAE	JUVENILES	ADULTS
13. Long finned squid *(Loligo pealei)*	n/a	n/a	**Direct:** Adult squids tend to be demersal during the day and pelagic at night (Hammer, 2000). There is a potential for entrainment.	**Direct:** Adult squids tend to be demersal during the day and pelagic at night (Hammer, 2000). There is a potential for entrainment.
14. Short finned squid *(Illex ilecebrosus)*	n/a	n/a		
15. Atlantic butterfish *(Peprilus tricanthus)*			**Direct:** Juvenile butterfish are pelagic species. No significant direct effects anticipated. **Indirect:** Temporary disruption of benthic food prey organisms.	
16. Summer flounder *(Paralicthys dentatus)*		Larvae occur in pelagic waters; therefore, no direct or indirect effects are expected.	**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. However, some mortality of juveniles could be expected from entrainment into the dredge. **Indirect:** Temporary disruption of benthic food prey organisms.	**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. **Indirect:** Temporary disruption of benthic food prey organisms.
17. Scup *(Stenotomus chrysops)*	N/a	n/a	**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. However, some mortality of juveniles could be expected from entrainment into the dredge. **Indirect:** Temporary disruption of benthic food prey organisms.	**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. Adults should be capable of relocating during impact. **Indirect:** Temporary disruption of benthic food prey organisms.
18. Black sea bass *(Centropristus striata)*	N/a		**Direct:** Physical habitat in borrow sites should remain basically similar to pre-dredge conditions. Offshore sites are mainly sandy soft-bottoms, however, some pockets of gravelly or shelly bottom may be impacted. Some mortality of juveniles could be expected from entrainment into the dredge. Some intertidal and subtidal rocky habitat may be impacted due to sand partially covering groins and potential shipwrecks along the shoreline. **Indirect:** Temporary disruption of benthic food prey organisms.	**Direct:** Physical habitat in borrow sites should remain basically similar to pre-dredge conditions. Offshore sites are mainly sandy soft-bottoms, however, some pockets of gravelly or shelly bottom may be impacted. Some intertidal and subtidal rocky habitat may be impacted due to sand partially covering groins and potential shipwrecks along the shoreline. **Indirect:** Temporary disruption of benthic food prey organisms.

MANAGED SPECIES	EGGS	LARVAE	JUVENILES	ADULTS
19. Surf clam *(Spisula solidissima)*	n/a	n/a	**Direct:** Complete removal within borrow sites during dredging. Exposure of similar substrate is expected to allow for future recruitment. **Indirect:** Temporary reduction in reproductive potential. *See shellfish section for more discussion.	**Direct:** Complete removal within borrow site during dredging. Similar substrate would allow for recruitment. No adult surf clams were found in Borrow Area B. **Indirect:** Temporary reduction in reproductive potential. *See shellfish section for more discussion.
20. Ocean quahog *(Artica islandica)*	n/a	n/a		
21. Spiny dogfish *(Squalus acanthias)*	n/a	n/a		
22. King mackerel *(Scomberomorus cavalla)*	**Direct Impacts:** Eggs are pelagic, therefore no adverse impacts are anticipated. **Indirect Impacts:** None anticipated.	**Direct Impacts:** Larvae are pelagic, therefore no adverse impacts are anticipated. **Indirect Impacts:** None anticipated.	**Direct Impacts:** Juveniles are pelagic, therefore no adverse impacts are anticipated. **Indirect Impacts:** Minor indirect adverse effects on food chain through disruption of benthic community, however, mackerel are highly migratory.	**Direct Impacts:** Adults are pelagic and highly migratory, therefore no adverse impacts are anticipated. **Indirect Impacts:** Minor indirect adverse effects on food chain through disruption of benthic community, however, mackerel are highly migratory.
23. Spanish mackerel *(Scomberomorus maculatus)*	**Direct Impacts:** Eggs are pelagic, therefore no adverse impacts are anticipated. **Indirect Impacts:** None anticipated.	**Direct Impacts:** Larvae are pelagic, therefore no adverse impacts are anticipated. **Indirect Impacts:** None anticipated.	**Direct Impacts:** Juveniles are pelagic, therefore no adverse impacts are anticipated. **Indirect Impacts:** Minor indirect adverse effects on food chain through disruption of benthic community, however, mackerel are highly migratory.	**Direct Impacts:** Adults are pelagic and highly migratory, therefore no adverse impacts are anticipated. **Indirect Impacts:** Minor indirect adverse effects on food chain through disruption of benthic community, however, mackerel are highly migratory.
24. Cobia *(Rachycentron canadum)*	**Direct Impacts:** Eggs are pelagic, therefore no adverse impacts are anticipated. **Indirect Impacts:** None anticipated.	**Direct Impacts:** Larvae are pelagic, therefore no adverse impacts are anticipated. **Indirect Impacts:** None anticipated.	**Direct:** Cobia are pelagic and migratory species. No significant direct effects anticipated. **Indirect:** Temporary disruption of benthic food prey organisms.	**Direct:** Cobia are pelagic and migratory species. No significant direct effects anticipated. **Indirect:** Temporary disruption of benthic food prey organisms.
25. Dusky shark *(Charcharinus obscurus)*		**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. Mortality from dredge unlikely because embryos are reported up to 3 feet in length (McClane, 1978). Therefore, the newborn may be mobile enough to avoid a dredge or placement areas. **Indirect:** Temporary disruption of benthic food prey organisms and food chain within borrow and placement		

MANAGED SPECIES	EGGS	LARVAE	JUVENILES	ADULTS
		sites.		
26. Sandbar shark *(Charcharinus plumbeus)*		**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. However, some mortality of larvae may be possible from entrainment into the dredge or burial in nearshore, but not likely since newborns are approx. 1.5 ft in length (pers. conv. between J. Brady-USACE and H.W. Pratt-NMFS) and are considered to be mobile. **Indirect:** Temporary disruption of benthic food prey organisms and food chain within borrow and placement sites.	**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. Juveniles are mobile and are capable of avoiding impact areas. **Indirect:** Temporary disruption of benthic food prey organisms and food chain within borrow and placement sites.	**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. Adults are highly mobile and are capable of avoiding impact areas. **Indirect:** Temporary disruption of benthic food prey organisms and food chain within borrow and placement sites.
27. Tiger shark *(Galeocerdo cuvieri)*		Physical habitat in borrow site should remain basically similar to pre-dredge conditions. Mortality from dredge or fill placement unlikely because newborn are reported up to 1.5 feet in length (McClane, 1978). Therefore, the newborn may be mobile enough to avoid a dredge or placement areas. **Indirect:** Temporary disruption of benthic food prey organisms and food chain within borrow and placement sites.	**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. Juveniles are mobile and are capable of avoiding impact areas. **Indirect:** Temporary disruption of benthic food prey organisms and food chain within borrow and placement sites.	

Of the 27 species identified with Fishery Management Plans, the proposed project could have immediate direct impacts on habitat for surf clams, ocean pout, black sea bass, egg and larval stages of winter flounder and several shark species. This is attributable to the benthic or demersal nature of these species and their affected life stages. However, the affect on surf clams and other benthic food-prey organisms present in the borrow areas and sand placement areas is considered to be temporary as benthic studies have demonstrated recolonization following dredging operations within 13 months to 2 years. Minor elevation differences resulting from dredging may even serve to enhance bottom habitat for a number of these species. Post-construction monitoring will be useful in determining the severity of habitat alterations and its direct and indirect impacts on EFH.

Important physical/chemical parameters such as changes in substrate composition, dissolved oxygen levels, and bathymetry will be monitored. Biological monitoring would involve benthic grab samples to measure recruitment of the infauna community, commercial surf clam surveys, and bottom trawls (if necessary) within affected areas. This monitoring would serve to provide valuable information in the early phases of the project concerning the effects on EFH to base future adaptive management measures to minimize any adverse effects in subsequent periodic nourishment cycles.

5.2.10 Birds

The project impact area is host to a variety of migratory shorebirds, colonial nesting waterbirds, migratory waterfowl, raptors, and other passerine bird species. Of particular concern, are potential adverse impacts to migratory shorebirds and colonial nesting waterbirds, which include several Federal and State listed threatened and endangered species (discussed in the Endangered Species Section). This is due to the fact that the beach and dune areas will be directly impacted during initial construction and periodic nourishment. Shorebird species such as semipalmated sandpiper (*Calidris pusilla*) and several other sandpiper species (*Calidris spp*.) may be present during construction periods. Noise from construction operations may affect birds that are nesting or feeding in the area by disrupting these activities for brief or extended periods of time. Disturbance to nesters may cause the birds to abandon their nests. Colonial nesting bird sites occur at several locations within the project area (although they may not always be at the same location every year). Timing restrictions and buffer zones should be established to avoid adversely impacting any nest sites.

Gulls and shorebirds may become attracted to the point of discharge during sand placement, which would be attributed to feeding on the benthic organisms that were entrained into the dredge from the offshore borrow site. However, shorebirds may experience a temporary decline in food availability within the affected area shortly after construction ceases until intertidal benthic infauna re-establish within the impacted areas. This impact is not well studied, however, it is assumed that this would be a temporary impact based on known rapid recolonization of replenished beaches by typical benthic infauna. In order to gain a better understanding of the potential impacts to prey resources of shorebirds following construction activities, the Corps is currently conducting a nearshore benthic monitoring study in Ocean City, New Jersey. This study is sampling prey resources prior to, and at two time frames after fill activities to track any changes to the benthic community in terms of density and diversity and to track the recovery rate of the species present. Upon completion of this study, the Corps will be better able to time construction and nourishment cycles to help minimize impacts to feeding and nesting shorebirds.

5.2.11 Mammals

The impacts are expected to be temporary and minor. Mammalian wildlife inhabiting the beach and dune areas are expected to temporarily relocate from the impact area to adjacent habitats during placement of material on the beach. Mammalian wildlife species are expected to return after construction is completed and the habitat value for many species may improve slightly with a more stable vegetated dune and wider beach.

While harbor seals have been observed in the vicinity of the project area, they are not expected to be present within the area of impact for the project. Seals are generally “shy”, skittish animals that generally avoid people, and busy populated beaches. For this same reason, they would be expected to avoid the project area during construction activities. Any seals in the vicinity would be expected to temporarily relocate until construction activities have been completed.

5.2.12 Reptiles and Amphibians

Reptiles and amphibians inhabiting the beach and dune areas could become temporarily displaced during construction activities, however, species such as the hognose snake and Fowler’s toad would be able to return upon completion of beach and dune construction. No wetlands or inter-dunal swales were identified within the affected areas; therefore, there would be no adverse impacts associated with breeding habitat for amphibians and some reptiles. In fact, the habitat value for terrestrial reptiles and amphibians may improve slightly with a more stable dune and wider beach. Project construction is also not expected to result in adverse impacts on diamondback terrapin breeding habitat.

5.2.13 Threatened and Endangered Species

The piping plover, which is State and Federally listed as threatened, is a frequent inhabitant of New Jersey's sandy beaches. Past nesting sites of this species within the project area have included Mantoloking and Island Beach State Park, although no nesting has occurred in either area since 1997 and 1989, respectively. If a piping plover nest is discovered within the project area prior to the commencement of the initial beach nourishment and periodic maintenance activities, the Corps will contact the New Jersey Department of Environmental Protection, Division of Fish and Wildlife and the U.S. Fish and Wildlife Service to determine appropriate measures to protect the piping plovers from being disturbed. These measures will include establishing a buffer zone around the nest, and limiting construction to be conducted outside of the nesting period (15 March - 15 August). In addition, the Corps has agreed to arrange for piping plover monitors following project construction

Beach nourishment 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 may be short-lived as the area could become recolonized as early as a few days after it is completed. 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 that 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 northern New Jersey (USFWS, 1999b). 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, 1999b).

To address these issues, the Philadelphia District has 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 is reviewing the BA and will subsequently issue a Biological Opinion based upon their review. The requirements outlined in the Biological Opinion will be adopted and adhered to in order to comply with this statute. Formal consultation will be ongoing throughout the project life where 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.

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 initial construction or periodic maintenance may involve avoidance of the area (if possible), collection of seeds to be planted in non-impacted areas, and timing restrictions.

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. Dredging encounters with sea turtles have been more prevalent along waters of the southern Atlantic and Gulf coasts, however, incidences of "taking" sea turtles have been increasing in waters of the middle Atlantic coast. Endangered whales, such as the highly endangered Right whale, may also be transient visitors within the project area. As with all large vessels, there is a potential for a collision of the dredge with a whale that could injure or kill a whale. Coordination with the National Marine Fisheries Service (NMFS) in accordance with Section 7 of the Endangered Species Act has been undertaken on all Philadelphia District Corps of Engineers dredging projects that may have impacts to Federally threatened or endangered marine species.

A Biological Assessment that discusses Philadelphia District hopper dredging activities and potential effects on Federally threatened or endangered species of sea turtles has been prepared, and was formally submitted to the NMFS in accordance with Section 7 of the Endangered Species Act. A biological opinion was provided by the NMFS in November of 1996. As a term and condition of the incidental take statement included in this opinion, the NMFS is requiring monitoring of all hopper dredge operations in areas where sea turtles are present between June and November by trained endangered species observers. Adherence to the findings of the Biological Opinion will insure compliance with Section 7 of the Endangered Species Act. Recent projects that have utilized a hopper dredge between June and November have included NMFS approved sea turtle observers on the dredge to monitor for sea turtles during dredging. Observers inspect the hopper, skimmer, and draghead after each load looking for signs of interaction with endangered or threatened species. Other measures that may be taken to reduce the impact to sea turtles include the use of rigid dragarm deflectors and pre-dredging trawling.

5.2.14 Recreation

Direct adverse impacts on recreation will be temporary and localized in nature. Project construction during warm season months may temporarily displace beachgoers such as bathers and others enjoying the beach within the immediate impact area. Recreational surf fishing will be temporarily affected by the project, since the public and fishermen will not be permitted to enter the actual work segments. However, since the project will be constructed in sections, only those sections actually under construction will be closed to the public. Impacts to beach and fishing access will be localized and relatively short-lived. In fact, over all, the project is likely to improve recreational opportunities by creating and maintaining a wider, more stable beach.

In the long-term, the proposed action will not impede public access to the beach. Public access to the beaches in the affected areas will be maintained by the construction of dune walkovers. Vehicle access ramps would be provided to allow for beach access for authorized vehicles.

Within the near and offshore areas, boaters may be temporarily displaced in the vicinity of the dredging operations for safety reasons. This impact is temporary and localized, and boaters will be allowed to return to the borrow area(s) after construction ceases.

5.2.15 Cultural Resources Impacts

Proposed project construction has the potential to impact cultural resources in three areas. These are the existing shoreline, near-shore underwater area adjacent to the shoreline, and offshore borrow areas. In the beach and near-shore areas, potential impacts to cultural resources could be associated with the placement and compaction of sand during berm and dune construction. Dredging activities in offshore borrow areas could impact submerged historic shipwrecks.

The Phase 1A and shoreline cultural resources investigation conducted by Hunter Research, Inc. in 1996 identified various late 19^{th}- and early 20^{th} century cultural features along the shoreline including numerous wooden groins, pilings and timbers, occasional structural remains, disassociated artifact scatters, and standing buildings located immediately west of and outside the project area. The groins and pilings are not considered National Register-eligible. Five historic resources of specific note are: two early to mid-20^{th}-century buildings located at the southwestern end of Point Pleasant Beach; a series of planks and pilings located between Carter and Sea Avenues (also on Point Pleasant Beach), which may represent the remains of the 19^{th}-century "Ocean Hotel;" a possible shipwreck located 15 feet offshore of South Mantoloking/Camp Osborn Beach near Seneca Dunes; and two 20^{th} –century amusement piers "Casino" and "Funtown" situated on the Seaside Heights shore at Sherman and Porter Avenues. With the exception of the possible shipwreck, for which further study is recommended, none of these resources are considered to possess historic architectural or archaeological qualities that merit listing in the National Register.

