New Jersey Shore Protection Study
Great Egg Harbor Inlet to Townsends Inlet

Feasibility Report
Integrated Environmental Impact Statement
Appendix A: Pertinent Correspondence

September 2001
U.S. Army Corps of Engineers
Philadelphia District

New Jersey Shore Protection Study
Great Egg Harbor Inlet to Townsends Inlet

Feasibility Report and Integrated Environmental Impact Statement (EIS)

September 2001

ABSTRACT: This feasibility report/EIS presents the findings of a study to determine the feasibility of implementing a long-term storm damage reduction plan for the communities of Ocean City, Strathmere, and Sea Isle City, New Jersey. It provides the findings of economic, social, environmental, and engineering analyses that were used to select a plan of action. The potential impacts, if any, 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 Engineer 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.

New Jersey Shore Protection Study
GREAT EGG HARBOR INLET TO TOWNSENDS INLET FEASIBILITY STUDY
Feasibility Report and Integrated Environmental Impact Statement (EIS)

EXECUTIVE SUMMARY

Proposed Action: Storm damage reduction for Ocean City and Ludlam Island utilizing beachfill to construct a protective berm and dune.

Location of Action: City of Ocean City, Strathmere (Township of Upper), City of Sea Isle City Cape May County, New Jersey

Type of Statement: Feasibility Report and Integrated Environmental Impact Statement (EIS)

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

Study Sponsor: New Jersey Department of Environmental Protection (NJDEP)

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Summary

This report presents the results of a feasibility phase study to determine an implementable solution and the extent of Federal participation for a project that provides storm damage reduction for the communities of Ocean City, Strathmere, and Sea Isle City. All of these communities are located in Cape May County, New Jersey.

The Great Egg Harbor Inlet to Townsends Inlet Feasibility Study is one of six site-specific areas recommended by the New Jersey Shore Protection Study. It was authorized by resolutions adopted by the U.S. House of Representatives and U.S. Senate in December, 1987. This feasibility study was cost-shared between the Federal Government and the State of New Jersey through the New Jersey Department of Environmental Protection (NJDEP) and was conducted under the provisions of the Feasibility Cost Sharing Agreement executed 17 April 1997. This feasibility study was initiated on this date.

The study area is located in southern New Jersey and extends approximately 24.1 kilometers (15 miles) in length from Great Egg Harbor Inlet to Townsends Inlet. The study area lies in Cape May County and consists of two barrier islands, Peck Beach and Ludlam Island. An existing Federal beachfill exists in the northern portion of Ocean City, from Seaview Road to 34th Street. The study area has been historically subject to significant damage due to storm events. The 1962 Northeaster resulted in damage to 8,467 structures within the entire study area at a cost of $140,000,000 (converted to 1999 dollars). Continued real estate development since this time has increased the potential for storm damages.

The feasibility study evaluated various alternative plans of improvement based on hurricane and storm damage reduction benefits.

The selected plan for South End Ocean City consists of a berm and dune utilizing sand obtained from an offshore borrow source. The dune crest will have a top elevation of +3.9 meters (+12.8 ft) NAVD88, while the berm will extend from the seaward toe of the dune for a distance of 30.5 meters (100 feet) at an elevation of 2.1 meters (7.0 ft) NAVD88 before sloping down at 1V:25H to elevation -0.38 meters (-1.25ft) NAVD88. The remainder of the design template parallels the existing profile slope to the depth of closure. The total width from the seaward toe of the dune to Mean High Water (MHW) is 66 meters (218 feet).

The plan extends from 34th Street to 59th Street for a total length of 4,268 meters (14,000 feet or 2.6 miles). Initial sand quantity is estimated at 1,218,000 cu meters (1,603,000 cu yds) which includes design fill quantity of 912,000 cu meters (1,192,000 cu yds) plus advanced nourishment of 306,000 cu meters (403,000 cu yds). Periodic nourishment of 306,000 cu meters[1] (403,000 cu yds) is scheduled to occur every 3 years synchronized with the existing Federal beachfill project at Ocean City (Great Egg Harbor Inlet to 34th Street). Material would be taken from the borrow sources identified in this report as “M8”.

The selected plan for Ludlam Island consists of a berm and dune utilizing sand obtained from an offshore borrow source. The dune crest will have a top elevation of +4.5 meters (+14.8 ft)

[1] Includes overfill factor

NAVD88, while the berm width will extend from the seaward toe for a distance of 15 meters (50 ft) at an elevation of 1.8 meters (6.0 ft) NAVD88 before sloping down (varying from 1V:30H to 1V:50H) to elevation –0.38 meters (-1.25 ft) NAVD88. The remainder of the design template parallels the existing profile slope to the depth of closure. The total width from the seaward toe of the dune to Mean High Water (MHW) varies depending upon location from 58 to 87 meters (190 to 285 feet).

The plan extends from 38 meters (125 feet) north of Seaview Avenue in Strathmere to Pleasure Ave (just beyond 93rd Street) in Sea Isle City for a total length of 10,507 meters (6.5 miles). In addition, there is a taper of 224 meters (734 feet) into Corson's Inlet State Park and a taper of 20 meters (66 feet) into the terminal groin south of 93rd Street. Total length of beachfill, including tapers, is 10,751 meters (6.7 miles). The plan also includes the extension of two stormwater outfall pipes at both 82nd and 86th Street in Sea Isle City by 46 meters (150 feet).

Initial sand quantity is 3,911,000 cu meters (5,146,000 cu yds) which includes design fill quantity of 2,528,000 cu meters (3,326,000 cu yds) plus advanced nourishment of 1,383,000 cu meters[2] (1,820,000 cu yds). Periodic nourishment of 1,383,000 cu meters (1,820,000 cu yds) is scheduled to occur every 5 years.

A Section 404(b)(1) evaluation has been prepared and is included in this Environmental Impact Statement and Feasibility Report. 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 outputs based on hurricane and storm damage reduction. The plan provides average annual net benefits of approximately $2,041,000 and a benefit-to-cost ratio of 2.0 for South End Ocean City and provides average annual net benefits of approximately $2,256,000 and a benefit-to-cost ratio of 1.6 for Ludlam Island.

The total initial project cost of construction is estimated at $43,161,000 (Oct 2000 price level) and would be cost-shared 65% Federal, 35% non-Federal. The Federal share of this first cost is $28,054,000 and the non-Federal share is $15,107,000. Lands Easements, Rights-of-Ways, Relocations and Dredged Material Disposal Areas (LERRD) costs are $424,000 and will be credited towards the non-Federal sponsor's cash contribution.

Periodic nourishment is expected to occur at 3-year intervals for the South End Ocean City portion of the project and at 5-year intervals for Ludlam Island subsequent to the completion of initial construction (year 0). Over 50-years, the total periodic nourishment cost is estimated to be $160,784,000 (Oct 2000 price level) and includes E&D monitoring during construction. Based on the Water Resources Development Act of 1999, cost-sharing for the periodic nourishment would be 50%.
The ultimate cost of construction which includes initial construction, project monitoring, and fifty years of periodic nourishment is estimated to be $203,945,000 (Oct 2000 price level), cost-shared 53% Federal, 47% non-Federal, based on WRDA 1999 cost-sharing. All costs also

[2] Includes overfill factor

include planning, engineering, and design. Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) is not included in this cost and is a non-Federal responsibility.

New Jersey Shore Protection Study
GREAT EGG HARBOR INLET TO TOWNSENDS INLET FEASIBILITY STUDY
Feasibility Report and Integrated Environmental Impact Statement (EIS)

Description of the Selected Plan

Protective Berm and Dune - South End Ocean City, NJ

Component	**Dimensions**	**Remarks**
Berm Elevation	+2.1m (7.0 ft) NAVD 88	Same as existing
Berm Width	30.5 meters (100 feet)	Same as average existing
Distance from seaward toe of dune to Mean High Water (MHW)	66 meters (218 feet)	
Beachfill Slope	1:30 to 1:25	Approximates existing
Dune Height	+3.8 meters (+12.8 ft) NAVD88	Existing bulkhead = 3.3 meters (10.8 ft) NAVD88
Dune Width (at crest)	7.6 m (25’)	Standard Caldwell section
Dune Side Slopes	1:5	Standard Caldwell section
Dune offset for maintenance	None	
Length of fill	4,268 meters (14,000 feet or 2.6 miles)	
Initial Sand Quantity	1,218,000 cubic meters (1,603,000 cu yds)	Includes advanced nourishment
Periodic Nourishment	306,000 cubic meters (403,000 cu yds)	3 year cycle
Major Replacement	382,000 cubic meters (503,000 cu yds)	Year 24. Includes periodic nourishment quantity. Same dune grass and sand fence quantities as initial fill.
Taper Section	None	Tapers into groin at 59th Street.
Borrow Source Location	M8	Located outside 3 mile limit. Requires MMS agreement.
Dune Grass	Surface area =79,624 m^2 (857,089 ft^2)	12”x12” spacing
Sand fence	4,092 meters (13,426 feet)	Single row
Outfall Extensions	None	
Dune Cross-overs	22	

Protective Berm and Dune - Ludlam Island

Component	**Dimensions**	**Remarks**
Berm Elevation	+1.8 m (6.0 ft) NAVD 88	Same as existing
Berm Width	15 meters (50 feet)	Same as average existing
Distance from seaward toe of dune to Mean High Water (MHW)	varies depending upon location from 58 to 87 meters (190 to 285 feet)	
Beachfill Slope	1:50 to 1:30	Approximates existing
Dune Height	+4.5 meters (+14.8 ft) NAVD88	Existing promenade in Sea Isle City +3.7 meters (12.0 ft)
Dune Width (at crest)	7.6 m (25')	Standard Caldwell section
Dune Side Slopes	1:5	Standard Caldwell section
Dune offset for maintenance	None	
Length of fill	10,751 meters (6.7 miles), including tapers	
Initial Sand Quantity	3,911,000 cu meters (5,146,000 cu yds)	Includes advanced nourishment
Periodic Nourishment	1,383,000 cu meters (1,820,000 cu yds)	5 year cycle
Major Replacement	1,600,000 cu meters (2,105,000 cy yds)	Year 25. Includes periodic nourishment quantity. Same dune grass and sand fence quantities as initial fill.
Taper Section	224 meters (734 feet) into Corson's Inlet State Park and a taper of 20 meters (66 feet) into the terminal groin south of 93rd Street.	
Borrow Source Location	L1, L3, C1	
Dune Grass	Surface area =282,000 square meters (3,035,000 sq ft)	12"x12" spacing
Sand fence	11,000 meters (36,000 ft)	Single row
Outfall Extensions	Two @ 46 meters (150 ft) each	
Dune Cross-overs	113	

Note: The following information is presented as a requirement for the Environmental Impact Statement (EIS).

ENVIRONMENTAL IMPACT STATEMENT SUMMARY

PURPOSE AND NEED

The purpose of this statement is to evaluate the anticipated environmental impacts of the alternatives with emphasis on the selected plan that was developed for the purpose of hurricane and storm damage reduction for the communities of Ocean City, Strathmere, and Sea Isle City, Cape May 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 the structures and property associated with these communities.

The principal source of economic damages identified in Ocean City, Strathmere, and Sea Isle City 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 and wave attack 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.

Three levels of screening investigated an array of structural and non-structural alternatives that address storm damage reduction. The study area was divided into two portions, one encompassing Ocean City and the other for Ludlam Island. The first level of screening (Cycle 1) involved the following alternatives:

- No action (Ocean City and Ludlam Island)
- Permanent Evacuation (Ocean City and Ludlam Island)
- Regulation of Future Development (Ocean City and Ludlam Island)
- Berm Restoration (Ocean City and Ludlam Island)
- Dune Restoration (Ocean City and Ludlam Island)
- Geotextile tubes (Ocean City and Ludlam Island)
- Berm and Dune Restoration (Ocean City and Ludlam Island)
- Berm and Dune Restoration Using Structural Reinforcement (Ocean City and Ludlam Island)
- Groinfield (Ocean City and Ludlam Island)
- Berm and Dune Restoration w/Groin Field (Ocean City and Ludlam Island)
- Berm and Dune Restoration Using Structural Reinforcement and Groin field (Ocean City and Ludlam Island)

- Increase Height of Existing Bulkhead (Ocean City)
- Bulkhead or Seawall (includes some nourishment) (Ludlam Island)
- Offshore Detached Breakwater (Ocean City and Ludlam Island)
- Berm and Dune Restoration w/Offshore Detached Breakwater (Ocean City and Ludlam Island)
- Perched Beach (Ocean City and Ludlam Island)
- Offshore Submerged Feeder Berm (Ocean City and Ludlam Island)
- Beach Dewatering (Ocean City and Ludlam Island)

Several of the alternatives were eliminated after the first level of screening based on engineering, environmental, socio-economic and relative costs. The remaining alternatives considered for Cycle 2 Screening were:

- Permanent Evacuation (Ludlam Island)
- Berm Restoration (Ocean City and Ludlam Island)
- Geotextile Tubes (Ludlam Island)
- Berm and Dune Restoration (Ocean City and Ludlam Island)
- Berm and Dune Restoration w/Structural Reinforcement (Ludlam Island)
- Berm and Dune Restoration with Groinfield (Ocean City and Ludlam Island)
- Bulkhead/Seawall (Ludlam Island)
- Berm and Dune Restoration w/ Structural Reinforcement and Groin field (Ocean City and Ludlam Island)

Cycle 2 screening further winnowed down 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.

Most of the plans that were considered in Cycle 2 included some aspect of beachfill placement. An investigation was undertaken to identify a suitable sand source. The utilization of an upland sand source was ruled out due to the volume of sand needed for a beachfill 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 screenings were conducted to identify suitable offshore sources that meet engineering, environmental, and socio-economic criteria for utilization. A total of eight sites were considered. Of these eight sites, four of them were determined to be suitable for utilization as sand sources.

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

- Berm restoration (Ocean City and Ludlam Island)
- Berm and dune restoration (Ocean City and Ludlam Island)
- Berm and dune restoration with structural reinforcement (Ocean City and Ludlam Island)
- Berm and dune restoration w/groin field (Ocean City and Ludlam Island)
- Berm & dune restoration w/structural reinforcement/groin field (Ocean City and Ludlam Island)

- Permanent Evacuation (Ludlam Island - Whale Beach area only)

Cycle 3 analysis involved optimization of the remaining alternatives into various configurations that were compared against their relative costs. Most of the beachfill plans considered meet the planning objectives in that they provide a degree of storm damage reduction, which is greater than the cost of implementation. The optimization in Cycle 3 identified the National Economic Development Plan (NED), which is the plan that maximizes beneficial contributions to the Nation while meeting planning objectives. The Cycle 3 screening concluded that only berm and dune restoration utilizing sandy material dredged from a nearby offshore source should be considered further for both areas. The NED plan identified for Ocean City is berm and dune restoration utilizing beachfill. The dune crest will have a top elevation of +3.9 meters (+12.8 ft) NAVD88, a top width of 7.6 meters (25 ft) and side slopes of 1V:5H. The berm will extend from the seaward toe of the dune for a distance of 30.5 meters (100 feet) at an elevation of 2.1 meters (7.0 ft) NAVD88 before sloping down at 1V:25H to elevation -0.38 meters (-1.25ft) NAVD88. The remainder of the design template parallels the existing profile slope to the depth of closure. The total width of the berm from the seaward toe of the dune to Mean High Water (MHW) is 66 meters (218 feet). The plan extends from 34th Street to 59th Street for a total length of 4,268 meters (14,000 feet or 2.6 miles). Initial sand quantity is 1,218,000 cu meters (1,603,000 cu yds) which includes design fill quantity of 912,000 cu meters (1,192,000 cu yds) plus advanced nourishment of 306,000 cu meters (403,000 cu yds). Periodic nourishment of 306,000 cu meters (403,000 cu yds) is scheduled to occur every 3 years synchronized with the existing Federal beachfill project at Ocean City (Great Egg Harbor Inlet to 34th Street).

The NED plan identified for Ludlam Island is also berm and dune restoration utilizing beachfill. The dune crest will have a top elevation of +4.5 meters (+14.8 ft) NAVD88, a top width of 7.6 meters (25 ft) and side slopes of 1V:5H. The berm width will extend from the seaward toe for a distance of 15 meters (50 ft) at an elevation of 1.8 meters (6.0 ft) NAVD88 before sloping down (varying from 1V:30H to 1V:50H) to elevation –0.38 meters (-1.25 ft) NAVD88. The remainder of the design template parallels the existing profile slope to the depth of closure. The total width from the seaward toe of the dune to Mean High Water (MHW) varies depending upon location from 58 to 87 meters (190 to 285 feet). The plan extends from 38 meters (125 feet) north of Seaview Avenue in Strathmere to Pleasure Ave (just beyond 93rd Street) in Sea Isle City for a total length of 10,507 meters (6.5 miles). In addition, there is a taper of 224 meters (734 feet) into Corson's Inlet State Park and a taper of 20 meters (66 feet) into the terminal groin south of 93rd Street. Total length of beachfill, including tapers, is 10,751 meters (6.7 miles). Initial sand quantity is 3,911,000 cu meters (5,146,000 cu yds) which includes design fill quantity of 2,528,000 cu meters (3,326,000 cu yds) plus advanced nourishment[3] of 1,383,000 cu meters (1,820,000 cu yds). Periodic nourishment of 1,383,000 cu meters (1,820,000 cu yds) is scheduled to occur every 5 years. The plan also includes the extension of two stormwater outfall pipes at both 82nd and 86th Street in Sea Isle City by 46 meters (150 feet).

[3] Includes overfill factors

These plans were chosen because they provide the maximum net benefits over costs based on storm damage reduction. The details of the NED Plan are discussed in greater detail in the Selected Plan section.

MAJOR CONCLUSIONS AND FINDINGS

Berm and dune restoration utilizing beachfill w/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 is feasible and proven to work in high energy environments. The somewhat transient nature of beachfill is actually advantageous because the beachfill 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 w/nourishment uses material typical of the adjacent areas, sand, to buffer the shoreline structures 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 unlike groins. When the protective beach is totally dispersed by the 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.

Some of the suggested non-structural storm damage reduction alternatives are currently being practiced, such as development regulation. Consequently, implementation is somewhat of a moot point. Others such as land acquisition are prohibitively expensive and are socially unacceptable in any event.

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 (beachfill) site.

Both 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 beachfill 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 *et al*., 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 the cumulative loss of shoals as important fish habitat in the region, which prompted the selection of suitable sand sources without prominent shoal habitat. New Jersey coastal waters including the sand borrow source areas support a surfclam (*Spisula solidissima*) fishery with varying degrees of productivity.

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.

Concerns regarding potential adverse impacts on the Federally threatened piping plover (*Charadrius melodus*) and the sea beach amaranth (*Amaranthus pumilus*) have resulted in the development of a programmatic biological assessment to comply with the Endangered Species Act. The biological assessment is being conducted outside of this document, however, the findings and conclusions of the subsequent biological opinion (to be issued by the US Fish and Wildlife Service) will be adhered to for this action to protect these species. Two of the offshore sand source sites (M8 and L3) are or have portions located within the Outer Continental Shelf waters under the jurisdiction of the Minerals Management Service (MMS). Extraction of sand from these areas requires authorization from the Minerals Management Service through a signed Memorandum of Agreement.

The following table provides for a summarization of issues to be addressed in this statement that were identified during project scoping.

GREAT EGG HARBOR INLET TO TOWNSENDS INLET FEASIBILITY STUDY ISSUES IDENTIFIED DURING STUDY SCOPING PROCESS				
SUBJECT		**ISSUE(S)**	**AGENCY OR PUBLIC ENTITY RAISING ISSUE(S)**	**ACTION**
Fisheries	Shellfish	• Impacts on commercial surfclam (*Spisula solidissima*) fishery • "Lump" areas are identified as prime surfclam habitat	• National Marine Fisheries Service • U.S. Fish and Wildlife Service • NJ Department of Environmental Protection (Bureau of Shellfisheries)	• Avoid lump areas as much as possible • Through monitoring, identify areas with commercial densities and coordinate results with NJDEP to determine if modifications are necessary.

GREAT EGG HARBOR INLET TO TOWNSENDS INLET FEASIBILITY STUDY
ISSUES IDENTIFIED DURING STUDY SCOPING PROCESS

SUBJECT		ISSUE(S)	AGENCY OR PUBLIC ENTITY RAISING ISSUE(S)	ACTION
	Marine Finfish	• Impacts on fish habitat and structure such as "lumps", wrecks, artificial reefs, and areas identified as prime fishing areas. • Impacts dredging in Site L1 would have on the adjacent Sea Isle Lump (Site L2) • Impacts beach replenishment would have on shore-based recreational fishing activities (loss of rock structures and habitat due to covering with sand). • Impacts on Essential Fish Habitat (EFH) pursuant to the Magnuson-Stevens Fishery Conservation Management Act	• U.S. Fish and Wildlife Service • National Marine Fisheries Service • NJ Department of Environmental Protection (Bureau of Marine Fisheries)	• Avoid areas such as wrecks, artificial reefs, and lumps to the maximum extent possible. It may not be possible to completely avoid all lumps, but dredging should be done to minimize those impacts. • Assess impact of dredging Site L1 on Sea Isle Lump (Site L2). Determine if dredging L1 could actually enhance L 2 • Assess the number of rock structures within the impact area and determine magnitude sand burial would have on these habitats/structures • Consider potential impacts on Federally managed fish species with identified EFH within the study area, and develop mitigative measures to avoid or minimize adverse impacts.

GREAT EGG HARBOR INLET TO TOWNSENDS INLET FEASIBILITY STUDY ISSUES IDENTIFIED DURING STUDY SCOPING PROCESS				
SUBJECT		**ISSUE(S)**	**AGENCY OR PUBLIC ENTITY RAISING ISSUE(S)**	**ACTION**
Wildlife	Terrestrial Wildlife	• Impacts on important wildlife habitats such as wetlands	• NJ Department of Environmental Protection (Bureau of Wildlife Management)	• There are no vegetated wetlands within the immediate impact area. Terrestrial habitats such as beach and dunes would be discussed, however, impacts are not expected to be significant because these areas are highly dynamic.

GREAT EGG HARBOR INLET TO TOWNSENDS INLET FEASIBILITY STUDY ISSUES IDENTIFIED DURING STUDY SCOPING PROCESS				
SUBJECT		**ISSUE(S)**	**AGENCY OR PUBLIC ENTITY RAISING ISSUE(S)**	**ACTION**
Threatened and Endangered Species	Terrestrial	• Identify direct, indirect, and cumulative impacts on Federal and State threatened and endangered species • 30-40 pairs of piping plover (Federally threatened, State endangered) nest within study area • 2-5 least tern (State threatened) colonies typically exist within the study area (Corson's Inlet & Townsends Inlet areas) • A black skimmer (State endangered) colony exists at Corson's Inlet (Strathmere Natural Area) • Conduct investigation of the presence of sea beach amaranth (*Amaranthus pumilus*) prior to any construction activity. • It may be expected that the Corps should require local municipalities to apply and enforce protection measures	• U.S. Fish and Wildlife Service • NJ Department of Environmental Protection (Bureau of Endangered and Non-game Wildlife)	• Discuss potential direct, indirect and cumulative impacts on these species • Coordinate mitigative measures such as timing restrictions, monitoring, select berm widths, and other features to optimize habitat • The expectation that the Corps should require local communities to protect these species may become a contentious issue. This issue will need to be addressed through coordination and agreements. • The Philadelphia District has submitted a programmatic biological assessment to address Section 7 Endangered Species Act consultation requirements.

GREAT EGG HARBOR INLET TO TOWNSENDS INLET FEASIBILITY STUDY ISSUES IDENTIFIED DURING STUDY SCOPING PROCESS				
SUBJECT		**ISSUE(S)**	**AGENCY OR PUBLIC ENTITY RAISING ISSUE(S)**	**ACTION**
	Marine	• Several Federally listed threatened and endangered sea turtles and marine mammals are known to inhabit New Jersey coastal waters, and may be impacted by project activities	• National Marine Fisheries Service • U.S. Fish and Wildlife Service	• Mitigation measures and monitoring requirements will be conducted as per the Biological Opinion rendered by NMFS.
Open Space Resources	State Parks and Natural Areas	• Significant losses of dunes have resulted from recent northeasters • Potential impacts project may have on park resources	• NJ Department of Environmental Protection (Div. of Parks and Forestry)	• The Ludlam Island portion of the selected plan includes a 734 foot taper into the Strathmere Natural Area. • Consideration was given in the project design to avoid adverse impacts to park areas
Project Alternatives		• Address all structural and non-structural alternatives	• U.S. Fish and Wildlife Service	• An array of structural and non-structural alternatives were considered during the plan formulation process
Outer Continental Shelf (OCS) Mineral Resources		• Any potential sand sources that are identified within OCS waters requires coordination with the Minerals Management Service • Assure that action agency complies with NEPA and other Federal statutes	• Minerals Management Service (MMS)	• Coordinate potential actions impacting OCS resources with MMS and develop a Memorandum of Agreement with MMS.

New Jersey Shore Protection Study
Great Egg Harbor Inlet to Townsends Inlet
Feasibility Study

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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, improve the information available to coastal planners and engineers, and be used by various resource agencies to help preclude further degradation of the coastal waters. This report presents the results of the sixth site specific study under the New Jersey Shore Protection Study, the Great Egg Harbor Inlet to Townsends Inlet Feasibility Study.

1.1 Study Authorization

The New Jersey Shore Protection Study was authorized by resolutions adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environment and Public Works of the U.S. Senate in December 1987 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 hearby 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 hearby 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. Reconnaissance studies are conducted at 100% Federal expense and are normally completed in 12 months. 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 April 1995, the Great Egg Harbor Inlet to Townsends Inlet Reconnaissance Study was initiated to address shoreline erosion and subsequent storm damage vulnerability. This study was conducted through the General Investigations program at 100% Federal expense under the New Jersey Shore Protection Study authority. The duration of the Great Egg Harbor Inlet to Townsends Inlet Reconnaissance Study was set at one year according to then-existing Corps policy and completed in April 1996. It identified problems and opportunities in the study area relating to hurricane and storm damage reduction and recommended proceeding to the next level of study, namely the feasibility phase.

The reconnaissance report was reviewed and comments were supplied by CECW-PE (Planning Division, Washington Headquarters of the US Army Corps of Engineers) in a memorandum dated 18 June 1996. Besides comments on the report, this memorandum also stated, "*Headquarters review confirms that the reconnaissance report identified a hurricane and storm damage reduction project that is environmentally, economically, and engineeringly sound. However, the Administration has determined that hurricane and storm damage reduction projects, generally, should be considered for implementation by state and non-Federal interests that benefit from them. Consistent with this policy, funds have not been included in the President's Fiscal Year 1997 budget to support the federal share of the feasibility study. Accordingly, further effort on this study, including providing responses to the enclosed comments and scheduling of the Reconnaissance Review Conference, should not be undertaken at this time.*"

However, funds to initiate the feasibility study were added by Congress in the Fiscal Year 1997 Energy and Water Development Appropriations Act. The Philadelphia District responded to CECW-PE comments and was then authorized to execute the Feasibility Cost-Sharing Agreement (FSCA) in a memorandum from CECW-PE, dated 18 February 1997. The

FSCA was signed with the non-federal sponsor, the New Jersey Department of Environmental Protection (NJDEP), and the feasibility study was initiated on 17 April 1997. Feasibility study funds were also added by Congress in fiscal years 1998, 1999, and 2000.

The Great Egg Harbor Inlet to Townsends Inlet Feasibility Study was conducted as a hurricane and storm damage reduction initiative under the General Investigations (GI) program utilizing the New Jersey Shore Protection Study authority. Feasibility studies are cost shared 50% with a non-Federal sponsor. The New Jersey Department of Environmental Protection (NJDEP) is the non-Federal study sponsor.

1.3 Study Purpose & Scope

The purpose of a feasibility study is to ensure the timely and economical completion of a quality feasibility report that is expected to recommend an implementable solution to the identified problems.

This feasibility report presents the results of a feasibility level study conducted pursuant to the previously mentioned resolutions and 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 and documented basis for decision-makers at all levels to judge the recommended solution(s)

This report documents the analysis of existing conditions, without project conditions, plan formulation, and project designs in order to provide hurricane and storm damage reduction for the study area. The evaluations were based on site-specific technical information developed during the course of the study. This included photogrammetry; surveys; hydraulic, hydrologic, and economic evaluations; geotechnical investigations; and environmental and cultural resource inventories.

This feasibility report will detail the following for the study area:

a. Define problems and opportunities
b. Identify potential solutions
c. Identify costs, benefits, environmental and social impacts of potential solutions
d. Present the optimized plan for each problem
e. Present the Project Cooperation Agreement (PCA) responsibilities of the non-federal sponsor

1.4 Study Area

The study area is located in southern New Jersey and extends approximately 24.1 kilometers (15 miles) in length from Great Egg Harbor Inlet to Townsends Inlet (Figure 1.4-1). The study area lies in Cape May County and consists of two barrier islands, Peck Beach and Ludlam Island.

The island known as Peck Beach contains both Ocean City and a portion of Corson's Inlet State Park and measures about 12.4 kilometers (7.6 miles) in length (Figure 1.4-2). Ocean City is a highly developed residential town that possesses a significant year-round population along with a high seasonal population. A Federal beachfill project currently exists at the northern portion of Ocean City. Therefore, the feasibility study focused on the areas of Peck Beach not included in the existing project. These areas are: the "South End"(south of 36th Street) of Ocean City (Photos 1.4-1 to 1.4-2); the "Gardens" area which exists adjacent north of the existing project and extends from Seaview Road to the Ocean City–Longport Bridge along Great Egg Harbor Inlet (Photo 1.4-3); and the Peck Beach portion of Corson's Inlet State Park (Photo 1.4-4). Their respective lengths are 4.1 kilometers (2.5 miles), 518 meters (1,700 ft), and 1.0 kilometer (0.6 miles). The acreage for the Peck Beach portion of Corson's Inlet State Park is about 138 hectares (340 acres) and is used by a variety of shorebirds, including piping plovers and black skimmers. Corson Inlet possesses a very narrow natural channel and is considered closed to navigation by the Coast Guard.

The remaining barrier island is Ludlam Island, which extends 11.7 kilometers (7.3 miles) and includes an approximately 40 hectare (98 acre) portion of Corson's Inlet State Park and the towns of Strathmere and Sea Isle City (Figure 1.4-3). The northern portion of this island contains the town of Strathmere and the area known as Whale Beach. Strathmere, located in Upper Township, consists of mostly residential structures and very little commercial development compared to other nearby shore towns (Photos 1.4-5, 1.4-6). Whale Beach is a narrow, sparsely developed stretch of Ludlam Island that encompasses the southern portion of the town of Strathmere and the northern portion of Sea Isle City, the town located adjacent south of Strathmere (Photos 1.4-7, 1.4-8). Sea Isle City encompasses the remainder of Ludlam Island (Photos 1.4-9, 1.4-10). This town is a highly developed residential community similar to Ocean City. This area also contains a high seasonal population along with a significant year-round population. The southern portion of Sea Isle City contains the residential area known locally as Townsends Inlet (Photo 1.4-11).