In addition to the visible historic remains noted along the shoreline, various other cultural features are referenced in the project vicinity in the documentary record (chiefly on historic maps). These include four lifesaving stations, two hotels and a number of residences. Some of these features, notably the lifesaving stations, appear to have been destroyed, while others may still survive either above or below ground inland and immediately west of the shoreline. None have been observed as lying within the area of the current project. No trace was seen of a second shipwreck that was reported as being exposed briefly on the Mantoloking beach before being reburied.

The Phase IB cultural resources investigations conducted by Dolan Research, Inc. in 2000 identified 19 "high probability remote sensing targets" in the submerged near-shore area. No remote sensing targets were identified in the project's two offshore borrow areas or on the terrestrial portions of the shoreline. Proposed construction activities have the potential to impact the one possible shipwreck site located near Seneca Dunes and the 19 targets identified in the near-shore zone. Additional Phase II underwater investigations will be conducted during PED phase to identify the nature and historical significance of these 20 targets. The results of this additional work will be coordinated with the New Jersey Historic Preservation Office. Section 106 consultation under the National Historic Preservation Act of 1966, as amended, is ongoing and will be concluded prior to any project construction activity.

5.2.16 Visual and Aesthetic Values

There are two temporary adverse aesthetic impacts that would come in the form of visual impacts and odor impacts that are expected to be present during and immediately after construction. These impacts stem from the chemically reduced state of the beachfill material, which would initially be dark in color and may produce unpleasant odors (rotten egg odor), which may consist of hydrogen sulfide. Generally, if there is a high amount of organic material in the sediments, this impact would be more significant. However, since this material is predominantly sandy material (less than 1% total organic carbon), these impacts are expected to be minor and temporary. The material once placed on the beach is expected to undergo chemical oxidation as the beach dewaters and sorts from the high wave energy and becomes exposed to direct sunlight. The sand is expected to become lighter and odors would subside within a few days after pumping ceases.

Permanent aesthetic impacts stem from the obstruction of an ocean view by the dune along ocean front properties. However, project dimensions for the berm elevation and foreshore and nearshore slopes were chosen to approximate the natural dimensions of the beach as determined from historical profiles. The maximum design dune height considered during plan formulation was chosen so as not to significantly impact views along the commercial recreation boardwalks at Seaside Heights and northern Point Pleasant Beach, where no dunes presently exist. For the remaider of the project areas, which have existing dunes of varying heights, the maximum design dune height considered was set approximately 2 feet higher than the maximum existing dune height. The minimum berm width considered during formulation was determined based upon average existing berm width. Maximum berm widths considered were limited to 25 feet greater than average existing berm widths. Dune height and berm width for the selected plan were chosen based on optimizing the dimensions of these features to maximize net NED benefits.

The native beach material is predominately a poorly graded, or well-sorted, medium to fine sand, with little to no gravel or fines (silt and/or clay). The material within the borrow sites is generally finer than the native material, but provides suitable material compatible with the existing beach. Initial fill placement may exhibit some scarping since the construction template matches the existing beach slope in the project area, which is considerably steeper than most beaches in New Jersey. The potential for significant scarping is expected to be minimal. In addition, the sorting and distribution of sand that occurs with exposure to wave and current action would eventually result in a naturally graded beach similar to what existed prior to introduction of new sand.

The placement of beach fill for berm and dune restoration is a more natural and soft structural solution to reducing storm damages. With the exception of short-term impacts during construction, overall aesthetics of the beach would be improved as a result. A natural-looking beach and dune would be more aesthetically pleasing and attractive to residents and tourists. Despite the visual benefits the berm and dune restoration alternative would provide, a restored dune may inhibit ocean views in some project impact areas. Obstruction of an ocean view is likely to occur from the ground level; thus areas that do not have raised structures (higher than the proposed dune elevation of +18 feet NAVD in Seaside Heights and northern Point Pleasant Beach and +22 feet NAVD in the remainder of the project area would have an obstructed ocean view. The without project condition of waves breaking on or very close to the toe of the existing dune, seawall and bulkhead in many locations along the project area is equally aesthetically displeasing to some. A project of this magnitude will change the existing character of the beach front. Once the proposed beachfill is in place however, the area where the waves break will be much further from shore, therefore making the waves easier to see from the homes and businesses, and minimizing negative aesthetic impacts.

5.2.17 Noise Impacts

Minor 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 feet 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. 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 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. Additional noise may be caused by a pumpout station, if necessary. Depending on future circumstances, the construction may be conducted overnight to meet construction schedules. All noise impacts would end upon cessation of construction activities.

Excessive noise in the vicinity of nesting piping plovers or colonial nesting bird colonies could disrupt nesting activities, and may cause them to abandon their nests. Therefore, noise impacts will be a consideration as part of the Section 7 Endangered Species Act consultation process. This would involve the establishment of buffer zones around nest locations.

5.2.18 Impacts on Human Life

Based on the inherent risks in coastal environments, the potential for loss of life under extreme storm events in this environment is always present. Most states and local governments have established emergency evacuation plans to minimize loss of life during a natural disaster (i.e., hurricanes, coastal storms, etc.). Usually, impending storms are tracked in advance so that emergency measures may be implemented. The recommended plan of improvement was formulated based on storm damage reduction to structures. Any reduction in the potential loss of human life that may be associated with flooding and coastal storm events was not quantified, and therefore, can only be considered incidental.

Sand placement and deposition on the beaches, intertidal zone and nearshore may result in modified depths as the sand becomes redistributed within the nearshore zone after beachfill is placed. This may result in changes in the bathing and swimming areas, where certain areas may become shallower to unfamiliar bathers and swimmers. Lifeguards and local officials would need to become aware of differences in the nearshore bathymetry and adjust accordingly to changing depths and currents to minimize swimming hazards in the affected areas.

5.2.19 Environmental Justice Impacts

No significant adverse impacts under Executive Order 12989, dated February 11, 1994 (Environmental Justice in Minority Populations) are expected because there are no minority or low-income communities living within or near the project impact area.

5.2.20 Cumulative Impacts

Cumulative impact as defined in CEQ regulations is the "impact on the environment which results 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."

Projects of this nature using beach fill from an offshore borrow site are becoming increasingly common in coastal areas as areas of high development become susceptible to the erosive forces present. Numerous beach nourishment projects have been conducted along the Atlantic Coast since the 1960's by local, State and Federal agencies as well as private interests. Depending on circumstances such as the methods being utilized to alleviate the coastal erosion and ensuing storm damages and the existing ecological and socio-economic conditions, it is difficult to gauge the net cumulative effects of these actions. The scientific literature generally supports that beach fill projects, if planned properly, have short-term and minor adverse ecological effects, however, no studies are known to consider regional or national cumulative impacts of these projects on resources of concern.

Because there are several beach replenishment projects that have been built or are active long-term commitments, or are currently being planned along the New Jersey coastline, the cumulative loss of offshore sandy shoals and that impact on fisheries and essential fish habitat has been identified as a concern. The shoals on the inner continental shelf have been increasingly relied upon to provide sand for beach nourishment projects, which could lead to a significant decrease in the amount of shoal habitat (USFWS, 1999). Table 5-3 provides a brief summary of recent past and active projects conducted along the New Jersey Coast and future planned Federal projects, which involve 50-year commitments to replenishing the associated beaches. Active projects are Federal projects that have been authorized by Congress and have already undergone initial construction (and several nourishment cycles) which will continue for the remainder of the 50-year period of Federal participation. The scope of this table focuses on recent actions and locations within the Philadelphia District along the New Jersey Atlantic Coast (from Manasquan Inlet to Cape May Point).

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. Two active Federal projects are present at Cape May City and Ocean City that each utilize a sand source offshore and at an adjacent inlet. Non-Federal projects have been conducted recently (since 1995) 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 a total area of 1,067 acres of marine habitat. Approximately 71% of the affected areas are inlet ebb shoal habitat 753 acres and 29% 314 acres of the affected areas are considered prominent offshore shoal or "lump" habitats.

Table 5-3 Summary of Recent Past, Active, and Proposed Future Beach Nourishment Projects along the Atlantic Coast of New Jersey within Philadelphia District Boundaries (Manasquan Inlet to Cape May Point)

Project	**Action Agency**	**Type of Project**	**Project Status**	**Sand Borrow Site ID**	**General Location of Sand Borrow Site**	**Designated Beach**	**Total Area of Sand Borrow Site**	**Type and Area of Habitat Affected or Proposed to Be Affected at Sand Borrow Site Location**				
								Inlet Ebb Shoal	**Offshore Shoal of Lower Relief**	**Prominent Offshore Shoal or "Lump"**	**Area Designated as NJ's Specific Sport and Commercial Fishing Grounds**	**Area of Wreck Zones, Reefs, and Other Habitat Features**
						Recent Past and Active Projects						
Cape May Inlet to Lower Township	USACE/NJ DEP	Federal project with 50-years of periodic nourishment	Active	M-1 (mostly depleted- will be seeking new source for future nourishment)	1.4 – 1.6 miles offshore Cape May City	Cape May City and Lower Township	192.0 acres			192.0 acres		
Avalon/Sea Isle City Beachfill	Avalon and Sea Isle City	Periodic dredging and beachfill placement from both municipalities	Periodic	Townsends Inlet	Townsends Inlet Ebb Shoal	Avalon and Sea Isle City	72.0* acres	72.0* acres				
Strathmere and Southern Ocean City	NJDEP	Previously Used and Proposed for 2000	Periodic	Corson's Inlet	Corson's Inlet Ebb Shoal	Strathmere/So. Ocean City	52*acres	52*acres				
Southern Ocean City	NJDEP	Utilized for sand in 1995	One-time use	OC-3	2.1 – 2.6 miles off So. Ocean City	Southern Ocean City	122 acres			122 acres		
Great Egg Harbor Inlet and Peck Beach	USACE/NJ DEP	Federal project with 50-years of periodic nourishment	Active	Great Egg Harbor Inlet	Great Egg Harbor Inlet Ebb Shoal	Northern Ocean City (34th St. to Surf Road)	579 acres	579 acres				
Brigantine Beachfill	City of Brigantine	Intermittent	Completed 1997 & 2000	Brigantine Inlet	Brigantine Inlet Ebb Shoal	Brigantine	50* acres	50*acres				
Total Area of Habitat Affected by Recent Past and Active Projects							**1,067 acres**	**753 acres**		**314 acres**		

Project	Action Agency	Type of Project	Project Status	Sand Borrow Site ID	General Location of Sand Borrow Site	Designated Beach	Total Area of Sand Borrow Site	Type and Area of Habitat Affected or Proposed to Be Affected at Sand Borrow Site Location				
								Inlet Ebb Shoal	**Offshore Shoal of Lower Relief**	**Prominent Offshore Shoal or "Lump"**	**Area Designated as NJ's Specific Sport and Commercial Fishing Grounds**	**Area of Wreck Zones, Reefs, and Other Habitat Features**
Proposed Federal Projects												
Lower Cape May Meadows	USACE/NJ DEP	Federal project with 50-years of periodic nourishment	Proposed (PED Phase)	4	0.8 – 1.0 miles offshore Cape May City	Cape May Meadows/ Cape May Point	163 acres		163 acres trough area between finger shoals			
				5	1.1 – 2.0 miles offshore Cape May City	Cape May Meadows/ Cape May Point	177 acres			177 acres finger shoal and trough		
				P1	1.1 – 1.5 miles	Cape May Meadows/ Cape May Point	201 acres			201 acres of finger shoal and trough		
Townsends Inlet to Cape May Inlet	USACE/NJ DEP	Federal project with 50-years of periodic nourishment	Proposed (PED Phase)	G	Hereford Inlet Ebb Shoal	Stone Harbor Point/Stone Harbor	167 acres	167 acres				
				E	Townsends Inlet Ebb Shoal	Avalon/ Seven Mile Beach	146 acres	146 acres				
Great Egg Harbor Inlet to Townsends Inlet	USACE/NJ DEP	Federal project with 50-years of periodic nourishment	Proposed (Feasibility Phase)	C1	Corson's Inlet Ebb Shoal	Strathmere Periodic Nourishment	197 acres	197 acres				
				L1	2.0 – 3.2 miles offshore Sea Isle City	Sea Isle City	1,517 acres		1,517 acres			
				L3	2.0 – 4.0 miles offshore Whale Beach / Strathmere	Whale Beach/ Strathmere	2,082 acres		2,082 acres			
				M8	3.4 – 4.3 miles offshore So. Ocean City	Southern Ocean City (Peck Beach)	852 acres		852 acres			

Project	Action Agency	Type of Project	Project Status	Sand Borrow Site ID	General Location of Sand Borrow Site	Designated Beach	Total Area of Sand Borrow Site	Type and Area of Habitat Affected or Proposed to Be Affected at Sand Borrow Site Location				
								Inlet Ebb Shoal	**Offshore Shoal of Lower Relief**	**Prominent Offshore Shoal or "Lump"**	**Area Designated as NJ's Specific Sport and Commercial Fishing Grounds**	**Area of Wreck Zones, Reefs, and Other Habitat Features**
Absecon Island	USACE/NJ DEP	Federal project with 50-years of periodic nourishment	Proposed (PED Phase)	A	Absecon Inlet Ebb Shoal	Longport/ Ventnor/ Margate/ Atlantic City	339 acres	339 acres				
Brigantine Island	USACE/NJ DEP	Federal project with 50-years of periodic nourishment	Proposed (PED Phase)	D	Brigantine Inlet Ebb Shoal	City of Brigantine	375 acres	375 acres				
Barnegat Inlet to Little Egg Inlet (Long Beach Island)	USACE/NJ DEP	Federal project with 50-years of periodic nourishment	Proposed (PED Phase)	D1	2.2 – 3.4 miles offshore Harvey Cedars/ Surf City	Long Beach Island (LBI)	567 acres		567 acres			108.6 acres portion of 1 wreck zone
				D2	3.4 – 4.3 miles offshore Harvey Cedars	LBI	572 acres		572 acres			
				A	Barnegat Inlet Ebb Shoal	LBI	83 acres	83 acres				
Manasquan Inlet to Barnegat Inlet	USACE/NJ DEP	Potential for Federal project with 50-years of periodic nourishment pending findings of the study	Proposed (Feasibility Phase)	A	1.7 – 2.7 miles offshore Island Beach S.P.	Seaside Park/ Seaside Beach/ Lavallette	460 acres		460 acres			
				B	1.3 – 2.0 miles offshore Mantoloking	Point Pleasant Beach/ Mantoloking	360 acres		360 acres			
Total Estimated Area of Offshore Habitat Affected by Proposed Federal Projects							**8,258 ac**	**1,307 ac**	**6,573 acres**	**378 acres**		
Total Estimated Area of Offshore Habitat Affected by Recent Past, Currently Active and Proposed Federal Projects							**9, 029 ac**	**1,886 ac**	**6,573 acres**	**692 acres**		

Project	Action Agency	Type of Project	Project Status	Sand Borrow Site ID	General Location of Sand Borrow Site	Designated Beach	Total Area of Sand Borrow Site	Type and Area of Habitat Affected or Proposed to Be Affected at Sand Borrow Site Location				
								Inlet Ebb Shoal	Offshore Shoal of Lower Relief	Prominent Offshore Shoal or "Lump"	Area Designated as NJ's Specific Sport and Commercial Fishing Grounds	Area of Wreck Zones, Reefs, and Other Habitat Features
Proposed Federal Outer Continental Shelf Sand Resources												
Outer Continental Shelf Federal Sand Resource Areas	U.S. Dept. of the Interior Minerals Manage-ment Service	Sand Mineral Resources Available for Future Beach Replenishment Projects	Proposed	A1	4.2 – 6.2 miles offshore Sea Isle City	Not determined	3,674 acres			Sea Isle Shoal 665 acres Sea Isle Lump 109 acres	Sea Isle Shoal 665 acres Sea Isle Lump 109 acres	Fish Haven Area 272 acres
				A2	7.3 – 9.4 miles offshore Sea Isle City	Not determined	4,659 acres		3,536 ac	Avalon Shoal 1,123 acres	Inshore Stone Bed 702 acres Avalon Shoal 1,123 acres	2 wreck zones 661 acres
				G1	3.4 – 5.2 miles offshore Brigantine	Not determined	2,584 acres		2,149 ac	Brigantine Shoal 435 acres	Brigantine Shoal 435 acres	1 wreck zone 414 acres
				G2	3.4 – 5.5 miles offshore Brigantine	Not determined	3,240 acres		2,865 ac	Brigantine Shoal 375 acres	Brigantine Shoal 375 acres	
				G3	3.5 – 6.0 miles offshore Brigantine Inlet	Not determined	2,419 acres		2,419 ac			2 wreck zones 88 acres
				C1	3.4 – 5.2 miles offshore Harvey Cedars)	Not determined	4,323 acres		4,323 ac			1 wreck zone 231 acres
				F1	6.3 – 8.0 miles offshore Chadwick Beach	Not determined	668 acres		668 acres			
				F2	5.5 – 7.0 miles offshore Mantoloking	Not determined	1,825 acres		431 acres	Manasquan Ridge 1,394 acres	Manasquan Ridge 1,394 acres	
Total Estimated Area of Offshore Habitat Affected by Proposed Federal Outer Continental Shelf Sand Resources							**23,392 acres**		**16,391 ac**	**4,101 acres**	**3,399 acres**	**1,666 acres**

Definitions/Assumptions:

***** These sites overlap with proposed larger sites. Areas of potential affected habitat were based on the larger overlapping sites to avoid double counting area quantities.