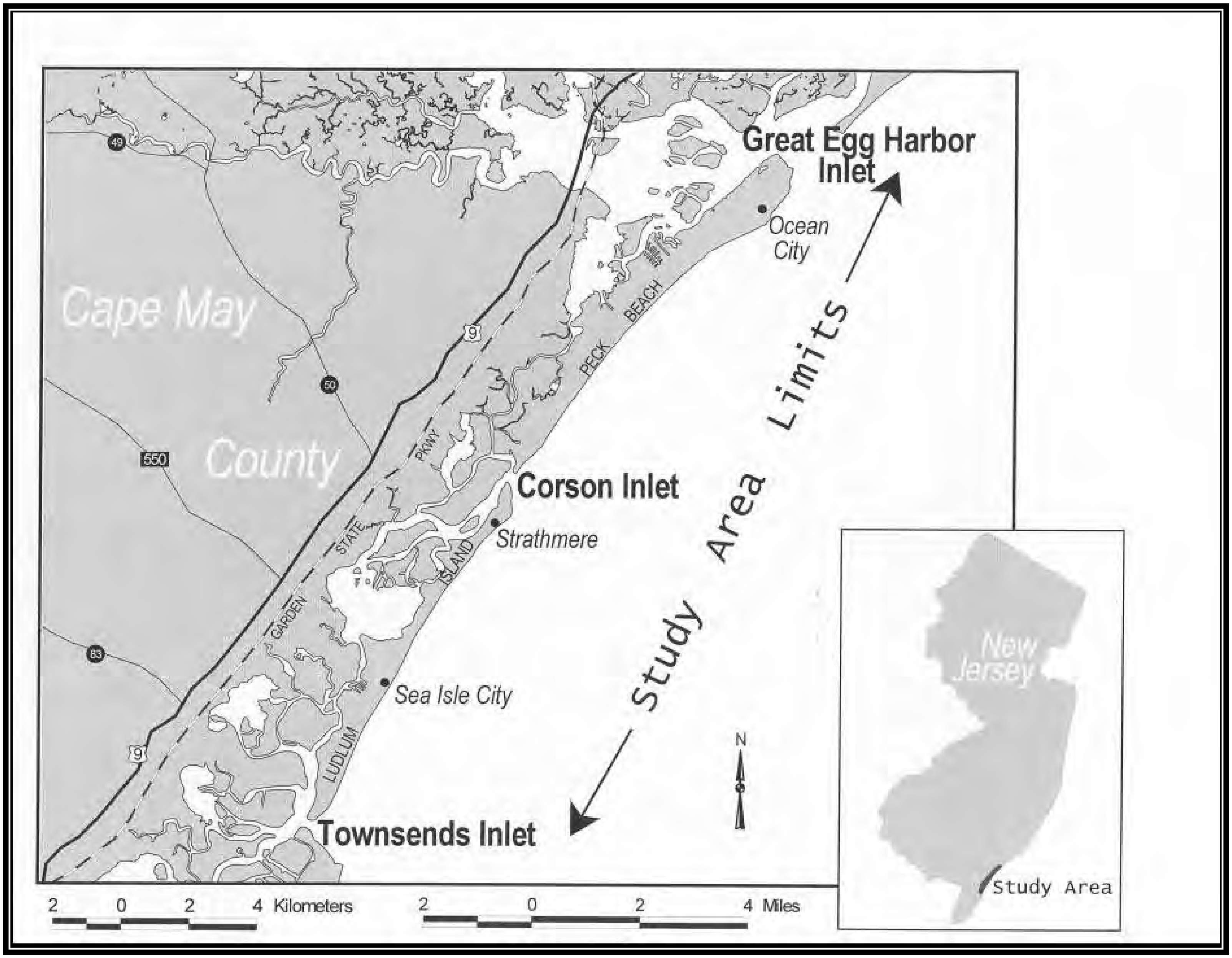

Figure 1.4-1 Study Area Map

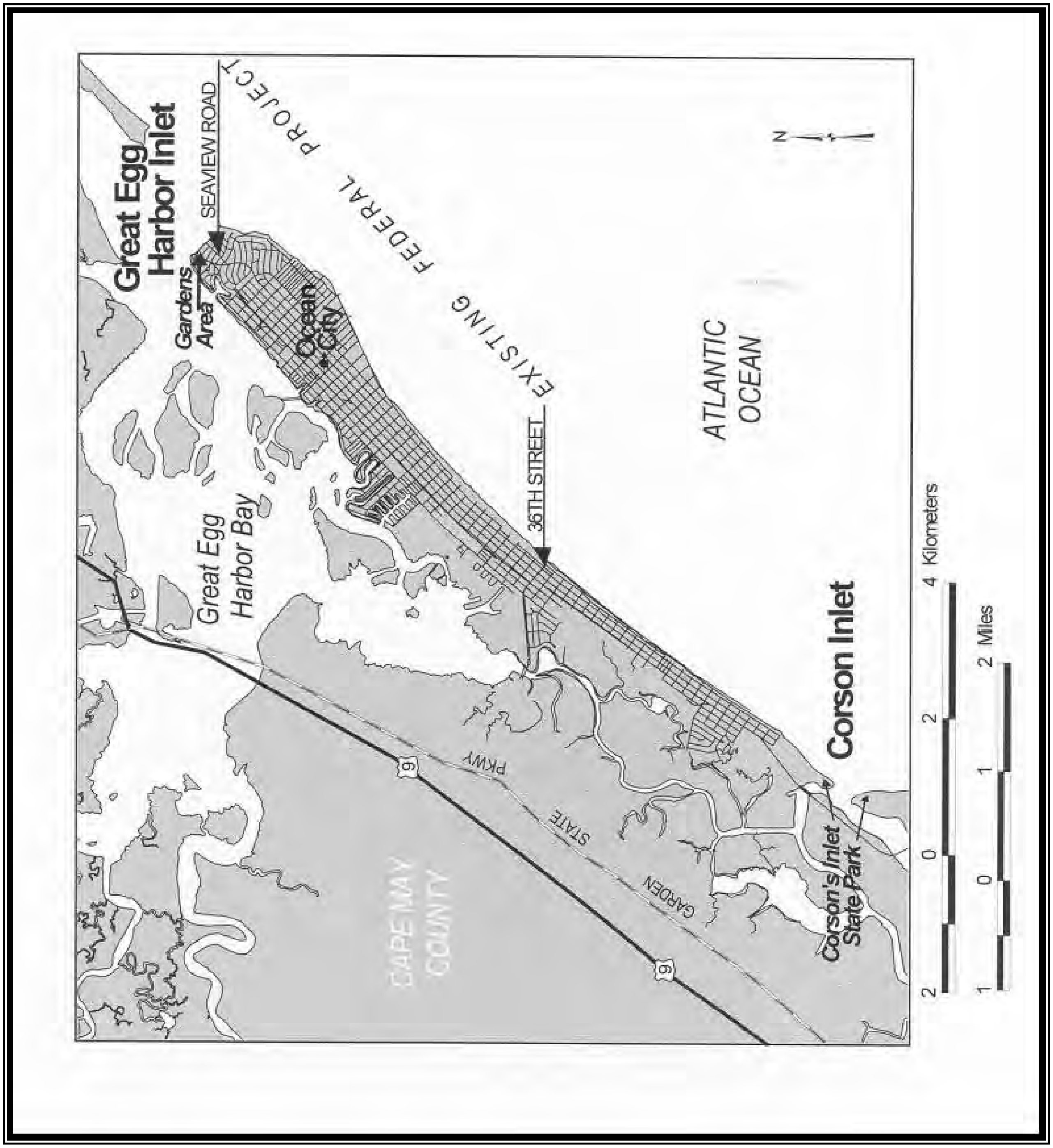

Figure 1.4-2 Ocean City Map

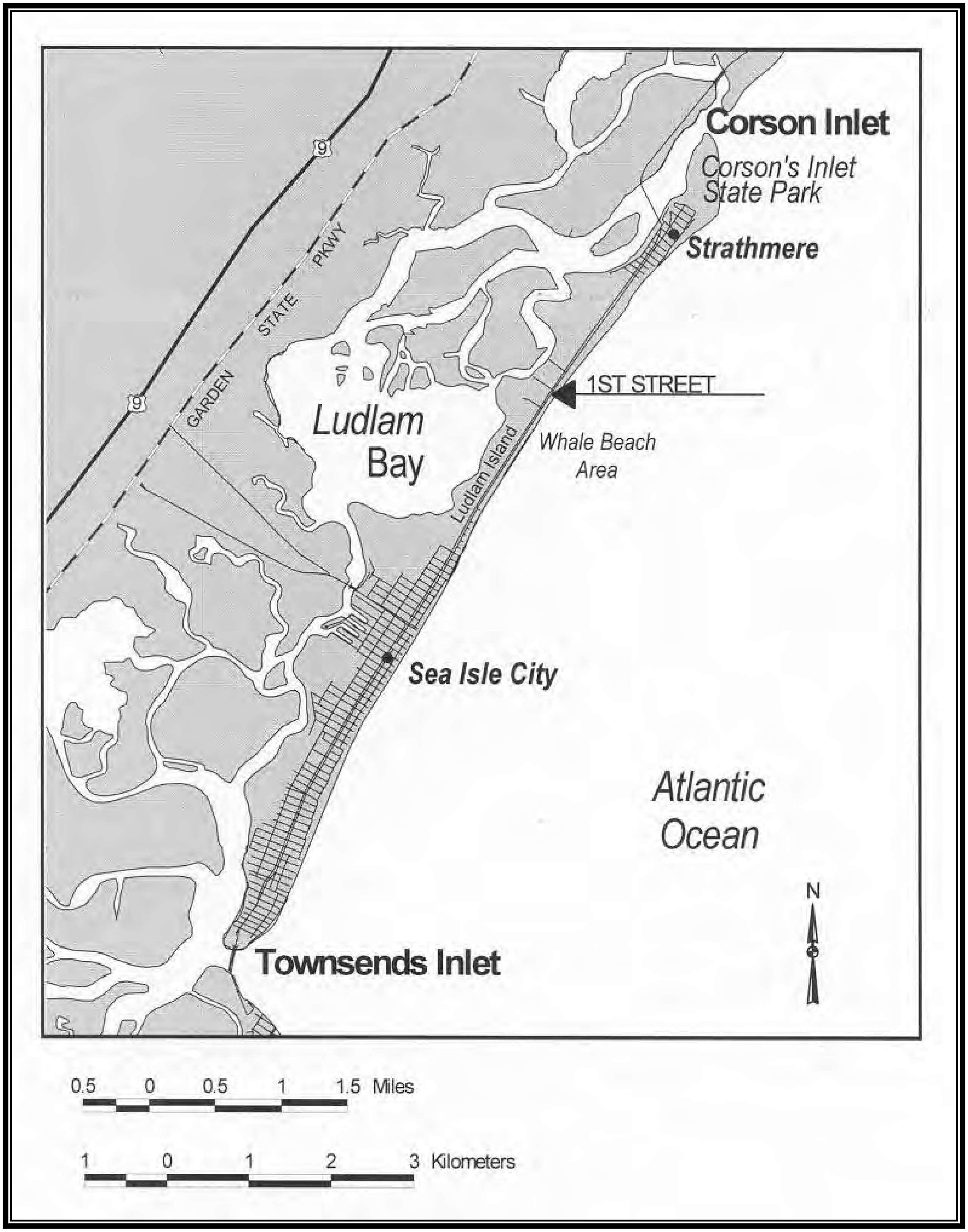

Figure 1.4-3 Ludlam Island Map

Photo 1-1 South End Ocean City, NJ – 10/25/99

Photo 1-2 South End Ocean City, NJ – 10/25/99

Photo 1-3 Gardens Area of Ocean City, NJ – 10/25/99

Photo 1-4 Corson's Inlet State Park, NJ - 5/95

Photo 1-5 Strathmere, NJ – 2/6/98

Photo 1-6 Strathmere, NJ – 10/25/99

Photo 1-7 Whale Beach Area, Sea Isle City, NJ, looking towards Strathmere – 10/25/99

Photo 1-8 Whale Beach Area, Sea Isle City, NJ, looking southwest – 10/25/99

Photo 1-9 Sea Isle City, NJ, looking towards Whale Beach and Strathmere, 8/30/95

Photo 1-10 Sea Isle City, NJ, looking southwest, 8/30/95

Photo 1-11 Townsends Inlet area of Sea Isle City, NJ, 10/25/99.
Following construction of terminal groin and beachfill placement by locals.

1.5 Prior Studies, Reports, and Projects

Numerous studies have been completed in the study area by both the Corps of Engineers and the State of New Jersey on the subjects of storm damage reduction, beach erosion control, and navigation improvements. Studies and reports dating back to 1922 pertaining to the project area were made by the State of New Jersey Board of Commerce and Navigation, New Jersey State Beach Erosion Commission, New Jersey Department of Conservation and Economic Development, the Beach Erosion Board (now Coastal Engineering Research Board-CERB), and the Philadelphia District, Corps of Engineers (CENAP). These reports are summarized in the following table:

Table 1.5.1-1 Summary of Prior Reports

Publication & Date	Agency	Subject or Recommendation
General Study Area		
Report on the erosion and protection of the New Jersey Beaches (1922)	Board of Commerce & Navigation of New Jersey	Proposed norms and guides to produce effective coast protective works to combat erosion of beaches along New Jersey shores.
Report on the erosion and protection of the New Jersey Beaches (1924)		Outlined general details of construction and maintenance of shore protection structures for New Jersey beaches to supplement report of 1922.
Report on the erosion and protection of the New Jersey Beaches (1930)		Contains details of significant types of shore protection structures at specific locations along New Jersey coast, and conclusions on their effectiveness; updating the reports of 1922 and 1924.
Interim Report (not published) (1933)	Corps of Engineers - Beach Erosion Board	Summarized information gathered in past investigations to serve as a guide in future beach erosion and shore protection studies.
General summary description of coast protection requirements (Jan. 1949)	State Beach Erosion Commission	Proposed plan for shore-protection structures to protect communities along the Atlantic Ocean between Sandy Hook and Cape May Point.
Preliminary Examination Report, New Jersey Coast Flood Control (31 Dec 1945)	Corps of Engineers	Determined that construction of works for protection of areas on the New Jersey coast from floods due to tide, and wind was not economically feasible.
Technical Memorandum 55 (1954)	Beach Erosion Board	Studies the statistical occurrence of various waves off Penobscot Bay, Maine; Nauset Beach, Cape Cod, Mass; New York Harbor entrance; and off Chesapeake Bay entrance.
Bulletin 63, Geologic Series (1954) New Jersey (prelim. Draft) (1954)	NJ Department of Conservation Economic Development	Discusses a study of the geomorphology, littoral materials, littoral forces, and littoral measurements.
Technical Memorandum No. 77 (1956)	Corps of Engineer - Beach Erosion Board	Reported on 1952 Ocean City beachfill and shoreline response to March 1955 storm.

Publication & Date	Agency	Subject or Recommendation
House Document 208, 86th Congress, 1st. Session (1960)	Corps of Engineers	Reported on a cooperative beach erosion control and shore protection study of New Jersey coast from Barnegat Inlet to Delaware Bay, and recommended adoption of projects for numerous communities along the coast.
Postflood Report - Coastal Storm of 6-7 March 1962 Southern New Jersey and Delaware (Dec. 1962)	Corps of Engineers	Described the March 1962 storm and the effects on the Atlantic Coast of New Jersey south of Manasquan Inlet, the bay shore of New Jersey and Delaware and the Atlantic Coast of Delaware.
House Document 38, 89th Congress, 1st Session (1965)	Corps of Engineers	Recommended that proposed plans of protection from storms and hurricanes for Atlantic Coast of Southern New Jersey and Delaware not be adopted.
House Document 91-160, 1st Session (1969) New Jersey Coastal Inlets and Beaches-Great Egg Harbor to Stone Harbor	Corps of Engineers	Proposed beach erosion control and navigation improvements for area between Great Egg Harbor Inlet to Stone Harbor. Improvements included beachfill, navigation channel, jetty and groin construction.
NJ Shore Protection Master plan (1981)	NJ Department of Environmental Protection	Comprehensive beach erosion control study of entire Jersey coast. Recommended initial beachfill with periodic expansion to meet demand and maintenance of beach with nourishment.
Summary Report-Impacts of Coastal Energy Development on New Jersey's Shorefront Recreational Resources (1984)	NJ Department of Environmental Protection	Described economic, social, demographic and land use of NJ shore; estimated value of shorefront recreational economy; modeled economic, social, fiscal, demographic impact of facility development; linked these impacts with losses in tourism.
New Jersey Shore Protection Study, Report of Limited Reconnaissance Study (1990)	Corps of Engineers	Reported on various shore protection and water quality issues along the entire New Jersey coastline. Recommended full reconnaissance level studies at designated locations.
New Jersey Shore Protection Study, Great Egg Harbor Inlet to Townsends Inlet Reconnaissance Study (April 1996)	Corps of Engineers	Recommended progression to the feasibility phase of study.
Great Egg Harbor Inlet		
Preliminary Examination Report submitted to Congress 13 Dec. 1954	Corps of Engineers	Recommends a survey to consider improvement of entrance channel to inlet.
Post flood Report Coastal Storm of 28-29 March 1984 Delaware and New Jersey Coast (January 1985)	Corps of Engineers	Described the March 1984 storm and the effects on the Atlantic Coast of Delaware, New Jersey, and the Delaware Bay Shoreline.
Ocean City, NJ		
House Document 184, 83rd Congress, 1st. Session (1953)	Corps of Engineers	Recommended artificial placement of fill to widen ocean beach and extension of 7 existing groins as deferred construction when required.
Phase I General Design Memorandum, Great Egg Harbor Inlet and Peck Beach, Ocean City NJ (1976)	Corps of Engineers	Plan of improvement provided for jetties, an inlet channel, bulkhead, beachfill and groin construction.

Publication & Date	Agency	Subject or Recommendation
Final Report, Beach Nourishment Evaluation Study, Ocean City, NJ (1981)	City of Ocean City	Technical document to provide information upon which Ocean City can base future decisions on use and operation of city dredge for nourishment.
Flood Insurance Study for Ocean City, New Jersey (1983)	Corps of Engineers	Divided city into various insurance zones based on the potential damage to structures in each zone.
Update of Flood Insurance Study for Ocean City, New Jersey (1983)	FEMA	Updated zoning based upon predictions of wave crest elevations as the base flood elevations on flood insurance rate maps. Made communities aware of hazards resulting from water velocity and wave action.
Beach Erosion Control -Navigation Study, Great Egg Harbor Inlet to Peck Beach-Ocean City, NJ (1985)	Corps of Engineers	Provided much simplified plan from 1976 report for navigation (dredging only) and beach erosion control (beachfill).
Engineering Analysis of City of Ocean City's beaches (1986) (Weggel and Sorrensen)	City of Ocean City	Lowering of selected existing groins and beachfill.
Plan Reevaluation and Scheme Selection (Technical Review Meeting No 1), Great Egg Harbor Inlet to Peck Beach-Ocean City, NJ (1988)	Corps of Engineers	Finalized project reevaluation efforts and incorporated North Atlantic Division comments as related to 1985 report.
General Design Memorandum and Final Supplemental Environmental Impact Statement, Great Egg Harbor Inlet and Peck Beach-Ocean City NJ (1990)	Corps of Engineers	Plan of improvement consisted of beachfill with periodic nourishment. Initial construction completed July 1993.
Corson Inlet and Ludlam Island		
General Design Memorandum, Corson Inlet and Ludlam Beach, NJ (1976)	Corps of Engineers	Plan of improvement provided for jetties, an inlet channel, bulkhead, beachfill and groin construction. Never constructed due to lack of state funding.
Beach and Inlet Changes at Ludlam Beach, NJ (Misc Report No. 80-3) (1980)	Corps of Engineers Coastal Engineering Research Center - Ft. Belvoir, Virginia	Provides basic engineering information on changes in volume of sand on beaches and on changes in shoreline position

1.5.1 Federal Involvement

The history of Corps involvement in the New Jersey coast is long and intricate. Before 1930, Federal government involvement in shore erosion was limited to the protection of public property. With the enactment of the River and Harbor Act of 1930 (Public Law 71-520, Section 2), the Chief of Engineers was authorized to perform studies on erosion problems in cooperation with municipal and state governments in order to devise a means for preventing further erosion of the shores. Until 1946, the Federal aid was limited to studies and technical advice. In that year, and again in 1956 (PL 84-826) and 1962 (PL 87-874), the law was amended to provide Federal participation in the cost of a project and allowed limited contribution to the protection of privately owned shores which would benefit the public. Both public use and access to the beach areas are requirements for Federal participation in shore protection projects.

The New Jersey Shore Protection Study was initiated in 1989 to investigate shoreline protection and water quality problems which exist along the entire coast. The *Limited Reconnaissance Phase of the New Jersey Shore Protection Study* identified and prioritized those coastal reaches which have potential Federal interest based on shore protection and water quality problems which can be addressed by the Corps of Engineers. The limited reconnaissance study report was completed in September 1990 and recommended six study reaches along the New Jersey coast. One of those reaches recommended for study was from Great Egg Harbor Inlet to Townsends Inlet.

In April 1995, the Great Egg Harbor Inlet to Townsends Inlet Reconnaissance Study was initiated to address shoreline erosion and subsequent storm damage vulnerability. This study was conducted through the General Investigations program at 100% Federal expense under the New Jersey Shore Protection Study authority. The duration of the Great Egg Harbor Inlet to Townsends Inlet Reconnaissance Study was set at one year according to then-existing Corps policy and completed in April 1996. It identified problems and opportunities in the study area relating to hurricane and storm damage reduction and recommended proceeding to the next level of study, namely the feasibility phase.

1.5.1.1 Federal Studies at Ocean City, NJ

There have been a number of reports that have specifically addressed the problems at Ocean City. The following reports most directly relate to the current feasibility study:

In 1976, the *Phase I General Design Memorandum Great Egg Harbor Inlet and Peck Beach-Ocean City, New Jersey* contained a plan of improvement that included jetties, a deposition basin, navigation channel, and beachfill extending from Great Egg Harbor Inlet south to 59th Street. This plan had been modified from the plan previously authorized in *House Document 91-160, 1st Session (1969) New Jersey Coastal Inlets and Beaches-Great Egg Harbor to Stone Harbor*. A project was not constructed following the 1976 study since the State of New Jersey indicated that the project could no longer be financially supported at that time. Therefore, this proposed project was placed on “inactive” status.

However, in 1982, the State indicated renewed interest in a scaled down version of this project based on the findings of their *NJ Shore Protection Master Plan (1981)* and a new source of funding from a bond issue was passed by the electorate. Consequently, the project was “reactivated” in 1982. In 1985, at the request and under contract to NJDEP through a “work-for-others program”, CENAP prepared the *Beach Erosion Control-Navigation Study, Great Egg Harbor Inlet to Peck Beach-Ocean City, NJ*. Project features were scaled down substantially from the previous 1976 report to include beachfill with periodic nourishment from Surf Road extending south to 50th Street.

A benefit re-evaluation study was completed by CENAP in 1987 and finalized in 1988 with the report entitled *Plan Reevaluation and Scheme Selection (Technical Review Meeting No 1), Great Egg Harbor Inlet to Peck Beach-Ocean City, NJ*. The plan of construction still included beachfill extending south to 50th Street.

The *General Design Memorandum and Final Supplemental Environmental Impact Statement, Great Egg Harbor Inlet to Peck Beach-Ocean City, NJ (1990)* presented the results of detailed engineering and design studies. This report is the basis for the existing Federal project and recommended that beachfill only extend from Surf Rd southward to 34th Street (excluding taper sections). The area from 34th Street south to 59th Street in Ocean City was not included in the Federal project due a lack of incremental economic justification at that time.

1.5.1.2 Existing Federal Projects at Ocean City, NJ

The *Great Egg Harbor and Peck Beach-Ocean City, NJ Federal Shore Protection Project* is located at the northern end of the study area. The project (including taper sections) extends from the Seaview Road groin south to 36th Street in Ocean City (Figure 1.4-2). The project is 6,889 meters (22,600 ft) in length and has a minimum top berm width of 30.5 meters (100 ft) (with the exception of the taper section). Initial construction of the project, which also includes 50 years of periodic nourishment, was completed in July 1993. The first nourishment cycle was conducted in two phases and completed in December 1994 and August 1995 respectively. The second nourishment cycle was competed in September 1997. The next cycle is scheduled for fall 2000.

The Federal Emergency Management Agency (FEMA) has provided funding in both 1998 and 1999 to replace sand lost due to storm erosion at the South End. Total project costs were $250,000 and $225,000 respectively with cost-sharing 75% FEMA and 25% local.

1.5.1.3 Federal Studies at Ludlam Island

Previous reports have been conducted for this portion of the study area and are listed in Table 1.5-1. Most recently, the US Army Corps of Engineers completed the *Phase I General Design Memorandum Corson Inlet and Ludlam Beach, New Jersey (1976)*. The selected plan was similar to the one previously recommended in *House Document 91-160, 1st Session (1969) New Jersey Coastal Inlets and Beaches-Great Egg Harbor to Stone Harbor*.

The former plan provided for:

- A 983 meter (3,225 ft) jetty at the updrift side and a 853 meter (2,800 ft) jetty at the downdrift side of Corson Inlet.
- Dredging and maintaining a 91 meter (300 ft) wide navigation channel at Corson Inlet.
- Beachfill placement, 10.3 kilometers (33,900 ft) in length, to provide a minimum berm width of 9.1 meters (30 ft). Initial beachfill material was to be provided from initial dredging of the navigation channel (16%) and deposition basin (84%) for a total of 1,094,000 cubic meters (1,440,000 cy). The deposition basin would have been created adjacent to the updrift jetty. Periodic nourishment would have consisted of bypassing 882,000 cubic meters (1,160,000 cy) of sand to be dredged every 2 years

from the deposition basin plus an additional 24,000 cubic meters (32,000 cy) from the navigation channel.

- Reimbursement (limited to the percentage of Federal involvement) to the State of New Jersey for 6 constructed groins located at 31st, 36th, 41st, 44th, and 52nd Streets and a groin extension at 47th Street.

- Construction of additional groins at Vincent and Randolph Roads (191 meters/625 ft) in Strathmere and at 57th Street (186 meters/610 ft) in Sea Isle City.

The major primary benefits from this proposed project were:

- Reduction in damages to vessels along with recreational and commercial boating benefits from the proposed improvements at Corson Inlet.

- Prevention of erosion damages along Ludlam Beach.

- Recreational swimming benefits from the proposed beach improvements.

- Recreational sport fishing benefits that would accrue from construction of the jetties.

The proposed project was never constructed since the State of New Jersey indicated that the project could no longer be financially supported at that time. Therefore, the project was placed on "inactive" status in 1978. In 1982, the state indicated renewed interest in a scaled down version of this project based on the findings of their *NJ Shore Protection Master Plan (1981)*. The current project status is designated "deauthorized".

1.5.2 State Involvement in Shore Protection

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 (NJDEP), 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). Shore protection is presently handled by the Division of Natural and Historic Resources, Engineering and Construction Element. An annual appropriation of one million dollars was established and maintained until 1977. Due to extensive destruction 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 including the *Great Egg Harbor Inlet to Peck Beach Shore Protection Project* which is located within the current study area..

In 1978, the legislature passed a Beaches and Harbors Bond Act (P.L., 1978, c.157) and instructed the NJDEP to prepare a comprehensive Shore Protection Master Plan in order to reduce the impacts and conflicts between shoreline erosion management and coastal development. Released in 1981, it has served as a guide to suitable alternatives for the mitigation of erosion and to develop a list of priorities among the engineering plans.

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

The issue of providing stable funding for shore protection at the State level had been raised on several occasions. The two storms during the winter of 1991-92 prompted a Governor's Shore Protection Summit in February of 1992. As a result, the Shore Protection and Tourism Act of 1992 was passed, thereby creating the first dedicated stable source of funding for shore protection equaling, at a minimum, $15 million annually. This was upgraded to $25 million in 1999.

1.5.3 Local Shore Protection Projects

1.5.3.1 Local Projects at South End Ocean City, NJ

In combination with the existing Federal project, approximately 275,250 cubic meters (360,000 cubic yds) of beachfill was placed at the South End in 1995. The project extended from 36th to 59th Streets and consisted of an approximately 30.5 meter (100 ft) berm width. Project cost totaled $1,650,000 and was paid for by both State and local funds. A similar project was completed in December 2000. Sand quantity was 91,436 cu meters (300,000 cu yds) at a cost of $1,500,000 which was also paid for by State and local funds.

With the exception of dune grass and sand fence installation projects, all previous projects have consisted of hard structures such as groins and bulkheads. In 1907, the municipality constructed 1,465 meters (4,800 ft) of timber wave breaker at the southwest end of the island. This structure apparently was not effective and was destroyed in 1913. North from the northern end of this structure, between 36th and 49th Streets, the municipality constructed four sections of timber wave breakers totaling 975 meters (3,200 ft) in 1920. In 1915, the municipality constructed seven timber groins, between 50th and 56th Streets, and in 1929 the State and municipality combined to extend the length of these groins to 53 meters (175 ft). These seven groins are mostly covered and are in poor to fair condition. Just south of these groins, at 57th and 58th Streets, the municipality constructed two timber groins 53 meters (175 ft) and 69 meters (225 ft) in length, respectively, in 1920. These two groins are also mostly covered and in poor condition. In 1926 the State and municipality constructed a stone groin 183 meters (600 ft) long at 59th Street, which is the southwest end of the developed section of the island. This groin is inclined to the east with respect to the shore. The groin is in fair condition with accretion on both sides. In 1926 the municipality constructed a timber groin 38 meters (125 ft) long from the inner end of and at right angles to the south side of the stone groin. The timber groin is covered with sand and has been effective in protecting the south side of the inner end of the 59th Street groin from being flanked.

In 1952 the municipality constructed three sections of timber bulkhead totaling 2,100 meters (6,900 ft) in the reach between 43rd and 58th Streets. Sections of these bulkheads were destroyed during the storm of 6-7 March 1962. As an emergency measure after that storm, the destroyed or damaged sections of bulkhead in that reach were rebuilt. A total length of 4,025 meters (13,200 ft) of new bulkhead with stone revetment was constructed in the reach between 34th and 57th Streets after the storm. At present, a continuous line of stone-revetted bulkhead having a top elevation of approximately +3.2 meters (10.8 ft NAVD88) extends from 34th Street to the fishing pier below 58th Street.

Numerous projects which include beachfills, bulkheads, and groins, have also been constructed at the northern portion (north of 34th Street) of Ocean City and are documented in previous USACE reports.

1.5.3.2 Local Projects at Strathmere (Upper Township), NJ

In November 2000, a permit application was submitted to the Corps by the State of New Jersey to place 76,196 cu meters (250,000 cu yds) of sand along Strathmere between Seaview Drive and Prescott Road. This project is expected to occur in the fall of 2001. The application also mentions that a project of similar scale is expected to occur every 5 years.

In 1920, the municipality constructed five timber groins 46 meters (150 ft) to 76 meters (250 ft.) in length and a timber wave breaker approximately 244 meters (800 ft) long. This groin field was eventually extended northward to Corson Inlet frontage to contain nine groins. These groins were not maintained and have either disintegrated or been covered by sand in Corson Inlet. The wave breaker constructed also no longer exists.

Considerable erosion to the natural barrier dune in this reach occurred during the storm of 6-7 March 1962. The dune was rebuilt to a top elevation of +2.8 meters (9.3 ft NAVD88) with a sand fence along the top to stabilize the dune and to encourage the natural building-up of the dune.

Serious erosion to the dune face and the beach at Strathmere during the storm of September 1964 and the continued erosion during subsequent moderate storms had left this area of shoreline particularly vulnerable to storm damage. As a result, around 1967, the State and municipality constructed a bulkhead and rebuilt the eroded dune to a top elevation of +3.4 meters (11.2 ft NAVD88) along a 968 meter (3,175 ft) reach from above Seaview Avenue to south of Sherman Road.

The State also built groins at Seaview, Seaspray, and Seabreeze Avenues in 1966, a groin at Seacliff Avenue in 1964, groins at Randolph and Putman Roads in 1968, groins at Otis and Sumner Roads in 1970, and a groin at Willard Road in 1973. In 1982, groins 152 meters (500 ft) in length were constructed at Hamilton, Grant, and Taylor Avenues by the State and municipality.

Table 1.5.3-1 Beach Replenishment Projects, 1982 To Present - Strathmere (Upper Township), NJ

Date Completed	Quantity of Material (cubic meters)*	Total Project Cost	Description & Comments
1982	34,400	Unknown	None
1984	1,223,360	$ 2,500,000 (incl post storm)	Extended from Williams Road in Strathmere south to 1st Street in Sea Isle City.
1984	452,640	see above	Followed storm of March 1984.
1999	10,640	$94,000	Placed along inlet frontage.
2001 (proposed)	76,196	$1-2 million (estimated)	Between Seaview Drive and Prescott Road

*divide by 0.76 to convert to cubic yards

1.5.3.3 Local Projects at Sea Isle City, NJ

The City of Sea Isle City and State of New Jersey have performed various beach replenishment and erosion control protective structure projects with the most recent activity has involved placing sand to cover exposed geotechnical tubes in the Whale Beach area. Prior projects were based on some of the recommendations from *House Document 91-160, 1st Session (1969) New Jersey Coastal Inlets and Beaches-Great Egg Harbor to Stone Harbor*. These recommendations were also later detailed in *General Design Memorandum, Corson Inlet and Ludlam Beach, NJ (1976)*. These projects can be found on the following tables 1.5.3.3-1 and 1.5.3.3-2.

Table 1.5.3-2 Beach Replenishment Projects, 1976 To Present - City of Sea Isle City, NJ

Date Completed	Quantity Of Material (cubic meters)*	Total Project Cost	Description & Comments
11/76	21,080	$51,255	Reconstruction of protective dune, 1st Street and 57th Street to 80th Street.
8/78	297,000	$581,560	Dune reconstruction & beachfill, City of Sea Isle City. This project involved the hydraulic placement of sand along the Sea Isle City beachfront from 57th Street to 93rd Street.
11/81	8,740	$38,640	Emergency beachfill along Atlantic Ocean shore-front. This project extended from 60th Street to 66th Street. Work involved the placement of a bankrun gravel material to construct an emergency dune.
11/83	2,750	$15,622	Emergency dune reconstruction, 80th to 81st Street. The work of this project involved the placement of a trucked in bankrun sand material.
1/84	Equipment Rental to Haul Sand	$42,636	Emergency dune reconstruction and beachfill, 79th Street to 82nd Street, Phase II. The work of this project involved the rental of equipment to haul sand from and area south of 88th Street to rebuild the sand dune between 79th and 82nd Streets.
1984	626,650	$3,652,500	The construction of a sand beachfill along the Atlantic Ocean shorefront of Sea Isle City. Work on this project extended from 47th Street to 86th Street.
1985	1,000	$33,397	Emergency dune reconstruction, 79th Street to 83rd Street. This project involved the placement of a bankrun gravel core and bankrun sand material in the area from 79th Street to 83rd Street. Work was undertaken as an emergency procedure to protect the project area. This work was necessary due to the damage caused by Hurricane Gloria in September, 1985.
1987	122,000	$480,940	Sand beachfill along the Atlantic Ocean shorefront of Sea Isle City. This work involved the placement of sand between 86th Street and 76th Street in Sea Isle City. This project was necessary due to the damage caused by Hurricane Gloria in September, 1985.
1992	306,000	$1,280,000	Sand beachfill along shorefront from 75th Street to 90th Street.
1995	18,043 sand 11,657 dune core	$242,280	FEMA sponsored dune repair extending from 1st Street to 15th Street. The dunes from 3rd-6th Street were breached during a storm on 1/8/96.
1995	91,750	$452,659	Sand beachfill along shorefront from 90th Street to Townsends Inlet.
1999	270,560	$1,435,513	Sand beachfill along shorefront from 88th to 93rd.
2000		$135,000	Sand to cover exposed geotextile tubes , 1st to 15th Street
2001 (proposed)		$150,000 (est.)	Sand to cover exposed geotextile tubes , 1st to 15th Street

*divide by 0.76 to convert to cubic yards

Table 1.5.3-3 Municipal Erosion Control Protective Structures - 1973 To Present - City of Sea Isle City, NJ

Date Completed	Total Project. Cost	Description & Comments
10/74	$572,893	Removal of existing timber pile crib groins and the construction of new timber and stone groins at 44th and 47th Streets. The construction of a new timber and stone groin at 52nd Street.
5/76	$403,125	This project involved the construction of a timber bulkhead from 55th Street to 57th Street, and the construction of a new timber and stone groin at 57th Street.
2/83	$1,570,000	Construction of timber and stone groins along the Atlantic Ocean shorefront, City of Sea Isle City at 62nd Street, 67th Street, 73rd Street, and 78th Street.
1989		A demonstration pre-cast concrete breakwater was constructed by Breakwaters International, Inc. in July 1989 at 8th and 10th Streets. Severe settling probably due to ancient peat deposits compromised the structure foundation. Cracks appeared in the structure and waves would break over the lower section of the breakwater even during low tide
1993	$1,284,915	Construction of two timber and stone groins at 83rd Street and 88th Street.
1997	$163,398	Construction of 274 meters (900 ft) of geotextile tube between 91st Street and 93rd St.
1998	$393,000	Construction of 1,220 meters (4000 ft) of geotextile tube between 1st Street to 13th St.
1999	$1,267,090	Construction of terminal groin at 93rd Street.

Prior to these recent structures, a stone groin 78 meters (255 ft) long was constructed by the State and municipality in 1945 at 33rd Street, and is still in good condition. Seven groins were constructed by the municipality in 1923. They were severely damaged during the 1944 storm and later storms, and were reconstructed by the State and municipality between 1952 and 1954. Most of these no longer exist although some were later rebuilt.

A recreation pier was reconstructed twice after it was destroyed in the 1944 and 1950 storms; however, after the entire middle section of the pier was damaged in the November 1953 storm it was not rebuilt. Erosion destroyed 1,448 meters (4,750 ft) of timber wave breaker that was constructed by the city in 1923. After erosion moved the shore line landward, property owners constructed 1,852 meters (6,075 ft) of bulkhead from 29th Street to 52nd Street (most of this bulkhead was constructed between 1945 and 1955). These structures have been virtually destroyed during subsequent storms.

Between 1950 and 1955 the city constructed and maintained 585 meters (1,920 ft) of timber bulkhead or sand fences at thirty street ends to prevent damage by beach front wave action in the central section of the city. These structures likewise have been destroyed during subsequent storms.

Considerable beach and dune erosion occurred along the shoreline during the storm of March 1962. Subsequently, the eroded dunes were rebuilt to a top elevation ranging from about +2.8 meters (9.3 ft NAVD88) at the center of the city to about +3.4 meters (11.2 ft NAVD88) at the Townsends Inlet area as an emergency measure. A continuous line of sand fence was constructed along the top of the dune to aid in stabilizing and building-up of the dune.

In the reach between 40th Street and 44th Street, a paved promenade was constructed after the March 1962 storm in lieu of a sand dune. The promenade has a top elevation of +3.7 meters (12.0 ft NAVD88) and consists of two parallel rows of timber bulkhead 7.3 meters (24 feet) apart. The bulkheads are sand filled and topped with a two-inch bituminous pavement with a six-inch gravel base. The seaward face of the promenade is revetted with stone.

In 1967, the State constructed a timber bulkhead with stone revetment between 29th and 40th Streets. Shortly, thereafter, the municipality extended the promenade from 40th Street northward to 32nd Street.

In 1971, the state constructed an additional section of timber bulkhead with stone revetment from 44th Street south to 55th Street. This bulkhead was eventually extended to 57th Street in 1976 along with the construction of a timber and stone groin at that point. The promenade was eventually extended from 29th Street to 57th Street.

The State also constructed and/or rebuilt groins at 31st, 36th, 41st, 44th, 47th, and 52nd Streets between 1967 and 1973. After a coastal storm in December 1974 the dunes from 55th to 89th Street were rebuilt to elevation +2.7 meters (9.0 ft NAVD 88) as the result of an emergency declared by the Federal Emergency Management Agency (FEMA).

1.6 Expected Future Projects

1.6.1 Ocean City

Due to the existing infrastructure, the relatively large year-round population, and vital tourism impacts to the State, it is extremely unlikely that this area would ever be abandoned. Historically, both State and local governments have taken whatever actions necessary to provide some degree of storm damage protection. Local and state officials have indicated that subsequent beachfills of at least similar magnitude and frequency as the 1995 and 2000 beachfills will be required and accomplished in the foreseeable future.

1.6.2 Ludlam Island

Similar to Ocean City, recent history has demonstrated that the State of New Jersey and local governments will take whatever actions necessary to maintain some degree of storm protection at this location. Regardless of the project scale, the common goal has been to "hold the line", maintaining the beach profile at a critical condition. Significant amounts of funds have been used to address long-term problems (e.g. groin construction) and "hot-spots". This is most clearly indicated at the Townsends Inlet area of Sea Isle City, where over $6,000,000 has been spent since 1992 on an approximately 10 block stretch. Many other recent projects are relatively small-scale, intended to basically "hold the line" until funding becomes available for larger scale projects. The recent use of geotextile tubes along both the Whale Beach and Townsends Inlet areas are examples. In 2000 and 2001, due to the erosive conditions, sand placement was required to cover the exposed tubes. This particular project would be expected to continue in the foreseeable future.

In November 2000, a permit application was submitted to the Corps by the State of New Jersey to place 76,196 cu meters (250,000 cu yds) of sand along Strathmere between Seaview Drive and Prescott Road. This project is expected to occur in the fall of 2001 and is expected by the state to reoccur every 5 years.

Other proposed projects include plans for a beachfill (roughly 266,000 cubic meters) in the center of town ranging from approximately 45th to 54th Streets and the construction of 5 groins.

In 1997, NJDEP and the City of Sea Isle City were granted a Corps permit to construct 5 low-profile groins at 6th, 11th, 16th, 21st, and 26th Streets along with a 912,000 cubic meter (1,200,000 cy) beachfill extending from 1st Street to 31st Street. At this time, the future of this potential project is doubtful for various reasons.

Regardless, the existing Cape May County roadway (County Road 619-Landis/Commonwealth Avenue) located adjacent to the homes would still be maintained. Therefore, it is likely that some project would need to be constructed to maintain the roadway and its location.

The existing beach profile is at a critical position at many locations along Ludlam Island. In many locations, the high tide line reaches the bulkhead. Since extensive groin construction has taken place along most of the island, the most likely local projects following the economic base year (2005) of this study would be beachfill placement. With the exception of the southern portion of Sea Isle City, the last major beachfill placement along the entire island occurred in 1984. This was both in response to the existing conditions and the March 1984 storm (less than a 20-year frequency event). It can be estimated that beachfill placement of similar magnitude will be conducted at about the economic base year for the entire island. This corresponds with the planned beachfill placement for Strathmere and Sea Isle City mentioned previously. A conservative estimate for the frequency of future beachfill placement would be on the order of about 20 years, based on history and anticipated storm events. However, it is likely that beachfill placement would be performed more frequently especially since most of the planned groin construction has been completed, thereby freeing up funds for beachfill placement.

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2 EXISTING CONDITIONS

2.1 Socio-Economic Resources

2.1.1 Population and Land Use

The study area is located along the Atlantic coast of New Jersey extending approximately 24.1 kilometers from Great Egg Harbor Inlet to Townsends Inlet. It encompasses three coastal communities, which include Ocean City, Strathmere and Sea Isle City. Because Strathmere is an unincorporated community statistics will be presumed to be similar to the county's records.

Cape May County is the second least populated county within New Jersey with a total population of 95,089 year-round residents in 1990, equaling 1.2% of the state's permanent population. Cape May County's economy relies almost entirely on the tourist industry, unlike the majority of New Jersey communities. Although New Jersey is known for having a strong farming industry, only 2% of Cape May's work force is employed in farming, fishing or forestry while over 46.4% of the county's residents depend on service and sales oriented companies. Because of the county's dependency on tourism, their unemployment rate remains the second highest within the state. Since 1985, the unemployment rate fell from 11.1% to 7.1% in 1990, still well above the national average of 5.5%. Unlike the county, Ocean City has a relatively low unemployment rate of 3.5%.

2.1.2 Housing Characteristics

Although the towns of Ocean City and Sea Isle City have continued to grow, they have done so at a decreasing rate. One aspect of this slowing growth trend is displayed in the number of total dwelling units that have been authorized building permits in recent years. In 1986 Ocean City was granted 525 permits while Sea Isle received 204. In 1990 however, Ocean City received only 44 permits with Sea Isle receiving 61. This decline in construction is partially due to new regulations and restrictions being placed on contractors. The lack of sewer systems in most townships, particularly along the Delaware Bay, has forced the County Health Board to grant approval for development only if the developer can show plans for adequate sanitation facilities and wastewater management. Once a community installs sewer lines, Cape May County additionally mandates a minimum of 3,500 square feet of land per unit. Despite this slowing growth trend and these new regulations, it is projected that Cape May County as a whole, will increase by 17% from the year 1990 to 2000.

According to the 1990 census, the total number of dwelling units in Cape May County were 85,537, an increase of 13,430 or 18.6% from 1980. Of these units, 49,074 were considered year-round units (57.4%). The majority of these homes are owner occupied with 25% renter occupied. Almost half of the new dwelling units (48.4%) during the 1980s were added in three municipalities: Lower Twp (2,180), Ocean City (2,164) and Upper Twp. (2,154). Significant increases were also reported in Sea Isle City with (1,394). The median home value in Cape May County for both occupied and vacant single family homes was $112,800 in 1990 with a median rent of $474.

Table 2.1.2-1 Housing Unit Occupancy

	Total Units	Vacant	Occupied	Owner Occupied	Renter Occupied
Cape May County	85,537	47,681	37,856	27,242	10,614
New Jersey	3,075,310	280,599	2,794,711	1,813,381	981,330

Source: U.S. Census

2.1.3 Income

The growth of total personal income was far greater in Cape May County during the 1981 1991 period than in the State or the nation as a whole. Total personal income in the county increased to $2,204 million in 1991, an increase of 113.7% from 1981. This greatly exceeded the 91.5% increase in the nation and the 105% increase in the state during the same time period.

Table 2.1.3-1 1990 Income Data

	Median Household Income	Per Capita Income
Cape May County	$30,435	$15,538
Ocean City	$32,018	$20,399
Sea Isle City	$32,218	$17,768

2.2 Geotechnical Analysis

2.2.1 Geomorphology

The study area 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 250 kilometers (155 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 runs from the Navesink Highlands southeastward to the Mount Holly area, with the land rising gradually from the sea as a moderately dissected plain to an elevation of approximately 91 meters (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 0.5 meters to 1.5 meters per kilometer (2.6 ft to 7.9 ft per mile) for nearly 167 kilometers (104 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 stoney deposits. It extends from Cape Cod to Florida, and is by far the world's largest sandy continental shelf.

2.2.2 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 beach, in the central portion of the state.

2.2.3 Barrier Beaches

The New Jersey barrier beaches belong to a land form susceptible to comparatively rapid changes. In the study area, the barrier islands range in width from 300 meters (about 1000 feet) to about 1,500 meters (about 5,000 feet). Landward of the barrier beaches and inlets of the study area are tidal bays, which range from five to eight kilometers (3 to5 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 thorofares. 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 brings in more sediments in suspension from the ocean on flood tide than they remove on ebb tide. The vegetation of the lagoon, both in marsh and bay, serves to trap and retain the sediments.

2.2.4 Drainage of the Coastal Plain.

The stream drainage system of the New Jersey coastal plain developed at a time when sea level was lower than at present. The subsequent rise in sea level has drowned the mouth of coastal streams where tidal action takes place. This tidal effect extends up the Delaware River to Trenton, NJ, a distance of 223 kilometers (139 miles). The formation of the barrier beaches 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 beaches 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.

2.2.5 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 progress southward. Between Bay Head and Cape May City, the coastal lagoons, tidal marshes and barrier beaches fringe the coast. These formations have contributed to the sands of the present beaches. During Quaternary time, changes in sea level caused the streams alternately to spread deposits of sand and gravel along drainage outlets and later to remove, rework, and redeposit the material over considerable areas, concealing earlier marine formations. One of these, the Cape May formation consisting largely of sand and gravel, was deposited during the last interglacial stage, when the sea level stood 10 to 14 meters (38 to 46 feet) higher than at present. This material was deposited along valley bottoms, grading into the estuarine and marine deposits of the former shoreline. In places along the southern New Jersey coast, there is a capping of a few feet of Cape May formation. This capping is of irregular thickness and distribution, that generally forms a terrace about 7.5 to 10.5 meters (25 to 34 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.

2.2.6 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 30 meters per kilometer (155 feet per mile) to a depth of more than 2,000 meters (1.2 miles) 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. The beds vary greatly in thickness, increasing seaward to a maximum thickness of

4,000 meters (2.5 miles) then decreasing to 2,500 meters (1.5 miles) 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 1,500 meters (1 mile) near the edge of the continental shelf.

2.2.7 Geologic History

The sea successfully advanced and retreated across the 250-kilometer (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 variations in sea level continued to take place during Pleistocene time. Glacial periods brought a lowering in sea level as water was locked up in the high ice masses. As the sea level fell to a beach line, kilometers seaward of the present shoreline, Pleistocene sediments were deposited on the coastal plain and in valleys cut into older formations. The water released through glacial melt during interglacial periods brought a rising of sea level and beaches were formed far inland of the present shore.

2.2.8 Beach Sampling

(All elevations in NAVD88 datum)

Beach samples were collected on five survey lines along southern Ocean City and along nine survey lines on Ludlam Island. A distance of approximately one mile was used to determine separation between the survey lines that were sampled. The following survey lines were sampled along southern Ocean City: OC51, OC53, OC55, OC57, and OC59 (Figure 2.7.8-1). Samples were collected by Ocean Surveys, Inc. in both March and September 1997 at the following location along the survey line: dune base, berm crest, midberm, mean high water, mean low water, -2.21 meters (-7.25 feet), -4.04 meters (-13.25 feet), and –5.87 meters (-19.25 feet). The Ludlam Island survey lines that were samples are as follows: LI-1, LI-2A, LI-3, LI-4A, LI-5A, LI-5C, LI-6A, LI-6BA, and LI-6D (Figure 2.7.8-1). Samples for Ludlam Island were collected in two time periods, the first being January to April 1998 and the second October to December 1998. The samples were collected at the following locations along the survey lines: dune base, mean high water, mean low water, -2.21 meters (-7.3 ft), -4.04 meters (-13.3 ft), and –5.87 meters (-19.3 ft). Unfortunately, a certain number of samples were not obtained during the Ludlam Island sampling. For January to April 1998 the samples not collected were LI-1: -2.21 meters (-7.3 ft), -5.87 meters (-19.3 ft); LI-2: -2.21 meters (-7.3 ft); LI-3: -2.21 meters (-7.3 ft), -5.87 meters (-19.3 ft); LI-4A: -5.87 meters (-19.3 ft). The samples not collected for the October to December 1998 were LI-6BA: -2.21 meters (-7.3 ft); -4.04 meters (-13.3 ft).

2.2.9 Potential Borrow Area Delineation

The *Great Egg Harbor Inlet to Townsends Inlet Reconnaissance Study (April 1996)* identified several potential borrow areas for southern Ocean City and Ludlam Island using existing information. In order to positively identify sources of sand for the Great Egg Inlet to Townsends Inlet Feasibility Study, a series of sub-bottom acoustic profiling lines were conducted off of Ludlam Island. Forty-seven vibrocores were then obtained to identify specific material types in certain areas.

2.2.9.1 Acoustic Sub-bottom Profile

An acoustic survey of the area between Sea Isle City, NJ and Corson Inlet, NJ was conducted between 31 July 1997 to 5 August 1997. A seismic reflection method, which measures the response of a medium to the passage of an elastic wave, was utilized. A subbottom profiler operating at a frequency of 3.5 kHz was used. Accurate positioning for the survey was accomplished using a DGPS satellite receiver connected to a data link receiver tuned to the U.S. Coast Guard GPS transmitter at Sandy Hook, NJ. The geophysical survey provided project area-wide data on the topography of the sea bottom and the sub-bottom acoustic (seismic) reflectors to a depth of about 15.24 meters (50 feet) below the sediment / water interface. Eleven profiling lines were run parallel to the coast with an additional four lines that zigzagged across the area surveyed to total 144.84 kilometers (90 miles) of acoustical surveying. The lines ranged in distance offshore from approximately 2.4 (1.5) to 6.4(4) kilometers (miles).

2.2.9.2 Vibrocore Borings

Thirty-seven vibrocores, NJV-347 to NJV-379, were collected, in the Atlantic Ocean off the coast of New Jersey, within the limits of the acoustic survey. The samples were collected from 31 July 1997 to 5 August 1997. The desired depth of penetration for the vibrocores was 6.10 meters (20 feet). The fieldwork included positioning of the vessel using a DGPS navigation system, obtaining continuous core samples and penetration records. All vibrocores were retrieved using a 271B Alpine pneumatic vibrocorer with particle size analysis of the sediment retrieved in the vibrocores.

In the vicinity of Corson Inlet New Jersey, 10 vibrocores, NJV-521 to NJV-530, were collected by Duffield Associates. The samples were collected in July 1999 to a desired depth of penetration of 3.05 meters (10 feet). The fieldwork was similar to that which was detailed above, however the vibrocoring was conducted aboard a 15.24 meters by 6.10 meters (50 feet by 20 feet) barge positioned by a tugboat. The vibrocores were advanced utilizing a 203.2 millimeter (8 inch) Alpine pneumatic vibrocorer. A visual classification and particle size analysis was conducted on the sediment retrieved in the vibrocores.

2.2.10 Native Beach Characteristics

Two separate composite grain size curves were developed for southern Ocean City and Ludlam Island beach material. The mean grain size for lower Peck Beach is 2.13 phi units (0.23 mm) with a standard deviation of 0.88 phi units (0.54 mm). This corresponds to poorly graded sand based on the Unified Classification System. All survey lines which were sampled were used in the development of the composite grain size curves, however only the March 1997 data was used because it yield a coarser mean for the beach material. This means if the borrow area material is suitable to the coarser mean grain size then it will also be suitable for the finer mean grain size during the summer beach. Borrow material should be the same size or slightly coarser than the native material on the beach to be nourished.

The mean grain size for Ludlam Island is 2.52 phi units (0.17 mm) with a standard deviation of 0.87 phi units (0.55 mm). According to the Unified Soil Classification System the beach material is poorly graded sand. The composite grain size curves were developed from all the survey lines that were sampled and both sampling events.

2.2.11 Borrow Area Suitability Analysis

Ideally, borrow material should be the same size or slightly coarser than the native material on the beach to be nourished. If the borrow material has a significantly smaller grain size, the profile will be out of equilibrium with the local wave and current environment, and will therefore be quickly eroded either offshore or alongshore. This analysis compares the native sediment characteristics to the borrow material characteristics. The analysis was completed using the methodology put forth in the Shore Protection Manual (1984). Overfill factors (R_a) and renourishment factors (R_j) were calculated for each potential borrow area. The overfill factor estimates the volume of fill material needed to produce one cubic yard of stable beach material after equilibrium (when the fill and native materials are compatible) is reached. Consequently, overfill factors are greater or equal to one. For example, an overfill factor of 1.2 would indicate that 1.2 cubic yards of borrow material would be required to produce 1.0 cubic yards of stable material. This technique assumes that both the native and composite borrow material distributions are nearly lognormal.

The renourishment factor is a measure of the stability of the placed borrow material relative to the native beach material. Desirable values of the renourishment factor are those less than or equal to one. For example, a renourishment factor of 0.33 would mean that renourishment, using the borrow material, would be required one third as often as renourishment using the same type of material that is currently on the beach.

There were six[4] potential borrow areas identified in this phase of study. The six areas are C1, L1, L2, L3, M3, and M8 and shown in Figure 2.2.11-1. Coordinates can be found on Table 2.2.11-1. The vibrocores that fell within the delineated borrow areas were analyzed for

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[4] Two additional potential borrow areas, O and N, located off Strathmere and Sea Isle City respectively, were initially delineated but later removed from consideration due to substandard material (high fines content).

suitability with the native beach material of both the Ocean City and Ludlam Island beaches. In order to perform borrow area suitability analysis the mean grain size and standard deviation, both in phi units, were computed for each five foot increment of the vibrocore. Overfill factors were then computed using the native beach and vibrocore's five foot increment mean grain size and standard deviation. The subbottom depth of the vibrocore was then compared with the overfill factor to identify to which depth the particular vibrocore would be composited. After compositing the vibrocore to a particular depth, overfill and renourishment factors were computed for each vibrocore to identify if the factors were within acceptable parameters. The final composite for a particular borrow area was developed from the individually composited vibrocores for that particular borrow area and overfill and renourishment factors were then calculated for each area. These factors were then analyzed to ensure that the borrow material was suitable for each native beach.

Figure 2.2-1 Highest Rated Potential Borrow Areas

Table 2.2.11-1 Highest Rated Potential Borrow Areas - Coordinates

New Jersey State Plane Coordinates NAD 83 Datum

Point	Northing (m)	Easting (m)	Northing (ft)	Easting (ft)	Latitude (N)	Longitude (W)
M8-1	37,928	143,205	124,435	469,833	39.17499	-74.57864
M8-2	39,077	142,568	128,205	467,743	39.18533	-74.58602
M8-3	41,592	144,078	136,457	472,697	39.20800	-74.56857
M8-4	40,813	144,865	133,901	475,279	39.20099	-74.55945
L1-1	36,329	137,864	119,189	452,309	39.16052	-74.64043
L1-2	35,085	139,383	115,107	457,291	39.14933	-74.62284
L1-3	32,187	137,494	105,601	451,094	39.12321	-74.64464
L1-4	33,511	136,275	109,943	447,095	39.13511	-74.65876
L3-1	36,944	138,179	121,207	453,342	39.16607	-74.63679
L3-2	38,718	140,738	127,027	461,738	39.18208	-74.60720
L3-3	38,443	141,887	126,125	465,508	39.17961	-74.59390
L3-4	37,026	142,072	121,475	466,115	39.16685	-74.59174
L3-5	36,537	141,124	119,871	463,005	39.16244	-74.60271
L3-6	34,958	139,538	114,691	457,801	39.14819	-74.62104
L3-7	36,329	137,864	119,189	452,309	39.16052	-74.64043
CI-1	40,038	137,474	131,358	451,029	39.19393	-74.64501
CI-2	40,786	138,209	133,812	453,441	39.20068	-74.63651
CI-3	41,578	137,107	136,409	449,826	39.20779	-74.64928
CI-4	41,395	136,935	135,810	449,261	39.20615	-74.65127
CI-5	40,864	137,486	134,068	451,098	39.20137	-74.64489
CI-6	40,415	137,084	132,595	449,750	39.19732	-74.64953
M3-1	39,404	139,193	129,279	456,668	39.18825	-74.62510
M3-2	42,766	141,535	140,309	464,353	39.21856	-74.59803
M3-3	41,612	142,834	136,521	468,613	39.20817	-74.58298
M3-4	39,284	140,844	128,883	462,086	39.18718	-74.60599
M3-5	39,110	139,350	128,312	457,183	39.18559	-74.62328
L2-1	32,187	137,494	105,601	451,094	39.12321	-74.64464
L2-2	35,085	139,383	115,107	457,291	39.14933	-74.62284
L2-3	33,915	140,810	111,269	461,975	39.13881	-74.60630
L2-4	31,157	139,061	102,221	456,237	39.11395	-74.62649

The overfill and renourishment factors for area C1 (Corson Inlet) are summarized in Table 2.2.11-2. All the above vibrocores were composited to their full length of approximately 3 meters (10 feet). All the vibrocores above are compatible with the native material on both Ocean City and Ludlam Island with the exception of NJV-523, which was not compatible with the Ocean City material. This vibrocore was still included in the composite because of its compatibility with the Ludlam Island material. Borrow area C1 contains approximately 760,000 cu meters (1,000,000 cu yards) of appropriate sand.

Table 2.2.11-2 Overfill and Renourishment Factors for Borrow Area C1

			South End Ocean City		Ludlam Island	
Vibrocore	**Mean Grain Size M_ϕ (Phi)**	**Standard Deviation σ_ϕ (Phi)**	**Overfill Factor R_a**	**Renourishment Factor R_j**	**Overfill Factor R_a**	**Renourishment Factor R_j**
NJV-522	2.22	0.65	1.5	0.390	1.0	0.883
NJV-523	1.70	0.88	1.0	0.610	1.0	0.385
NJV-524	2.04	0.74	1.0	1.045	1.0	0.661
NJV-525	1.77	0.90	1.0	0.649	1.0	0.408
NJV-526	2.07	1.06	1.1	1.060	1.0	0.468
Composite	1.96	0.89	1.0	0.815	1.0	0.513

The overfill and renourishment factors for area L1 are summarized in Table 2.2.11-3. All vibrocores for area L1 were composited to a depth of 4.57 meters (15 feet) with the exception of NJV-372 and NJV-373, which were composited to a depth of 1.52 meters (5 feet). All vibrocores for the area are compatible with both of the native beach materials. This area contains approximately 12,310,000 cu meters (16,100,000 cu yards) of sand.

Table 2.2.11-3 Overfill and Renourishment Factors for Borrow Area L1

			South End Ocean City		Ludlam Island	
Vibrocore	**Mean Grain Size M_ϕ (Phi)**	**Standard Deviation σ_ϕ(Phi)**	**Overfill Factor R_a**	**Renourishment Factor R_j**	**Overfill Factor R_a**	**Renourishment Factor R_j**
NJV-359	1.97	1.26	1.1	0.493	1.0	0.307
NJV-372	1.72	0.97	1.0	0.564	1.0	0.353
NJV-373	1.41	1.75	1.1	0.101	1.1	0.061
NJV-374	2.01	1.03	1.0	0.725	1.0	0.455
Composite	1.86	1.29	1.1	0.414	1.0	0.257

The overfill and renourishment factors for area L2 are summarized in Table 2.2.11-4. Vibrocore NJV-366 was composited to a depth of 6.10 meters (20 feet) and vibrocore NJV-371 was composited to a depth of 4.57 meters (15 feet). Both vibrocores for the area are compatible with the Ocean City and Ludlam Island native beach materials. Borrow area L2 contains approximately 9,120,000 cu meters (12,000,000 cu yards) of sand.

Table 2.2.11-4 Overfill and Renourishment Factors for Borrow Area L2

			South End Ocean City		Ludlam Island	
Vibrocore	Mean Grain Size M_ϕ (Phi)	Standard Deviation σ_ϕ (Phi)	Overfill Factor R_a	Renourishment Factor R_j	Overfill Factor R_a	Renourishment Factor R_j
NJV-366	0.53	0.94	1.0	0.151	1.0	0.093
NJV-371	0.75	1.01	1.0	0.178	1.0	0.110
Composite	0.63	0.98	1.0	0.161	1.0	0.100

The overfill and renourishment factors for area L3 are summarized in Table 2.2.11-5. Vibrocores NJV-357 and NJV-362 were composited to a depth of 3.0 meters (10 feet) and vibrocores NJV-360 and NJV-365 were composited to a depth of 4.6 meters (15 feet). The compatibility analysis shows that borrow area L3 is better suited as a sand source for the Ludlam Island area. This is because of the higher than normal overfill and renourishment factors for a number of vibrocores when compared to the Ocean City native beach material. This borrow area contains approximately 16,714,000 cu meters (21,861,000 cu yards) of sand.

Table 2.2.11-5 Overfill and Renourishment Factors for Borrow Area L3

			South End Ocean City		Ludlam Island	
Vibrocore	Mean Grain Size M_ϕ (Phi)	Standard Deviation σ_ϕ (Phi)	Overfill Factor R_a	Renourishment Factor R_j	Overfill Factor R_a	Renourishment Factor R_j
NJV-357	1.97	0.66	1.1	1.038	1.0	0.657
NJV-360	2.31	1.26	1.3	0.726	1.0	0.454
NJV-362	2.20	0.78	1.2	1.205	1.1	0.764
NJV-365	2.19	0.94	1.1	0.998	1.0	0.629
Composite	2.19	0.98	1.1	0.949	1.0	0.598

The overfill and renourishment factors for area M3 are summarized in Table 2.2.11-6. Vibrocores NJV-352, NJV-369, and NJV-376 were composited to a depth of 1.5 meters (5 feet), vibrocores NJV-353 and NJV-377 were composited to a depth of 3.0 meters (10 feet), vibrocore 370 was composited to a depth of 4.6 meters (15 feet), and vibrocore NJV-351 was composited to a depth of 6.1 meters (20 feet). This borrow area is compatible with both the Ocean City and Ludlam Island native beach material. Borrow area M3 contains approximately 8,740,000 cu meters (11,500,000 cu yards) of sand.

Table 2.2.11-6 Overfill and Renourishment Factors for Borrow Area M3

			South End Ocean City		Ludlam Island	
Vibrocore	Mean Grain Size M_ϕ (Phi)	Standard Deviation σ_ϕ (Phi)	Overfill Factor R_a	Renourishment Factor R_j	Overfill Factor R_a	Renourishment Factor R_j
NJV-351	1.70	0.74	1.0	0.710	1.0	0.447
NJV-352	1.37	0.84	1.0	0.441	1.0	0.276
NJV-353	1.96	1.29	1.1	0.464	1.0	0.289
NJV-369	1.69	1.13	1.0	0.438	1.0	0.273
NJV-370	1.73	1.33	1.1	0.334	1.0	0.207
NJV-376	1.99	1.28	1.1	0.488	1.0	0.304
NJV-377	2.20	0.92	1.1	1.034	1.0	0.653
Composite	1.79	1.18	1.0	0.456	1.0	0.284

The overfill and renourishment factors for area M8 are summarized in Table 2.2.11-7. Vibrocores NJV-349 and NJV-350 were composited to a depth of 1.5 meters (5 feet) and vibrocore NJV-356 was composited to a depth of 4.6 meters (15 feet). The Ocean City and Ludlam Island native beach materials are both compatible with the material that is contained in the borrow area. Borrow area M8 contains approximately 4,940,000 cubic meters (6,500,000 cu yards) of material.

Table 2.2.11-7 Overfill and Renourishment Factors for Borrow Area M8

			South End Ocean City		Ludlam Island	
Vibrocore	Mean Grain Size M_ϕ (Phi)	Standard Deviation σ_ϕ (Phi)	Overfill Factor R_a	Renourishment Factor R_j	Overfill Factor R_a	Renourishment Factor R_j
NJV-349	1.16	1.23	1.0	0.206	1.0	0.127
NJV-350	2.25	1.17	1.2	0.781	1.1	0.489
NJV-356	2.18	1.31	1.2	0.576	1.1	0.359
Composite	1.99	1.33	1.2	0.449	1.1	0.279

2.3 Environmental Resources

2.3.1 General Environmental Setting

The general coastal environment is typical of coastal barrier island and trapped bay conditions. The barrier island complex consists of two long, narrow barrier islands of low elevation, Peck Beach and Ludlam Island, separated from one another by Corson Inlet. This type of complex is a common feature along coastal plains with a gentle slope and a tidal range of less than 4 meters (13 ft). The islands are fronted with sandy beaches and upland dunes, which help to shield the barrier island complex. Both Peck Beach Island and Ludlam Island are characterized by urban development, however, undeveloped tracts occur along the bay edges and at Corson's Inlet State Park/Strathmere Natural Area. Seashore and water-oriented summer recreation are the predominant land-uses including residential rentals and support services for commercial establishments.

2.3.2 Soils

The most dominant soil types within the study area are Coastal Beach – Urban Land Complex (CU), Fill land – sandy organic substratum (FM), Tidal marsh –deep (TD), and Tidal marsh – moderate (TM) (USDA, 1977). Coastal beach and urban land complex (CU) areas consist of undeveloped coastal beaches and of coastal beach areas used for residential or commercial purposes. Undeveloped portions are areas of non-coherent, loose sand that has been worked and reworked by waves, tides, and wind, and is still subject to such action. These areas are also subject to mechanical regrading and beach replenishment after storm events. Fill land (FM) consists of areas that have been filled with several feet or more of soil, dredged material, or other geologic material. The Fill land – sandy organic substratum is mostly on the western edge of the barrier beach along the ocean, and was previously subject to tidal inundation. The tidal marsh series (TD and TM) are very poorly drained, silty or mucky flats that are flooded twice daily by tides. The tidal marsh soils are generally found on the western edge of the barrier island flats.

2.3.3 Air Quality

Through the State Implementation Plan (SIP), The New Jersey Department of Environmental Protection 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 focussed on any facility or combination of facilities, which emit high concentrations of air pollutants into the atmosphere. Manufacturing facilities, military bases and installations, oil and gas rigs, oil and gas storage or transportation facilities, power plants, deepwater ports, LNG facilities, geothermal facilities, highways, railroads, airports, ports, sewage treatment plants, and desalinization plants are facilities and activities that may cause air quality problems. In New Jersey, there are nine pollutant standards index-reporting regions. The study area falls within the Southern Coastal Region, which covers Cape May and Atlantic Counties.

The nearest air monitoring stations in the Southern Coastal Region are located in Atlantic City, Nacote Creek and Somers Point. In 1997, the stations in Atlantic City monitored for carbon monoxide and inhalable particulates. The station at Nacote Creek monitored for sulfur dioxide and ozone. The Somers Point station monitored for sulfur dioxide only. With the exception of ozone, there were no exceedences in ambient air quality standards for the parameters measured in 1997. 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, 1998). Because of high levels of ozone, the pollutant standards index (PSI) approached the health standard on two days (June 26 and July 12) and exceeded the health standard on two days (July 13 & 14) in 1997 at the Nacote Creek station. For ozone specifically, measurements at the Nacote Creek station exceeded the New Jersey and National Standards for the maximum daily 1-hour average primary standard with a total of 3 days 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). Cape May County is classified as moderate non-attainment (0.138 - 0.159 ppm) for ozone (NJDEP, 1998).

2.3.4 Water And Sediment Quality

Mixing occurs in nearshore waters due to the turbulence created from wave energy interacting with the bottom at shallower depths. Mixing becomes less prominent in greater depths where stratification can develop during warm periods. Water temperatures generally fluctuate seasonally. 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 3.6 meters (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 12 meters (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.