Inlet Ebb Shoal Habitat – areas within or immediately offshore inlets that are characterized by high energy shifting sands

Offshore Shoal of Lower Relief – areas that contain slight rises and drops or are generally flat with relatively stable sand/gravel bottoms.

Prominent Offshore Shoals or "Lumps" – offshore sand/gravel areas that have distinct bathymetric features that generally contain areas with depths of 9.14 m (30 ft) or shallower (blue areas on NOAA Navigation Charts) surrounded by deeper areas. These areas also include shoals identified as specific sport and commercial fishing grounds in Long et al. 1982.

Area Designated as NJ's Specific Sport and Commercial Fishing Grounds – Specific Sport and Commercial Fishing Grounds as delineated in Long et al. 1982.

Area of Wreck Zones, Reefs, and Other Habitat Features – Includes offshore wreck and reef zones as delineated by Long et al. 1982. This also includes reefs and other fish structures as identified on NOAA Navigation Charts.

USACE – U.S. Army Corps of Engineers

NJDEP – New Jersey Department of Environmental Protection

There are 7 Federal projects (including Manasquan to Barnegat Inlet) proposed along various segments of the NJ Atlantic Coast within the Philadelphia District that involve beachfill placement from offshore or inlet sand sources. These combined with the recent past and currently active projects constitute a significantly higher amount of offshore or inlet areas that will be utilized as sand sources. It is estimated that a total of 9,029 acres of marine benthic habitat would be impacted. This includes 1,866 acres of inlet ebb shoals, 6,573 acres of offshore shoals of lower relief and 692 acres of prominent offshore shoal or "lump" habitats. The proposed Federal projects result in an increase of over 800 % of total marine benthic habitat impacted over the existing used sites. This includes a 250% increase in inlet ebb shoals being used and a 161% increase in prominent offshore shoals or "lump" habitats. No offshore shoal areas with lower relief were previously impacted, therefore, the 6,573 acres of this type of habitat will only be affected with the proposed Federal projects.

The two sand borrow sites proposed for the Manasquan Inlet to Barnegat Inlet project represents only about 9% of the marine benthic habitat impacted by all of the previously impacted and the proposed (Federal) impacted sites. This percentage may increase slightly, however, if future infilling of the initial borrow areas is insufficient to provide enough material for nourishment during years 28 through 50 of the period of Federal participation. Alternate borrow sites will be identified for potential future use during PED phase. When choosing borrow areas for the project, areas of lower relief were selected in an effort to avoid prominent shoal areas, which are considered valuable fish and shellfish habitat. Since lower relief areas do not contain significant "lumps" of sand, it is necessary to affect larger areas of bottom to obtain the required quantities of sand. This coupled with dredging depth restrictions (not creating deep, anoxic pits), and the available depth of sand determines the overall sizes of the borrow sites. For these reasons, the aerial extent of habitat disturbed is unavoidable to meet the project needs. However, it should be noted that the actual impacts are considered to be temporary to the benthic community, and do not represent a permanent loss of marine benthic habitat. These areas would be impacted incrementally over the 50-year period of Federal participation with each periodic nourishment cycle. Based on the projected nourishment quantities per cycle, it is estimated that approximately 45 acres of marine bottom would be impacted. Impacts to any new borrow areas identified are expected to be similar but would vary depending upon the depth of excavation. Each area previously disturbed from a previous nourishment cycle (and initial construction) would be untouched and allowed to become recolonized by benthic fauna, therefore, the affected areas would not be subject to continued disturbance, and there would be no permanent loss of habitat. It is anticipated that the benthic community would be recovered within several years after disturbance.

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 sites proposed for this project do 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. These types of habitat were avoided through careful site selection and coordination with fishery resource agencies. Some minor and temporary impacts would result in a loss of food source in the affected areas, which is expected to be approximately 45 acres at a time with each periodic nourishment. This impact would affect demersal or bottom-feeding EFH species such as summer flounder and windowpane flounder.

Cumulative losses of EFH for surf clams can be avoided by not dredging deep holes, and leaving similar sandy substrate (w/ 3 feet of sand or more) for recruitment.

It should be noted, however, that some fishery habitat may be slightly impacted over time in the nearshore area. As previously discussed, 19 nearshore cultural targets have been identified within the project area, at least 7 of which could potentially provide some form of hard bottom fish habitat. These targets could be impacted over time as the construction template stabilizes into the design template to meet existing conditions. This is accomplished through the migration of sand from the placement site seaward. This migration of sand has the potential to cover part, or all of any hardened structure within the nearshore area. It is anticipated that these impacts would be minor and would most likely only result in an accumulation of sand around the bottom of any given structure. Further investigations are planned, however, in the PED phase of this project to conclusively identify these targets and assess their cultural and fisheries significance. Any structures deemed significant will be monitored during and after project implementation in order to assess any impacts. If impacts do occur, and fisheries habitat is found to be reduced, coordination with NJDEP and NMFS will be conducted in order to determine the appropriate course of action. This coordination could result in project modifications, in the form of adaptive management, or mitigation.

Several large sites were identified as Outer Continental Shelf Federal Sand Resource Areas by the Minerals Management Service (MMS) to be used as potential sand sources for future beach replenishment projects. These sites are generally 3.4 – 8.0 miles offshore and cover large portions of bottom with a total coverage of 23,392 acres. Because of the large nature of these sites, they contain primarily offshore shoal areas of lower relief, however, portions of these areas contain prominent offshore shoal or “lump” areas. Some of these prominent shoals are identified in Long et al. 1982 as NJ’s Specific Sport and Commercial Fishing Grounds. Although these sites have been identified as potential sand sources, there have been no specific proposals for their use at this time (personal communication with B. Drucker – MMS).

Table 5-4 provides brief summaries of recent past, currently active, and proposed future Federal beach replenishment projects on beaches within the Philadelphia District Corps of Engineers’ geographic boundaries along the New Jersey Coast (from Manasquan Inlet to Cape May Point). Since 1995 a total of approximately 14.4 miles of New Jersey Atlantic Coast shoreline beaches within the Philadelphia District have received beachfill placement. This represents nearly 15% of the N.J. beaches south of Manasquan Inlet. These include three Federal projects and six State and local municipality projects. Two of these areas, Brant Beach and Harvey Cedars, had sand placed on the beach that was obtained from land sources.

Included among the seven proposed Federal projects or studies, there are nine Federal project locations in N.J (south of Manasquan Inlet) where beachfill placement is proposed. The proposed Federal projects combined with the existing projects 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. The proposed project for the Manasquan Inlet project area represents nearly 21% of the affected beaches and 14.6% of all of the beaches along this entire stretch of coast.

Table 5-4 Shoreline Area Impacts for Recent Past, Active, and Proposed Future Beach Nourishment Projects along the Atlantic Coast of New Jersey within Philadelphia District Boundaries (Manasquan Inlet to Cape May Point)

Projects	Action Agency	Quantity of Sand Filled or Proposed for Initial Construction	Quantity of Sand Estimated for Periodic Nourishment (If Applicable)	Periodic Nourishment Cycle (Years)	Date of Most Recent Fill Placement	Length of Affected Atlantic Coast Shoreline	% of Atlantic Coast Shoreline within Philadelphia District Boundaries that is Affected*
Recent Past and Currently Active Projects							
Cape May Inlet to Lower Township	USACE/NJDEP	1,400,000 yd^3	360,000 yd^3	2	1999	3.24 mi	3.4%
Cape May Section 227 Demonstration Project**	USACE	30,000 yd^3			2000	0.22 mi	
Avalon**	Avalon	Unknown			1998	0.52 mi	0.5%
Sea Isle City**	Sea Isle City	243,000 yd^3			1999	0.32 mi	0.3%
Southern Ocean City**	NJDEP	1,000,000 yd^3			1995	2.6 mi	2.7%
Great Egg Harbor Inlet and Peck Beach	USACE/NJDEP	6,200,000 yd^3	1,100,000 yd^3	3	1997	4.28 mi	4.5%
Brigantine**	Brigantine	1,200,000 yd^3			1997	0.86 mi	0.9%
Brant Beach**	NJDEP	50,000 yd^3			1997	0.61 mi	0.6%
Harvey Cedars**	NJDEP	525,000 yd^3			1995	1.78 mi	1.9%
Subtotal of Previous and Currently Active Projects						**14.4 mi**	**15.1%**

Projects	Action Agency	Quantity of Sand Filled or Proposed for Initial Construction	Quantity of Sand Estimated for Periodic Nourishment (If Applicable)	Periodic Nourishment Cycle (Years)	Date of Most Recent Fill Placement	Length of Affected Atlantic Coast Shoreline	% of Atlantic Coast Shoreline within Philadelphia District Boundaries that is Affected*
Proposed Federal Projects							
Lower Cape May Meadows	USACE/NJDEP	2,372,000 yd^3	650,000 yd^3	4	NA	1.99 mi	2.1%
Stone Harbor Point	USACE/NJDEP	1,366,000 yd^3		NA	NA	0.26 mi	0.3%
Avalon/Stone Harbor	USACE/NJDEP	3,111,000 yd^3	746,000 yd^3	3	NA	8.66 mi	9.1%
Ludlam Island	USACE/NJDEP	5,123,587 yd^3	1,504,346 yd^3	5	NA	6.7 mi	7.0%
Southern Ocean City	USACE/NJDEP	1,540,000 yd^3	348,000 yd^3	3	NA	2.6 mi	2.7%
Absecon Island	USACE/NJDEP	6,200,000 yd^3	1,666,000	3	NA	7 mi	7.3%
Brigantine	USACE/NJDEP	648,000 yd^3	312,000 yd^3	6	NA	1.76 mi	1.8%
Long Beach Island	USACE/NJDEP	7,400,000 yd^3	1,900,000 yd^3	7	NA	17 mi	17.8%
Manasquan Inlet to Barnegat Inlet	USACE/NJDEP	10,689,000 yd^3	961,000 yd^3	4	NA	14 mi	14.6%
Subtotal of Proposed Federal Projects						**60.0 mi**	**62.5%**
Total of All Projects						**67.5 mi**	**70.3%**

*Philadelphia District Corps of Engineers Geographic Boundaries along the NJ Atlantic Coast are from Manasquan Inlet to Cape May Point
** Previously affected beaches that overlap or have portions that overlap with proposed Federal projects. These beaches were precluded from totals of all projects since they overlap with proposed Federal projects

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 nearshore 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 beachfill areas being impacted at one time.

Based on current budget expectations and project schedules, it is anticipated that the remainder of the beachfill projects not yet constructed will be implemented between 2002 and 2005. Currently it is anticipated that the Townsend’s Inlet project will be constructed in 2001, as well as the next Cape May City nourishment cycle. In 2003, the Absecon Island, Brigantine Island, and Lower Cape May Meadows projects are scheduled for construction. In 2004, the Long Beach Island, and Great Egg Harbor projects are scheduled for initial construction and Ocean City and Cape May City are scheduled for nourishment activities. In 2005, the Manasquan project is scheduled for construction. It should be noted, however, that these schedules are subjective and hinge on the amount of money received in the District’s budget for any given year, as well as the condition of each beach itself. These numbers are used here only as an estimate of construction schedules and potential cumulative impacts.

Based on initial construction schedules, Table 5-5 estimates yearly nourishment activities within the District’s boundaries for the next 20 years. The number of years between nourishment cycles for any given project is based upon estimates of the future erosion rates at each project site and range between 2 years and 7 years, which accounts for the changes in the number of projects being nourished in any given year. Based on these estimates, nourishment activities are expected to take place at between 1 and 4 locations on any given year, with 3 locations being the average.

Table 5-5 Estimated Nourishment Activities over next 20 Years along the Atlantic Coast of New Jersey within Philadelphia District Boundaries (Manasquan Inlet to Cape May Point)

Year	Number of Nourishment Activities	Year	Number of Nourishment Activities
2002	2	2012	2
2003	3	2013	3
2004	4	2014	3
2005	2	2015	4
2006	3	2016	1
2007	3	2017	3
2008	3	2018	4
2009	3	2019	3
2010	3	2020	2
2011	3	2021	2

In addition to the potential impacts to benthic, fisheries and surf clam resources discussed, the proposed 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 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 proposed 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 some cases eliminated. If the results of the Ocean City nearshore benthic sampling which is currently ongoing indicate that the benthic community is not recovering as quickly as anticipated (within 4-5 months) it is possible that plover habitat may be negatively impacted 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. 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 14^{th} street for several cycles since this area is fairly stable.

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 three of the nine proposed locations will be impacted during any given year, however, these activities should not cause the species any undo 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. In addition, more information will be available regarding the exact impact and recovery rate of the benthic community following the completion of the benthic work at Ocean City.

Even more uncertainty exists when trying to quantify the potential impacts to seabeach amaranth since the species does not currently exist within any of the project areas. If seabeach amaranth does establish itself in southern New Jersey however, the protection measures being developed with USFWS 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.