Scott and Bruce (1999) and Scott and Wirth (2000) measured water quality in four proposed offshore sand borrow areas (L1, L3, M3, and O1) (Table 2.3.4-1) in September and October 1998 and November 1999. Temperature, pH, dissolved oxygen (DO), conductivity, and salinity were measured relative to depth. The bottom depths varied from a mean depth of 11.9 meters (39 feet) in Areas M3 and O1 to 14.5 meters (47.6 feet) in Area M8. The measurements taken found the water columns to be fairly homogeneous with little differences detected between sites. Most of the water column measurements showed no evidence of stratification except DO, which was slightly lower for most of the stations at the sediment interface (bottom) than at the water surface. Water temperatures were slightly higher in September than those in October.

Table 2.3.4-1 Water Quality Measurements Recorded at Selected Borrow Stations (Scott and Bruce, 1999, Scott and Wirth, 2000)

Station	Date	Depth	Temp. (°C)	pH	DO (ppm)	Conductivity (umhos/cm)	Salinity (ppt)
L1-21	9/24/98	Surface	22.2	7.55	-	48.2	31.5
		Bottom	21.4	7.19	-	48.2	31.6
L1-01	10/28/98	Surface	16.08	7.78	8.6	47.1	30.7
		Bottom	16.00	7.85	7.9	47.2	30.8
L1-55	10/27/98	Surface	16.17	7.78	8.1	47.1	30.7
		Bottom	16.07	7.88	7.8	47.2	30.8
M3-14	9/22/98	Surface	23.6	7.87	7.3	48.1	31.3
		Bottom	21.9	7.61	5.4	48.1	31.4
O1-02	9/22/98	Surface	23.5	7.90	6.2	48.0	31.5
		Bottom	22.4	7.95	5.6	48.1	31.5
L1-04	11/02/99	Surface	15.7	7.7	8.5	47.8	31.0
		Bottom	15.7	7.7	8.1	47.1	30.5
L1-13	11/01/99	Bottom	15.96	7.63	5.1	47.5	30.9
		Surface	15.52	7.59	5.2	47.4	30.9
L3-04	11/05/99	Bottom	14.82	7.76	9.4	46.9	30.7
		Surface	14.82	7.82	7.5	47.0	30.9

Water quality is generally indicated by measuring levels of the following: nutrients (nitrogen/phosphorus), pathogens, floatable wastes, and toxins. Rainfall is an important parameter for studying water quality; runoff leads to non-point 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 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.

Point source discharges from coastal wastewater treatment facilities can affect water quality at bathing beaches. Accordingly, the NJDEP routinely monitors the treatment of effluent at these facilities, to ensure that they operate in accordance with the requirements of their permits. 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 the 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, the Cape May County Health Department sampled recreational beachwater for bacteria and pathogens. Sampling was conducted once a week during the swimming season. During the 1998 summer swimming season in Cape May County, water quality criteria were never exceeded; therefore, there were no beach closings (U.S. EPA, 1999).

In addition, the NJDEP monitors coastal waters for human pathogens and indicator bacteria to determine the suitability for shellfish harvest. There are three distinct areas along the ocean coast within the study area where shellfish harvests are prohibited based on water quality (Figure 2.3.4-1). Prohibited shellfish areas are waters condemned for the harvest of oysters, clams and mussels. The first prohibited area extends from the northern terminal groin of Ocean City along Great Egg Harbor Inlet and extends south to 34th St. This area is delineated by width from the beach to the seaward edges of the groins. This classification is based on urban runoff entering into storm drains that discharge into the ocean along this stretch. The second prohibited shellfish area extends from Ocean City 34th St. (Beach Patrol Building) and extends south to the Anglers Fishing Pier (just North of Corson's Inlet State Park). This area is delineated by width from the beach extending seaward approximately 2.75 kilometers (1.5 nautical miles). This area is based on the existence of a sanitary sewer line that extends seaward approximately 1.68 kilometers (5,500 feet) from the shoreline. This sanitary sewer line is operated by the Cape May Municipal Utilities Authority's Ocean City Wastewater Treatment Plant. This prohibited area may be decreased based on a survey that recommends that 591 hectares (1,460 acres) of the 1,109 hectare (2,740 acre) prohibited area surrounding the facility's outfall be upgraded to an approved status (NJDEP, 1997). This is based on a draft survey that shows acceptable water quality during the period of 1989 through 1995. Borrow Area M3 lies adjacent to this prohibited area, however, it is outside of the boundary delineated by NJDEP. The third prohibited area within the study area is located along the ocean coast from the Townsends Inlet area of Sea Isle City south to Stone Harbor. This classification is based on the Cape May County Municipal Authority's Avalon Wastewater Treatment Plant, which has a sanitary sewer outfall that extends approximately 1.46 kilometers (4,800 feet) seaward from the shoreline in Avalon (NJDEP, 1996 and NJDEP, 1997).

Scott and Bruce (1999) and Scott and Wirth (2000) found that surficial sediments in the borrow areas (L1, L3, M3, M8, O1, and Corson Inlet) were predominantly composed of medium to fine sands with some stations containing higher percentages of coarse sands and some gravels. However, there were several stations that contained sediments with silt/clay content above 30%, which classifies them as muddy sands to muds. 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).

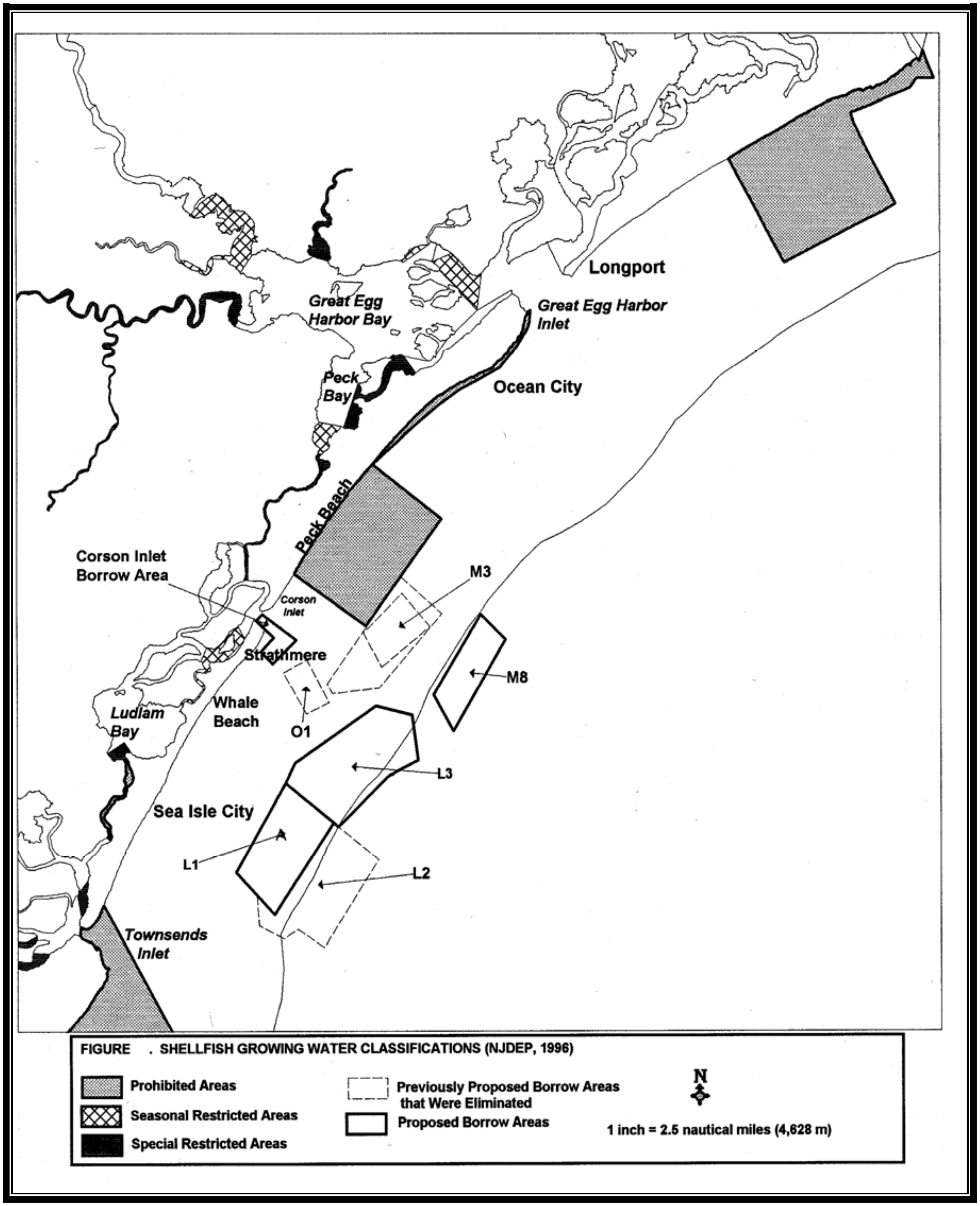

Figure 2.3-1 Shellfish Growing Water Classifications (from NJDEP, 1996)

There are no known significant contamination sources in the vicinity of the project area such as industrial outfalls or known dumpsites, however, the possibility for 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 areas because the substrate is primarily sand that has been subjected to high circulation and flushing from oceanic currents. However, this cannot be conclusively supported without analytical data to confirm that no contamination exists within the borrow sites.

2.3.5 Wetland Habitats

The estuarine waters of New Jersey, together with their associated salt marshes and tidal creeks, constitute a highly productive ecosystem of considerable importance to marine fisheries, wildlife, shore protection and recreation. Wetlands are very important in flood control, help to preserve water quality, are significant as wildlife habitats, provide nursery habitats and refuge for juvenile finfish, and encourage shellfish growth and harvest. In the project vicinity, tidal salt marsh systems are associated with back bay complexes including: Great Egg Harbor Bay, Peck Bay, Ludlam Bay and Townsends Sound, all located on the landward side of the barrier islands. Behind Sea Isle City, the tidal salt marsh system that encompasses Townsends Sound is interspersed with shallow bays, forested fringe wetlands and mesic uplands to the west.

The backbays are comprised of open water, a low marsh zone, tidal flats, a high marsh zone, and a transition zone. Vegetation of open water is primarily composed of algal species like sea lettuce (*Ulva lactuca*), which is dominant in backbays, and SAV's (submerged aquatic vegetation) such as eelgrass (*Zostera marina*). Eelgrass is a common SAV in the back bays, which can form extensive beds important for fish, shellfish and other wildlife species. The low marsh zone is typically dominated by saltmarsh cordgrass (*Spartina alterniflora*). There are two forms of saltmarsh cordgrass: high vigor (taller, robust form) and low vigor (shorter form). High vigor usually occurs in areas adjacent to open water areas such as tidal guts, ditches and ponds where inundation and flushing is greatest. Low vigor usually occurs in the interior marsh areas where tidal flushing is not as great and salinity may be a little higher due to high evaporation. Tidal flats are areas that are muddy or sandy areas covered with water at high tide and exposed at low tide. Some of these flats may be pannes, which are mudflats within the interior of the marshes where high salinity may preclude most forms of vegetation, with the exception of a few plant species such as glasswort (*Salicornia* spp.). 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 transition zone, 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 non-point source pollution and activities affecting wildlife. Plants typical of the transition zone include both upland and marsh species such as marsh elder (*Iva frutescens*), groundsel-tree (*Baccharis halimifolia*), bayberry (*Myrica spp.*), saltgrass (*D. spicata*), sea-blite (*Sueda maritima*), poison ivy (*Rhus radicans*), and common reed (*Phragmites australis*).

2.3.6 Dune Habitat

Natural dunes or remnants of ones are present within the study area, especially at Corson's Inlet State Park and Strathmere State Natural Area. 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 are adapted to the harsh conditions present such as low fertility, heat, and high energy from the ocean and wind. The dominant plant on these dunes is American 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 undeveloped portions of the study area such as Corson's Inlet State Park and Strathmere Natural Area, 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*).

2.3.7 Upper Beach Habitat

The upper beach or supralittoral zone typically lies below the primary dune and above the intertidal zone. An upper beach zone 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.

2.3.8 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.

2.3.8.1 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. In October 1998, benthic macroinfauna of the intertidal zone and nearshore subtidal zone was sampled by Scott and Bruce (1999) throughout the study area. The most dominant taxa found in both of these zones was the small common surf-zone clam (*Donax variabilis*), the highly mobile haustorid amphipod (*Amphiporeia virginiana*), the mole crab (*Emerita talpoida*), and the mobile polychaete

(*Scolelepis squamata*). Comparisons were made in this study between the sand-filled area of Ocean City where the currently authorized Federal beach replenishment project is located and remaining undisturbed 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 sand-filled area samples of the intertidal zone, however, total biomass was significantly lower in the sand-filled area of the nearshore subtidal zone.

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.

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.

2.3.9 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 2.3.9-1). The boundaries of these zones may vary depending on relative depths and wave heights present.

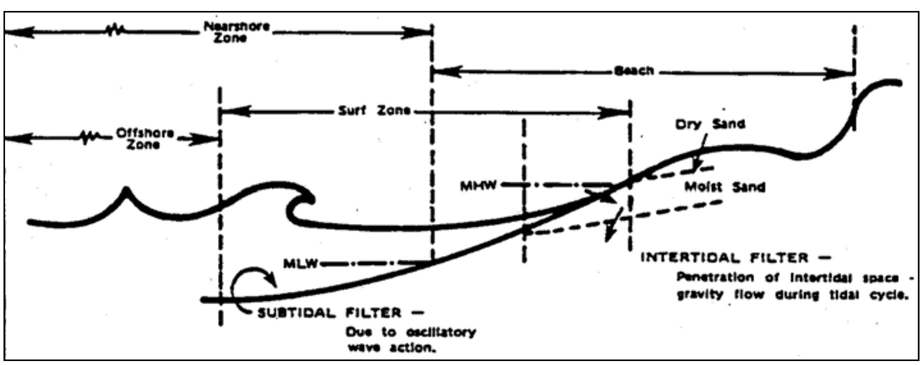

Figure 2.3-2 Beach, Intertidal, Nearshore, and Offshore Zones

2.3.9.1 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). Some of the more common marine invertebrates recorded in the nearshore area of Peck Beach are presented in Appendix B – Table 1.

In October 1998 and November 1999, benthic investigations were performed by Scott and Bruce (1999) and Scott and Wirth (2000) at several potential offshore sand borrow sites (L1, L3, M3, M8, O1 and Corson Inlet Ebb Shoal) (Figure 2.2.11-1). In addition, several outside reference sites were sampled to offer for comparison. The community composition of the offshore borrow areas and reference areas were very similar and are considered to be relatively diverse (Table 2.3.9-1). Overall, a total of 148 taxa were identified from all of the borrow and reference areas in Scott and Bruce (1999) and 132 taxa were identified in the added sites of L1-west, L3, and M8 in Scott and Wirth (2000). The Corson Inlet Site was analyzed separately because it exhibited a distinctly different benthic community due to significant habitat differences with the other sites. The mean number of taxa per sample ranged from 20.2 (L3) to 28.85 (L1). The Corson Inlet Site had a mean number of 11.25 taxa per sample. The diversity indices, as measured by the Shannon Wiener Index and the Simpson's Dominance Index, indicated that the benthic community was relatively evenly distributed for all of the offshore sites. The diversity indices were low for the Corson Inlet Site, which is expected given that it is a high-energy environment. All of the offshore areas were dominated (over 60%) by polychaete worms. The Corson Inlet area was dominated by the bivalve, *Donax fossor*. Amphipod crustaceans also contributed substantially to the faunal composition, but to a lesser extent in the offshore areas and at the Corson Inlet area. The mean abundance of the top 10 dominant taxa of each borrow area contributed to over 80% of the mean total abundance in each of the offshore areas. Of the 27 dominant taxa (from both Scott and Bruce, 1999 and Scott and Wirth, 2000) collected from the offshore areas, twelve were polychaete taxa. Most of the dominant polychaete taxa were small, surface dwelling organisms. The small surface dwelling spionid worm *(Apoprionspio pygmaea)* and the small bristle worm (*Polygordius* spp.) were the most dominant taxa in all of the offshore areas. These two taxa alone contributed between 50% (Area L1) and 74% (Area M3) of the mean total abundance of these areas. In contrast, the small surfzone clam (*Donax fossor*) alone contributed 72% of the mean total abundance in the Corson Inlet area. For the offshore areas, Polychaetes were the highest in mean biomass ranging from 22% to 53% of the biomass among the major taxonomic groups. In the Corson Inlet area, bivalves (*Donax fossor*) were the highest in mean biomass, which represented nearly 49% of the total mean biomass. Other prominent taxa found include the polychaete, *Spiophanes bombyx,* Oligochaeta, dwarf tellin (*Tellina agilis*), surfclam (*Spisula solidissima*), a tanaid arthropod (*Tanaissus psammophilus*) and several amphipod taxa (*Ampelisca* spp., *Acanthohaustorius* spp., *Protohaustorius* cf. *deichmannae*).

Table 2.3.9-1 Summary of Benthic Community Parameters at the Borrow Sites and Nearby Reference Areas. (Scott and Wirth, 2000)

Standard error of estimate is in parenthesis. Means with the same letter are not significantly different as indicated by Duncan's Multiple Range Test.

Parameter	Area L1	Area M3	Area O1	Area L1 West	Area L3	Area M8	Corson Inlet Area*
Total Number of Taxa	139 (69)	101 (40)	88 (20)	69 (15)	106 (40)	88 (16)	25
Number of Taxa (#/sample)	28.86(c) (0.53)	23.20(a,b) (0.95)	24.40(b) (1.31)	22.40(a,b) (0.88)	20.20(a) (0.64)	21.25(a,b) (0.94)	11.25 (2.63)
Shannon-Wiener Index	2.86(a,b) (0.09)	2.59(a) (0.15)	2.32(a) (0.22)	2.83(a,b) (0.24)	2.58(a) (0.13)	2.72(a) (0.20)	1.49 (0.43)
Simpson's Dominance Index	0.72(b,c) (0.02)	0.66(a,b) (0.04)	0.58(a) (0.06)	0.71(a,b) (0.05)	0.67(a,b) (0.03)	0.70(a,b) (0.05)	0.45 (0.13)
Total Abundance (#/m^2)	12823(b) (845)	13502(b) (3524)	12343(b) (2080)	5683(a) (787)	6599(a) (880)	6180(a) (1088)	5608 (1665)
Amphipod Abundance (#/m^2)	1675(a) (251)	558(a,b) (81)	425(b) (86)	1674(a) (451)	405(c) (107)	770(a,b) (244)	1091 (496)
Bivalve Abundance (#/m^2)	239.13(a) (27)	286(a,b) (57)	389(b) (94)	174(a) (53)	259(a,b) (73)	369(b) (184)	4045 (1623)
Polychaete Abundance (#/m^2)	9027(b) (847)	11481(a,b) (3396)	10396(b) (2107)	3427(a) (828)	4439(a) (871)	4416(a) (1135)	421 (268)
Total Biomass (g/m^2)	2.93(a,b) (0.23)	1.90(a,b) (0.30)	1.43(b) (0.21)	1.60(b) (0.45)	3.17(a) (0.94)	1.98(a,b) (0.80)	0.82 (0.24)
Amphipod Biomass (g/m^2)	0.68(c) (0.10)	0.18(a,b) (0.04)	0.11(a,b) (0.03)	0.28(b) (0.05)	0.18(a,b) (0.04)	0.21(a,b) (0.04)	0.14 (0.04)
Bivalve Biomass (g/m^2)	0.16(a) (0.03)	0.18(a) (0.07)	0.17(a) (0.06)	0.53(a) (0.48)	0.46(a) (0.37)	0.05(a) (0.02)	0.40 (0.13)
Polychaete Biomass (g/m^2)	1.06(a) (0.09)	0.88(a,b) (0.13)	0.76(a,b) (0.11)	0.57(a,b) (0.09)	1.11(a) (0.19)	0.43(b,c) (0.09)	0.20 (0.08)
Mean Number of Taxa > 2 cm in length	2.00 (b) (0.15)	1.34 (a,b) (0.15)	1.40 (a,b) (0.20)	1.47 (a,b) (0.26)	1.65 (a,b) (0.15)	1.44 (a,b) (0.33)	0.75 (0.48)

*Corson Inlet Area was not compared directly to other areas due to significant differences in habitat.

Larger benthic macroinvertebrates not easily sampled in the grab samples of the 0.04 sq. M. Young sampler were obtained from commercial surfclam dredges in the same areas. The most frequently collected invertebrates included: surfclam, knobbed whelk (*Buscyon carica*), channel whelk (*Buscyon canaliculatum*), horseshoe crab (*Limulus polyphemus*), moon snail (*Polinices* sp., *Lunatia* sp.), spider crab (*Libinia emarginata*), and hermit crab (*Pagarus* sp.) (Scott and Bruce, 1999). In Scott and Wirth (2000), the surfclam and starfish (Echinodermata) were the most frequently sampled larger invertebrates in areas L1-west, L3, and M8.

2.3.10 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 is predominantly 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.

2.3.11 Fisheries

2.3.11.1 Finfish

The proximity of several embayments allows the coastal waters of New Jersey to have a productive fishery. Many species utilize the estuaries behind Ludlam Island and Peck Beach 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 (*Paralichtys dentatus*), sea bass (*Centropristis striata*), striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), winter flounder (*Pseudopleuronectes americanus*), tautog (*Tautoga onitiss*), weakfish (*Cynoscion regalis*), scup (*Stenotomus chrysops*), white perch (*Morone americana*), and Atlantic menhaden (*Brevoortia tyrannus*). In a study conducted at Peck Beach, 178 species of saltwater fishes were recorded (Appendix B – Table 2). 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 near shore 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.

The estuarine marsh complex is an important nursery area for coastal New Jersey fisheries. Larval and/or juvenile individuals were present for 90 of the 105 species collected in the nearby Hereford Inlet Estuary survey. The protection afforded by the relatively calm waters, added protection from offshore predators and abundant food sources enhance this habitat for early life stages. At least 28 of the 105 species reproduced in the area while the majority of the most commercially valuable species spawned in the adjacent coastal waters.

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 southern 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 onitiss*). 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.

2.3.11.2 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 surfclams *(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. Surfclams 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 surfclam has a wide distribution and abundance within the mid-Atlantic Region (Figure 2.3.11-1). Surfclams most commonly inhabit substrates composed of medium to coarse sand and gravel in turbulent marine 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). Surfclams 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 surfclam fishery supports the largest molluscan fishery in New Jersey, accounting for, by weight, 67% of the State's total molluscan commercial landing in 1999. This catch represents over 84% of the total Mid-Atlantic and New England area catch for 1999, with a value of over 21 million dollars. Recently, surfclam stocks have been increasing in Cape May County Waters. Surfclam resources in Cape May County (ie. below Great Egg Harbor Inlet) have contributed 14.4% to the total harvest in the 1999-2000 season, and had been as high as 24.8% in the 1998-1999 season. In 1999, this region contributed 24.8% of the total New Jersey estimated standing stock of surfclam (NJDEP letter from L.Schmidt, dated 6/28/01). The

NJDEP has established surfclam conservation zones along the NJ coast, which prohibits harvest in these areas. However, there are no areas identified within the study area (NJDEP, 1996). The NJDEP has recently noted that based on data collected during the NJDEP surfclam inventory surveys of 1996 and 1997, surfclam stocks within this region are improving (NJDEP letter dated 4/23/98).

For the feasibility study, several potential sand borrow areas were investigated for juvenile and commercial adult surfclam stocks. Scott and Bruce (1999) and Scott and Wirth (2000) found that the density of juvenile surfclams within Areas L1, M3, O1, L3, M8 and Corson Inlet were within the ranges and intermediate of densities of other borrow area studies (Brigantine and Long Beach Island) along the New Jersey Coast. A commercial surfclam survey was also performed by Scott and Bruce (1999) and Scott and Wirth (2000). Commercial densities were estimated by the number of tows and the areas of coverage of the tows (Table 2.3.11-1).

Area L1 east and L3, the largest of the sites that were investigated, also had the largest surfclam stocks with an estimate of 1.37 million and 2.17 million commercial clams, respectively. The Corson Inlet Area had the highest density of surfclams estimated at 3.06 bushels per five-minute tow. The Corson Inlet Area also had the third highest estimated stock of 1.13 million commercial clams over the smallest area (81.7 ha). Areas L1-east and L3 had the next highest densities of 1.99 and 1.12 bushels per five-minute tow, respectively. Areas M3 and O1 had significantly lower densities with 0.01 and 0.47 bushels per five-minute tow, respectively. Scott and Bruce (1999) and Scott and Wirth (2000) noted that the average numbers of bushels per dredge tow was less for these sites when compared with other regional studies conducted by NJDEP along the New Jersey Coast. The mean number of bushels per five-minute tow for C1 (Corson Inlet Ebb Shoal Area) (3.06), which had the greatest mean number of bushels collected per five-minute tow among all of the sites, was approximately 56% less than the calculated mean value of 7.04 bushels per five-minute tow for nearby NJDEP sample stations 16-25, which are scattered around the vicinity of all of the borrow sites (NJDEP, 1997b). However, the wide ranges in surfclam densities in some of the sites suggest that the large densities demonstrate “patchiness” in their distribution within these sites.

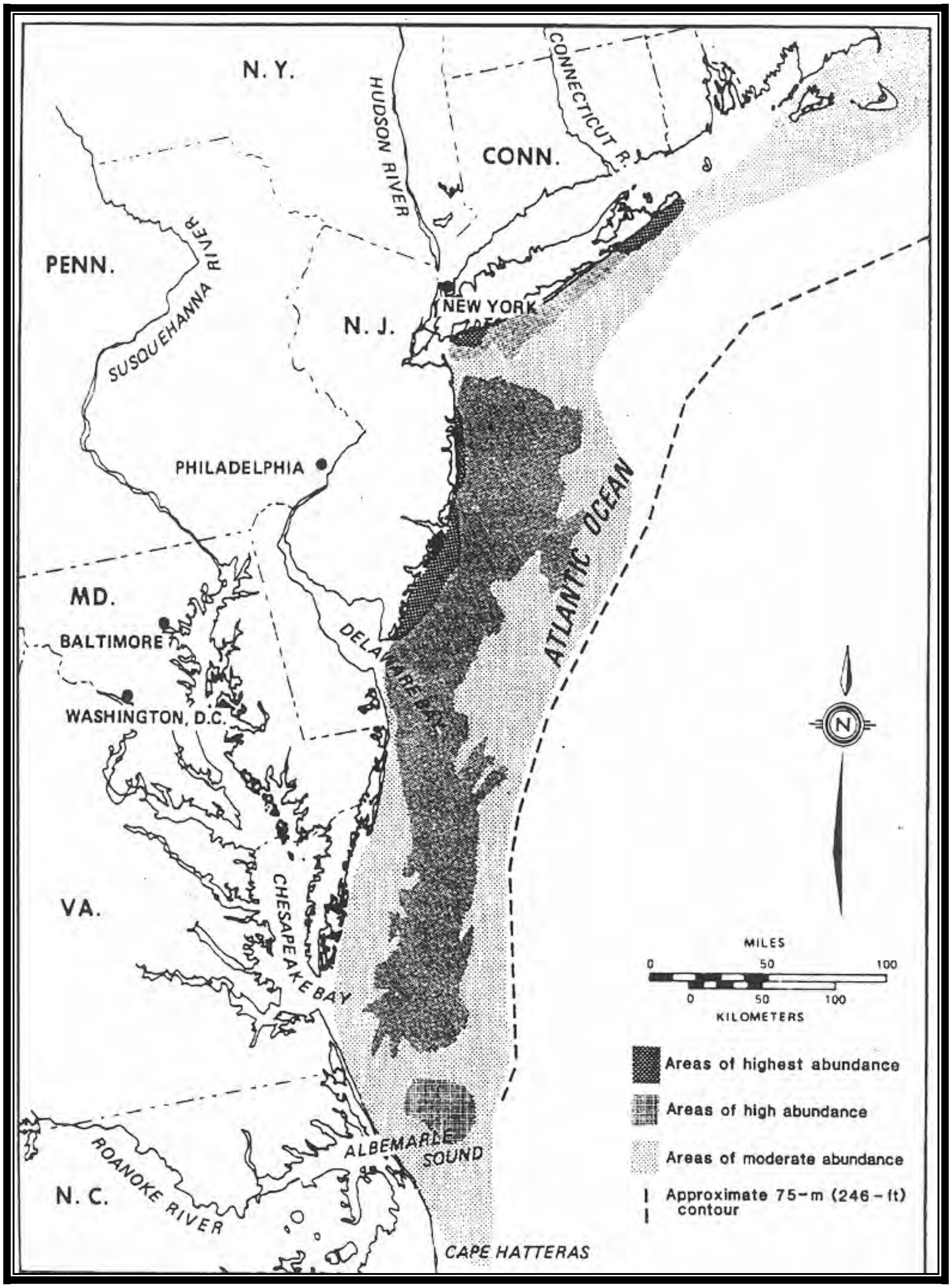

Figure 2.3-3 Distribution of Mid-Atlantic Surfclams within the Mid-Atlantic Bight (Fay et al. 1983).

Table 2.3.11-1 Summary of Adult Surfclam Stocks of Potential Borrow Areas (from Scott and Bruce, 1999, and Scott and Wirth, 2000)

Borrow Area	Area in hectares (ha) or acres (ac)	Mean Juvenile Surfclam Densities From Benthic Grabs (#/M^2)	# of CommercialDredge Tows	Mean # of CommercialClams/Tow	Mean Area Dredged per Tow	Estimated Commercial Surfclam Densities (Mean #bushels/5-minute tow) (Range is in parenthesis	Total Estimated Surfclam Stock
L1 east	449 ha 1109.75 ac	46.8	22	154	624.7 m^2 6725 ft^2	1.99 (0.02 – 18.82)	1,370,000
M3	237.60 ha 587.13 ac	129.0	11	0.45	264.1 m^2 2842 ft^2	0.01 (0.0 – 0.03)	10,000
O1	122.3 ha 302.24 ac	72.0	7	46	298.1 m^2 3209 ft^2	0.47 (0.0 – 1.26)	160,000
L1-West	326.6 ha 807 ac	40.9	15	46	446.8 m^2 4810 ft^2	0.73 (0.0 – 3.8)	344,660
L3	843.8 ha 2,085 ac	19.9	43	69	327.6 m^2 3526 ft^2	1.12 (0.0 – 10.7)	2,172,375
M8	342.8 ha 847 ac	22.7	17	62	332.7 m^2 3581 ft^2	1.03 (0.0 – 5.5)	679,161
C1 (Corson Inlet Ebb Shoal)	81.7 ha 202 ac	5.68	4	327	226.8 m^2 2441 ft^2	3.06 (1.0 – 6.3)	1,131,809

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 study 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).

As described in the water quality section, there are three primary areas identified as prohibited from shellfish harvesting along the ocean coast within the study area. These areas are along the beaches of northern Ocean City, a large area between 34th St. and the Angler's Pier near Corson's Inlet State Park and an area extending from Townsends Inlet to Stone Harbor. In prohibited areas, the waters are condemned for the harvest of oysters, clams, and mussels because of the potential for human pathogens and toxins.

2.3.11.3 Prime Fishing Areas

Several locations within the study area such as the "Sea Isle Lump" (part of Borrow Area L2) and "Sea Isle Shoal" are classified as Prime Fishing Areas (NJAC 7:7E-3.4) by NJDEP (Figure 2.3.11-2). 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 fish habitats of value, within the study area include artificial reefs, wreck sites, groins and jetties. An artificial reef composed of tires is located approximately 7.3 kilometers (4 nautical miles) offshore from Corson Inlet, and is approximately 0.7 kilometers (0.38 nautical miles) southeast of borrow area M8.

2.3.11.4 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 (Figure 2.3.11-2). The study area contains EFH for various life stages for 26 species of managed fish and shellfish. Table 2.3.11-2 presents the managed species and their life stage that EFH is identified for within the 10 x 10 minute squares (#52, 53, 63, and 64) 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 2.3.11-3.

A review of EFH designations and the corresponding 10 x 10 minute squares, which encompasses numbers 52, 53, and 63 contain areas designated as "Habitat Areas of Particular Concern" (HAPC) for the sandbar shark. HAPC are areas of EFH that are judged to be particularly important to the long-term productivity of populations of one or more managed species, or to be particularly vulnerable to degradation (NOAA, 1999). Although not formally listed as a HAPC, offshore shoal areas, also called "lumps" are sandy areas in the offshore zone that are generally 10 meters (30 feet) or less in depth surrounded by deeper, flatter areas. These areas are believed to attract higher numbers of finfish species and are frequently targeted by recreational fishermen. It is believed that these lumps provide some bottom structure as well as a hydrodynamic environment attractive to resident or migratory fish and/or their prey.

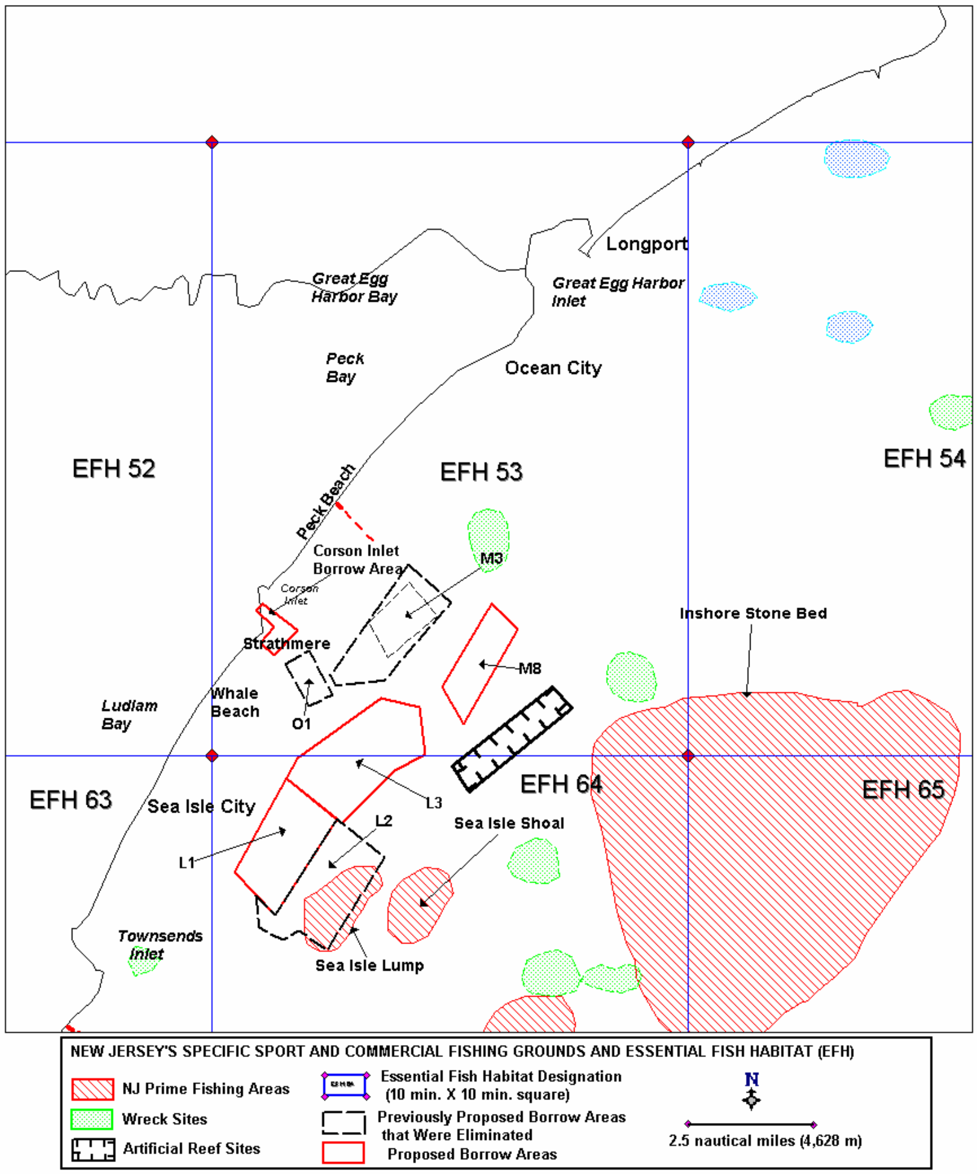

Figure 2.3-4 Prime Fishing Areas, Essential Fish Habitat Designations, and Potential

Sand Borrow Areas[5].

Table 2.3.11-2 Summary of Species with EFH Designation in the 10 Min. X 10 Min. Squares of 52, 53, 63 and 64 (NOAA, 1999)

Managed Species	Eggs	Larvae	Juveniles	Adults
Atlantic cod *(Gadus morhua)*				52, 53, 63, 64
Whiting (*Merluccius bilinearis)*	63	63	63	
Red hake *(Urophycis chuss)*	52, 53,63, 64	52, 53, 63, 64	52, 53, 63, 64	
Winter flounder (*Pleuronectes americanus*)	53, 63	53, 63	53, 63	53, 63
Windowpane flounder *(Scopthalmus aquosus)*	52, 53, 63, 64	52, 53, 63, 64	52, 53, 63, 64	52, 53, 63, 64
Atlantic sea herring *(Clupea harengus)*			52, 53, 64	52, 53, 63, 64
Monkfish *(Lophius americanus)*	52, 53, 63, 64	52, 53, 63, 64		
Bluefish *(Pomatomus saltatrix)*			52, 53, 63, 64	52, 53, 63, 64
Long finned squid *(Loligo pealei)*	n/a	n/a	64	
Short finned squid *(Illex ilecebrosus)*	n/a	n/a		
Atlantic butterfish *(Peprilus tricanthus)*			52, 53, 63	
Summer flounder *(Paralicthys dentatus)*		52, 53, 63	52, 53, 63, 64	52, 53, 63, 64
Scup *(Stenotomus chrysops)*	n/a	n/a	52, 53, 63, 64	52, 53, 63, 64
Black sea bass *(Centropristus striata)*	n/a		52, 53, 63, 64	52, 53, 63, 64
Surfclam *(Spisula solidissima)*	n/a	n/a	52, 53, 64	52, 53, 64
Ocean quahog *(Artica islandica)*	n/a	n/a		
Spiny dogfish *(Squalus acanthias)*	n/a	n/a		
King mackerel *(Scomberomorus cavalla)*	52, 53, 63, 64	52, 53, 63, 64	52, 53, 63, 64	52, 53, 63, 64
Spanish mackerel *(Scomberomorus maculatus)*	52, 53, 63, 64	52, 53, 63, 64	52, 53, 63, 64	52, 53, 63, 64
Cobia *(Rachycentron canadum)*	52, 53, 63, 64	52, 53, 63, 64	52, 53, 63, 64	52, 53, 63, 64
Sand tiger shark *(Odontaspis taurus)*		52, 53, 63, 64		52, 63, 64
Atlantic angel shark *(Squatina dumerili)*		63,64	63,64	63,64
Dusky shark *(Charcharinus obscurus)*		52, 53, 63, 64		
Sandbar shark *(Charcharinus plumbeus)*		HAPC (52, 53, 63) , 64	HAPC (52, 53, 63) , 64	HAPC (52, 53, 63) , 64
Tiger shark *(Galeocerdo cuvieri)*		53, 63, 64		
Atl. Sharpnose shark *(Rhizopriondon terraenovae)*				63

[5] Area O1 was eliminated from consideration for geotechical reasons and areas L2 and M3 due to habitat concerns expressed by NJDEP

Table 2.3.11-3 Habitat Utilization of Identified EFH Species and their Summary of Species with EFH Designation in the 10 Min. X 10 Min. Squares of 52, 53, 63 and 64 (NOAA, 1999)

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)	
Winter flounder (*Pseudopleuronectes americanus)* (NOAA, 1999); Pereira et al, 1998; McClane, 1978)	**Habitat:** Mud to sand or gravel; from Jan to May with peak from Mar to April in 0.3 to 4.5 meters inshore; 90 meters or less on Georges Bank. 10 to 32 ppt salinity.	**Habitat:** Planktonic, then bottom oriented in fine sand or gravel, 1 to 4.5 m inshore. 3,2 to 30 ppt. salinity. **Prey:**nauplii, harpacticoids, calanoids, polychaetes, invertebrate eggs, phytoplankton.	**Habitat:** Shallow water. Winter in estuaries and outer continental shelf. Equally abundant on mud or sand shell. **Prey:** copepods, harpacticoids, amphipods, polychaetes	**Habitat:** 1-30 m inshore; less than 100m offshore; mud, sand, cobble, rocks, boulders. **Prey:** omnivorous, polychaetes and crustaceans.
Red hake *(Urophycis chuss)* (Steimle et al. 1998)	**Habitat:** Surface waters, May – Nov.	**Habitat:** Surface waters, May –Dec. Abundant in mid- and outer continental shelf of Mid-Atl. Bight. **Prey:** copepods and other microcrustaceans under floating eelgrass or algae.	**Habitat:** Pelagic at 25-30 mm and bottom at 35-40 mm. Young inhabit depressions on open seabed. Older juveniles inhabit shelter provided by shells and shell fragments. **Prey:** small benthic and pelagic crustaceans (decapod shrimp, crabs, mysids, euphasiids, and amphipods) and polychaetes).	
Windowpane flounder *(Scopthalmus*	**Habitat:** Surface	**Habitat:** Initially	**Habitat:** Bottom	**Habitat:** Bottom

Managed Species	Eggs	Larvae	Juveniles	Adults
aquosus) (Chang, 1998)	waters <70 m, Feb-July; Sept-Nov.	in pelagic waters, then bottom <70m,. May-July and Oct-Nov. **Prey:** copepods and other zooplankton	(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	(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
Atlantic sea herring *(Clupea harengus)* (Reid et al., 1998)			**Habitat:** Pelagic waters and bottom, < 10 C and 15-130 m depths **Prey:** zooplankton (copepods, decapod larvae, cirriped larvae, cladocerans, and pelecypod larvae)	**Habitat:** Pelagic waters and bottom habitats; **Prey:** chaetognath, euphausiids, pteropods and copepods.
Monkfish *(Lophius americanus)* (Steimle et al., 1998)	**Habitat:** Surface waters, Mar. – Sept. peak in June in upper water column of inner to mid Continental shelf	**Habitat:** Pelagic waters in depths of 15 – 1000 m along mid-shelf also found in surf zone **Prey:** zooplankton (copepods, crustacean larvae, chaetognaths)		
Bluefish *(Pomatomus saltatrix)*			**Habitat:** Pelagic waters of continental shelf and in Mid-Atlantic estuaries from May-Oct. **Prey:** squids, smaller fish	**Habitat:** Pelagic waters; found in Mid-Atlantic estuaries April – Oct. **Prey:** squids, smaller fish
Long finned squid *(Loligo pealei)*	n/a	**Habitat:** EFH for Pre-recruits is pelagic waters over the Continental Shelf		
Short finned squid *(Illex ilecebrosus)*	n/a	**Habitat:** EFH for Pre-recruits is pelagic waters over the Continental Shelf		
Atlantic butterfish *(Peprilus tricanthus)*	**Habitat:** Pelagic waters		**Habitat:** Pelagic waters in 10 – 360 m	**Habitat:** Pelagic waters **Prey:** jellyfish, crustaceans, worms, and small fishes
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:**	**Habitat:** Demersal

Managed Species	Eggs	Larvae	Juveniles	Adults
			Demersal waters	waters offshore from Nov – April
Black sea bass *(Centropristus striata)*	n/a		**Habitat:** Demersal waters over rough bottom, shellfish and eelgrass beds, man-made structures in sandy-shelly areas	**Habitat:** Demersal waters over structured habitats (natural and man-made), and sand and shell areas
Surfclam *(Spisula solidissima)*	n/a	n/a	**Habitat:** Throughout bottom sandy substrate to 3' in depth from beach zone to 60 m.	
Ocean quahog *(Artica islandica)*	n/a	n/a		
Spiny dogfish *(Squalus acanthias)*	n/a	n/a		
King mackerel *(Scomberomorus cavalla)*	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone.	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. **Prey:** zooplankton and fish eggs	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone **Prey:** zoo-plankton, shrimps, crab larvae, squids, herrings, silversides, and lances.	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone **Prey:** squids, herrings, silversides, and lances.
Spanish mackerel *(Scomberomorus maculatus)*	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory **Prey:** zooplankton and fish eggs	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory **Prey:** zoo-plankton, shrimps, crab larvae, squids, herrings, silversides, and lances.	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory **Prey:** squids, herrings, silversides, and lances
Cobia *(Rachycentron canadum)*	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. 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 **Prey:** crabs, shrimps, and small fishes	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory **Prey:** crabs, shrimps, and small fishes
Sand tiger shark *(Odontaspis taurus)*		**Habitat:** Shallow		**Habitat:** Shallow

Managed Species	Eggs	Larvae	Juveniles	Adults
		coastal waters, bottom or demersal		coastal waters, bottom or demersal **Prey:** small fishies (including mackerels, menhaden, flounders, skates, sea trouts, and porgies), crabs and squids.
Atlantic angel shark *(Squatina dumerili)*		**Habitat:** Shallow coastal waters	**Habitat:** Shallow coastal waters	**Habitat:** Shallow coastal waters, bottom (sand or mud near reefs)
Dusky shark *(Charcharinus obscurus)*		**Habitat:** Shallow coastal waters		
Sandbar shark *(Charcharinus plumbeus)*		**Habitat:** Shallow coastal waters HAPC is identified for pupping areas.	**Habitat:** Coastal and pelagic waters HAPC is identified for pupping areas.	**Habitat:** Shallow coastal waters HAPC is identified for pupping areas.
Scalloped hammerhead shark *(Sphyrna lewini)*			**Habitat:** Shallow coastal waters	
Tiger shark *(Galeocerdo cuvieri)*		**Habitat:** Shallow coastal waters		
Atl. Sharpnose shark *(Rhizopriondon terraenovae)*				**Habitat:** Shallow coastal waters

2.3.12 Birds

2.3.12.1 Beaches and Dunes

One hundred and twenty-nine bird species are believed to utilize dune areas at the south end of Peck Beach Island, in the region of Corson's Inlet State Park (Appendix B. Table 1). Forty-one species may also nest there. This remnant of a formerly widespread habitat on Peck Beach still is intensively utilized by birds, and is a potential habitat for species that were former inhabitants. A number of hawks, herons, shorebirds and a wide variety of terrestrial species are expected to occur.

Abundant food in the intertidal zone provides excellent feeding conditions for many birds. Relatively undisturbed sandy areas above the mean high tide level are utilized by shorebirds as nest sites. The beaches throughout the study area along with any associated dunes are nesting grounds for the Federally threatened, state endangered piping plover (*Charadrius melodus*), large colonies of State threatened least tern (*Sterna dougallii*), common tern (*Sterna hirundo*), and black skimmer (*Rynchops niger*), with occasional use by spotted sandpiper (*Actitis macularia*) and gull-billed tern (*Gelochelidon nilotica*). The State's Non-game and Endangered Species Program monitors the occurrence of black skimmer, piping plover, and least tern within the study area. According to recent surveys there are prime nesting areas on southern sections of Peck Beach Island, in Corson's Inlet State Park near Corson Inlet, and at the northern extent of Ludlam Island in Strathmere, north of Whale Beach (per. comm. Dave Jenkins, NJDEP). The largest recorded colony of black skimmer in this area inhabit the Strathmere Natural Area at Corson Inlet. On the outer coastal plain behind Ludlam Island, salt marsh complexes and patches of forest along the mainland edge support nesting and feeding activity for migrating neotropical passerines, and other birds along the Atlantic flyway.

The following transient species may use dune and intertidal beach habitats on Peck Beach during their spring and winter migrations: ruddy turnstone (*Arenaria interpres*), northern horned lark (*Octocoris alpestris*), snowy owl (*Nyctia sandvicensis*), and brown pelican (*Pelecanus occidentalis*). Several gull species also breed in the intertidal zone such as, herring gull (*Larus argentatus*), great black-backed gull (*Larus marinus*), and laughing gull (*Larus atricilla*).

Several species of gulls are common along New Jersey's shores, and are attracted to forage on components of the beach wrack such as carrion and plant parts. These gulls include the laughing gull (*Larus atricilla*), herring gull (*L. argentatus*), and ring-billed gull (*L. delawarensis*).

The beaches and upper dune areas may be inhabited by a number of non-marine birds such as the savannah sparrow (*Passerculus sandwichensis*), song sparrow (*Melospiza melodia*), mourning dove (*Zenaida macroura*), gray catbird (*Dumetella carolinensis*), northern mockingbird (*Mimus polyglottos*), and brown thrasher (*Toxostoma rufum*). Other birds common to the area include boat-tailed grackle (*Quiscalus major*), sharp-tailed sparrow (*Ammodramus caudacutus*), seaside sparrow (*A. maritimus*), eastern kingbird (*Tyrannus tyrannus*), tree swallow (*Tachycineta bicolor*), northern bobwhite (*Colinus virginianus*) and red-winged blackbird.

2.3.12.2 Back Bays

The shallow marsh habitat and dredged material disposal islands in back bay areas provide habitat for a variety of wading birds including: cattle egret (*Bubulcus ibis*), great egret (*Casmerodius albus*), little blue heron (*Egretta caerulea*), snowy egret (*Egretta thula*), tricolored heron (*Egretta tricolor*), yellow-crowned night-heron (*Nyctanassa violacea*), and black-crowned night-heron (*Nycticorax nycticorax*). Heron rookeries and gulleries have been sited on marsh islands, although not as numerous as in regions immediately to the north and south of Townsends Inlet.

Appendix B - Table 2 lists waterfowl surveyed during mid-winter 1995 and spring 1995 by the Division of Fish, Game and Wildlife, NJDEP. The flight segments were divided into zones. Zone 1 includes Great Egg Harbor and Peck Bay, and extends from Longport Boulevard to Roosevelt Boulevard, and west to Route 9. Zone 2 includes Corson Sound and Ludlam Bay, with its coastal extent between Roosevelt and Sea Isle City Boulevard. Zone 3 covers Townsends and States Sound along the backbay, and Sea Isle City Boulevard to Townsends Inlet along the coast. To summarize the findings of this survey, bufflehead, mallard, black duck, and brant are the most plentiful, with greater occurrences during the winter migration.

Nesting activity by mallards (*Anas platyrhynchos*) and black ducks has been documented in the study area. 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 back bays 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*).

Migrating birds following both the ocean coastline and the Delaware River Valley may converge in Cape May County and use the coastal wetlands and adjoining areas for nesting habitat. There are believed to be approximately 450 species of birds, which are endemic to, or naturalized in, the eastern United States. Based on habitat data and past records, 305 of those taxa are expected to occur in the project vicinity regularly (See Appendix B for a complete listing).

2.3.12.3 Nearshore and Offshore

Many species of birds utilize open water marine habitat for feeding and resting. Birds utilizing this area may include gulls, terns (*Sterna* spp.), scoters (*Melanitta spp*.), oldsquaw (*Clangula hyemalis*) and loons (*Gavia immer*). Open ocean species such as gannet (*Sula bassanus*), blacklegged kittiwake (*Rissa triadctyla*), storm *petrel (Oceanites oceanicus*), and shearwaters (*Puffinus* spp.) may also be present offshore.

2.3.13 Mammals

2.3.13.1 Beaches and Dunes

Terrestrial mammalian species are more likely to be found in the more upland habitats along the ocean coast. Several species of mammals are associated with dune habitats such as the raccoon (*Procyon lotor*), eastern cottontail (*Sylvilagus floridanus*), red fox (*Vulpes fulva*), white-footed mouse (*Peromyscus leucopus*), meadow vole (*Microtus pensylvanicus*), and white-tailed deer (*Odocoileus virginianus*).

Twenty-one non-marine mammal species are known or expected to occur on Peck Beach (Appendix B - Table 4). Of these, New Jersey considers two species to be threatened (Keen's myotis and the small footed myotis), and one is of undetermined status (rice rat). The rice rat, once found along coastal areas, has not been seen there for approximately 30 years. Thirteen of the 21 species (59%) are known to utilize tidal marshes. Twelve species are believed to utilize strand thickets, 9 kinds occur in urban areas, 7 utilize meadow, 5 occur in dune areas, and 4 inhabit reed grasslands.

2.3.13.2 Nearshore and Offshore

A number of marine mammals are commonly observed in New Jersey Atlantic coastal waters. Cetaceans (whales and dolphins) may be present within the affected area (Appendix B. – Table 7). Some of the taxa likely to be seen in the project area include: bottlenose dolphin (*Tursiops turncatus*), common dolphin (*Delphinus delphis*), common porpoise (*Phocoena phocoena*), short-finned pilot whale (*Globiocephala sieboldii macrorhyncus*) and fin whale (*Balaenoptera physalus*). The project area is within the range of the harbor seal (Phoca vitulina), which may be seen in the vicinity on an occasional basis.

2.3.14 Reptiles And Amphibians

2.3.14.1 Beaches and Dunes

Common reptilian and amphibian species associated with dune habitats may include Fowler's toad (*Bufo woodhousei fowleri*), eastern hognose snake (*Heterodon platyrhinos*), and box turtle (*Terrapene carolina*). Tidal marsh and adjacent upland dunes of the inland bays system are important habitats for feeding and nesting of the diamondback terrapin (*Malaclemys terrapin terrapin*). A list of non-marine reptiles and amphibians and their habitats is presented in Appendix B – Table 3.

2.3.14.2 Nearshore and Offshore

Several sea turtle species may be present in New Jersey Coastal waters on an occasional basis. See discussion under Rare, Threatened and Endangered Species and Appendix B – Table 7.

2.3.15 Rare, Threatened and Endangered Species

2.3.15.1 Beaches and Dunes

The Federally listed (threatened) and state listed (endangered) piping plover (*Charadrius melodus*) has nested historically within several areas of the study area, including the northern portion of Peck Beach near Great Egg Harbor Inlet, the middle portion of Peck Beach, and nearly the entire length of Ludlam Beach to its southernmost point at Townsends Inlet (USFWS, 1999). The NJDEP estimates fifteen to eighteen pairs (down from a previous thirty to forty pair estimate) of piping plovers nest within this area, which represents approximately 16% (formerly 25%) of the nesting population of New Jersey (NJDEP letter from L.Schmidt, dated 6/28/01). Nesting piping plovers are found in all three municipalities that make-up this stretch of coastline (Ocean City, Strathmere (Upper Township), Sea Isle City) (NJDEP letter dated 4/23/98). These small shorebirds nest on coastal sandy beaches above the high tide-line on mainland coastal beaches, sand flats, and barrier island coastal beaches. The nesting sites are typically located on gently sloping foredunes, blowout areas behind primary dunes, washover areas cut into or between dunes, ends of sandspits, and on sites with deposits of suitable dredged or pumped sand (USFWS, 1999). The nesting season usually begins in March when the birds arrive. The nesting actually begins in mid-to-late April and ends in July when the young are finally fledged, however, the nesting seasons can vary. Shortly after hatching, the young leave the nest and begin foraging within the intertidal zone. The adults accompany the young during this critical period until they are fledged 25 –35 days later.

There are two to five least tern (state endangered) colonies that have existed in the study area over the past decade. The areas that most consistently support nesting least terns are around Corson Inlet and Townsends Inlet. One of the largest black skimmer (State endangered) colonies in New Jersey is located in Corson Inlet, frequently on the Strathmere Natural Area (NJDEP letter dated 4/23/98). However, it is noted that the Strathmere Natural Area has recently been subjected to storm events and erosion that have gradually resulted in the loss of approximately 40% of the natural area. This loss has directly impacted the State's largest black skimmer colony whereas, there where 1,200 birds present in 2000 and approximately 100 birds in 2001 (with no nests) (NJDEP letter from L.Schmidt, dated 6/28/01).

There are several osprey (*Pandion haliaetus*) pairs (state threatened) that nest mostly on artificial structures in this region, however, they are abundant immediately south of the study area. One pair of peregrine falcons (*Falco peregrinus*) (Federally threatened, state endangered) nest in a nesting box behind Sea Isle City. There is another pair that nests on the marshes of the Tuckahoe River, but are believed to be using the marshes behind this coastal reach to feed (NJDEP letter dated 4/23/99).

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 beachfill. 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, Delaware, and Maryland (USFWS, 1999).

2.3.15.2 Nearshore and Offshore

The New Jersey coast may be occasionally visited by five species of threatened and endangered sea turtles. These turtles include the loggerhead turtle (*Caretta caretta*), green turtle (*Chelonia mydas*), hawksbill turtle (*Eretmochelys imbricata*), Kemp's ridley turtle (*Lepidochelys kempii*) and leatherback turtle (*Dermochelys coriacea*).

Six species of endangered whales may occasionally be encountered in nearshore waters within the study area during their migrations. These include sperm whale (*Physeter catodon*), fin whale (*Balaenoptera physalus*), humpback whale (*Megaptera novaeangliae*), blue whale (*Balaenoptera musculus*), sei whale (*Balaenoptera borealis*) and black right whale (*Balaena glacialis*).

2.3.16 Reserves, Preserves Parks And Public Land

The State of New Jersey manages two areas along the ocean coast within the study area. Corson's Inlet State Park is on the north side of Corson Inlet and occupies approximately 138 hectares (341 acres) comprised of beach, dune, and marsh habitats. The south side of Corson Inlet is occupied by the Strathmere State Natural Area. The Strathmere State Natural Area is approximately 38.4 hectares (95 acres) comprised of beach and dune habitats, and was acquired by the State of New Jersey from the Pennsylvania Natural Lands Trust in 1969 with funding from the New Jersey Green Acres Land Acquisition Act of 1961, and was later assigned to the Division of Parks and Forestry in 1970 to ensure that this unique area would be kept in its native state in perpetuity (personal communication with Robert Cartica, office of Natural Lands Management). The Strathmere Natural Area and Corson's Inlet State Park are important areas for nesting birds such as the Federally threatened and State endangered piping plover, and nesting colonies of black skimmers and least terns, one of the largest colonies in the state. Both areas are under the management of the New Jersey Division of Parks and Forestry; however, management of colonial nesting birds and shorebirds is conducted by the NJ Division of Fish, Game and Wildlife. These areas are accessible to the public for recreation activities; however, restrictions may be in place during the bird-nesting season.

The backbay areas of the study area contain hundreds of acres of public lands as part of the Cape May Wetlands Wildlife Management Area. This tract is over 4,586 hectares (11,332 acres) and is bounded by Ocean Drive and the Garden State Parkway, east-west; Cape May Harbor (Ocean Drive) in the south and Roosevelt Boulevard in the north. One small parcel is located north of Roosevelt Boulevard on Peck Bay. There are five bay and sound areas (Corson Sound, Ludlam Bay, Jenkins Sound, Richardson Sound and Jarvis Sound) within this tract. This coastal wetland area is almost all salt marsh with less than 40 hectares (100 acres) of upland-field habitat. This area is managed by the New Jersey Division of Fish and Wildlife for fish and wildlife habitat, however, recreational activities such as hunting, fishing, crabbing, clamming, birdwatching and boating are allowed within this area.

2.3.17 Recreation

Recreational opportunities abound within the study area, drawing millions of people to Cape May County each year. The beaches are the primary attraction, however varieties of wildlife-oriented activities are also available. The beaches on Peck Beach and Ludlam Island 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 Sea Isle Lump and Sea Isle Shoals are popular destinations for sportfishermen. Corson's Inlet State Park and Strathmere State Natural Area offer birdwatching and hiking opportunities. The back bay estuaries of Great Egg Harbor Bay, Peck Bay, Corson Sound, Ludlam Bay, and all of the tidal tributaries and waterways offer recreational opportunities such as clamming, crabbing, fishing, boating, sailing, windsurfing, and birdwatching. The marshes of the Cape May Wetlands Wildlife Management Area offer birdwatching and waterfowl hunting opportunities for the public to enjoy.

2.3.18 Community Settings

2.3.18.1 Land Use

Land use in Cape May County includes residential and recreational communities, publicly owned parks and wildlife areas, agricultural lands, forested areas and wetlands. Developed portions of the county primarily consist of resorts, motels, hotels, campgrounds, restaurants, marinas, shopping centers and homes. Farmland acreage has decreased as lands are converted to residential and commercial use. Between 1955 and 1985, more than half of the county's farmland acreage went out of production. Overall, farm acreage has decreased from a peak of 25,767 hectares in 1960 to a low of 6,345 hectares in 1983.

While some forested areas have been cleared for development, the current trend is to retain as many trees as possible to make building sites more attractive. Greater than 30 percent of the land in Cape May County is forested. Over 16,000 hectares of land in Cape May County are preserved for a variety of recreation and conservation purposes. This acreage includes 8,269 hectares of state-owned wildlife management areas; 7,206 hectares of State-owned parks, forests and natural areas; and 540 hectares of county-owned parks. In addition, 32,240 hectares of forested uplands and wetlands have been designated as National Pinelands Reserve lands. Approximately 42 percent of the county is comprised of marine, estuarine and freshwater wetlands.

2.3.18.2 Visual and Aesthetic Values

Aesthetics refer to the sensory quality of the resources (sight, sound, smell, taste, and touch) and especially with respect to judgment about their pleasurable qualities (Canter, 1993; Smardon et al. 1986). The aesthetic quality of the study area is influenced by the natural and developed environment. Except for the Corson Inlet area and Whale Beach, the beachfront of Peck Beach (Ocean City) and Ludlam Island (Sea Isle City) 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. The Corson Inlet area with Corson’s Inlet State Park and Strathmere State Natural Area offers visitors a more natural aesthetic quality with natural beaches, vegetation, wildlife, and surf.

2.3.18.3 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 Ocean City and Sea Isle City, 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.

2.4 Cultural Resources

Barrier islands and adjacent Atlantic coastal regions are among the most dynamic environments on earth and dynamic change was no less a hallmark in the prehistoric past. As a consequence, reconstructing past environmental conditions in order to predict prehistoric site locations in the study area is extraordinarily complex. Between 14,000 and 7,000 years ago, melting ice sheets raised sea levels that eventually covered the continental shelf and coastal prehistoric sites. Warmer climate resulted in a succession of vegetation types moving northward, while the coastline and associated marine and eustatic environments were developing from the east. As temperatures warmed and the climate alternated between dry and moister periods during the Holocene, open grassy environments were replaced by boreal evergreen forests and then by deciduous forests. The presence of both freshwater and saltwater species in the back bay areas and shorefront provided a rich resource base that attracted prehistoric peoples to the area. Of the four major prehistoric periods present in New Jersey, the two latest periods, the Woodland and Contact periods, are represented by a variety of sites in the general project vicinity. There are no reported prehistoric sites within the current limits of the study area. The closest known prehistoric sites are located more than seven miles from the study area in Pleasantville and near Linwood.

Historic settlement of southern New Jersey began with the arrival of Dutch explorers in the 1620's, but did not begin in earnest until the English gained control of the area in the 1660's. Cape May County boundaries were established by the 1690's and by 1723 the county had sufficient population to warrant division into three townships. The barrier island now known as Ocean City was once known as Peck Beach, which was part of Upper Township. Peck Beach was an important whaling station during the eighteenth and nineteenth centuries. The numerous sand bars along the barrier islands and inlets made the area treacherous to coastal shipping. At least 35 shipwrecks have been reported off the study area shoreline.

The Corps has consulted with the New Jersey State Historic Preservation Office (NJ SHPO) and other interested parties in order to fulfill our cultural resources responsibilities under the National Historic Preservation Act of 1966, as amended, and its implementing regulations, 36 CFR Part 800. As part of this work, the District has completed numerous cultural resources investigations in the project area to identify and evaluate historic properties that could potentially be impacted by proposed beach nourishment activities. The following discussion summarizes the results of these investigations.

The Philadelphia District completed two cultural resources investigations in association with the existing *Great Egg Harbor and Peck Beach-Ocean City, NJ Federal Shore Protection Project* located in the northern portion of the study area. This existing project extends from Great Egg Harbor Inlet south to 34th street in Ocean City. The first investigation, entitled *Offshore Cultural Resources Field Survey, Great Egg/Peck Beach, Ocean City, New Jersey (Tidewater Atlantic Research, 1985)*, recorded and analyzed remote sensing data to identify two small underwater magnetic targets on the perimeter of the project's 125 hectares (310 acre) offshore borrow area. The two target areas were avoided during subsequent sand borrowing activities.

In the second investigation, described in the report entitled *Submerged Cultural Resources Investigation, Great Egg Harbor Inlet & Peck Beach, Ocean City, New Jersey (Dolan Research Inc., 1994)*, researchers conducted supplemental remote sensing in an expanded 117 hectares (290 acre) area adjacent to the offshore borrow area referenced above. Five newly acquired underwater targets were identified. Underwater ground truthing operations determined that no material associated with significant cultural resources was present at these target locations. The investigation could not relocate the two underwater targets previously identified by Tidewater Atlantic Research in 1985.

The State of New Jersey, in consultation with the Philadelphia District, conducted a Phase 1 cultural resources investigation in 1995 for a state sponsored beach nourishment project located between 34th and 59th streets in Ocean City. In the report of this study entitled *Phase I Submerged and Shoreline Cultural Resources Investigations, Peck Beach (34th Street to Corson Inlet), City of Ocean City, Cape May County, New Jersey (Dolan Research, Inc. & Hunter Research, Inc. 1996)*, researchers conducted background and documentary research; a terrestrial pedestrian survey of the shoreline at low tide; an underwater archaeological survey of one offshore borrow area using magnetic, acoustic, and bathymetric remote sensing equipment. Two historic structures of note were identified during the low water survey. The first was a derelict fishing pier located at the foot of 59th Street. It was constructed circa 1913 and abandoned in 1982. The second structure was identified near the foot of 48th Street and contained portions of the cement foundation of the former Berkeley Hotel, erected circa 1900 and destroyed by fire in 1928. Both of these structures are in an advanced state of disrepair and neither is considered eligible for inclusion in the National Register. The remote sensing survey identified no potentially significant underwater resources in the proposed borrow area.

For the present study, a Phase 1A cultural resources documentary investigation of the entire 15 mile long study area was conducted in 1997. In the report entitled *Phase 1A Cultural Resources Investigations, Great Egg Harbor Inlet to Townsends Inlet, Cape May County, New Jersey" (Dolan Research, Inc. and Hunter Research, Inc. 1999*), researchers utilized background and documentary research, and analysis and evaluation of assembled research data, to assess the potential for cultural resources with an emphasis on study areas not previously investigated. No field investigations were carried out as part of this research.

This research identified two previously documented prehistoric sites recorded within two miles of the study area. Site 28CM19 is located at 19th Street in Ocean City on the beach at or slightly above the high tide level. Artifacts associated with this site, recorded in 1989, include two netsinkers and a piece of burnt whale bone. The remains of the site were observed after a major coastal storm, but no additional investigation has been subsequently carried out in this section of the beach. The second prehistoric site, 28CM42, is located two miles inland from the shoreline, opposite Ocean City, on a peninsula jutting out into Peck Bay near Egg Harbor Bay. This site may contain evidence of occupation dating from the Paleo-Indian period through the Late Woodland Period.

Although historically lacking major ports, New Jersey's Atlantic Coast lies along a number of the most active shipping routes during the 18th, 19th and 20th centuries. No less than 45 ships are known to have been wrecked in the neighborhood of Peck Beach alone. A complete list of ships known to have been lost near the study area is included in Appendix G of the report. Although most of these wrecks occurred some distance offshore, several ships are known to have met their final end on Peck and Ludlam Beaches. The most famous of these was the bark *Sindia* which ran a ground and sank at the foot of 17th Street in Ocean City on December 15, 1901. Heavily damaged by salvors, the wreck is now buried under sand recently placed to renourish the beach.