Mitigation measures which have been proposed for this project are similar to those proposed in previous studies conducted by the Philadelphia District of the Corps. These measures include preconstruction benthic and surf clam (where applicable) sampling prior to initial construction and each subsequent nourishment cycle, yearly surveys of seabeach amaranth once a project has been constructed, yearly monitoring of piping plovers once a project has been constructed, and beach elevation surveys to determine the exact extent and location of fill required for nourishment activities. Benthic monitoring that has been conducted over the past 10 years on the active borrow site used for Ocean City has shown that the macrobenthic community was able to colonize the borrow area rapidly and establish a population similar to conditions existing in the region 2 years after the last dredging event. Surf clam data in the area suggested that juvnile recruitment was substantial (Versar 1998). Studies conducted on the benthic community in the nearshore area of the Ocean City project area showed similar results, indicating rapid colonization of the area following placement activities. These results are further bolstered by extensive borrow area and nearshore sampling efforts that were conducted by the New York District on northern New Jersey beaches which were similar to the results of the Ocean City investigations.

In addition to the measures discussed above, steps taken to minimize impacts during construction are also fairly standard among the District's beach restoration projects. Dredging windows are employed when necessary, dredging is conducted in a manner to avoid creating deep pits, dredging locations within borrow areas are rotated when possible to reduce impacts, buffer areas are established around cultural targets within borrow areas, and borrow areas are chosen to minimize impacts to shellfish and fisheries resources. With the inclusion of these measure in all projects, cumulative impacts for the District activities are expected to be minimized to the greatest extent possible.

5.2.21 Short-Term Uses of the Environment and Long-Term Productivity

The no action alternative does not involve short-term uses but would affect the long-term economy of the project area. On the other hand, the berm and dune restoration alternative would enhance the economy by storm damage reduction as well as by providing additional recreational area.

5.2.22 Irretrievable Uses of Resources

The no action alternative does not involve a commitment of resources. The berm and dune restoration alternative would involve the utilization of time and fossil fuels, which are irreversible and irretrievable. Sand mined from the offshore borrow area is not an irretrievable use of the sand resource since the sand will be redistributed into the littoral system within 4 nautical miles from the borrow location. Impacts to the benthic community would not be irreversible, as benthic communities would redevelop with cessation of all dredging activity.

5.2.23 Mitigation Measures

Mitigation measures are methods, practices and techniques that can be implemented to reduce the amount of adverse environmental impacts during and after construction. The following sequence of steps, in order of priority, was identified in the Council on Environmental Quality's 1978 Regulations and should be considered in the planning process:

1. Avoid the impact by not taking a certain action or parts of the action.
2. Minimize impacts by limiting the degree or magnitude of the action and its implementation.
3. Rectify the impact by repairing, rehabilitating, or restoring the affected environment.
4. Reduce or eliminate the impact over time by preservation and maintenance operations during the life of the action.
5. Compensate for the impact by replacing or providing substitute resources or environments.

Mitigation measures are either institutional in that environmental mitigation is inherent in project alternative selection, or as measures incorporated into the construction and operation and maintenance of the project. Several institutional measures have already been adopted to minimize the impacts on these resources. These measures include the selection of the beach nourishment alternative. This alternative offers a more naturalistic and softer approach for storm damage reduction. Selection of this alternative is based on its relatively low ecological impacts and its cost effectiveness. Another institutional measure is the utilization of offshore sand borrow areas. These areas are characterized by high energy and shifting sands resulting in a benthic community of lower abundance and diversity as compared to more stable benthic environments. Therefore, biological impacts are expected to be lower. Another measure is the selected use of suitable sand grain sizes for beach nourishment. The selection of borrow areas is based on compatibility studies for sand grain sizes. The selection of coarser beach nourishment quality material will minimize impacts on water quality at the dredging site and discharge (placement) site.

An additional mitigation measure that was adopted for the proposed action is the careful selection of flatter areas (away from known prime fish habitats or prominent relict shoals) to obtain sand. This measure utilizes "avoidance and minimization" as described in the Council on Environmental Quality's 1978 regulations. However, as discussed in the preceding paragraphs, the berm and dune restoration alternative does contain unavoidable impacts to several environmental resources of concern. Implementing several measures during construction, and operation and maintenance of the project can minimize these impacts. Mitigation measures recommended for construction, and operation and maintenance of the project involve minimizing adverse impacts to benthic resources, fisheries, endangered species, recreation and noise. The following measures are recommended, however, their implementation is dependent upon the circumstances that may be encountered at the time of project construction or periodic nourishment/maintenance.

5.2.23.1 Benthic Resources

The majority of unavoidable impacts are likely to be incurred on the benthic communities within the project area. Recommended measures to minimize the effects of dredging in the borrow areas include dredging in a manner as to avoid the creation of deep pits, exposing similar substrate in affected areas, alternating locations of periodic dredging, conducting dredging during months of lowest biological activity (when possible), and the utilization of a pipeline delivery system to help minimize turbidity. The implementation of a benthic-monitoring program concurrent with periodic maintenance activities would document project impacts and aid in avoiding impacts to sensitive areas during the periodic nourishment activities. Benthic monitoring would be useful in documenting the extent and rate of recovery of affected areas. Benthic community composition, abundance, diversity and substrate grain sizes would be important factors in determining recovery. If monitoring reveals unforeseen impacts on the benthic community in affected areas, appropriate adaptive management measures may be required to refine construction practices during periodic nourishment to minimize any adverse impacts.

5.2.23.2 Fisheries and Essential Fish Habitat

Adverse impacts to surf clam resources may be minimized by implementing a monitoring program for the subsequent periodic dredging in the borrow site. This monitoring may be necessary to determine if there is a commercially viable population of surf clams, and to locate areas within the proposed borrow site where surf clam densities are low enough to avoid the destruction of any significant stocks. Coordination with the appropriate resource agencies prior to periodic dredging for beach maintenance will be conducted to determine where surf clam monitoring is necessary. Impacts could be further minimized by allowing for the post-dredging conditions to contain suitable benthic substrate for recolonization and recruitment of benthic species necessary as a food source. Avoidance of permanently altering significant bottom structure or eliminating prominent sandy shoals (such as the “Seaside Lumps”) is a mitigative measure adopted for minimizing impacts to essential fish habitat identified within the project area. Dredging deep borrow pits could facilitate the deposition of fine grained sediments and would also result in poor oxygen circulation, which would be unsuitable for surf clam recruitment. It is expected that dredge cuts would be reworked by ocean currents and subsequent slumping would result in broad shallow pits. This is expected to allow for adequate circulation and make conditions suitable for surf clam recruitment and other benthic species. Another mitigative measure already adopted into the project was reducing the size originally proposed for Borrow Area A in order to avoid impacting surf clams. Since this reduction in size did not allow enough material for initial construction, the Corps expanded Borrow Area B where no adult surf clams were present in the initial surveys. Post-project monitoring would allow for the implementation of appropriate adaptive management measures for these sites during periodic nourishment if impacts are more adverse than anticipated. If monitoring shows that viable populations of surf clams exist within the offshore borrow areas, measures will be taken to minimize impacts to the clams. These measures may include further coordination with NJDEP to determine exact dredging locations and possibly avoiding areas all together.. All measures will be fully coordinated with the appropriate Federal, State and local agencies.

Adverse impacts on finfish and essential fish habitat are being avoided by the selection of borrow sites that do not have any prominent habitat features such as prominent relict shoals, hard bottoms or reefs. The borrow sites selected are, for the most part, composed of a sandy featureless bottom. Removal of sand in these areas is expected to result in broad shallow pits, which may actually increase the habitat heterogeneity slightly. It is especially important that the post dredge environment is suitable for benthic recruitment and recovery to minimize the initial indirect impact of the loss of prey organisms for a number of bottom feeders.

Adverse impacts to the nearshore cultural targets can be minimized by conducting further investigations to conclusively identify these targets and assess their cultural and fisheries significance. Since at least 7 of these targets could potentially provide some form of hard bottom fish habitat, monitoring of these structures will be undertaken. Any structures which are not currently covered with sand could be impacted over time as the construction template stabilizes into the design template to meet existing conditions. This is accomplished through the migration of sand from the placement site seaward. This migration of sand has the potential to cover part, or all of any hardened structure within the nearshore area. It is anticipated that these impacts would be minor and would most likely only result in an accumulation of sand around the bottom of any given structure. Further investigations are planned, however, in the PED phase of this project. Any structures deemed significant will be monitored during and after project implementation in order to assess any impacts. If impacts do occur, and fisheries habitat is found to be reduced, coordination with NJDEP and NMFS will be conducted in order to determine the appropriate course of action. This coordination could result in project modifications, in the form of adaptive management, or mitigation. Monitoring and coordination for these targets will also be conducted with NJSHPO in terms of potential cultural impacts.

5.2.23.3 Rare, Threatened and Endangered Species

The selected plan has the potential to adversely affect state and Federal listed threatened and endangered birds if they begin nesting in the project area again. In addition, the possibility of potential future impacts on the endangered plant, seabeach amaranth also exist if this species becomes established in the project area. Formal consultation with the USFWS is being undertaken in compliance with Section 7 of the Endangered Species Act to address these issues. A Biological Assessment has been prepared and was submitted to the USFWS for review and the development of a Biological Opinion document. In these documents, measures to mitigate the potential direct, indirect, and cumulative impacts to these species are addressed. Measures currently proposed by the Corps include identification and monitoring of nests/populations, imposing timing restrictions when possible, establishing protective buffer zones, adopting protective construction practices, and agreements with the State and local municipalities to further protect these resources through the management of their beach activities. Once the Biological Opinion has been received from the USFWS, the Manasquan Inlet project, as well as other Philadelphia District projects, will adopt the recommendations outlined in order to avoid and minimize impacts to these protected species.

Depending on the timing of the dredging and the type of dredge to be used, it may be necessary to implement mitigative measures to avoid adversely impacting threatened or endangered sea turtles. If a hopper dredge is used between June and November of any year, NMFS approved turtle/marine mammal monitors will be present on the dredge and would follow the procedures outlined in the NMFS Biological Opinion (NMFS, 1996).

5.2.23.4 Air Quality and Noise

Utilizing heavy machinery fitted with approved muffling apparatus that reduces noise, vibration, and emissions can reduce air quality and noise impacts. Construction activities can be scheduled for normal daytime hours to further reduce noise impacts to the surrounding communities.

5.2.24 Environmental Monitoring

Environmental monitoring is an integral component of the Engineering and Design (E&D) for initial construction and for each periodic nourishment cycle under the proposed plan. Three types of monitoring may be required: (1) benthic and surf clam investigations of the sand borrow areas; (2) monitoring pursuant to Section 7 of the Endangered Species Act for sea turtles, piping plovers, and seabeach amaranth; and (3) nearshore fisheries/cultural resources monitoring.

5.2.24.1 Benthic Monitoring

The objectives of the benthic monitoring are to document physical and biological changes of the impacted benthic environment in the sand borrow areas, and to provide updated data on un-impacted portions of the borrow area that would be dredged in subsequent nourishment cycles. As part of the benthic monitoring plan, the dredging contractor(s) for the initial construction and periodic nourishment cycles will be required to record the coordinates of the locations of where the dredging had occurred, and to measure the bathymetry of these areas before and after the dredging is completed. This would help avoid dredging deep pits, and to document the locations of where the impacts have occurred for follow-up investigations. The impacted areas would be subsequently studied within a period of 2-3 years following dredging to document any changes in the bathymetry, sediment composition, and benthic macroinvertebrate community since it was last dredged. This would be accomplished by conducting comparisons with the baseline bathymetric, sediment composition, and benthic macroinvertebrate data. In addition, monitoring for any significant concentrations of commercial surf clam stocks would be conducted in areas proposed for periodic nourishment within the confines of the established borrow site.

Specific details of the benthic monitoring would be developed and coordinated with the appropriate resource agencies prior to each periodic nourishment cycle. This allows the Corps and other resource agencies to remain flexible to better determine monitoring needs, data gaps, and appropriate methodologies. At a minimum, the benthic monitoring would be consistent with the baseline benthic studies and surf clam surveys.

Further investigations with regard to near shore cultural targets which have been identified are planned in the PED phase of this project. Any structures deemed significant by the COE and NJSHPO will be monitored during and after project implementation in order to assess any impacts. If impacts do occur, and fisheries habitat is found to be reduced, coordination with NJDEP and NMFS will be conducted in order to determine the appropriate course of action. This coordination could result in project modifications, in the form of adaptive management, or mitigation. Monitoring and coordination for these targets will also be conducted with NJSHPO in terms of potential cultural impacts

5.2.24.2 Surf Clam Monitoring

A surf clam survey will be performed during PED (prior to construction) to provide an update on the condition of commercial surf clam stocks prior to construction. This is necessary due to the potential variability of surf clam stocks that may occur over the period of time from the feasibility study to construction. If significant commercial stocks are identified within the sand borrow site locations, the District will coordinate with NJDEP Bureau of Shellfisheries todetermine the proper course of action.

Benthic macroinvertebrate and commercial surf clam monitoring will correspond with each periodic nourishment cycle. Benthic sampling will be conducted within previously impacted areas and reference areas to compare with baseline data to establish the rates of recovery or impacts on the benthic infauna community including recruitment of juvenile surf clams. Benthic sampling shall be conducted using the same methodology utilized by Versar (2000). This will also include physical measurements of the impacted areas: depth, sediment grain size analyses of surficial sediments, temperature, dissolved oxygen content, and salinity. Commercial surf clam sampling shall also be conducted using the methodology utilized by Versar (2000). Commercial surf clam tows will be conducted in the previously impacted areas as well as the portion of the borrow site intended for use prior to periodic nourishment. Results of the commercial surf clam survey will be provided to the NJDEP Bureau of Shellfisheries.

5.2.24.3 Rare, Threatened and Endangered Species Monitoring

As discussed previously in this document, there is a potential for the dredging required under the selected plan to have adverse impacts on several marine species (particularly sea turtles) protected under the Endangered Species Act. A Biological Opinion (NMFS, 1996) from the National Marine Fisheries Service (NMFS) was issued to the Philadelphia District as part of formal Section 7 Endangered Species Act consultation. The Biological Opinion requires that if a hopper dredge is used during the months of June through November, the Corps is required to have a trained, NMFS approved sea turtle/marine mammal observer on the dredge. The monitoring specifications were provided by NMFS in the Biological Opinion. It should be noted that sea turtle/marine mammal observers are required only when a hopper dredge is used between June and November. The use of other dredges (such as bucket or hydraulic dredges) during this period or the use of a hopper dredge outside of this period does not require an observer/monitoring.

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 any construction activities. If construction activities are to take place during the nesting and brood rearing season of the Federally 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. This would provide the basis for the establishment and identification (e.g., fencing and signing) of protective zones around identified piping plover nests and seasonal restrictions. This survey may also include the identification and location of State listed (endangered) species such as the least tern (*Sterna antillarum*) and black skimmer (*Rynchops niger*). Piping plover monitoring activities will also be conducted each nesting season following construction if plovers become re-established within the project area. This monitoring will be done in conjunction with NJDEP and be consistent with their yearly monitoring efforts. In order to minimize potential impacts not directly related to construction activities (i.e., recreation, maintenance, etc.), management plans will be developed by each community and implemented with respect to their practices for beach raking, emergency vehicles, pets, etc. These management plans will be developed in conjunction with NJDEP, Division of Fish and Wildlife and the USFWS.

As recommended by the USFWS, surveys will also be performed to identify and locate populations of the Federally listed (threatened) plant, seabeach amaranth (*Amaranthus pumilus*) within the project impact area prior to initial construction and periodic nourishment.

A programmatic Biological Assessment has been prepared to address formal Section 7 consultation for Federal beach replenishment actions along the New Jersey coast. Once the USFWS produces a Biological Opinion, the findings will be utilized to determine survey methods and construction management measures to avoid adverse impacts to Federally listed threatened and endangered species under the jurisdiction of the USFWS.

5.2.25 Environmental Statutes and Requirements

Preparation of the Draft Environmental Impact Statement (DEIS) has included coordination with appropriate Federal, State and local governmental agencies and the public. Section 401 Clean Water Act - Water Quality Certification has been requested from the New Jersey Department of Environmental Protection (NJDEP). A concurrence of Federal consistency with the New Jersey Coastal Zone Management Program, in accordance with Section 307(c) of the Coastal Zone Management Act, has been requested from NJDEP. A Section 404(b)(1) evaluation has been prepared and is included in Section 10. This evaluation concludes that the proposed action would not result in any significant adverse environmental impacts relative to the areas of concern under Section 404 of the Clean Water Act. In accordance with the Fish and Wildlife Coordination Act (FWCA), a planning aid letter was obtained and is provided in Appendix D of this report. A draft section 2(b) FWCA report has been requested from the U.S. Fish and Wildlife Service, and the comments will be addressed in the Final EIS. A draft Statement of Conformity is presented in Section 9 concluding that the proposed project would be in compliance with Section 176(c)(1) of the Clean Air Act Amendments of 1990.

Compliance will be met for all environmental quality statutes and environmental review requirements with distribution of the Final Environmental Impact Statement (FEIS) and with appropriate state approvals. Table 5-6 provides a list of Federal environmental quality statutes applicable to this statement, and their compliance status relative to the current stage of project review.

Table 5-6 Compliance with Environmental Quality Protection Statutes and other Environmental Review Requirements

Federal Statutes	Compliance of Proposed Plan
Archeological - Resources Protection Act of 1979, as amended	Partial
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	Full
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	Partial
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.
Partial 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. Project costs were initially calculated at a January 2000 price level. The final cost analysis was updated to a September 2000 price level.

5.3.1 Cost Contigencies

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. Fifteen 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 contruction due to future preconstruction erosion. Twelve 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 $58,223,000 (September 2000 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 5-7.

Table 5-7 Initial Construction Costs Summary (September 2000 Price Level)

Item	Quantity	Unit	Unit Price	Estimated Amount	Contingency	Total Cost
Lands and Damages						
Required Easements	1	Job	LS	$3,208,565	$481,985	$3,690,550
Total Lands and Damages				**$3,208,565**	**$481,985**	**$3,690,550**
Beach Construction						
Mobilization, Demobilization, and Preparatory Work	1	Job	LS	$1,815,206	$217,825	$2,033,031
Beach Fill	10,689,100	Cu Yds	$3.50*	$37,434,330	$5,615,150	$43,049,480
Remove Outfall Pipe	1	Job	LS	$8,244	$1,649	$9,893
Dune Grass	175	Acres	$10,787	$1,887,725	$377,545	$2,265,270
Sand Fence Parallel to Dune	133,410	LF	$4.12	$549,649	$109,930	$659,579
Sand Fence for Dune Crossovers	72,440	LF	$4.13	$299,177	$59,835	$359,013
Dune Crossover Decking	36,220	LF	$45.40	$1,644,388	$328,878	$1,973,266
Vehicle Crossovers	11	Ea	$2,885	$31,735	$6,347	$38,082
Total Beach Construction				**$43,670,455**	**$6,717,158**	**$50,387,613**
Planning, Engineering, and Design (P,E,&D) and Construction Management (S&A)						
Planning, Engineering, and Design (P,E,&D)	1	Job	LS	$2,103,565	$315,535	$2,419,100
Construction Management (S&A)	1	Job	LS	$1,500,000	$225,000	$1,725,000
Total P,E,&D and S&A				**$3,603,565**	**$540,535**	**$4,144,100**
Total Initial Construction Cost				**$50,482,585**	**$7,739,677**	**$58,222,262**
Rounded				**$50,483,000**	**$7,740,000**	**$58,223,000**

** Average unit price of beach fill for all cells, rounded to the nearest cent*

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 635 privately owned parcels with 366 ownerships, 128 commercially owned parcels with 67 ownerships, 73 publicly owned parcels with 6 ownerships. Detailed ownership data is provided in 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 $3,691,000 for project construction. More detailed information is provided in Appendix F of this report.

5.3.2.2 Public Access

Public access and adequate parking must be assured by the Non-Federal Sponsor as a prerequisite to the project. Existing public access and public parking vary by community. In Point Pleasant Beach, the beaches are either publicly owned or owned by private owners who operate beach badge systems that allow general public use of the beach from public street ends. In Bay Head, all oceanfront properties are privately owned; however, the Bay Head Improvement Association provides access points from public street ends and beaches are operated for public use through a beach badge system. The beach at Mantoloking is privately owned and the area between Herbert and Albertson Streets is operated by the Mantoloking Beach Association for public use through a beach badge system. The beach at Lavallette is publicly owned and controlled. Seaside Heights and Seaside Park beaches are either public or operated by private owners as commercial facilities open to the general public. Brick Township has two public beaches for swimming and one for fishing only, which are operated by a beach badge system. The beaches at Dover Township are publicly owned by the township which provides access points at all street ends and operates a beach badge system. Berkeley Township has public beaches operated by a beach badge system.

The Non-Federal Sponsor has confirmed that adequate public access will be provided including beach access every ¼ mile or closer with sufficient parking. Final details regarding public access provided by the Non-Federal sponsor will be completed in the PED phase of the study.

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.

Periodic nourishment construction cost is estimated to be $6,183,000 (Septermber 2000 price level) for each nourishment cycle. Estimated major replacement construction cost is $15,363,000 (September 2000 price level). Table 5-8 and Table 5-9 summarize periodic nourishment and major replacement costs.

Table 5-8 Periodic Nourishment Costs Summary (September 2000 Price Level)

Years, 4, 8, 12, 16, 20, 28, 32, 36, 40, 44, 48

Item	Quantity	Unit	Unit Price	Estimated Amount	Contingency	Total Cost
Lands and Damages						
Total Lands and Damages				**$0**	**$0**	**$0**
Beach Construction						
Mobilization, Demobilization, and Preparatory Work	1	Job	LS	$637,828	$76,539	$714,367
Beach Fill	960,900	Cu Yds	$4.10*	$3,942,690	$591,403	$4,534,093
Total Beach Construction				**$4,580,518**	**$667,943**	**$5,248,461**
Planning, Engineering, and Design (P,E,&D) and Construction Management (S&A)						
Planning, Engineering, and Design (P,E,&D)	1	Job	LS	$1,563,094	$234,464	$1,797,558
Construction Management (S&A)	1	Job	LS	$250,000	$37,500	$287,500
Total P,E,&D and S&A				**$1,813,094**	**$271,964**	**$2,085,058**
Total Construction Cost				**$6,393,612**	**$939,907**	**$7,333,519**
Rounded				**$6,394,000**	**$940,000**	**$7,334,000**

** Average unit price of beach fill for all cells, rounded to the nearest cent*

Table 5-9 Major Replacement Costs Summary (September 2000 Price Level)

Year 24

Item	Quantity	Unit	Unit Price	Estimated Amount	Contingency	Total Cost
Lands and Damages						
Total Lands and Damages				**$0**	**$0**	**$0**
Beach Construction						
Mobilization, Demobilization, and Preparatory Work	1	Job	LS	$637,828	$76,539	$714,367
Beach Fill	1,787,700	Cu Yds	$3.82*	$6,825,995	$1,023,899	$7,849,894
Dune Grass	175	Acres	$10,787	$1,887,725	$377,545	$2,265,270
Sand Fence Parallel to Dune	133,410	LF	$4.12	$549,649	$109,930	$659,579
Sand Fence for Dune Crossovers	72,440	LF	$4.13	$299,177	$59,835	$359,013
Dune Crossover Decking	36,220	LF	$45.40	$1,644,388	$328,878	$1,973,266
Vehicle Crossovers	11	Ea	$2,885	$31,735	$6,347	$38,082
Total Beach Construction				**$11,876,497**	**$1,982,973**	**$13,859,471**
Planning, Engineering, and Design (P,E,&D) and Construction Management (S&A)						
Planning, Engineering, and Design (P,E,&D)	1	Job	LS	$1,709,094	$256,364	$1,965,458
Construction Management (S&A)	1	Job	LS	$600,000	$90,000	$690,000
Total P,E,&D and S&A				**$2,309,094**	**$346,364**	**$2,655,458**
			Total Construction Cost	**$14,185,591**	**$2,329,338**	**$16,514,929**
			Rounded	**$14,186,000**	**$2,329,000**	**$16,515,000**

** Average unit price of beach fill for all cells rounded to the nearest cent*

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 (P,E,&D)

P,E,&D costs include preparation of plans and specifications, obtaining environmental and cultural resources permits (including 401 State Water Quality Certification and Coastal Zone Consistency), development and execution of the Project Cooperation Agreement (PCA), value engineering, engineering and design during construction, and project monitoring.

5.3.6 Project Monitoring (as part of Engineering and Design)

A beach fill project has a specific longevity and must undergo periodic inspection, maintenance and nourishment in order to preserve project functionality over the design life. The project monitoring plan will document beach fill performance and evaluate conditions within the borrow areas over the project life. 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, hydrographic surveys of borrow areas, sediment sampling of the beach and borrow areas, aerial photography, 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 project life. The monitoring program includes environmental and physical monitoring. A more detailed description of the physical monitoring program is provided in the Appendix A, Section 2. Average annual costs for project monitoring total $340,000 (September 2000 price level).

5.3.6.1 Project Performance Monitoring

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 longshore transport patterns of the beach fill. Approximately 70 profile lines along the project reach will be surveyed twice annually.

Inlet Hydrographic Surveys

Routine surveys of Barnegat Inlet and Manasquan Inlet are supported by other programs. This information will be used to analyze project impacts to adjacent inlets.

Borrow Site Hydrographic Surveys

Borrow site surveys will be performed before and after initial construction and nourishment and once midway through each nourishment cycle. Data will be used to monitor borrow area changes, evaluate infilling rates, and quantify availability of borrow material for future nourishment activities.

Aerial Photography

Aerial photography will be taken before and after initial construction and each nourishment, and twice annually between nourishment cycles along the project reach from Manasquan Inlet to Island Beach State Park. Aerial photography from Island Beach State Park to Barnegat Inlet is supported by other programs and will be incorporated in project analysis. Aerial photographs provide a complete record of shoreline response for regional-scale assessment of project performance and identification of project hot-spots.

Tide Data

Tide and storm water level information is available from existing tide gages at Sandy Hook and Atlantic City. A tide gage planned for installation at Barnegat Inlet through another program will also provide information for the project, and no additional data collection is required. 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

Environmental monitoring is an integral component of Engineering and Design (E&D) for initial construction and for each nourishment cycle under the proposed plan. Environmental monitoring provides a basis to assess whether the project has any impact (beneficial or adverse) on resources of concern. Monitoring data could be used as a basis to implement adaptive management measures to minimize adverse effects or to identify opportunities to enhance resources. Specific monitoring items are as follows:

Benthic/Surf clam Monitoring

Surf clam surveys will be performed prior to construction to provide an update on the condition of commercial surf clam stocks within designated borrow areas. This is necessary due to potential variability of surf clam stocks that may occur over the period of time from the feasibility study to construction. If significant commercial stocks are identified within the sand borrow areas, the District will coordinate with NJDEP Bureau of Shellfisheries to minimize impacts to the population during construction activities.

Benthic macroinvertebrate and commercial surf clam monitoring will correspond with each periodic nourishment cycle. Benthic sampling will be conducted prior to construction within previously dredged areas and reference areas to compare with baseline data to establish rates of recovery or impacts on the benthic fauna community. Benthic sampling shall be conducted using methodology employed by Versar, Inc. (2000). This will also include physical measurements of the impacted areas: depth, sediment grain size analyses of surficial sediments, temperature, dissolved oxygen content, and salinity. Commerical surf clam sampling shall also be conducted using the methodology employed by Versar, Inc. (2000). Commerical surf clam tows will be conducted in previously dredged areas and portions of the borrow areas intended for use prior to periodic nourishment. Results of the benthic and commercial surf clam surveys will be provided to the NJDEP Division of Fish and Wildlife.

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 indentify and locate the Federally listed (threatened) plant, seabeach amaranth (*Amaranthus pumilus*) within the project area prior to initial construction and subsequent nourishment cycles.

Currently, a programmatic Biological Assessment is being reviewed by the USFWS which addresses formal Section 7 consultation for Federal beach nourishment actions along the New Jersey coast. Once the USFWS produces a Biological Opinion, the findings will be utilized to determine survey methods and construction management measures to avoid adverse impacts to Federally listed threatened and endangered species under the jurisdiction of the USFWS.

Survey methods for State-listed species will be coordinated with USFWS and NJDEP Division of Fish, Game, and Wildlife.

Sea Turtle/Marine Mammal Monitoring

Monitoring for Federally protected sea turtles and marine mammals will be conducted if a hopper dredge is used for construction activities between June 15th and November 15th. This monitoring is required pursuant to the applicable Biological Opinion (Nation Marine Fisheries Service, 1996) to be in compliance with Section 7 of the Endangered Species Act.

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 USFWS Biological Opinion (pending) 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. Section 7 consultation with the USFWS will be reinitiated at least 135 days prior to any periodic nourishment.

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 Biological Opinion (pending). Section 7 consultation with the USFWS will be reinitiated at least 135 days prior to any periodic nourishment.

Cultural Resources Monitoring

An archeologist 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 offshore sand borrow areas. Any significant cultural resources that exist within the nearshore project area will be monitored to determine impacts from sand movement offshore from the construction template. Significance determination for 19 potential nearshore targets identified during this feasibility study will be completed during PED phase. Monitoring activities for any targets deemed significant will include a minimum of one survey annually, using a combination of side-scan and divers, to track any impacts migrating sand may have on identified resources from a cultural and fisheries aspect. 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 initial construction are estimated at $1,257,000 (September 2000 price level), including $1,024,000 in physical performance monitoring and $233,000 in environmental monitoring, of which $118,000 is for endangered species monitoring and surveys. Monitoring costs for periodic nourishment are estimated at $14,883,000 (September 2000 price level) including $13,026,000 in physical performance monitoring and $1,857,000 in environmental monitoring, of which $921,000 is for endangered species monitoring and surveys. Total average annual costs for all monitoring are estimated at $340,000 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 dune and berm template. Based on experience with similar projects, average annual maintenance costs were estimated at $100,000 (September 2000 price level).

5.3.8 Construction and Funding Schedule

The duration of initial construction was estimated at 15 months, including mobilization and demobilization. Construction duration for periodic nourishment was estimated at 4 months per cycle. Major replacement was estimated to take 8 months for construction. The Project Management Plan (PMP), which is a separate volume of this report, describes the schedule and activities for construction of the selected plan.

5.3.9 Interest During Construction

Interest during construction (IDC) was computed in accordance with Engineering Regulation 1105-2-100d. Construction costs were assumed evenly distributed over the construction period. P,E,&D and real estate acquisition were included in the calculations. Annualized IDC costs were calculated to be $178,000 (September 2000 price level).

Total estimated costs for the selected plan are presented in Table 5-10.

Table 5-10 Total Estimated Costs

Discount Rate	*6.375%*
Period of Economic Analysis	*50 years*
Price Level	*September 2000*
Base Year	*2004*
Initial Construction Cost (includes $1,257,000 of monitoring costs)	$58,223,000
Interest During Construction	$2,667,000
Total Periodic Nourishment (includes $15,147,000 of monitoring costs)	$96,920,000
Average Annual Costs (AAC)	
Initial Construction (includes $76,000 for monitoring)	$3,880,000
Periodic Nourishment (includes $264,000 in monitoring costs)	$1,774,000
Subtotal Average Annual Cost (includes $340,000 in monitoring costs)	$5,654,000
Interest During Construction (IDC)	$178,000
Operations and Maintenance (OMRR&R)	$100,000
Total Average Annual Cost	**$5,933,000**

5.4 Project Benefits

Total project benefits include storm damage reduction benefits, local costs foregone, and recreation benefits. All benefits were initially calculated at the January 2000 price level, and updated to the September 2000 price level in the final analysis.