There are currently four historic properties in the study area that are listed, or have been determined eligible for listing, on the National Register of Historic Places. Two Ocean City train stations, the 10th Street Station and the 34th Street Station, were listed in the National Register as part of a thematic nomination in 1984. The *Sindia* Shipwreck Site, an early 20th century steel-hulled, four-masted bark located along the shoreline at the foot of 17th Street in Ocean City, was determined eligible for listing in the National Register of Historic Places in 1989. The Ocean City-Longport Bridge was considered eligible for listing by the New Jersey State Historic Preservation Office in 1993.

A Phase 1B cultural resources investigation was conducted in 1998 along southern Ocean City and Ludlam Island. Entitled *Phase I Submerged and Shoreline Cultural Resources Investigations, Great Egg Harbor Inlet to Townsends Inlet, Cape May County, New Jersey (Hunter Research, Inc., Dolan Research, Inc. and Enviroscan, Inc. 1999*), the report of this investigation describes the results of this work which included: background and documentary research; visual inspection and magnetic survey of the shoreline areas at low tide; and remote sensing survey of offshore borrow areas and near-shore sand placement areas. No evidence of prehistoric archaeological resources was noted in the project area.

A number of 20th century structures along the shoreline were identified (pilings, timbers, jetties/groins) and not considered significant cultural resources. A late 19th/early 20th –century frame boat house and late 19th –century frame beach cottage were noted on the shoreline in Sea Isle City and may be considered eligible for listing on the National Register of Historic Places. Three magnetic anomalies were found within the tidal zone during the pedestrian magnetometer survey in Sea Isle City and may represent potentially significant cultural resources, such as shipwrecks. Two additional magnetic anomalies located in the nearshore sand placement area– one off Strathmere, the other off Ocean City - may also represent significant cultural resources.

Finally, three magnetic targets exhibiting shipwreck characteristics were located in Borrow Area M3. No potentially significant targets were identified in offshore Borrow Areas L1 and O1. (Potential borrow areas M3 and O1 were later removed from further consideration due to habitat and geotechnical concerns respectively).

Results from a supplemental remote sensing cultural resources survey of four additional offshore borrow areas (L3, L1, M8, C1) are not available at presstime. The results of all cultural resources investigations, including the above referenced studies, will be closely coordinated with the New Jersey Historic Preservation Office. Section 106 consultation will be concluded prior to any project construction activity.

A map showing the extent of the investigation discussed above is shown on Figure 2.4-1.

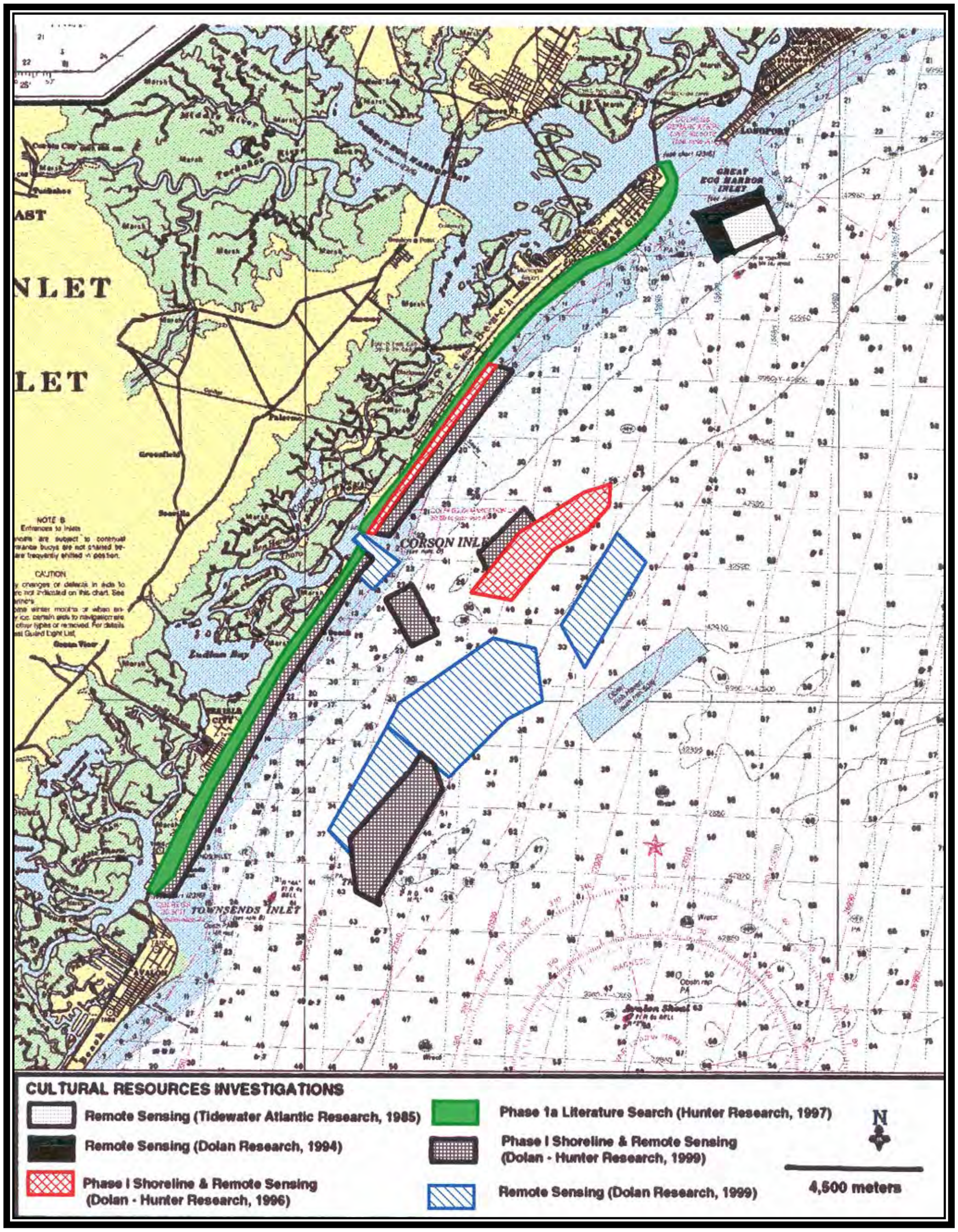

Figure 2.4-1 Cultural Resources Investigations

2.5 Hazardous, Toxic and Radioactive Wastes (HTRW)

Hazardous, Toxic and Radioactive Wastes (HTRW) include any hazardous substance regulated under the Comprehensive Environmental Response Compensation and Liability Act (CERCLA). Hazardous substances regulated under CERCLA include "hazardous wastes" under the Resource Conservation and Recovery Act (RCRA), "hazardous substances" identified under Section 311, of the Clean Air Act (CAA), "toxic pollutants" designated under Section 307 of the Clean Water Act (CWA), "hazardous air pollutants" designated under Section 112 of the CAA, and eminently hazardous chemical substances or mixtures that EPA has taken action under Section 7 of the Toxic Substances Control Act (TSCA), but does not include petroleum, unless already included in the above categories, or natural gas.

In accordance with the HTRW Guidance for Civil Work Projects, ER 1165-2-132, dated June 26, 1992, a literature survey was conducted for the Great Egg Harbor Inlet to Townsends Inlet study project area. The width of the study area is limited on the west by the easternmost street and extended one-half mile offshore. The survey looked at the historical background of the project area in order to identify any potential sources that may be suspected of introducing hazardous contaminants into the study area. The focus of the research was to find information that indicated whether or not potential sources may once have been located in the area and whether or not such sites may still be present.

Woodward Clyde Federal Services (WCFS), under contract, performed a HTRW literature search in October 1995, during the reconnaissance phase of study. They had identified six sites, all located on Ludlam Island.

In January 1999, the U.S. Army Corps of Engineers Philadelphia District conducted an HTRW literature search, using Environmental Risk Information and Imaging Services (ERIIS), for the feasibility phase of this study. The literature search identified thirteen sites that may potentially impact the potential project area. The sites with location and database are listed in Table 2.5-1 and shown in Figure 2.5-1. Of the six identified by WCFS only four sites, numbers 5, 8, 10 and 11 from Table 2.5-1, were determined to be a potential HTRW concern to the project area. The two facilities not listed, the New Jersey Bell Facility and Texaco Service Station, were researched during the feasibility phase of the study and found not to be an HTRW concern. There were a number of sites added during the feasibility phase of the study. This was done because the sites added where outside the project area, but were though to impact groundwater. This impact groundwater has the potential to migrate into the project area, which may pose a HTRW concern.

The databases that were identified in the search were: Comprehensive Environmental Response, Compensation, and Liability Information System, (CERCLIS), Facility Index System (FINDS), Resource Conservation and Recovery Information System-Small Quantity Generators (RCRIS_SG), New Jersey Underground Storage Tank Report (RST), New Jersey Pollution Discharge Elimination System (NPDES), Resource Conservation and Recovery Information System-Large Quantity Generators (RCRIS_LG), NJ Known Contaminated Sites List (HWS), New Jersey Leaking Underground Storage Tank Report (LUST), New Jersey Solid Waste Landfills Report (SWF).

A review of Corps of Engineers information on storm water outfalls showed that there are 22 outfalls in Ocean City, but none are located south of 34th Street, and two outfalls in Sea Isle City. A listing of these outfalls can be found in Table 2.5-2.

HTRW Investigations/Conclusions. A review of the literature search and comparison of the risk of encountering HTRW versus the study have lead to the following conclusions:

i. The project area has been primarily a residential area and most contamination could be attributed to non-point sources (parking lots, roadways, etc) and commercial activities (leaking underground storage tanks, waste generation/discharge). The storm water outfalls listed in Table 2.5-2 are a source of possible contamination, however since the area drained is residential, the severity of the contamination is low and will not pose a concern to the project.

ii. The proposed project will not worsen HTRW conditions in the project area. "With" Project and "Without" Project HTRW conditions are essentially the same.

iii. All sites listed in Table 2.5-1 are outside the project area. These sites all have either soil or groundwater HTRW issues and since they are outside of the project area only groundwater is of concern. The current plan does not include any type of onshore excavation where groundwater could be encountered. However, if the plan is changed there may need to be a reevaluation of the HTRW sites of concern for impacts.

iv. The potential offshore borrow areas identified for this study where analyzed for possible HTRW impacts. All of the HTRW sites listed can be eliminated as possible sources of contamination for the potential borrow areas because of their distance offshore.

v. The U.S. Army Corps of Engineers Philadelphia District performed a search using the Project Information Retrieval System (PIRS) for Formerly Used Defense Sites (FUDS) within the project boundaries. There were no sites identified in the project area or the potential borrow area locations.

Table 2.3.18-1 Summary of Sites

Site	Location	Database
1.) Strathmere River; Middle of River	Strathmere (Location Unknown)	CERCLIS, FINDS
2.) Private Residence	105 Winthrop Rd, Strathmere	RCRIS_SG
3.) Ocean Beach Trailer Resort	Commonwealth Ave, Strathmere	FINDS, NPDES
4.) Deauville Inn	201 Willard Rd, Strathmere	RST, NPDES
5.) Sea Isle Central Office	43rd Street at Landis Ave, Sea Isle City	RCRIS_LG
6.) JCPL Coal Gas Plant Site Formerly Sea Isle City Gas Plant.	39th and Central (N. Brewster and 39th Street) (N. Brewster and Garrison Street), Sea Isle City	CERCLIS RCRIS_LG FINDS, HWS
7.) Sea Isle Marine Basin	14 Old Sea Isle Blvd, Sea Isle City	RCRIS_LG FINDS
8.) USCG - Old US Coast Guard Station Townsends Inlet	Landis Ave at 82nd St, Sea Isle City	RCRIS_LG, HWS LRST
9.) Sea Isle City	4800 Central Ave, Sea Isle City	RCRIS_LG, FINDS
10.) Sea Isle City Landfill Sea Isle SLF	5th Street at Landis Ave, Sea Isle City 4416 Landis Ave, Sea Isle City	HWS, SWF
11.) Exxon Service Station	4400 Landis Ave, Sea Isle City	HWS, LUST, RST
12.) Pitt Stop	63rd Street at Central Ave, Sea Isle City	LUST, RST
13.) Vitiello Dock	317 43rd Place, Sea Isle City	LUST, RST

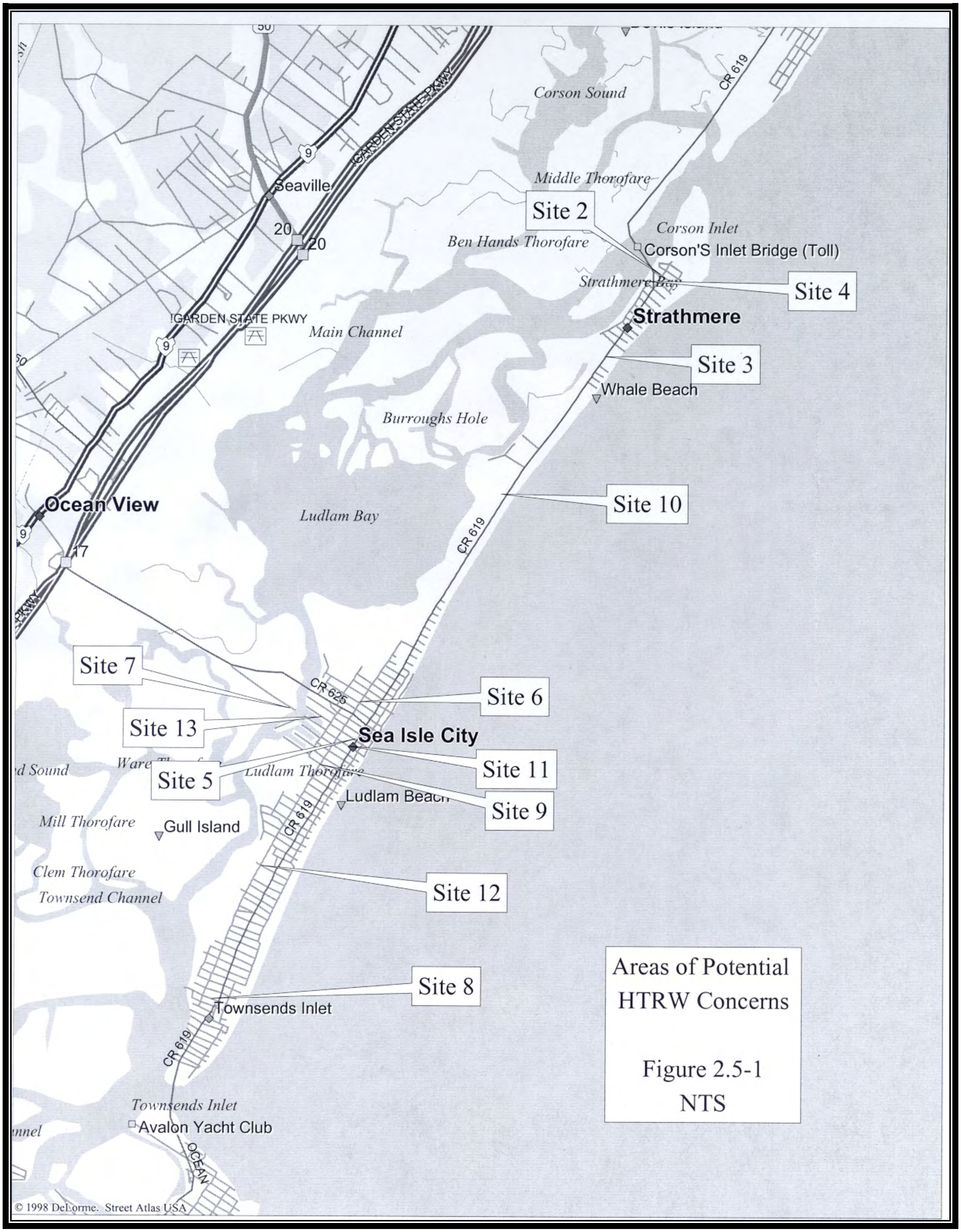

Figure 2.5-1 Areas of Potential HTRW Concerns

Table 2.3.18-2 Storm Water Outfalls

Outfall Number	Station	Approximate Location
1	3+70	Sea Spray Rd. Ocean City
2	15+52	Surf Rd. Ocean City
3	25+13	Beach Rd. and Atlantic Blvd. Ocean City
4	31+45	Morningside Rd. Ocean City
5	38+45	North St. Ocean City
6	44+16	First St. Ocean City
7	50+18	Second St. Ocean City
8	55+47	Third St. Ocean City
9	61+15	Fourth St. Ocean City
10	66+84	Fifth St. Ocean City
11	72+85	Sixth St. Ocean City
12	76+50	Plaza Pl. Ocean City
13	78+84	Seventh St. Ocean City
14	81+12	Plymouth Pl. Ocean City
15	84+89	Eighth St. Ocean City
16	87+09	Moorlyn Ave. Ocean City
17	90+99	Ninth St. Ocean City
18	97+77	Tenth St. Ocean City
19	103+97	Eleventh St. Ocean City
20	109+69	Twelfth St. Ocean City
21	115+3	Thirteenth St. Ocean City
22	121+15	Fourteenth St. Ocean City
23	N/A	82th St. Sea Isle City
24	N/A	86th St. Sea Isle City

2.6 Shore Protection Structural Inventory

(Note: All elevations are in NAVD88.)

2.6.1 Ocean City

2.6.1.1 Dunes

A fairly substantial dune system extends from 36th to 49th St. The crest elevation of this dune system varies mostly between +3.0 meters and +3.2 meters (10.0 and 10.5 ft), with several elevations as high as +3.5 m (11.5 ft) and as low as +2.8 m (9.0 ft). A somewhat narrower dune system extends from 49th to 59th St. The crest elevation of this system varies mostly between +2.7 (9.0 ft) and +3.2 m (10.5 ft) with elevations as high as +4.3 m (14.0 ft) and as low as +2.5 m (8.0 ft).

2.6.1.2 Bulkhead

A timber bulkhead with a stone revetment is in good condition and extends from 36th to 57th St. The top elevation of the bulkhead is about +3.2 m (10.5 feet).

2.6.1.3 Groins

There are eighteen groins in Ocean City south of 36th Street. Sixteen of the groins are constructed of timber. One groin is constructed of timber and concrete and one groin is constructed of timber and stone. Most of the groins are covered with sand and all are in poor/fair condition.

There are seven groins between 36th and 47th St; their crest elevations are approximately +3.7 m (12 ft) at the landward end and +1.0 m (3 ft) at the seaward end. Their lengths vary from 24 m (80 ft) to 61 m (200 ft) with a top width that varies from 0.4 to 1.8 m (1.3 to 6.0 ft).

There are seven groins between 50th and 56th St. Their crest elevations are approximately +1.4 to +2.1 m (4.5 ft to 7.0 ft) at the landward end and 0.2 to 1.1 m (0.7 to 3.5 ft) at the seaward end. Lengths of these groins are 53 m (175 ft) with a top width of 0.5 m (1.5 ft).

There are two groins between 57th and 58th St. Their crest elevations are +1.4 to +1.7 m (4.5 to 5.5 ft) at the landward end and +0.8 to +1.1 m (2.5 to 3.5 ft)at the seaward end. Lengths of these groins are 69 and 53 m (225 and 175 ft) with a top width of approximately 0.5 m (1.5 ft).

The remaining two groins are at 59th St. One is 38 m (125 ft) long with a top width of 0.5 m (1.5 ft), with a crest elevation of +2.4 m (8.0 ft) at the landward end and +1.7 m (5.6 ft) at the seaward end. The other is 183 m (600 ft) long with a top width of 2.4 m (8 ft), with a continuous crest elevation of +3.4 m (11.0 ft).

2.6.2 Strathmere

2.6.2.1 Dunes

A somewhat narrow dune system extends from the Corson Inlet to Tecumesh Ave. In general, the crest elevation of this system varies mostly between +2.7 and +3.6 m (9.0 and 12.0 ft), with elevations as high as +3.7 m (12.0 ft) and as low as +2.5 m (8.0 ft). A fairly substantial dune system extends from south of Sherman Ave. to the southern boundary of Strathmere. The crest elevation of this dune system varies mostly between +3.0 and +3.9 m (10.0 and 13.0 ft) with several elevations as high as +4.8 m (15.5 ft) and as low as +2.8 m (9.0 ft).

2.6.2.2 Bulkhead

A timber bulkhead, in poor condition, extends from Tecumesh Ave to Sherman Ave. The top elevation of the bulkhead is approximately +2.4 m (8.0 ft).

2.6.2.3 Groins

There are fifteen groins in Strathmere. Seven of the groins are constructed entirely of timber. Eight of the groins are constructed of timber with a stone rubble mound at the head of the groin. Several of the groins are covered with sand. The groins at Seabreeze, Winthrop and Sherman Avenues are in poor condition. The rest are in good/fair condition.

The five groins at Seabreeze, Seaspray, Seaview, Seacliff and Winthrop Aves have crest elevations of +2.4 m (8.0 ft) at the landward end and +0.8 m (2.5 ft) at the seaward end. Their lengths vary from 38 to 114 m (125 to 375 ft). The groins at Willard, Sumner and Otis Aves have crest elevations of +2.7 m (9.0 ft) at the landward end and +0.2 m (7.0 ft) at the seaward end. They have a length of 99 m (325 ft). The groins at Hamilton, Grant and Taylor Aves have crest elevations of +2.7 to +2.9 m (9.0 ft and 9.5 ft) at the landward end and +0.2 m (0.7 ft) at the seaward end. They have a length of 152 m (500 ft) and a top width of 4.3 m (14 ft). The remainder of the groins have somewhat individual characteristics. Their crest elevations vary from +2.4 to +3.0 m (8.0 to 10.0 ft) at the landward end and +1.1 to +2.7 m (3.6 to 9 ft) at the seaward end. Their lengths vary from 61 to 244 m (200 to 800 ft).

2.6.3 Sea Isle City

2.6.3.1 Dunes

A substantial dune system extends from 13th to 29th Sts. The crest elevation of this system varies mostly between +4.0 and +4.3 m (13.0 and 14.0 ft) and with elevations as high as +4.7 (15.5 ft) and as low as +3.7 m (12.0 ft). A more substantial dune system extends from 57th to 93rd Sts. The crest elevation of this dune system varies mostly between +3.8 and +4.7 m (12.5 and 15.5 ft) with several elevations as high as +5.5 m (17.9 ft) and as low as +3.6 m (11.8 ft).

2.6.3.2 Bulkhead

A timber bulkhead extends from 29th to 32nd Sts and serves as a promenade. A timber bulkhead with sand fill and a revetment in front serves as a promenade and extends from 32nd to 57th Sts. All are in good condition. The top elevation of the bulkhead/promenade is approximately +3.7 m (12.0 ft).

2.6.3.3 Groins

There are nineteen groins in Sea Isle City from 30th to south of 78th St. Four of the groins are timber crib groins which are no longer visible. Their crest elevations vary from +1.6 to +3.6 m (5.1 to 12.0 ft) at the landward end and +1.4 to +1.7 m (4.5 to 5.6 ft) at the seaward end. Their lengths vary from 91 to 227 m (300 to 745 ft) with a top width that varies between 2.4 to 2.7 m (8 to 9 ft). Thirteen of the groins are constructed of timber with a stone rubble mound head at the head of the groin; their crest elevations are +2.7 m (9.0 ft) at the landward end and +0.2 m (0.6 ft) at the seaward end. Their lengths vary from 175 m to 236 m (575 to 775 ft) with a top width that varies from 3.0 to 4.3 m (10 to 14 ft). One groin is constructed entirely of stone. It has a crest elevation of +3.6 m (12.0 ft) at the landward end and +2.4 m (8.0 ft) at the seaward end. It has a length of 78 m (255 feet) and a top width that varies between 3.7 to 4.3 m (12 to 14 ft). All are in fair/good condition.

In 1999, a 213 m (700 ft) stone terminal groin was constructed south of 93rd Street. It has a crest elevation of +2.1 m (6.8 ft) at the landward side and +0.5 m (1.8 ft) at the seaward side, with the middle portion elevation at –0.4 m (-1.2 ft). Top width ranges from 3 meters (10 ft) to 4.3 meters (14 ft).

2.6.3.4 Geotextile tubes

There are two sets of geotextile tubes in Sea Isle City. One exists at the north end of Sea Isle City extending from 1st to 13th Streets, a distance of approximately 1,220 meters (4,000 ft). It is about 3.6 m (12 ft) wide and 1.5 m (5 feet) high. The geotextile tube was covered with sand, forming a reinforced dune. Another geotextile tube location is at the Townsends Inlet area of Sea Isle City, specifically 274 meters (900 ft) of geotextile tube between 91st Street and 93rd Street. This geotextile tube is also covered with sand.

2.7 Physical Processes of the Coast

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

2.7.1 Waves

An analysis of general wave statistics for the study area is 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 (CEDRS) developed by the U.S. Army Engineer Coastal Engineering Research Center (CERC). The wave information for each location is derived from wind fields developed in a previous hindcast covering the period 1956 through 1975 and the present version of the WIS wave model, WISWAVE 2.0 (Hubertz 1992). Additionally, an updated hindcast for the next 18 years (1976-1993) was performed using an updated version of WISWAVE 2.0 (Brooks and Brandon, 1995). In order to better represent a realistic wave climate, tropical storms and hurricanes were included in the 1976-1993 hindcast.

The WIS output results are a verified source of information for wind and wave climate along the U.S. Atlantic Coast and have been used to gain a basic understanding of the wind and wave climate for the Great Egg Harbor Inlet to Townsends Inlet study area. Pertinent wave statistics are those derived for Station 68 of WIS Report 30 and 33 (Figure 2.7.1-1). The location of Station 68 is offshore of the northern part of the study area at Latitude 39.25 N, Longitude 74.25 W, in a water depth of approximately 18 m (59 ft). Monthly mean wave heights at Station 68 for the updated hindcast in WIS Report 33 range from 0.75 m (2.46 ft) in July to 1.59 m (5.22 ft) in March. The mean wave height at Station 68 for the 1976 to 1993 period is 1.2 m (3.9 ft) with a mean period of 8 sec. The maximum wave height for the 1976 to 1993 period is reported as 8.9 m (29.2 ft), with an associated peak period of 14 sec and a peak direction of 140 deg on 27 September 1985. The maximum wave height for the 1956 to 1975 period is reported as 6.9 m (22.6 ft), with an associated peak period of 14 sec and a peak direction of 86 deg on 7 March 1962. The maximum wind speed for Station 68 for the 1976 to 1993 period is reported as 31 m/sec (69 mph) at 60 deg on 27 September 1985 and 27 m/sec (60 mph) on 7 March 1962 for the 1956 to 1975 period.

No long-term prototype data has been collected for Great Egg Harbor Inlet/Peck Beach or Ludlam Island; however, field measurements of waves have been collected adjacent to Absecon Inlet and Townsends Inlet, NJ. Data was collected during the period November 1993 to January 1995 and at Townsends Inlet from July 1993 to August 1994. The data collected provide bulk parameters and directional spectral information at an offshore and a nearshore site. Field data have been analyzed using directional spectral analysis techniques to produce spectrally-based bulk parameters describing the wave records as well as discretized energy densities for frequency/direction bins. Data reports are available at the USACE Philadelphia District. Although the data at the nearshore sites are primarily site-specific, the offshore data may be useful in providing wave climate information for the Great Egg Harbor Inlet to Townsends Inlet study area.

Offshore wave data for storm erosion modeling was taken from a recent wave hindcast study. Location of the nodes in the study area are shown in Figure 2.7.1-1. Historic storm data were generated in the hindcast using a series of numerical models applied to two storm populations. The hindcast used 15 historic hurricanes and 15 historic northeasters that have affected district coastal areas in order to formulate the storm criteria. The computational points in the wave analysis were in water depths of about 15.25 m (50 ft) situated offshore of Ocean City and Ludlam Island. Wave data plots from the OCTI hindcast are provided in the Engineering Technical Appendix.

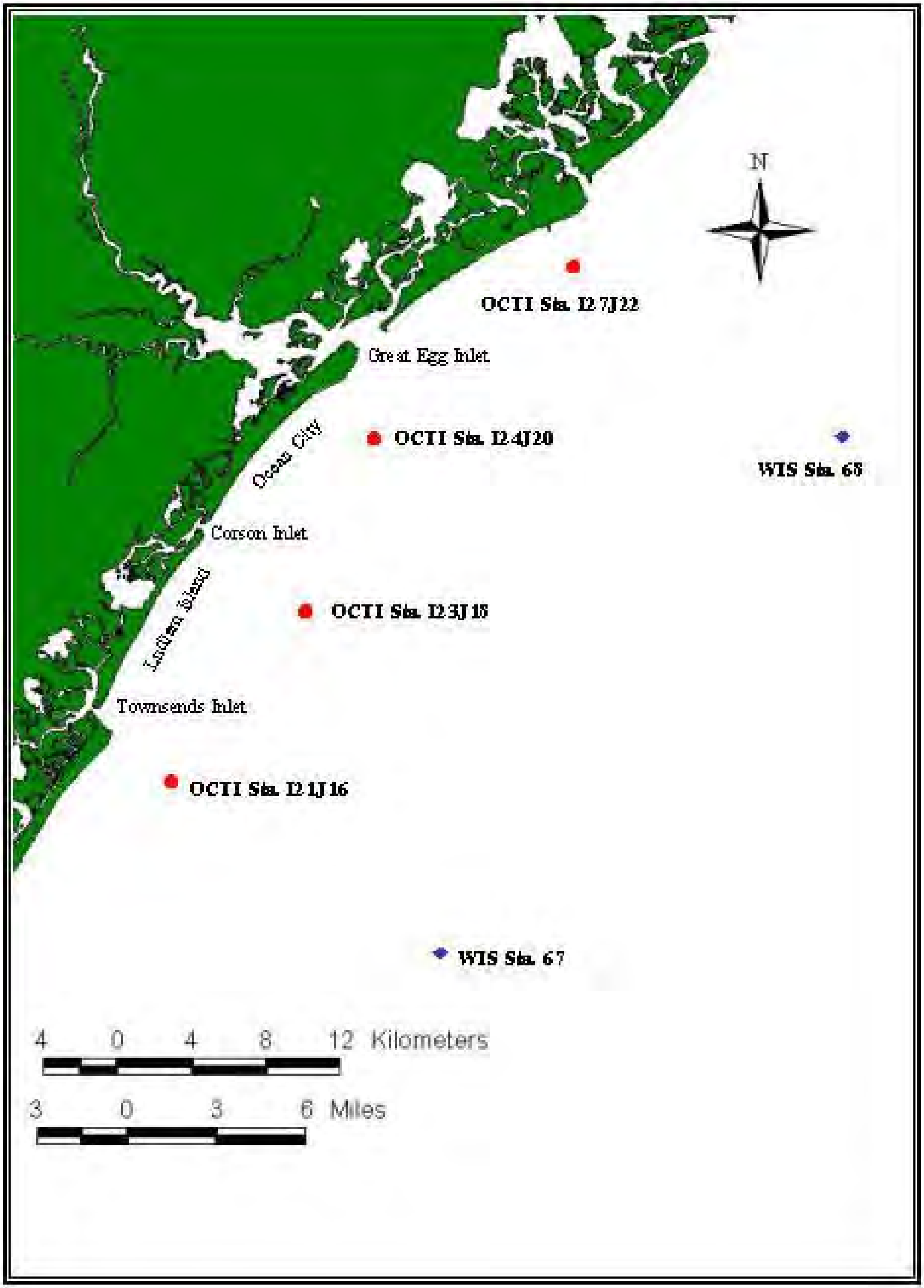

Figure 2.7-1 **Wave Information Study (WIS) Station Location Map**

2.7.2 Wind and Climate

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

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

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

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

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

As referenced in the 1984 Annual Summary from the State Marina site, prevailing winds are from the south and of moderate velocity (22 to 45 km/hr or 14 to 28 mph), and winds from the northeast have the greatest average velocity (between 31 and 32 km/hr or 19.2 and 19.9 mph). Wind data from this period also show that winds in excess of 45 km/hr (28 mph) occur from the northeast more than twice as frequently as from any other direction.

The maximum five-minute average velocity at Atlantic City was recorded during the hurricane of September 1944, with a value of 132 km/hr (82 mph) from the north. This storm also caused the largest recorded storm surge along the coast of New Jersey. The fastest "mile" windspeed at the Atlantic City Marina site from 1960 to 1984 was recorded during Hurricane Doria in August 1971 at 101 km/hr (63 mph) from the southeast. Wind records generally reflect the fact that the most extreme, but infrequent, winds accompany hurricanes during the August to October period. Less extreme but more frequent high winds occur during the November to March period accompanying northeasters.

2.7.3 Currents

There are two general classes of currents that can cause tangible effects on the stability of the study area shoreline. The first class is referred to as tidal currents that are generated by hydraulic head differences between water levels in the ocean and the back bay areas. The periodic rise and fall of the ocean water level adjacent to barrier islands such as Peck Beach is the principal driving force for the ebb and flood of tidal currents. Tidal inlets such as Great Egg Harbor and Corson Inlets provide the connection between ocean and back bay areas and constitute the zone in which the effects of tidal currents are most pronounced. The tidal currents at inlets can be important mechanisms for sediment transport, particularly as they interact with the second type of currents, longshore currents. Longshore currents are set up in 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. For example, an observer looking seaward from the surf zone would experience a longshore current flowing from right to left when the direction of wave approach is from the right of shore-normal. Along the central portion of barrier beaches such as Peck Beach or Ludlam Island, longshore currents provide the primary mechanism for sediment transport.