5.4.1 National Economic Development (NED) Benefits

The selected plan was optimized based on storm damage reduction benefits to structures. Total NED benefits include storm damage reduction to structures, improved property, and infrastructure. Average annual NED benefits are $8,294,000 (September 2000 price level) as shown in Table 5-11.

Table 5-11 Total NED Benefits

Discount Rate	*6.375%*
Period of Economic Analysis	*50 years*
Price Level	*September 2000*
Base Year	*2004*
Average Annual Storm Damage Benefits	
Structures	$7,885,000
Improved Property	$150,000
Infrastructure	$259,000
Total Average Annual NED Benefits	**$8,294,000**

5.4.2 Local Costs Foregone

Local communities in the study area have been involved in maintaining the beach to provide a minimal level of storm protection, and their involvement is expected to continue. As discussed in Section 3.2.4, the economic analysis of without project conditions included the existing base condition (for years 1 through 15) and a future condition (beyond year 15). The base condition assumed that locals would maintain the existing dune line through year 15. The future condition assumed that when the shoreline erodes to a critical point, local interests would intervene to hold the shoreline at that critical point through beach nourishment and dune maintenance. Based on engineering assessment of erosion rates and records of past local involvement, it was estimated that local interests would place an average of 32,000 cu yd/yr in the project area to maintain the dune line in years 1 through 15. Beyond year 15, it was estimated that local interests would nourish the beach with 1,402,000 cu yd every 7 years to maintain the shoreline at a critical point. Total average annual local costs foregone based on these assumptions is $865,000 (September 2000 price level).

Additionally, the estimate of Local Costs Foregone is supported by historical expenditures obtained through interviews with Mantoloking, Bay Head, and Dover Township (Ortley Beach). Expenditures include augmenting the dune, dune grass plantings, sand fencing, and regular beach surveys. The following tables show, historically, the amount of money spent each year in these communities.

HISTORICAL LOCAL COSTS FOREGONE INFORMATION

Mantoloking Cell 8	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Dune Maintenance											
Emergency Retainer Contract					$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000	$ 2,000
Beach Fill	$ 100,000				$ 100,000						
Random Beach Placement (10,000 cy)	$ 40,000				$ 40,000	$ 40,000	$ 40,000	$ 40,000	$ 40,000	$ 40,000	$ 40,000
Dune Grass and Dune Fencing	$ 100,000				$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000	$ 100,000
10-year revetment study	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000	$ 30,000
Geobags					$ 50,000	$ 50,000	$ 50,000				
Beach Surveys/Shore Protection Plan					$ 10,000	$ 6,500	$ 9,000	$ 15,000	$ 12,500	$ 8,500	
Beach Post Storm Assess/Eng Services					$ 500	$ 200	$ 17,000	$ 18,500	$ 15,300	$ 24,800	$ 14,600
Annual Expenditure	**$ 270,000**	**$ 30,000**	**$ 30,000**	**$ 30,000**	**$ 332,500**	**$ 228,700**	**$ 248,000**	**$ 205,500**	**$ 199,800**	**$ 205,300**	**$ 186,600**

Dover Twp:Ortley Beach Cell 4	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Dune Maintenance									$ 60,000	$ 60,000	
Emergency Retainer Contract											
Beach Fill											
Random Beach Placement (10,000 cy)											
Dune Grass and Dune Fencing	$ 5,000		$ 5,000		$ 5,000		$ 5,000		$ 5,000		$ 5,000
10-year revetment study											
Geobags											
Beach Surveys/Shore Protection Plan											
Beach Post Storm Assess/Eng Services											
Annual Expenditure	**$ 5,000**	**$ -**	**$ 5,000**	**$ -**	**$ 5,000**	**$ -**	**$ 5,000**	**$ -**	**$ 65,000**	**$ 60,000**	**$ 5,000**

Bay Head Cell 9	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Dune Maintenance **	$ 60,000	$ 60,000	$ 60,000	$ 60,000	$ 60,000	$ 60,000	$ 60,000	$ 60,000	$ 60,000	$ 60,000	$ 60,000
Emergency Retainer Contract											
Beach Fill											
Random Beach Placement (10,000 cy)											
Dune Grass and Dune Fencing											
10-year revetment study											
Geobags											
Beach Surveys/Shore Protection Plan					$ 7,500	$ 7,500	$ 7,500	$ 7,500	$ 7,500	$ 7,500	$ 7,500
Beach Post Storm Assess/Eng Services											
Annual Expenditure	**$ 60,000**	**$ 60,000**	**$ 60,000**	**$ 60,000**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**	**$ 67,500**

**paid by property owners yearly: no total expenditures available. Assume similar to Dover Twp. Costs

Total Local Costs based on 3 of the 11 cells

1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
$ 335,000	**$ 90,000**	**$ 95,000**	**$ 90,000**	**$ 405,000**	**$ 296,200**	**$ 320,500**	**$ 273,000**	**$ 332,300**	**$ 332,800**	**$ 259,100**

Average Expenditure over the past 10 years for 3 of 11 cells **257,173**

Assume each of the "unknown" cells now spends 25% of the "known" cells for dune fencing, dune grass, and building the dune every year

Seaside Heights and Point Pleasant (Cells 3, 10,11) do not have dunes, therefore no dune maintenance

	1992	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**
Berkeley Twp. Cell 1	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293
Seaside Park Cell 2	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293
Dover Twp: Lavallette Cell 5	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293
Dover Twp: North Beach Cell 6	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293
Brick Twp.Cell 7	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293	$ 64,293
Additional Costs Per Year	**$ 321,465**	**$ 321,465**	**$ 321,465**	**$ 321,465**	**$ 321,465**	**$ 321,465**	**$ 321,465**	**$ 321,465**	**$ 321,465**	**$ 321,465**	**$ 321,465**

TOTAL	**$ 656,465**	**$ 411,465**	**$ 416,465**	**$ 411,465**	**$ 726,465**	**$ 617,665**	**$ 641,965**	**$ 594,465**	**$ 653,765**	**$ 654,265**	**$ 580,565**

Presently, the Borough of Mantoloking has the most severe erosion problem. In 1980, this community instituted a Dune Building Program, which included an annual budget. As indicated above, Mantoloking expenditures have increased over the past ten years. It can be expected that other communities will follow Mantoloking as their own situations worsen and the long-term erosion problems threaten their infrastructure and structures along the beachfront.

The State of New Jersey is committed to helping these communities in the future should the erosion become severe and the structures and infrastructure are threatened.

5.4.3 Recreation Benefits

The beaches in New Jersey are consistently the number one travel destination within the state. Tourist dollars contribute directly and indirectly to the regional economy. The number of visitors and the willingness to pay determines the value inherent to this type of recreation.

5.4.3.1 CVM Survey

A contingent valuation method survey was completed by the Forum for Policy Research & Public Services of Rutgers University (Camden) for the project sponsor, New Jersey Department of Environmental Protection and the U.S. Army Corps of Engineers to determine willingness to pay for existing beach and “enhanced” beach use. This was accomplished by sampling in the beach communities of Atlantic City, Ventnor, Margate and Longport. It consisted of 1,063 interviews of a random sample of recreational beach users. The interviews were conducted in person on the beach during the summer of 1994.The surveys were approved by the Corps in accordance with OMB regulations and are attached as an appendix to this report.

In these surveys beachgoers were asked to indicate how important different factors were in deciding whether to visit a New Jersey beach. The primary factors of consideration were the quality of the beach scenery, how well maintained the beach was, the width of the beach, the number of lifeguards, and how family-oriented the beach was.

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 it was very crowded (only 2 feet between towels). Further it was determined that crowding was not considered a very important issued to the majority of beachgoers. As might be expected, areas with more crowding tended to be frequented by people who like large numbers. People who do not like crowds 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 asked progressively higher or lower amounts until the amount they value the beach was determined. Using this method it was found that the average value of a day at the beach based on all beach users, including those who provided a "zero" value was $4.22.

The beachgoers were then asked how much more they were willing to pay if the beach were widened. While the majority of beach goers were unwilling to pay extra, 16% were willing to pay, on average, $2.92 more per visit. For an improved beach the average value was $4.69 for willingness to pay, an average increase of $0.47 for all beachgoers. For the purpose of this study this value was indexed to September 2000 price level, for a willingness to pay average value of $0.55.

5.4.3.2 Benefit Analysis

Benefits were not computed from increased capacity because, based on a daily seasonal average day, crowding was found not to be a significant factor. However, benefits do arise from an increase in the value of the recreational experience. Because there is no precise definition of an "enhanced" beach it was necessary to define the term as used in this project. An "enhanced beach" represents a beach with a design berm width which, at a minimum, exceeds the without project berm width by 10 ft. This increment was chosen based on the assumption that one additional person requires an additional 10-ft by 10-ft area of beach. It should be noted however that this additional space is not being used to calculate benefits for additional users, but simply as a means to define an enhanced beach for current beach users.

Recreation benefits were based on existing badge sales for all communities except Bay Head and Point Pleasant Beach. In these communities, sample beach counts were taken to estimate weekday and weekend use. However, these samples gave counts that were higher than the estimated total beach use when extrapolated for the beach season. Therefore recreation benefits were calculated for these communities by using an average of 100 square ft (10-ft by 10-ft) per beach user with only 80% of the area used for recreational purposes. It was estimated that the recreational season would consist of 68 days reflecting a 30% loss of days due to inclement weather.

The total number of estimated users for each community with an enhanced beach was then multiplied by the difference between the average without project value and the average with project value of $0.55. No benefits were claimed for increased use of the beach. All of the benefits are based on the increased value of the beach to the current beach user. Total average annual recreational benefits are $2,124,000 (September 2000 price level).

5.4.4 Benefit-Cost Summary

The total average annual costs and benefits for the selected plan are summarized in Table 5-12. The plan includes total average annual net benefits of $5,350,000 with a Benefit to Cost Ratio (BCR) of 1.9.

Table 5-12 Benefit-Cost Summary for Selected Plan

Discount Rate	*6.375%*
Period of Economic Analysis	*50 years*
Price Level	*September 2000*
Base Year	*2004*
Average Annual Benefits	
Storm Damage Reduction	$8,294,000
Local Costs Foregone	$865,000
Recreation	$2,124,000
Total Average Annual Benefits	**$11,283,000**
Average Annual Costs	
Initial Construction (includes $76,000 in monitoring costs)	$3,880,000
Periodic Nourishment (includes $264,000 in monitoring costs)	$1,774,000
Subtotal Average Annual Cost (includes $340,000 in monitoring costs)	$5,654,000
Interest During Construction (IDC)	$178,000
Operations and Maintenance (OMRR&R)	$100,000
Total Average Annual Cost	**$5,933,000**
Net Benefits	**$5,350,000**
Benefit to Cost Ratio (BCR)	**1.9**

5.5 Risk and Uncertainty Associated with Coastal Projects

In accordance with ER 1105-2-100, parameters and variables central to estimating benefits and costs were varied in a sensitivity analysis. Primary variables that were considered in the sensitivity analysis include the discount rate and replacement costs for structures and contents.

The sensitivity analysis on the discount rate was calculated based on the January 2000 price level with a discount rate of 6.625%. The discount rate was varied +/- 1 percentage point to estimate a range of net benefits for different economic conditions. The base year for the project is in 3 years. A review of the trend in discount rates shows that the rate has not increased by more than 1 percentage point in any 4-year period since 1974.

Benefits were also calculated assuming a +/- 10% variation in replacement costs for structures and contents, based on a September 2000 price level. This analysis provides a range of net benefits that reflects uncertainty in values related to the plan's primary storm damage reduction output. Results of the sensitivity analyses are displayed in Table 5-13 and Table 5-14.

Table 5-13 Benefit-Cost Sensitivity to Discount Rate

Period of Economic Analysis	*50 years*
Price Level	*January 2000*
Base Year	*2004*
+1 Percentage Point (7.625%)	
Average Annual Benefits	$11,116,000
Average Annual Costs	$6,833,000
Net Benefits	**$4,283,000**
Benefit to Cost Ratio (BCR)	**1.6**
-1 Percentage Point (5.625%)	
Average Annual Benefits	$11,415,000
Average Annual Costs	$5,253,000
Net Benefits	**$6,162,000**
Benefit to Cost Ratio (BCR)	**2.2**

Table 5-14 Benefit-Cost Sensitivity to Replacement Costs

Discount Rate	*6.375%*
Period of Economic Analysis	*50 years*
Price Level	*September 2000*
Base Year	*2004*
+10% Replacement Costs	
Average Annual Benefits	$12,071,000
Average Annual Costs	$5,933,000
Net Benefits	**$6,138,000**
Benefit to Cost Ratio (BCR)	**2.0**
-10% Replacement Costs	
Average Annual Benefits	$10,495,000
Average Annual Costs	$5,933,000
Net Benefits	**$4,562,000**
Benefit to Cost Ratio (BCR)	**1.8**

5.6 Cost Sharing and Local Cooperation

5.6.1 Cost Apportionment

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 of the Water Resources Development Act of 1986 (WRDA 1986) 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 for sand placement costs and 100% non-Federal for dune grass, sand fence, and crossover major replacement costs. Table 5-15 summarizes cost-sharing for the selected plan.

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 5-15 Cost Sharing for the Selected Plan

Project Feature	Federal Cost	%	Non-Federal Cost	%	Total Cost
Initial Construction	**$37,845,000**	**65%**	**$20,378,000**	**35%**	**$58,223,000**
LERRD Credit	*$0*	*0%*	*$3,691,000*	*100%*	*$3,691,000*
Initial Cash Contribution	*$37,845,000*	--	*$16,687,000*	--	*$54,532,000*
Periodic Nourishment[1] (50 Years)	**$45,813,000**	**47%**	**$51,107,000**	**53%**	**$96,920,000**
Sand Placement	*$45,813,000*	*50%*	*$45,813,000*	*50%*	*$91,626,000*
Dune Grass, Sand Fence, and Crossovers	*$0*	*0%*	*$5,294,000*	*100%*	*$5,294,000*
Ultimate Project Cost[2] (50 Years)	**$83,658,000**	**54%**	**$71,485,000**	**46%**	**$155,143,000**
LERRD Credit	*$0*	*0%*	*$3,691,000*	*100%*	*$3,691,000*
Ultimate Cash Contribution (50 Years)	*$83,658,000*	--	*$67,794,000*	--	*$151,452,000*

1. Includes dune grass, sand fence, and crossover major replacement costs which are 100% Non-Federal. Sand placement costs are cost-shared 50% Federal, 50% Non-Federal.
2. Ultimate Project Cost for cost-sharing purposes does not include OMRR&R costs estimated at $100,000 annually, which are the responsibility of the Non-Federal Sponsor.

Note: Interest During Construction (IDC) estimated at $2,667,000 is not included in the above cost estimates.

5.6.2 Sponsor Cooperation and Financial Capability

In accordance with Section 105(a)(1) of WRDA 1986, the Manasquan Inlet to Barnegat 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 Philadlephia District shore protection projects including Cape May Inlet to Lower Township, NJ and Great Egg Harbor Inlet to Peck Beach, Ocean City, NJ. A schedule of estimated Federal and non-Federal expenditures for project implementation is shown in Table 5-16.

Table 5-16 Schedule of Estimated Federal and Non-Federal Expenditures

WRDA 99 Cost-Sharing
September 2000 Price Level

FY	Federal	Non-Federal			Total
		Cash	LERRD	OMRR&R	
2001	$0	$0			$0
2002	$400,000	$133,000			$533,000
2003	$334,000	$111,000	$3,691,000		$4,136,000
2004	$29,133,000	$12,855,000			$41,988,000
2005	$7,515,000	$3,339,000		$100,000	$10,954,000
2006	$232,000	$125,000		$100,000	$457,000
2007	$231,000	$124,000		$100,000	$455,000
2008	$3,271,000	$3,271,000		$100,000	$6,642,000
2009	$132,000	$132,000		$100,000	$364,000
2010	$132,000	$132,000		$100,000	$364,000
2011	$132,000	$132,000		$100,000	$364,000
2012	$3,271,000	$3,271,000		$100,000	$6,642,000
2013	$132,000	$132,000		$100,000	$364,000
2014	$132,000	$132,000		$100,000	$364,000
2015	$132,000	$132,000		$100,000	$364,000
2016	$3,271,000	$3,271,000		$100,000	$6,642,000
2017	$132,000	$132,000		$100,000	$364,000
2018	$132,000	$132,000		$100,000	$364,000
2019	$132,000	$132,000		$100,000	$364,000
2020	$3,271,000	$3,271,000		$100,000	$6,642,000
2021	$132,000	$132,000		$100,000	$364,000
2022	$132,000	$132,000		$100,000	$364,000
2023	$132,000	$132,000		$100,000	$364,000
2024	$3,271,000	$3,271,000		$100,000	$6,642,000
2025	$132,000	$132,000		$100,000	$364,000
2026	$132,000	$132,000		$100,000	$364,000
2027	$132,000	$132,000		$100,000	$364,000
2028	$5,214,000	$10,508,000		$100,000	$15,822,000
2029	$132,000	$132,000		$100,000	$364,000
2030	$132,000	$132,000		$100,000	$364,000
2031	$132,000	$132,000		$100,000	$364,000
2032	$3,271,000	$3,271,000		$100,000	$6,642,000
2033	$132,000	$132,000		$100,000	$364,000
2034	$132,000	$132,000		$100,000	$364,000
2035	$132,000	$132,000		$100,000	$364,000
2036	$3,271,000	$3,271,000		$100,000	$6,642,000
2037	$132,000	$132,000		$100,000	$364,000
2038	$132,000	$132,000		$100,000	$364,000
2039	$132,000	$132,000		$100,000	$364,000
2040	$3,271,000	$3,271,000		$100,000	$6,642,000
2041	$132,000	$132,000		$100,000	$364,000
2042	$132,000	$132,000		$100,000	$364,000
2043	$132,000	$132,000		$100,000	$364,000

FY	Federal	Non-Federal			Total
		Cash	LERRD	OMRR&R	
2044	$3,271,000	$3,271,000		$100,000	$6,642,000
2045	$132,000	$132,000		$100,000	$364,000
2046	$132,000	$132,000		$100,000	$364,000
2047	$132,000	$132,000		$100,000	$364,000
2048	$3,271,000	$3,271,000		$100,000	$6,642,000
2049	$132,000	$132,000		$100,000	$364,000
2050	$132,000	$132,000		$100,000	$364,000
2051	$132,000	$132,000		$100,000	$364,000
2052	$3,271,000	$3,271,000		$100,000	$6,642,000
2053	$132,000	$132,000		$100,000	$364,000
2054	$132,000	$132,000		$100,000	$364,000
Total	**$83,660,000**	**$67,796,000**	**$3,691,000**	**$5,000,000**	**$160,147,000**

5.6.3 Project Cooperation Agreement

A fully coordinated Project Cooperation Agreement (PCA) will be prepared subsequent to 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, 25 percent 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;

c. 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;

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 case the Non-Federal Sponsor shall perform such investigations in accordance with such written 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 granting agency verifies in writing that the expenditure of such funds is authorized.

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.

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6 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 the Manasquan Inlet south jetty southward to Island Beach State Park. This plan includes periodic nourishment every 4 years. Specific project details are presented in Section 5.1 of this report.

Initial construction costs total $58,223,000 (September 2000 price level) and would be cost-shared 65% Federal and 35% non-Federal while periodic nourishment would be cost-shared 50% Federal and 50% non-Federal. Detailed cost-sharing information can be found in Section 5.6 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

As a requirement in completing the feasibility study, a public notice shall be issued to inform all interested parties of the plan selected herein. Because the design of the recommended plan is not technically complex and is essentially complete, the Preconstruction, Engineering, and Design (PED) phase will consist primarily of the preparation of Plans and Specifications (P&S). Additional borrow area investigations and environmental coordination will be performed during PED to further delineate alternate borrow sources for future nourishment cycles as discussed in Section 2.4.8 of this report.

6.1.2 Additional Tasks

Following execution of a design cost sharing agreement, PED activities will be cost shared on a 75% Federal and 25% non-Federal basis. In the event PED efforts lead to construction, further reimbursement by the Non-Federal Sponsor would be made as a project cost shared item based on a 65% Federal and 35% non-Federal cost share for initial construction.

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 $5,350,000 and a benefit-to-cost ratio of 1.9.

Initial Project Cost

The total initial project cost of construction is estimated at $58,223,000 (September 2000 price level). The Federal share of this first cost is $37,845,000 and the non-Federal share is $20,378,000. Lands, Easements, Rights-of-Ways, Relocations, and Dredged Material Disposal Areas (LERRD) costs are $3,691,000 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 (year 0). Over the 50-year period of Federal participation, total periodic nourishment is estimated to be $96,920,000 (September 2000 price level) and includes E&D monitoring during construction.

Ultimate Project Cost

The ultimate cost of construction which includes initial construction, project monitoring, and fifty years of periodic nourishment is estimated to be $155,143,000 (September 2000 price level), cost-shared 54% Federal and 46% non-Federal based on WRDA 1999 cost-sharing. All costs include planning, engineering, and design. Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) is a non-Federal responsibility and not included in the cost share.

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 tranmittal 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.

Date	Timothy Brown Lieutenant Colonel, Corps of Engineers District Engineer

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7 LIST OF PREPARERS

The following individuals were primarily responsible for preparation and technical support for the Feasibility Study and Integrated Environmental Impact Statement.

Individual	**Responsibility**
Christine Bethke B.S. Economics 7 years planning experience	Economic Analysis
Beth Brandreth B.S. Marine Biology 10 years EA and EIS preparation and review experience	Scoping, EIS Preparation and Coordination
Gigi Geissele, P.E. B.S. Civil Engineering 10 years project design experience	Civil Works Design Engineering
Dan Kelly, P.E. B.S. Civil Engineering M.S. Civil Engineering 10 years geotechnical engineering experience	Borrow Area and Beach Fill Analysis
Robert Lowinski B.S. Civil Engineering M.S. Civil Engineering 6 years coastal engineering experience	Hydraulics/Coastal Engineering
Mike Swanda B.A. Anthropology 26 years cultural resources experience	Scoping, EIS Preparation (Cultural Resources)
William Welk B.S. Civil Engineering M.S. Mechanical Engineering 7 years cost engineering experience	Project Cost Estimate
Colleen Rourke B.S. Environmental Resource Management Master in Business Administration M.S. Information Science 4 years project management experience	Project Manager

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8 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. A final Section 2(b) report will be prepared by the USFWS following the review of this draft document. This report will provide official USFWS comments on the project pursuant to the Fish and Wildlife Coordination Act.

A copy of the Final Manasquan Inlet to Barnegat Inlet Feasibility Study and Integrated Environmental Impact Statement is being provided to the following individuals/agencies for review in addition to the interested public that requested copies.

8.1 Federal Level

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9 CLEAN AIR ACT STATEMENT OF CONFORMITY

CLEAN AIR ACT
STATEMENT OF CONFORMITY
MANASQUAN INLET TO BARNEGAT INLET FEASIBILITY STUDY
OCEAN 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. No air quality comments from the New Jersey Department of Environmental Protection were received during coordination of the final feasibility report and integrated environmental impact statement. The proposed project would comply with Section 176 (c)(1) of the Clean Air Act Amendments of 1990.

____
Date

____

Timothy Brown
Lieutenant Colonel, Corps of Engineers
District Engineer

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10 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 Manasquan Inlet to Barnegat Inlet and includes the communities of Point Pleasant Beach Borough, Bay Head Borough, Mantoloking Borough, South Mantoloking Beach, Normandy Beach, Chadwick, Ocean Beach, Lavallette Borough, Ortley Beach, Seaside Heights Borough, Seaside Park Borough, South Seaside Park, and Island Beach State Park. The specific areas involved are the beaches and nearshore zones within this area. Two offshore sand borrow sites are proposed.

B. General Description

The purpose of the project is hurricane and storm damage reduction through the placement of dredged material (sand) obtained from the offshore borrow sites on the beachfront in the form of a berm and dune. The plan extends approximately 14 miles from the northern boundary of Island Beach State Park, at Berkeley Township, northward to the Manasquan Inlet south jetty. Specifically, the plan includes a dune with crest elevation at +22-ft NAVD fronted by a 75-ft wide berm at elevation +8.5 ft NAVD; except at Seaside Heights and northern Point Pleasant Beach where the plan includes an +18-ft NAVD dune fronted by a 100-ft wide berm at +8.5 ft NAVD (Seaside Heights) and elevation +11.5 ft NAVD (Point Pleasant Beach). 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 10.7 million cy, which includes overfill factor and advanced nourishment. Periodic nourishment of approximately 960,832 cy is scheduled to occur every 4 years. Material for the northern portion of the project will be taken from Borrow Area B, while material for the southern portion of the project will be taken from Borrow Area A.

This plan was chosen because it provides the maximum net excess benefits over costs based on storm damage reduction. Details of the selected plan are shown in Figure 5-3 through Figure 5-27.

C. Authority and Purpose

The Manasquan Inlet to Barnegat 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.

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 beachfill material required for the project is estimated to be approximately 10,689,052 cy, which includes overfill factor and advanced nourishment. Periodic nourishment of 960,832 cy is scheduled to occur every 4 years. Material would be taken from Borrow Areas A and B. It is anticipated that during initial construction, approximately 6.3 million cy of material will be removed from Borrow Area A and 4.4 million will be removed from Borrow Area B. For each nourishment cycle, approximately 620,000 cy will come from Borrow Area A and 340,000 cy from Borrow Area B.

3. Source of Material. The proposed source of the beachfill material for the northern portion of the project is Borrow Area B which is a relatively flat area approximately 1- 2 miles offshore of Mantoloking. The size of the borrow area is approximately 360 acres. The existing depth within the borrow area is approximately –65 feet MLW. The second borrow area, which will be used as a sand source for the southern end of the project, is a relatively flat area approximately 2 – 2 ½ miles offshore of Island Beach State Park. The size of the borrow area is approximately 460 acres. The existing depth within the borrow area is approximately –69 feet MLW.

E. Description of the Proposed Discharge Site

1. Location. The proposed discharge locations are depicted in Figure 5-3 through Figure 5-27.

2. Size. The proposed plan will result in 175 acres of dune habitat and 127 acres of berm habitat above MHW. Below MHW, sand will cover approximately 214 acres of 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 Manasquan Inlet to the northern edge of Island Beach State Park. 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 subtidal nearshore habitats and marine open water.

5. Timing and Duration of Discharge:

There are no seasonal restrictions for beachfill 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 (April – August). For initial construction, the discharge would be continuous for approximately **15 months**. Periodic nourishment would occur over a duration of approximately **4 months** every **4 years** during the 50-year period of Federal participation. Estimated year of initial construction is 2004.

F. Description of Discharge Method

A hydraulic dredge or hopper dredge would be used to excavate the sandy material from the borrow areas. The material would be transported using a barge with a pump-out and/or pipeline delivery system to the beachfill placement site. Subsequently, final grading would be accomplished using standard construction equipment such as bulldozers.

II. FACTUAL DETERMINATION

A. Physical Substrate Determinations

1. **Substrate Elevation and Slope.** For the entire project area except Seaside Heights and northern Point Pleasant Beach, the final proposed elevation of the beach substrate after fill placement would be +8.5 feet NAVD at the top of the berm and +22 feet 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. For Seaside Heights and northern Point Pleasant Beach, the final proposed elevation will be +8.5 ft NAVD (Seaside Heights) and elevation +11.5 ft NAVD (Point Pleasant Beach) at the top of the berm and +18 feet at the crest of the dune. The proposed foreshore profile would be 1V:10H.

2. **Sediment Type.** The sediment type involved would be sandy beachfill material (consists 90% or greater of fine, medium and coarse sands and gravels) obtained from offshore sources.

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 redeposited within subtidal nearshore waters.

4. **Physical Effects on Benthos.** The proposed construction and discharges would result in initial burial of the existing beach and nearshore 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 sites would result in the removal of the benthic community from the substrate, however, similar conditions following dredging are expected to allow for recolonization of benthos within offshore borrow areas.

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. Offshore borrow areas would result in deepening the existing flat bottom by nine to thirteen feet.

6. **Actions Taken to Minimize Impacts.** Actions taken to minimize impacts include selection of fill material that is similar in nature to the pre-existing substrate, and the avoidance of the creation of deep pits from sand extraction from the borrow site. Prominent shoal or "lump" areas would be avoided to maintain topographic structure of the offshore bottom. Also, standard construction practices to minimize turbidity and erosion would be employed at discharge sites.

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 nearshore where the existing circulation pattern and flow would be offset seaward the width of the beachfill placement. Minor circulation differences are expected within the immediate vicinity of the borrow areas.

   b. **Velocity** - No effects on tidal velocity and longshore 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 Manasquan Inlet is reported to be 3.81 feet in the Tide Tables published annually by the National Oceanic and Atmospheric Administration (NOAA). The spring tide range is reported as 4.59 feet. 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 borrow area would be excavated in a manner to approximate natural slopes and contours to ensure normal water exchange and circulation. Utilization of sand from a clean, oceanic environment and its excavation with either a hopper or hydraulic dredge with a pipeline delivery system would also minimize water chemistry impacts. Also, shoal or "lump" areas would be avoided to maintain topographic structure of the offshore bottom.

C. Suspended Particulate/Turbidity Determinations

1. **Expected Changes in Suspended Particulates and Turbidity Levels in the Vicinity of the Disposal (Beachfill 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 beachfill 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 areas. Therefore, beachfill 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. Also, shoal or “lump” areas would be avoided to maintain bathymetric structure of the offshore bottom to minimize impacts on Essential Fish Habitat.

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/beachfill 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 complete removal of the benthic community within the borrow area and burial of benthos within the discharge (beachfill) 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 the discharge (beachfill placement) area through horizontal and in some cases vertical migrations of benthos. Recolonization within the borrow area is expected to occur within a few months to a few years via pelagic larval recruitment and

horizontal migrations. Some minor losses of benthos associated with rocky intertidal habitat are expected, as portions of rock groins would become partially covered with beachfill material.

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 beachfill placement site or removal at the dredging site. This is expected to be short-term as the beachfill placement sites could become recolonized by benthos within a few days or weeks and the borrow areas within a few months 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 beachfill 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 being addressed through a programmatic Biological Assessment 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 may be migrating through the sand borrow area depending on the time of year. Sea turtles have been known to become entrained and subsequently destroyed by suction hopper dredges. Use of a hopper dredge during a time of high likely presence (June – November) in the area could potentially entrain and destroy a sea turtle(s). Sea turtle monitors would be present in accordance with the Biological Opinion (NMFS, 1996) if a hopper dredge is required from (June – November).

7. **Other Wildlife** - The proposed plan would not significantly affect other wildlife.