Tidal currents and flow estimates for Great Egg Harbor Inlet are available from a study conducted in March 1995 by the Coastal Engineering Research Center (CERC) for the Philadelphia District. Acoustic Doppler Current Profiler (ADCP) measurements were taken to provide estimates of depth-averaged currents at specified cross-sections and flow volumes as a function of time over most of a tidal cycle. The three primary cross-sections used in this study are shown in Figure 2.7.3-1. Data for Range A indicate that during ebb tide, the higher water velocities are located along the southern end of the range where the channel is deep. During flood tide, velocities are more uniform across the range. Maximum depth-averaged velocities were approximately 120 cm/sec (3.9 ft/sec) and 100 cm/sec (3.3 ft/sec) for the ebb and flood tides respectively. Range B is regarded as two channels separated by a shoal, with depths of over 10 m (32.8 ft) in the western channel and approximately 4 m (13.1 ft) in the relatively narrow eastern channel.

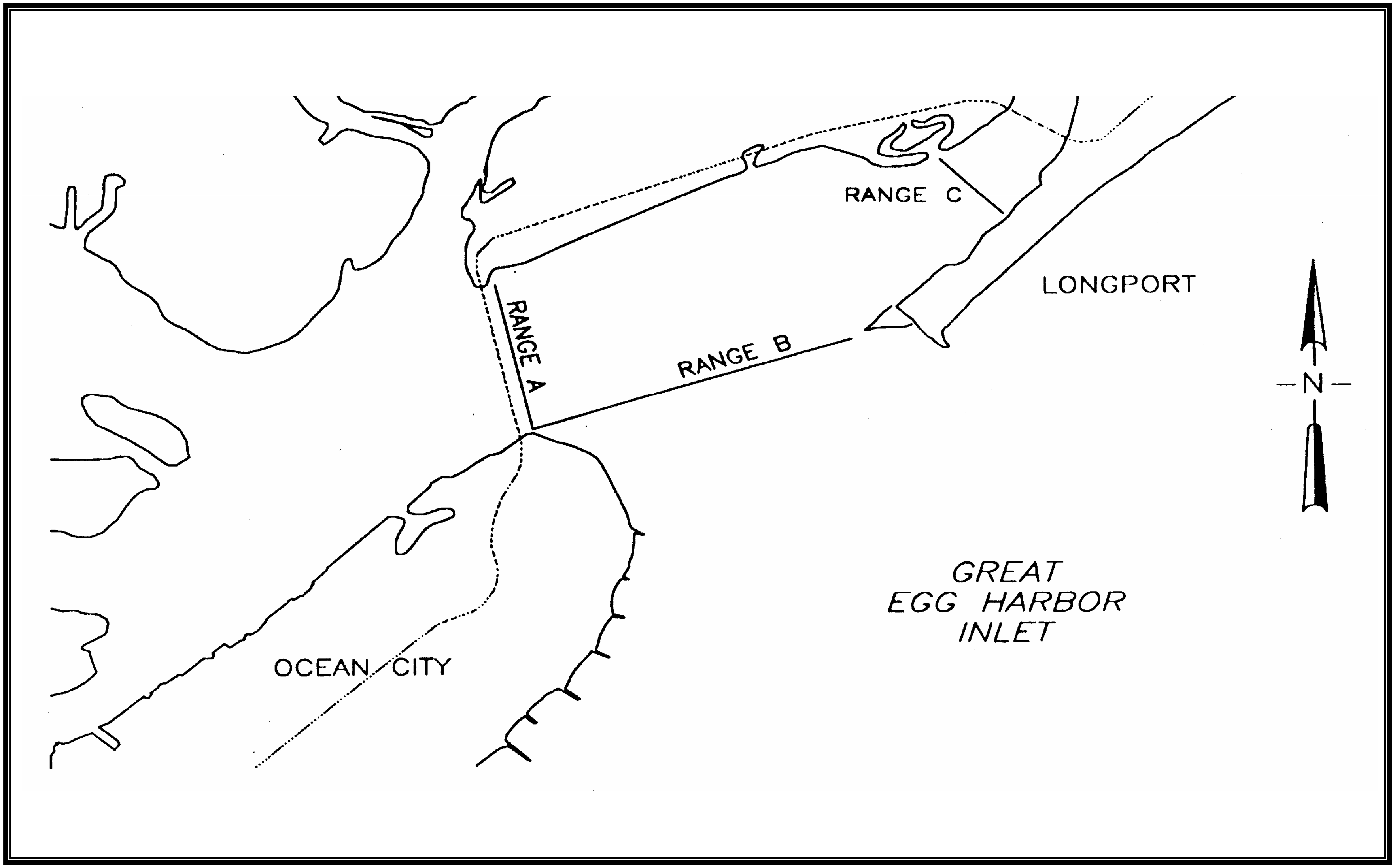

Figure 2.7-2 **Tidal Current Range Lines across Great Egg Harbor Inlet**

Maximum depth-averaged velocities during the ebb were approximately 110 cm/sec (3.6 ft/sec) and over 140 cm/sec (4.6 ft/sec) in the eastern and western channels respectively. During flood tide across Range B, maximum depth-averaged velocities were over 125 cm/sec (4.1 ft/sec) and 105 cm/sec (3.4 ft/sec) in the eastern and western channels respectively. Across Range C, higher velocities were found near the center of the range. Maximum depth-averaged velocities were 90 cm/sec (3.0 ft/sec) and 120 cm/sec (3.9 ft/sec) during the ebb and flood tides respectively. Complete analysis results are provided in a comprehensive report entitled *Current Survey of Great Egg Harbor Inlet, NJ with a Broadband Acoustic Doppler Current Profiler* available at the Philadelphia District.

Technical Report H-78-11 entitled *Numerical Simulation of Tidal Hydrodynamics, Great Egg Harbor and Corson Inlets, New Jersey* was prepared by the Waterways Experiment Station for the Philadelphia District. This investigation applied a numerical model to both inlets in order to quantitatively predict tidal hydrodynamics (exclusive of salt, sediment transport and wave action) for various improvement schemes. Model results were calibrated and verified using prototype water level and velocity data collected by Rutgers University in 1974-1975. The verified model shows maximum current velocities in the Corson Inlet throat of approximately 0.9 m/sec (2.95 ft/sec) on flood tide and 1.2 m/sec (3.94 ft/sec) on ebb tide. Maximum current velocities for the Great Egg Harbor throat north and south were simulated as approximately 0.76 (2.49) and 0.83 m/sec (2.72 ft/sec) on flood tide, respectively, and 0.9 (2.95) and 0.76 m/sec (2.49 ft/sec) on ebb tide, respectively. Prototype data and model results are available for numerous other locations throughout each inlet channel and within the channels leading into each inlet.

2.7.4 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 Great Egg Harbor Inlet is 1.16 m (3.81 ft) in the Tide Tables published annually by the National Oceanic and Atmospheric Administration (NOAA). The spring tide range is reported as 1.4 m (4.59 ft). The back bay areas adjacent to Ocean City show a very small reduction in tide range relative to the ocean shoreline. The 9th Street and 34th Street Bridge locations in Ocean City are reported as having mean and spring tide ranges of 1.13 (3.71) and 1.37 m (4.49 ft) respectively. The mean and spring tide ranges at Corson Inlet are 1.19 (3.90 ft) and 1.43 m (4.69 ft) respectively.

The mean and spring tide ranges on the Atlantic Coast of Sea Isle City are 1.25 (4.10 ft) and 1.52 m (4.99 ft) respectively. There is presently no NOS (National Ocean Service) tide gage operated along Peck Beach or Ludlam Island.

The NOAA tide gage nearest to the study area shoreline is located at the Trump Taj Mahal oceanfront pier in Atlantic City. Historically, a gage has been located on Absecon Island since July 1911. In July 1985, the gage was moved from its location at Atlantic City Steel Pier two miles south to a municipal fishing pier in Ventnor. In January 1992, the gage was moved from Ventnor to its present location at the Trump Taj Mahal Pier.

2.7.5 Ocean Stage frequency

The stage-frequency relationship derived for this study based upon a Gumbel best-fit distribution for recurrence levels greater than a 10-yr event are based upon the Weibull best-fit distribution to annual maxima measured at Atlantic City for a 10-yr event and lower is shown in Figure 2.7.5-1. Values of stage at selected reference frequencies are shown in Table 2.7.5-1. This relationship places the maximum water level ever recorded at Atlantic City, i.e. on September 14, 1944, of 2.12 m (6.96 ft) NAVD88 at the 50-yr level and the December 1992 storm peak water level of 1.88 m (6.17 ft) NAVD88 at approximately a 25-yr event. Table 2.7.5-2 presents the 20 highest observed stages adjusted for sea level rise. These water levels are considered as representative of the water levels experienced at the study area over the same period.

Table 2.7.5-1 Ocean Stage Frequency Data Peck Beach/Ludlam Island, NJ

Year Event	Annual Probability of Exceedance	Water Surface Elevation (m, NAVD 88)
5	0.20	1.53
10	0.10	1.68
20	0.05	1.87
50	0.02	2.17
100	0.01	2.41
200	0.005	2.72
500	0.002	3.05

1 meter = 3.28 ft

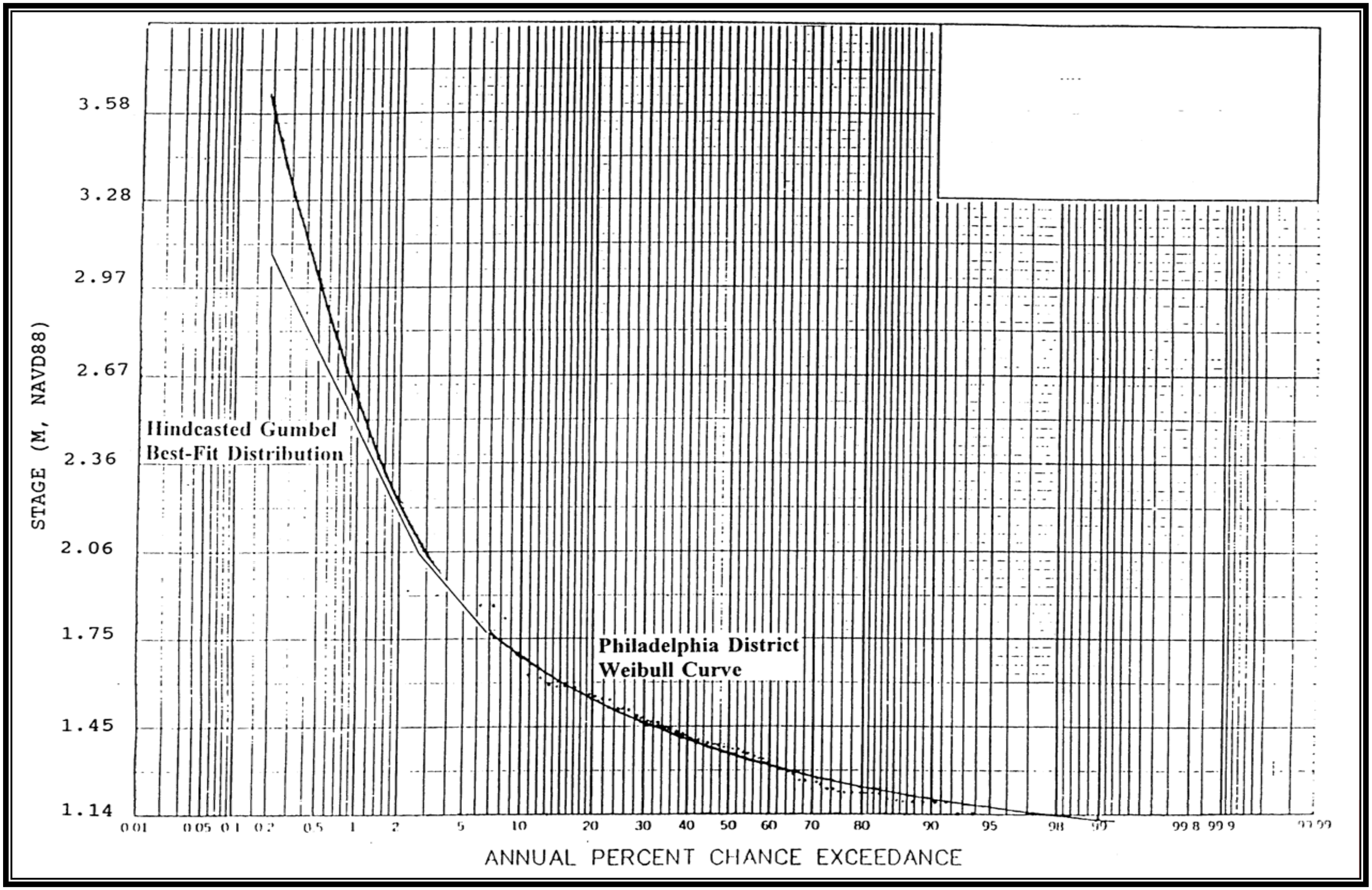

Figure 2.7-3 **Stage Frequency Relationship for Study Area**

Table 2.7.5-2 Stage Frequency Analysis, 20 Highest Stages Adjusted for Sea Level Rise Atlantic City, NJ 1912-1998

Year	Date	Rank	Adj. Stage, m NAVD88	Storm Type
1944	14 Sep 1944	1	2.11	HUR
1962	7 Mar 1962	2	1.92	NE
1950	25 Nov 1950	3	1.91	NE
1992	11 Dec 1992	4	1.87	NE
1985	27 Sep 1985	5	1.86	HUR
1976	9 Aug 1976	6	1.86	HUR
1991	31 Oct 1991	7	1.81	NE
1984	29 Mar 1984	8	1.69	NE
1980	25 Oct 1980	9	1.66	NE
1953	23 Oct 1953	10	1.62	NE
1989	19 Oct 1989	11	1.59	NE
1977	14 Oct 1977	12	1.58	HUR
1947	1 Nov 1947	13	1.58	NE
1972	22 Dec 1972	14	1.58	NE
1960	12 Sep 1960	15	1.56	HUR
1961	22 Oct 1961	16	1.56	HUR
1932	10 Nov 1932	17	1.55	HUR
1935	6 Sep 1935	18	1.54	HUR
1920	5 Feb 1920	19	1.54	NE
1994	Mar 1994	20	1.53	NE

1 m = 3.28 ft

2.7.6 Storms

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

Tropical storms and hurricanes, spawned over the warm low latitude waters of the Atlantic Ocean, are probably the best known and most feared storms. Hurricanes, characterized by winds of seventy-five miles per hour or greater and heavy rain, plague the Gulf and Atlantic seaboards in the late summer and autumn. Historically, the Hurricane of 1944 and Hurricane Gloria (1985) are ranked first and fifth, respectively, in terms of maximum stage at the Atlantic City gage.

Extratropical storms, often called "northeasters", present a particular problem to the Atlantic seaboard. Such storms may develop as strong, low pressure areas over land and move slowly offshore. The winds, though not of hurricane force, blow onshore from a northeasterly or easterly direction for sustained periods of time and over very long fetches. The damage by these storms may ultimately exceed the destruction from a hurricane. The March 1962 Northeaster ranks second only to the 1944 hurricane in terms of maximum stage. The northeasters which occurred in November 1950 and December 1992 rank third and fourth in the stage frequency analysis for the Atlantic City gage.

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

2.7.7 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 (NRC), 1987; Barth and Titus, 1984). Although local levels are falling in some areas, sea level is predominantly increasing with rates ranging from 1 to 5 mm/yr (0.04 to .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 30 cm (11.8 in) 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. Corps of Engineer's 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 4 mm/yr (0.16 in/yr) (Hicks and Hickman, 1988). Over the fifty year period of analysis, it is assumed that sea level will rise by approximately 0.2 m (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.

2.7.8 Beach Profile Surveys

Established beach profile survey lines for southern Ocean City and Ludlam Island are shown in Table 2.7.8-1 and Figure 2.7.8-1. The eight lines (7 onshore/offshore, 1 onshore only) located in southern Ocean City have been surveyed semi-annually since 1994 as part of the routine monitoring program for the Federal beachfill project. Four of these lines reoccupied historic line locations that had been established in 1963. The lines shown for Ludlam Island were established in 1997 and have been surveyed in September 1997 using a sea sled system and in May 1998 using traditional surveying methods.

Table 2.7.8-1 Survey Line Locations

Survey Line	Location
OC52	Vicinity of 38th St, Ocean City
OC53	Vicinity of 40th St, Ocean City
OC54	Vicinity of 42nd St, Ocean City
OC55	Vicinity of 45th St, Ocean City
OC56	Vicinity of 50th St, Ocean City
OC57	Vicinity of 54th St, Ocean City
OC59	Vicinity of 60th St, Ocean City
LI1	Vicinity of Williams Rd, Strathmere
LI2	Vicinity of Sumner Rd, Strathmere
LI2A	Vicinity of Prescott Rd, Strathmere
LI3	Whale Beach area
LI4	North Sea Isle City
LI4A	Vicinity of 32nd St, Sea Isle City
LI5	Vicinity of 46th St, Sea Isle City
LI5A	Vicinity of 49th St, Sea Isle City
LI5B	Vicinity of 61st St, Sea Isle City
LI5C	Vicinity of 69th St, Sea Isle City
LI6	Vicinity of 79th St, Sea Isle City
LI6A	Vicinity of 86th St, Sea Isle City
LI6B	Vicinity of 91st St, Sea Isle City
LI6C	Townsends Inlet

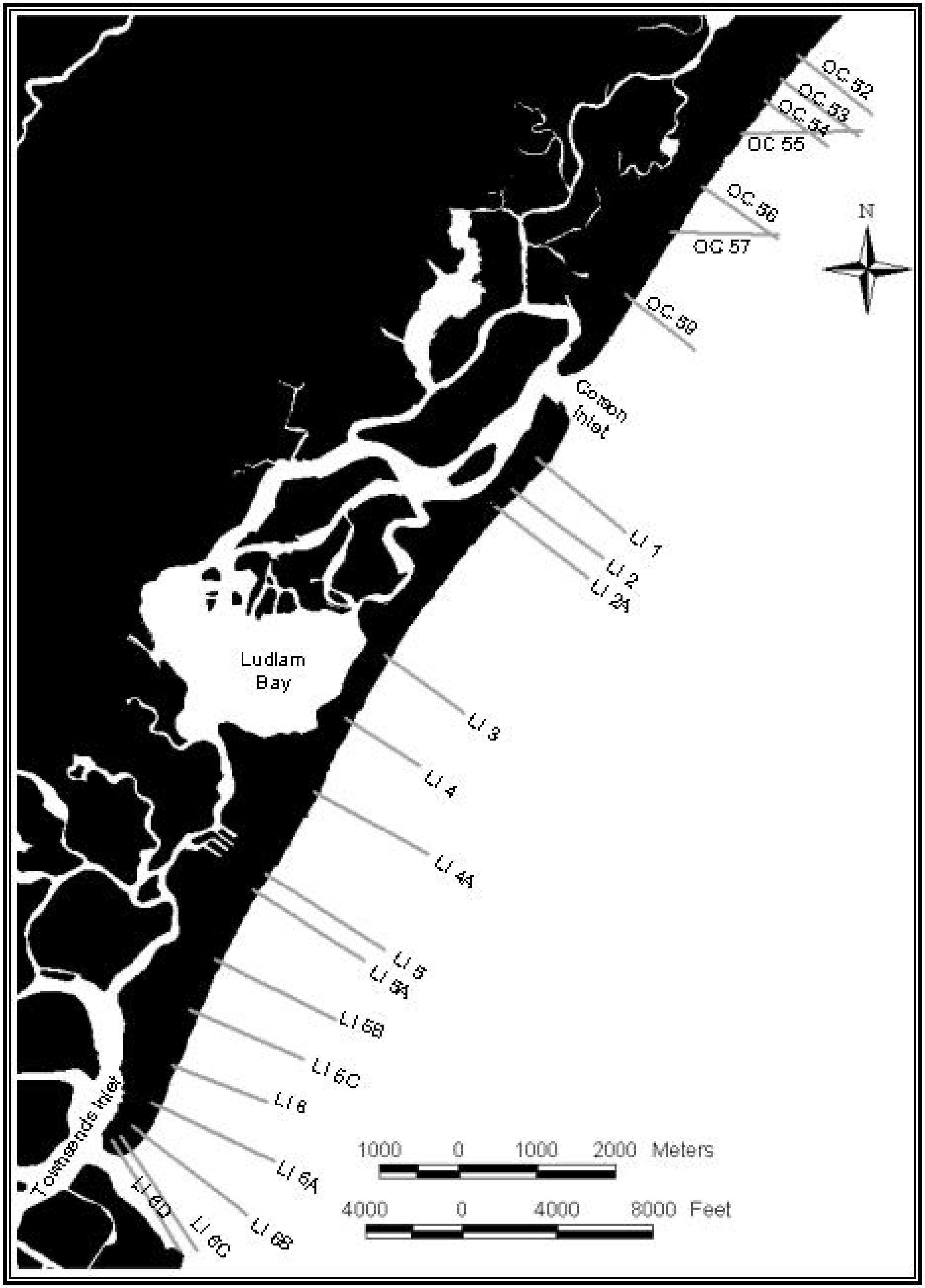

Figure 2.7-4 Profile Survey Lines for Ocean City and Ludlam Island

2.7.9 Historic Longshore 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. The net longshore transport along most of the study area is from northeast to southwest, although there are local reversals of drift near Great Egg Harbor and Corson Inlets.

Longshore transport in the vicinity of Ocean City. There have been a number of investigations that have evaluated shore processes and developed sediment budgets for the New Jersey coastline. A detailed analyses for the shoreline from Great Egg Harbor Inlet to Townsends Inlet study area was performed by CERC in 1975. This analysis reviewed the findings of several earlier reports and analyses with respect to shore processes and synthesized a sediment budget and longshore transport rates. For the Great Egg Harbor Inlet/Peck Beach area, CERC calculated a gross annual tranport rate of 873,886 m^3, (1,143,000 yd^3) with southerly and northerly components of 581,826 (761,000 yd^3) and 292,060 m^3 (382,000 yd^3) respectively. The computed net transport rate is thus 289,766 m^3/yr (379,000 yd^3/yr) to the south at the location of the northeast (Longport) side of Great Egg Harbor Inlet. An average annual sediment trapping rate of 117,741 m^3 (154,000 yd^3) for Great Egg Harbor Inlet was calculated resulting in a net input to the northeast end of Ocean City of 172,025 m^3 (225,000 yd^3) annually. A net deficit of 137,620 m^3 (180,000 yd^3) annually was computed along Ocean City, with a resultant average annual net transport rate at the southwest end of the island of 309,645 m^3 (405,000 yd^3).

The *General Design Memorandum (GDM) and Final Supplemental Environmental Impact Statement, Great Egg Harbor Inlet to Peck Beach-Ocean City, NJ (1990)* reevaluated the CERC analysis and concluded no significant contradictions for this portion of the study area. The GDM analysis determined an average annual erosion rate for the entire Ocean City shoreline of 150,617 m^3 (197,000 yd^3). Calculated erosion rates showed that approximately 196,490 m^3 (257,000 yd^3) erode annually along the northern 9 km (5.6 mi) of shoreline, whereas about 45,873 m^3 (60,000 yd^3) accrete annually along the southern 4 km (2.5 mi), yielding a net Ocean City erosion value of 150,617 m^3 (197,000 yd^3). The GDM analysis computed an average annual trapping rate of 192,668 m^3 (252,000 yd^3).

Longshore transport in the vicinity of Ludlam Island. A longshore transport analysis using the energy flux method was conducted for Ludlam Island by CERC (Everts, DeWall, and Czerniak, 1980). This analysis concluded transport values at Sea Isle City of 273,000 m^3/yr (357,000 yd^3/yr) to the North, 601,000 m^3/yr (786,000 yd^3/yr) to the south for a gross transport rate of 874,000 m^3/yr (1,143,000 yd^3/yr) and a net transport rate of 328,000 m^3/yr (429,000 yd^3/yr) to the South. Longshore transport was to the south from September to May and to the north in June and July. A longshore transport reversal node appears to exist about 450 m (1476 ft) south of Corson Inlet.

2.7.10 Sediment Budget

A sediment budget was developed and was based on the availability of shoreline position and wave data, the specific periods of analysis for the sediment budget were selected as 1977-1986 and 1986-1997. This sediment budget includes five control volumes for the study area: Great Egg Harbor Inlet, Peck Beach, Corson Inlet, Ludlam Island and Townsends Inlet. The detailed sediment budget analysis is provided in the Engineering Technical Appendix.

One of the important components of the sediment budget analysis is the determination of the potential longshore sand transport, which is an estimate of the maximum capacity of the breaking waves to carry sand alongshore in the presence of an unlimited supply of movable material. For this analysis, the GENESIS shoreline change model was used to develop the potential longshore sand transport rates along the study area shoreline. Local variations in longshore transport due to shoreline orientation changes were accounted for by applying the model using 61 m (200 ft) alongshore grid spacings for each of the two control volumes subject to longshore sand transport Peck Beach and Ludlam Island. Wave data from the hindcast at 3-hour intervals from 1988-1993 and the internal wave transformation routine in GENESIS were used to develop the potential longshore transport rates along each of the control volume shorelines. The longshore transport rates were averaged over the 6-year period for use in the sediment budget analysis periods. This procedure provided the average potential longshore sand transport rates to the left and to the right at each of the boundaries of the control volumes.

The sediment budgets produced for the periods 1977-1986 and 1986-1997 are shown in Figures 2.7.10-1 and 2.7.10-2, respectively. The average potential transport rates are depicted with arrows at each of the control volume boundaries. A more detailed description of the sediment budget methodology and results can be found in the Engineering Technical Appendix.

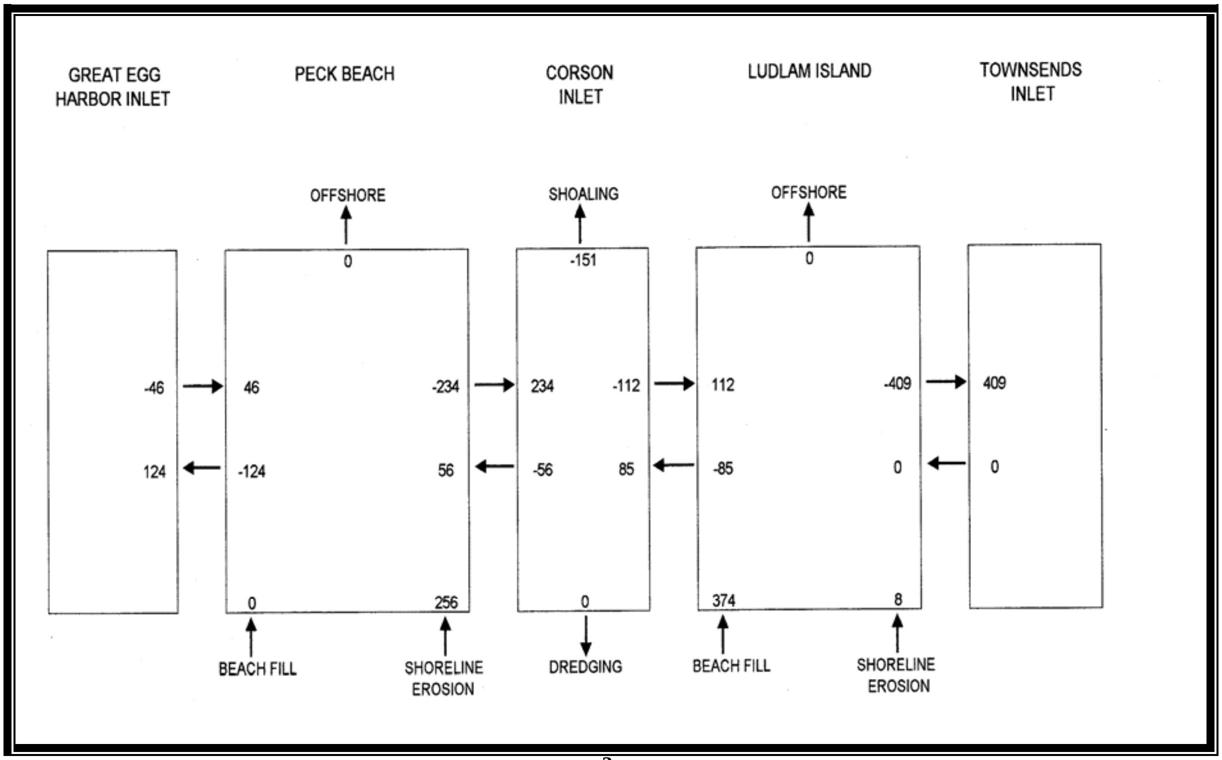

Figure 2.7-5 Sediment Budget Results (yds^3): 1977-1986

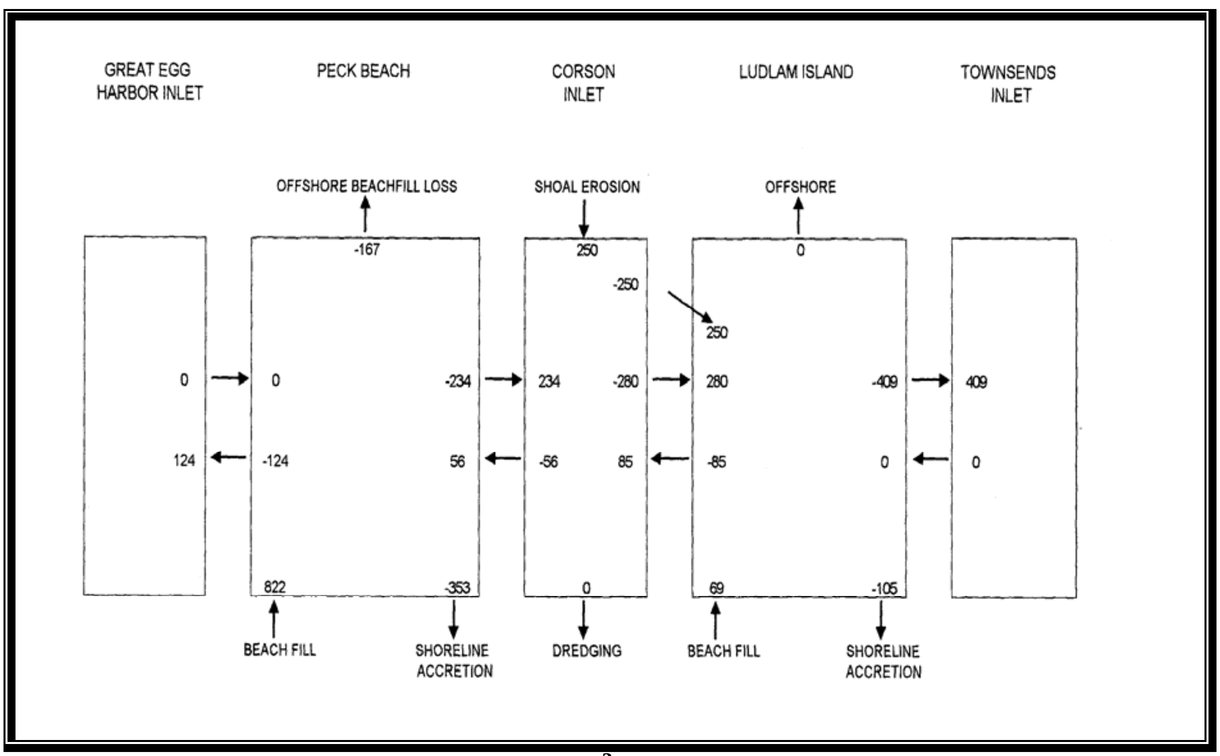

Figure 2.7-6 Sediment Budget Results (yds^3): 1986-1997

2.8 Summary of Historic Shoreline Conditions

Reports pertinent to this study were compiled and reviewed for this historic shoreline change evaluation. This information was used to develop a qualitative, and where possible, 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. *House Document 86-208, "Shore of New Jersey - Barnegat Inlet to Cape May Canal, Beach Erosion Control Study", 1959;*

2. *House Document 94-631, "New Jersey Coastal Inlets and Beaches - Barnegat Inlet to Longport", 1976;*

3. *"Report on a Study of the New Jersey Coastal Inlets and Beaches, Great Egg Harbor Inlet to Stone Harbor," U.S. Army Engineer District, Philadelphia, 1966.*

4. *" General Design Memorandum and Final Supplemental Environmental Impact Statement, Great Egg Harbor Inlet to Peck Beach-Ocean City, NJ, U.S. Army Engineer District, Philadelphia, 1990.*

5. *Everts, C. H. 1975 (unpublished). "Sediment Budget, Great Egg Harbor Inlet to Townsends Inlet, New Jersey," report for the Philadelphia District.*

6. *Everts, C. H., DeWall, A. E., and Czerniak, M. T. 1980. "Beach and Inlet Changes at Ludlam Beach, New Jersey," Miscellaneous Report No. 80-3, U.S. Army Engineer Coastal Engineering Research Center , Fort Belvoir, VA.*

7. *Farrell, S. C., Sullivan, B., Hafner, S., Lepp, T., and Cadmus, K. 1995. "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.*

8. *Farrell, S. C. et al. A number of profile lines are monitored annually by Stockton State College for the State of NJ as part of the NJ Beach Profile Network. A series of reports by Farrell, et al. (1991, 1993, 1994, 1995) analyzes this data for annual volumetric and morphologic changes.*

9. *Farrell, S.C., Inglin, D., Venanzi, 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.*

2.8.1 Prior Studies, Reports, and Projects for Ocean City

The shoreline along southern Ocean City has been characterized by intermittent dunes fronting bulkheads with a trend of relative stability to slight accretion. Several reports have examined historic shoreline trends in this area as summarized in the following paragraphs.

Everts (1975). As part of the sediment budget analysis developed by CERC, shoreline positions for Peck Beach were evaluated between 1949 and 1974. This analysis reports that the northern and southern ends of Peck Beach have an accretional trend while the region at the southern end of the Ocean City groin system has experienced an erosional trend. The central portion has remained relatively stable. As described in the Longshore Transport section, CERC calculated a net erosion of approximately 138,000 m^3/yr (180,500 yd^3/yr) over the length of Peck Beach.