8. **Actions to minimize impacts** - Impacts to benthic resources can be minimized at the borrow area by dredging in a manner as to avoid the creation of deep pits and allow disturbed areas in the borrow site to recover without future disturbance from dredging. Depending on the timing of the dredging and the type of dredge to be used, it may be necessary to implement mitigative measures to avoid adversely impacting threatened or endangered sea turtles. If a hopper dredge is used between June and November, measures to avoid or minimize impacts to these species may include utilizing NMFS approved turtle monitors, as required in formal Section 7 Endangered Species Act coordination. It is not necessary to implement this measure if dredging is conducted within the winter months when turtle activity is lowest in this area or if a hopper dredge is not required. Also, shoal or "lump" areas would be avoided to maintain topographic structure of the offshore bottom to minimize impacts on Essential Fish Habitat.

F. Proposed Disposal/Discharge (Beachfill Placement) Site Determinations

1. **Mixing Zone Determination**

   a. **Depth of water** - 0 to-20 feet mean low water
   b. **Current velocity** - Generally less than 3 feet 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 780 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** - Prior to construction, a Section 401 Water Quality Certificate and consistency concurrence with the State's Coastal Zone Management Program will be obtained from the State of New Jersey.

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 surfclam stocks within the nearshore placement sites and within the borrow areas. 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, state areas, specifically Island Beach State Park, may be temporarily affected by construction activities occurring adjacent to the Park boundaries. Since only a small portion of the construction will occur near the Park, the effects are expected to be minimal.

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. 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. Dredging would be conducted in a manner to avoid adversely impacting prominent shoals or "lumps" as essential fish habitat; therefore, the project would not contribute to cumulative losses of this resource.

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 Alternatives 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 Section 4 of the Feasibility Report and Integrated Environmental Impact Statement of which this 404(b)(1) analysis is a part. Several alternatives including No Action, Permanent Evacuation and Regulation of Future Development would likely have less adverse impacts on the aquatic ecosystem. However, these alternatives 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 these sources were 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 will be obtained from the New Jersey Department of Environmental Protection prior to initiation of discharges associated with this project.

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 upon completion of the F&WS's review of the District's Biological Assessment and preparation of a Biological Opinion addressing impacts and mitigative measures for piping plovers and seabeach amaranth. Formal Section 7 coordination procedures have been completed with respect to the use of hopper dredges during June – November and the potential effects on threatened and endangered sea turtles. Procedures with respect to the Biological Opinion (NMFS, 1996) will be followed to be in compliance with the Endangered Species Act.

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 is 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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11 REFERENCES

Abel, C.E., Tracy, B.A., Vincent, C.L., Jensen, R.E. (1989). "Hurricane Hindcast Methodology and Wave Statistics for Atlantic and Gulf Hurricanes from 1956 - 1975," WIS Report 19(AD A207 849), U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Barth, M.C. and Titus J.G. (eds). (1984). "Greenhouse Effect and Sea Level Rise: A Challenge for This Generation," New York: Van Nostrand Reinhold.

Brooks, R.M. and Brandon, W.A. (1995). "Hindcast Wave Information for the U.S. Atlantic Coast: Update 1976-1993 with Hurricanes," WIS Report 33(AD A298 660), U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS 39180-6199.

Canter, Larry W. (1993). "Environmental Impact Assessment (Draft Copy of Revised Edition – March 1993)," McGraw-Hill Book Company.

Corson, W.D., Resio, D.T., Brooks, R.M., Ebersole, B.A., Jensen, R.E., Ragsdale, D.S., and Tracy, B.A. (1981). "Atlantic Coast Hindcast Deepwater Significant Wave Information," WIS Report 2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Corson, W.D., Resio, D.T., Brooks, R.M., Ebersole, B.A., Jensen, R.E., Ragsdale, D.S., and Tracy, B.A. (1982). "Atlantic Coast Hindcast, Phase II: Wave Information," WIS Report 6, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Cutler, J.K. and Mahadevan, S. (1982). "Long-Term Effects of Beach Nourishment on the Benthic Fauna of Panama City Beach, Florida," MR 82-2, U.S. Army Corps of Engineers Coastal Engineering Research Center.

Dolan Research, Inc. (2001). "Phase I Submerged and Shoreline Cultural Resources Investigations, Manasquan Inlet to Barnegat Inlet, Ocean County, New Jersey" Prepared for USACE, Philadelphia District.

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.

Farrell, S. C., Speer, B., Hafner, S., Lepp, T., and Ebersold, S.E. (1997). "New Jersey Beach Profile Network, Analysis of the 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.

Fay, Clemon W., Richard J. Neves, and Garland Pardue. (1983). "Species Profiles: Life Histories and Environmental Requirements of Coastal Fishes and Invertebrates (Mid-Atlantic) - Surf Clam," U.S. Fish and Wildlife Service Report FWS/OBS-82/11.13 or U.S. Army Corps of Engineers Report TR EL-82-4.

FEMA (1989). "Guidelines and Specifications for Wave Elevation Determination and V Zone Mapping," Federal Emergency Management Agency, Federal Insurance Administration, Washington, DC.

Gebert, J.A. and Hemsley, J.M. (1991). "Monitoring of Jetty Rehabilitation at Manasquan Inlet, New Jersey," MP CERC-91-8, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Grosslein, M.D. and T.R. Azarovitz. (1982). "Fish Distribution," MESA New York Bight Atlas Monograph 15, New York Sea Grant Institute, Albany, NY.

Hammer, R.M. (2000). "Environmental Survey of Potential Sand Resource Areas: Offshore New Jersey," Draft report prepared for Minerals Management Service.

Hicks, S.D., and Hickman, L.E. (1988). "United States Sea Level Variations through 1986," Shore and Beach (July), Journal of the American Shore and Beach Preservation Association, Berkeley, CA.

House Document No. 208 (1959). "Shore of New Jersey-Barnegat Inlet to Cape May Canal, Beach Erosion Control Study", 86th Congress, 1st Session, Washington, DC, August 3, 1959.

House Document No. 361. "Shore of New Jersey from Sandy Hook to Barnegat Inlet, Beach Erosion Control Study", 84th Congress, 1957.

Hubertz, J.M. (1992). "A User's Guide to the WIS Wave Model, Version 2.0," WIS Report 27, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Hubertz, J.M., Brooks, R.M., Brandon, W.A., Tracy, B.A. (1993). "Hindcast Wave Information for the U.S. Atlantic Coast," WIS Report 30, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Hunter Research, Inc. (1993). "A Phase 1A Cultural Resources Investigation of the Manasquan River Basin, Monmouth and Ocean Counties, New Jersey."

Hunter Research, Inc. (1997). " Phase 1A Cultural Resources Investigations, Manasquan Inlet to Barnegat Inlet, Ocean County, New Jersey."

Hurme, A.K. and Pullen E.J. (1988). "Biological Effects of Marine Sand Mining and Fill Placement for Beach Replenishment: Lessons for Other Uses," Marine Mining, Volume 7, pp.123-136.

Jenkins, C. D. (1999). "Piping Plover Threat Assessment and Management," Project No. E-1-23. Job 2-C.

Jensen, R.E. (1983). "Atlantic Coast Hindcast, Shallow-Water, Significant Wave Information," WIS Report 9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Killam Associates. (1994). "Beach and Dune System Audit for Borough of Mantoloking,Ocean County, New Jersey."

Larson and N.C. Kraus (1989). "SBEACH: Numerical Model for Simulating Storm-Induced Beach Change, Report 1: Empirical Foundation and Model Development," TR CERC-89-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Long, D. and W. Figley. (1984). "New Jersey's Recreational and Commercial Ocean Fishing Grounds," New Jersey Department of Environmental Protection, Division of Fish, Game and Wildlife, Marine Fisheries Administration, Bureau of Marine Fisheries.

Louis Berger Group, Inc. (1999). "Environmental Report: Use of Federal Offshore Sand Resources for Beach and Coastal Restoration in New Jersey, Maryland, Delaware, and Virginia," prepared for The U.S. Department of the Interior – Minerals Management Service – Office of International Activities and Marine Minerals (INTERMAR) under Contract No. 1435-01-98-RC-30820.

Maurer, D., R.T. Keck, J. C. Tinsman, W.A. Leathem, C.A. Wethe, M. Huntzinger, C. Lord, T.M. Church. (1978). "Vertical Migration of Benthos in Simulated Dredged Material Overburdens," Vol 1: Marine Benthos, Technical Report D-78-35, U.S. Army Engineer Waterways Experiment Station, Vicksburg MS.

Murawski, W.S. (1969). "A Study of Submerged Dredge Holes in New Jersey Estuaries with Respect to Their Fitness as Finfish Habitat," Miscellaneous Report No. 2M, Division of Fish and Game, New Jersey Department of Conservation and Economic Development.National Research Council (NRC) (1987). "Responding to Changes in Sea Level," Marine Board, National Research Council, National Academy Press, Washington, DC.

National Marine Fisheries Service (NMFS), Northeast Region. (1996). "Endangered Species Act Section 7 Consultation: Biological Opinion for Dredging Activities Within the Philadelphia District," November 26, 1996.

National Research Council. (1995). "Beach Nourishment and Protection," Academic Press: Washington, D.C.

New Jersey Bureau of Fisheries. (1979). "Studies of the Back Bay Systems of Atlantic County – Final Report for Project 3-223-R-3," Nacote Creek Research Station, Port Republic, NJ.

New Jersey Department of Environmental Protection (NJDEP). (1988-1991). "Reevaluation Shellfish Growing Areas 49-51," Bureau of Marine Water Classification and Analysis.

New Jersey Department of Environmental Protection (NJDEP). (1995). New Jersey Bureau of Shellfisheries, "Annual Surf Clam Inventory Report."

New Jersey Department of Environmental Protection (NJDEP). (1996). "Shellfish Growing Water Classification Charts," Bureau of Marine Water Classification and Analysis.

New Jersey Department of Environmental Protection (NJDEP). (1997a). "Shellfish Growing Water Classification Annual Report –1996 Data," prepared by Bonnie J. Zimmer, Ph.D. Bureau of Marine Water Monitoring.

New Jersey Department of Environmental Protection (NJDEP). (1997b). "Inventory of New Jersey's Surf clam (*Spisula solidissima*) Resources," prepared by New Jersey Department of Environmental Protection for National Oceanic and Atmospheric Administration.

New Jersey Department of Environmental Protection (NJDEP). (1997c). "The Management and Regulation of Dredging Activities and Dredged Material in New Jersey's Tidal Waters."

New Jersey Department of Environmental Protection (NJDEP). (1998). "Blue Claws: Crabbing in New Jersey," prepared by P.G. Scarlett, W. Figley, and J. Dobarro. Internet address: http://www.state.nj.us/dep/fgw/blueclaw.htm.

New Jersey Department of Environmental Protection (NJDEP). (1999). "1998 Air Quality Report," Bureau of Air Monitoring.

NOAA. (1999). "Essential Fish Habitat Designations Within the Northeast Region (Maine to Virginia) – Working Copy," National Marine Fisheries Service. Gloucester, MA.

Parr, T., E. Diener and S. Lacy. (1978). "Effects of Beach Replenishment on the Nearshore Sand Fauna at Imperial Beach, California," MR 78-4, U.S. Army Corps of Engineers Coastal Engineering Research Center.

Reilly, Francis J. Jr. and Bellis, Vincent J. (1983). "The Ecological Impact of Beach Nourishment with Dredged Materials on the Intertidal Zone at Bogue Banks, North Carolina," U. S. Army Corps of Engineers Coastal Engineering Research Center.

Ropes, J.W. (1980). "Biological and Fisheries Data on the Atlantic Surf Clam, *Spisula solidissima*," U.S. Dep. Comm, NOAA, NMFS, Northeast Fisheries Center Tech. Ser. Rep. No. 24.

Rosati, J.D., Wise, R.A., Kraus, N.C., and Larson, M. (1993). "SBEACH: Numerical Model for Simulating Storm-Induced Beach Change, Report 3: User's Manual," IR CERC-93-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Saloman, C. H. (1974). “Physical, Chemical, and Biological Characteristics of Nearshore Zone of Sand Key, Florida, Prior to Beach Restoration,” U.S. Army Corps of Engineers Coastal Engineering Research Center, Fort Belvoir, VA, Final Report, unpublished.

Saloman, C.H., Naughton, S.P., and Taylor, J.L. (1982). “Benthic Community Response to Dredging Borrow Pits, Panama City Beach, Florida,” U.S. Army Corps of Engineers Coastal Engineering Research Center.

Scott, L.C. and C. Bruce. (1999). “An Evaluation and Comparison of Benthic Community Assemblages Within Potential Offshore Sand Borrow Sites and Nearshore Placement Sites for the Great Egg Harbor Inlet to Townsends Inlet, New Jersey Feasibility Study,” prepared by Versar, Inc. for U.S. Army Corps of Engineers, Philadelphia District under DACW61-95-D-0011 (0046).

Scott, L.C. and F. P. Wirth, III. (2000). “An Evaluation and Comparison of Benthic Community Assemblages within New Potential Sand Borrow Sites for Great Egg Harbor Inlet to Townsends Inlet, NJ,” prepared by Versar, Inc. for U.S. Army Corps of Engineers, Philadelphia District under DACW61-95-D-0011 (0048).

Smardon, R.C., Palmer, J.F., and Felleman, J.P. (1986). “Foundations for Visual Project Analysis,” John Wiley and Sons, Inc. New York, NY.

USACE (1984). “Shore Protection Manual,” U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

USACE, New York District. (1954). “Atlantic Coast of New Jersey, Sandy Hook to Barnegat Inlet,” Beach Erosion Control Report on Cooperative Study (Survey), serial No. 38.

USACE, Philadelphia District. (1974). “New Jersey Coastal Inlets and Beaches, - Interim Report on Barnegat Inlet To Longport,” September 1974.

USACE, Philadelphia District. (1990). “New Jersey Shore Protection Study - Report of Limited Reconnaissance Study,” September 1990.

USACE, Philadelphia District. (1995). “Seaside Park, New Jersey Beach Erosion Control Reconnaissance Study,” June 1995.

USACE, Philadelphia District. (1996). “Manasquan Inlet to Barnegat Inlet Reconnaissance Study.”

U.S. Environmental Protection Agency and U.S. Army Corps of Engineers. (1991). “Evaluation of Dredged Material Proposed for Ocean Disposal (Testing Manual),” EPA-503/8-91/001, Washington, DC.

U.S. Fish and Wildlife Service (USFWS). (1999a). "Planning Aid Report: Fenwick Island Interim Feasibility Study – Baseline Biological Resources and Potential Impacts of Dredging at a Candidate Offshore Sand Borrow Area," prepared by George Ruddy (USFWS) for the U.S. Army Corps of Engineers, Philadelphia District.

U.S. Fish and Wildlife Service (USFWS). (1999b). "Planning Aid Report: Great Egg Harbor Inlet to Townsends Inlet Feasibility Study Cape May County, New Jersey," prepared by Douglas Adamo (USFWS) for the U.S. Army Corps of Engineers, Philadelphia District.

Versar, Inc. (2000). "An Evaluation and Comparison of Benthic Community Assemblages within Potential Sites for the Manasquan Inlet to Barnegat Inlet, New Jersey Feasibility," prepared by Versar, Inc. for U.S. Army Corps of Engineers, Philadelphia District under DACW61-95-D-0011 (0075).

Wise, R.A., Smith, S.J., and Larson M. (1996). "SBEACH: Numerical Model for Simulating Storm-Induced Beach Change, Report 4: Cross-Shore Transport under Random Waves and Model Validation with SUPERTANK and Field Data," TR CERC-89-9, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

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Appendix G – Pertinent Correspondence

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