General Design Memorandum and Final Supplemental Environmental Impact Statement, Great Egg Harbor Inlet to Peck Beach-Ocean City, NJ. The average erosion rate for the entire Peck Beach shoreline was determined to be approximately 151,000 m^3/yr (197,500 yd^3/yr) as compared to 138,000 m^3/yr (180,500 yd^3/yr). calculated in the CERC analysis. In the GDM analysis, however, alongshore variability in shoreline stability was investigated by partitioning the shoreline into "cells". Erosion rates computed for the various cells show that approximately 196,500 m^3/yr (257,000 yd^3/yr) erode along the northern 8.9 km (5.5 mi), but approximately 46,000 m^3/yr (60,200 yd^3/yr) accrete along the southern 4.0 km (2.5 mi) of shoreline. As part of this analysis, changes in the Mean High Water shoreline were evaluated for the LRP profile lines surveyed since 1955. For the period from 1955 to 1984, an accretion rate of approximately 0.34 m/yr (1.12 ft/yr). was computed for LRP 97 located at 50th Street. This compares with the 0.30 m/yr (0.98 ft/yr). of accretion calculated for the same profile line between 1955 and 1963 (Philadelphia District, 1966).

Farrell et al. (1991-1995). A profile line at 56th Street in Ocean City is monitored routinely as part of the NJ Beach Profile Network. These surveys have been conducted annually in the fall since 1986 and once in the spring of 1995. The beach and small dune system in this area was eroded by the storms of 1991 and 1992 exposing the rock revetment and bulkhead. Farrell et al. (1994) reports 30 m (98 ft) of erosion between 1986 and 1993. Only minor changes occurred along this profile line between 1993 and 1994 (-2.4 m^3/m or -0.96 yd^3/ft), however, significant accretion occurred during the winter and spring of 1995 (38.7 m^3/m or 15.4 yd^3/ft) (Figure 2.8.1-1). The primary source of material during this period appears to be the Federal beachfill to the north. A beachfill operation was completed in the southern portion of Ocean City in August 1995.

Great Egg Harbor Inlet to Townsends Inlet Reconnaissance Study (1996). A qualitative analysis was done using digital shoreline change maps prepared for the State of New Jersey Historical Shoreline Map Series (Farrell et al. 1989). A transect in the vicinity of 50^{th} Street showed a minor erosional trend from 1836/42 to the 1932/36; an accretion trend from 1932/36 to 1971, and back to an erosional trend from 1971 to 1986.

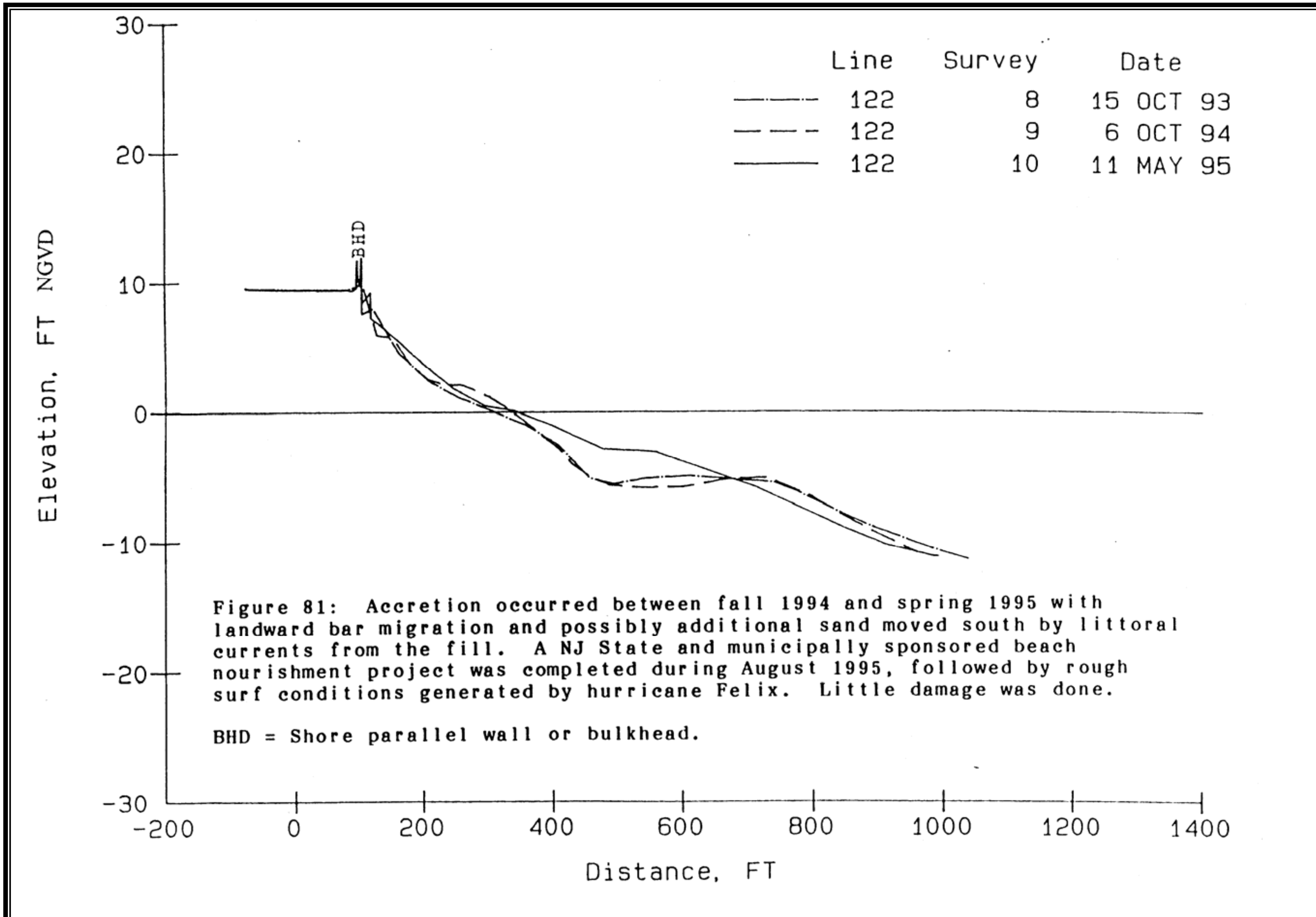

Figure 2.8-1 **NJ Beach Profile Network Line #122, 56th Street, Ocean City**

2.8.2 Historic Shoreline Change Analysis for Ocean City

As was done in the *Great Egg Harbor Inlet to Townsends Inlet Reconnaissance Study (1996)*, 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 March 1997 MHW shoreline obtained from digital photogrammetry that was obtained as part of the study. All the shorelines can be seen in Figure 2.8.2-1. 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. Shoreline change rates were computed for the following periods: 1899-1932/36, 1932/36-1971, 1971-1977, 1977-1986, and 1986-1997. Shoreline change rates were also computed for the time periods of: 1899-1997, 1932/36-1997, 1971-1997, and 1977-1997.

The shoreline change analysis involved rotating and translating each digital shoreline to a user-defined coordinate system grid. The grid ran alongshore for 5486 m (18,000 ft) to Corson Inlet from a specified origin defined just to the north of 36th Street and extended seaward 427 m (1,400 ft) from Asbury Ave. (Figure 2.8.2-2). The digital shorelines were segmented into discrete compartments alongshore on the grid that were spaced 305 m (1,000 ft) apart except in areas where the available data was too sparse and in the vicinity of Corson Inlet (Figure 2.8.2-3). 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 (see Engineering Technical Appendix). A linear “straight-line” fit of the mean shoreline positions from compartment to compartment was used to determine a shoreline change rate for Ocean City.

The analysis was performed initially assuming the presence of the 275,250 m^3 (360,000 yd^3) beachfill between 36th Street to 57th Street placed in 1995. A separate analysis was performed by subtracting out the beachfill to better represent natural trends and make it comparable with other historic rates for the area. The beachfill quantity was divided by the total distance over which it was placed (approximately 3,353 m (11,000 ft) and by vertical profile height of 8.2 m (27 ft). The vertical profile height is based on a –6.4 m (-21 ft) closure depth and an average berm height of 1.8 m (6 ft). The 1997 shoreline was translated landward by the calculated value of 10 m (33 ft) to account for the beachfill.

Shoreline change rates were computed for individual historic periods and then relative to 1997 with the 1995 beachfill in-place and with the beachfill subtracted out (see Engineering Technical Appendix).

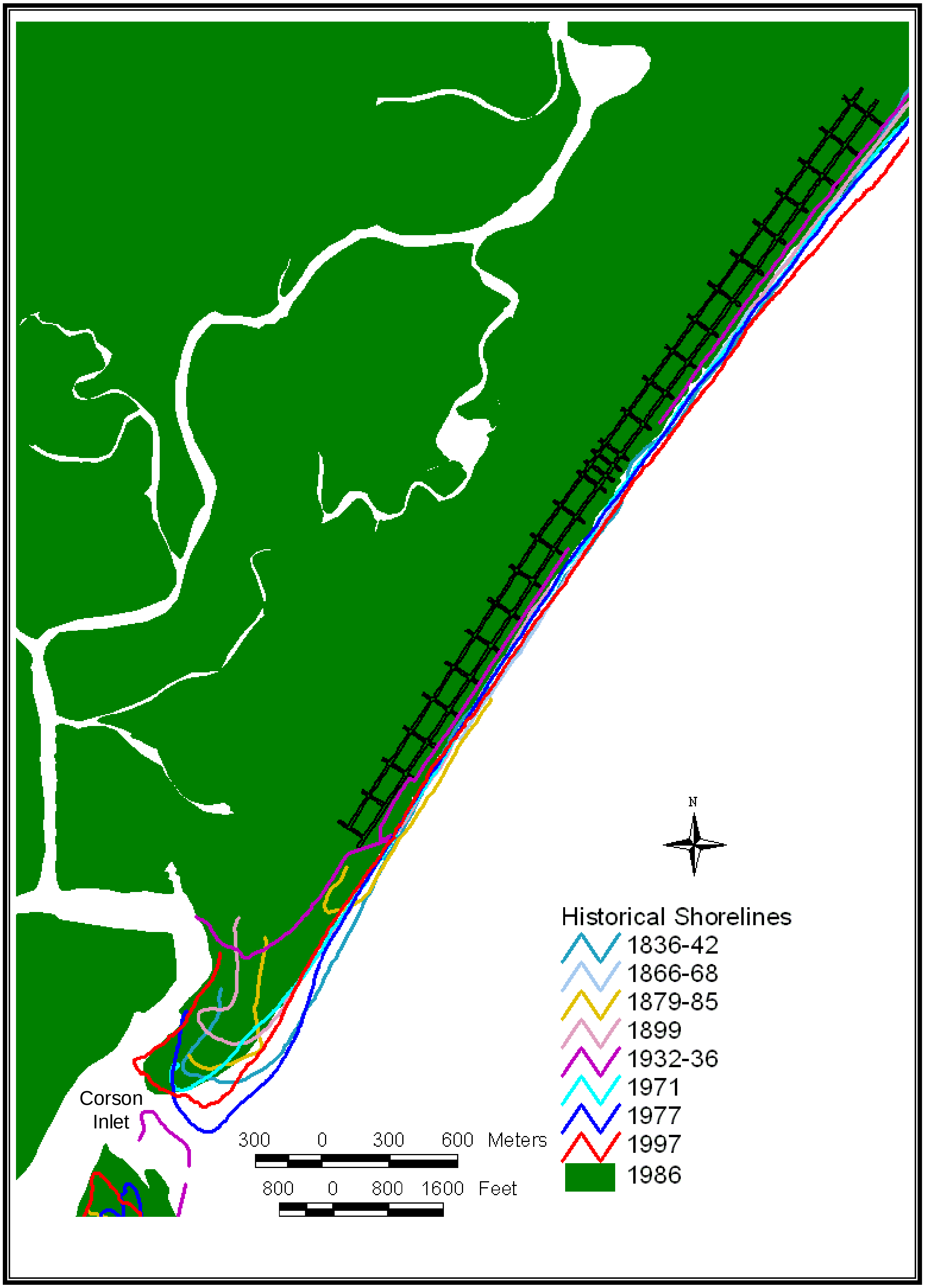

Figure 2.8-2 **Shoreline Change Map for Ocean City**

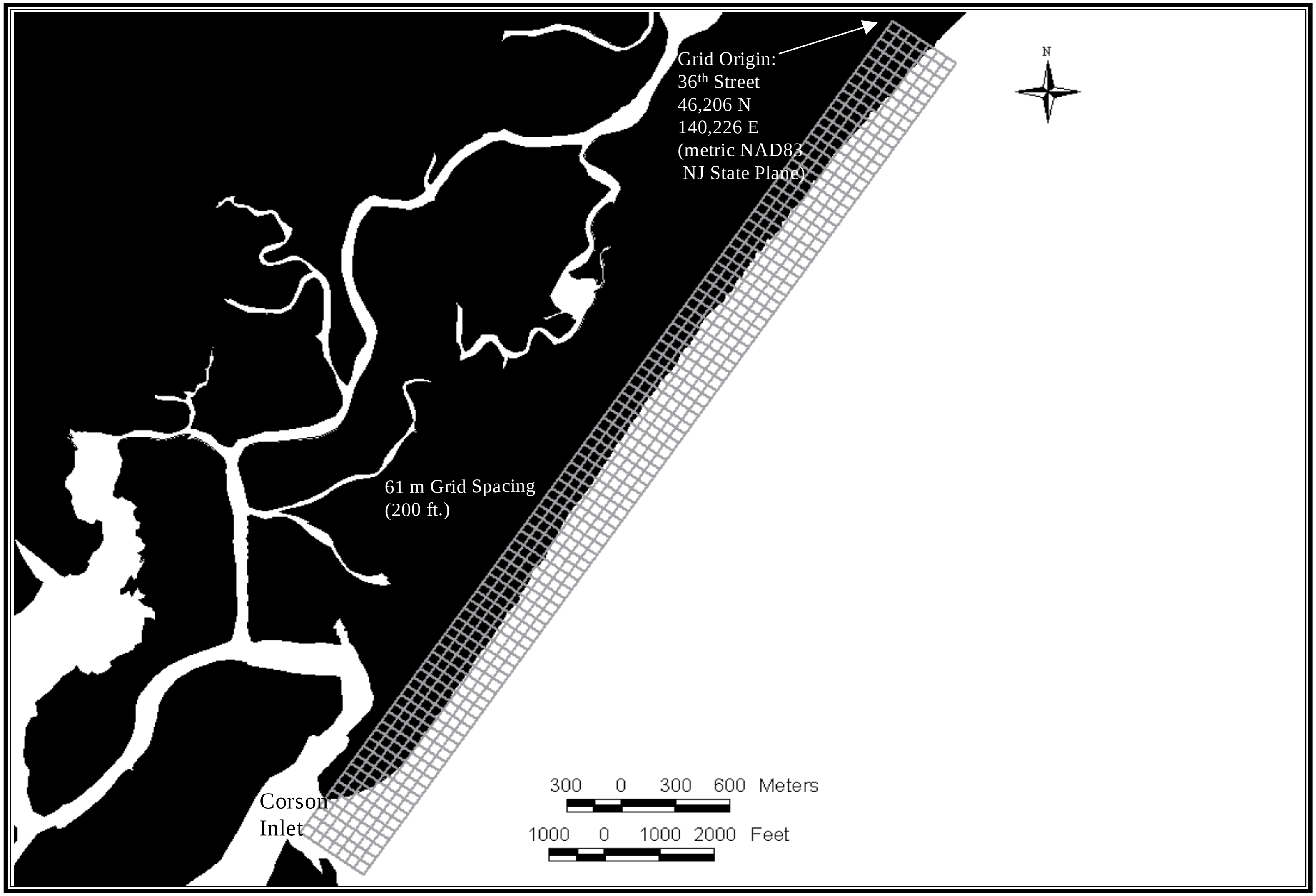

Figure 2.8-3 Shoreline Change Grid for Ocean City

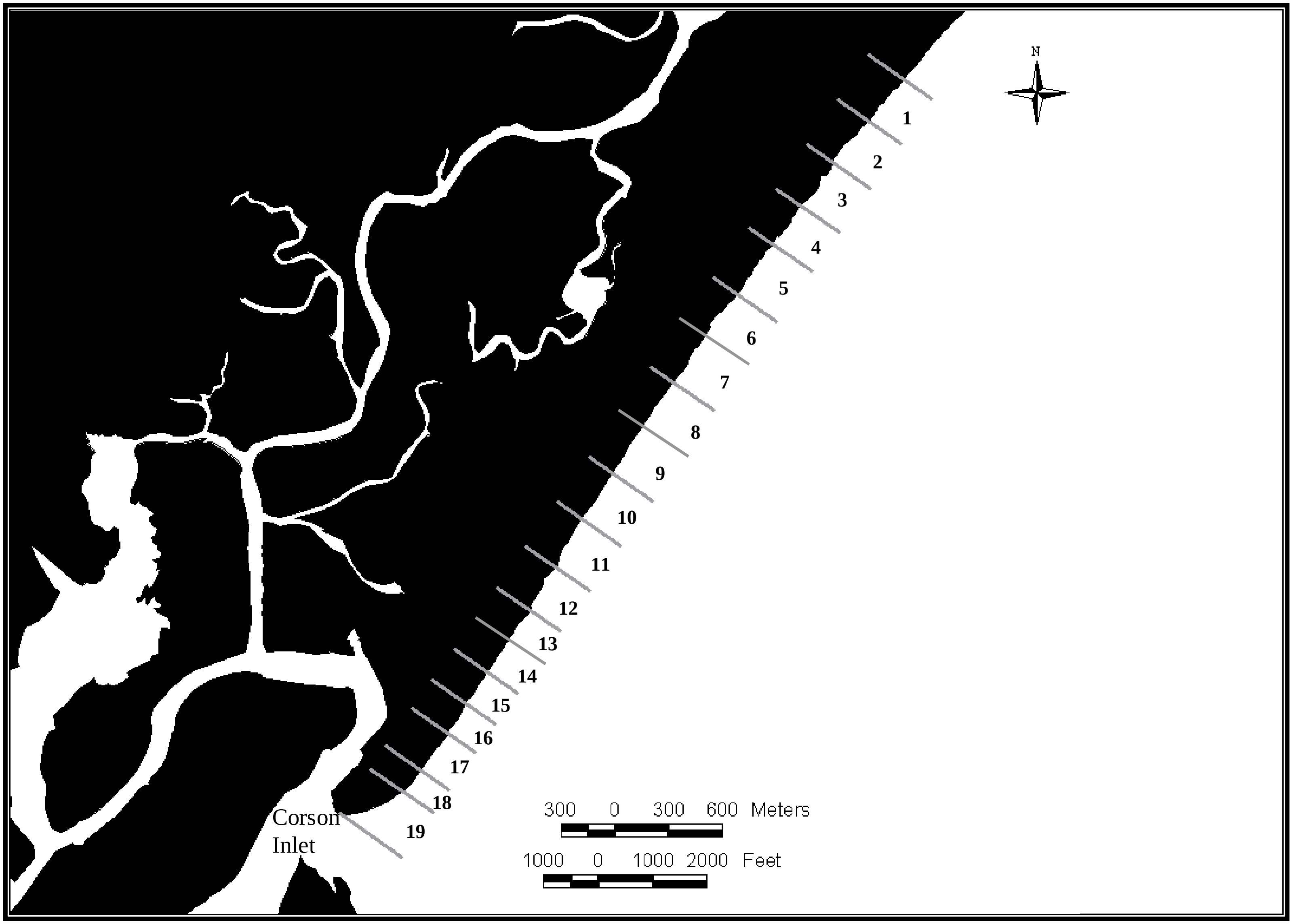

Figure 2.8-4 Shoreline Change Compartments for Ocean City

For each compartment within the two Ocean City cells, a weighted average was computed and is shown in Tables 2.8.2-1 and 2.8.2-2. These tables summarize the shoreline change rate on a cell by cell basis, based on the 1997 shoreline with and without the 1995 beachfill in-place, respectively. Cell delineation was based on physical and socio-economic conditions and will be referred to again in subsequent sections of this report.

Table 2.8.2-1 Shoreline Change Rates (Meters/Year) for Each Cell Based on 1997 Shoreline for Ocean City With 1995 Beachfill In-Place

(+ Accretion - Erosion NaN - Insufficient Data)

Cell	Length (m)	1932-1997	1971-1997	1977-1997	1986-1997
OCN (vic. 36th to 46th St)	1829	1.20	1.48	2.20	6.27
OCS (46th to 59th St)	1829	NaN	0.54	1.13	3.95

1 meter = 3.28 ft

Table 2.8.2-2 Shoreline Change Rates (Meters/Year) for Each Cell Based on 1997 Shoreline for Ocean City With 1995 Beachfill Subtracted Out

(+ Accretion - Erosion NaN - Insufficient Data)

Cell	Length (m)	1932-1997	1971-1997	1977-1997	1986-1997
OCN	1829	1.20	1.48	2.20	5.36
OCS	1829	NaN	0.54	1.13	3.19

2.8.3 Prior Studies, Reports, and Projects for Ludlam Island

Several reports have examined historical shoreline behavior along Ludlam Island. Summaries of these reports are provided. In addition, a rigorous qualitative analysis of shoreline behavior was done using digital shoreline change maps.

Everts, DeWall, and Czerniak (1980). In this CERC analysis, repetitive surveys of the above Mean Sea Level (MSL) beach were made along 20 profile locations on Ludlam Island (Figure 2.8.3-1). Between October 1962 and December 1972, 1,760 profiles were obtained from 90 surveys with the frequency varying significantly from both year to year and seasonally. The surveys provided data on temporal and spatial beach volume change and shoreline position.

The CERC study also evaluated historical data for six surveys from 1842 to 1955 as shown in Figure 2.8.3-2. The analysis concluded that the Ludlam Island shoreline north of Sea Isle City eroded at approximately 0.9 to 1.5 m/yr. (3 to 5 ft/yr), but at a lower rate to the south of Sea Isle City over this 113-year period. Additionally, shoreline positions over the period from 1949 to 1974 were measured from aerial photography and converted to rates of shoreline change (Figure 2.8.3-3). During this period, maximum erosion occurred in the north near Corson Inlet with intermediate erosion in the north and south indentation sections. The areas near the Sea Isle

City groins and the southern area at Townsends Inlet remained relatively stable. The yearly mean shoreline retreat rate for Ludlam Island was 2.0 m/yr. (6.5 ft/yr).

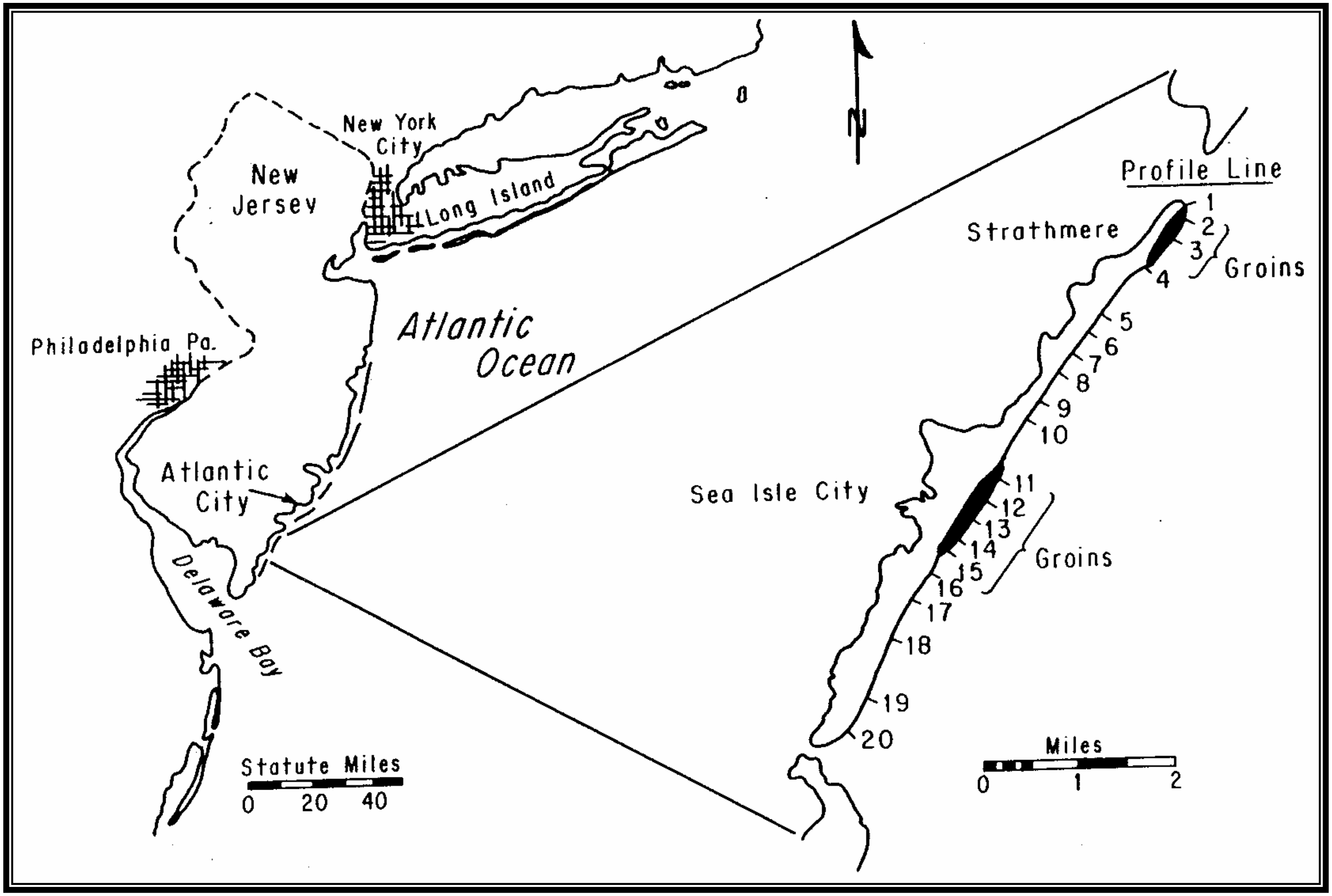

Figure 2.8-5 **Locations of Profile Lines, Ludlam Beach, NJ (from Everts, DeWall, and Czerniak, 1980)**

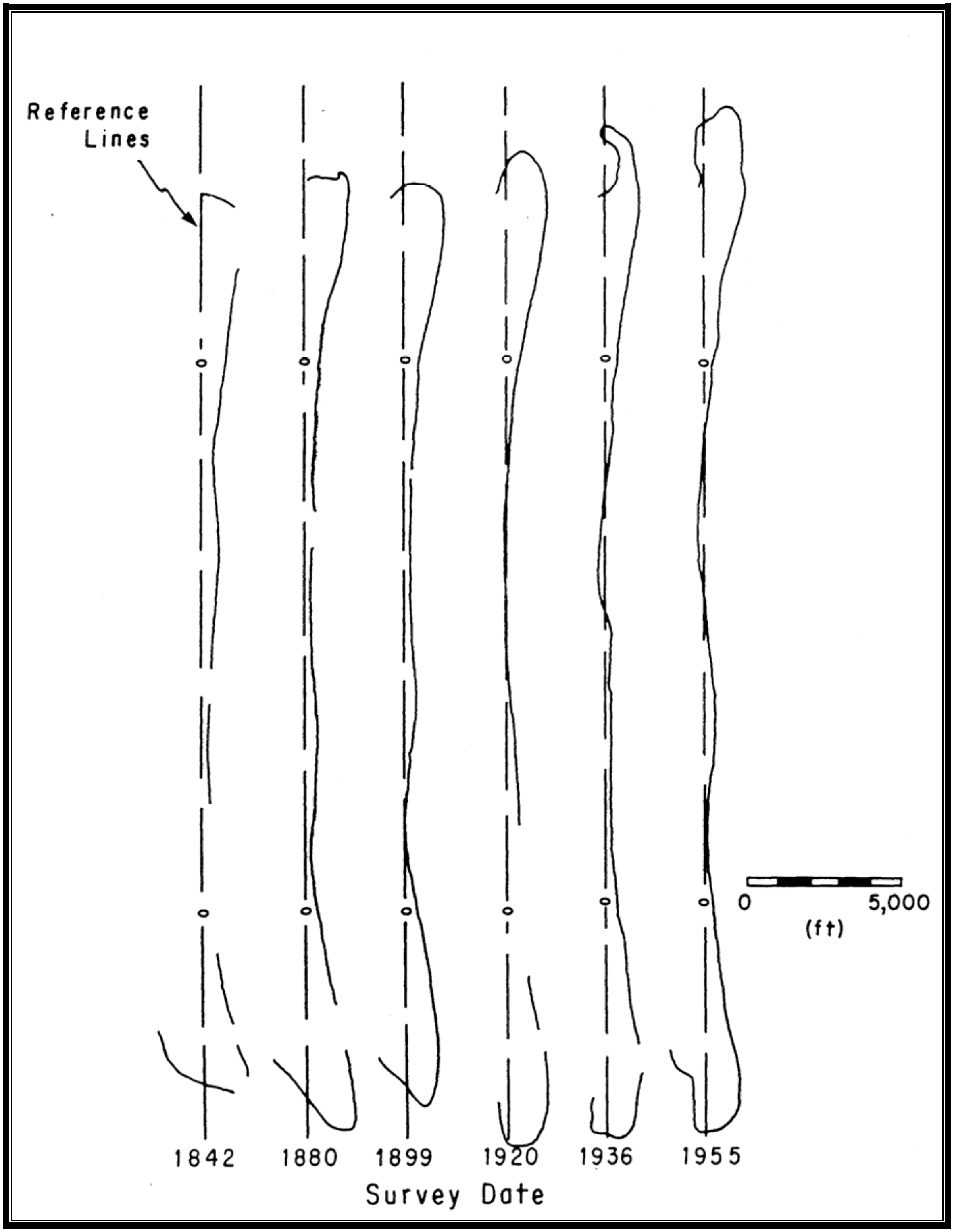

Figure 2.8-6 Shoreline Position of Ludlam Beach from 1842/1936 (U.S. Coast and Geodetic Survey Charts and 1955 (Corps of Engineers Survey)
(Modified from U.S. Army Engineer District, Philadelphia 1966)

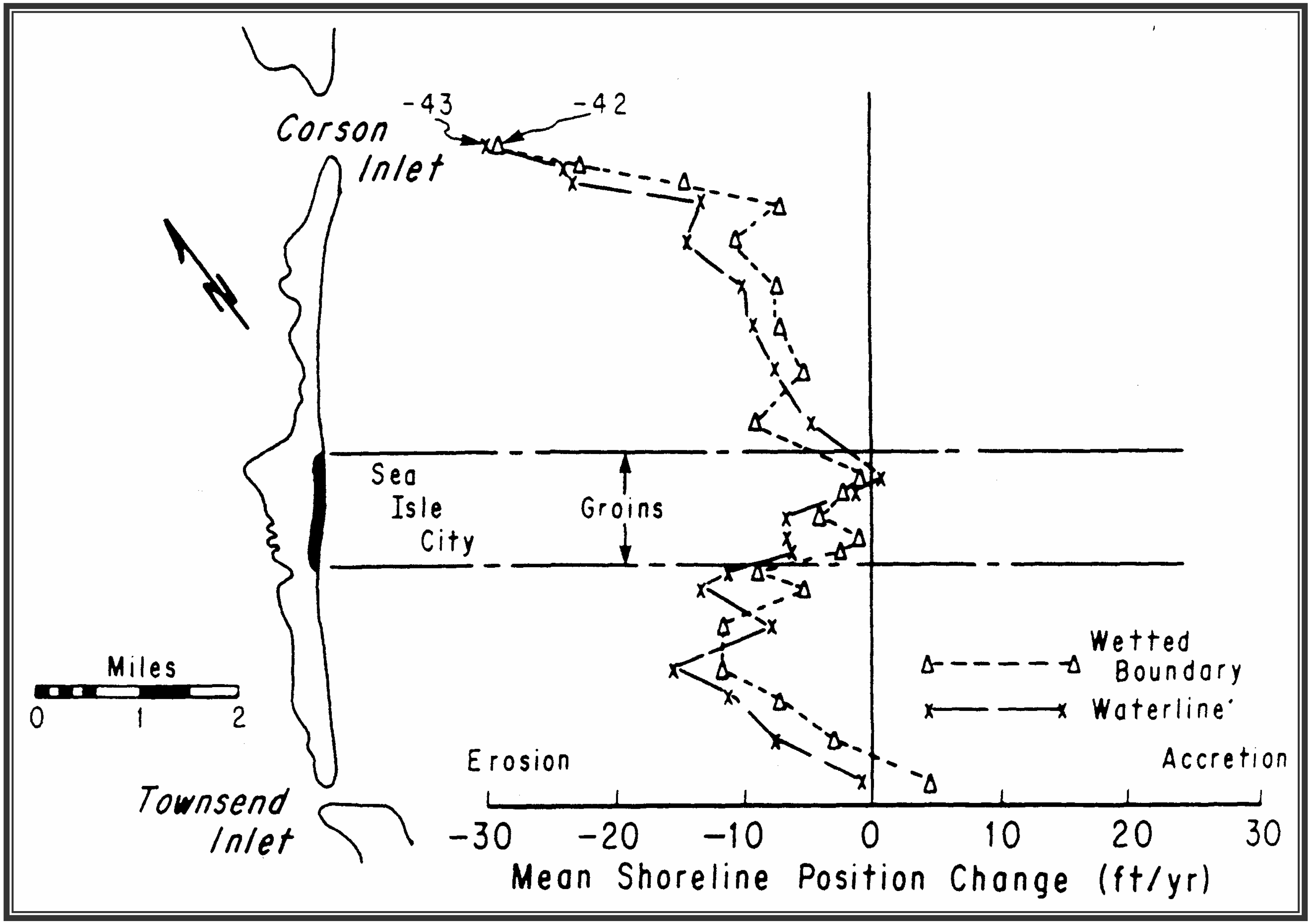

Figure 2.8-7 Shoreline Change for Ludlam Beach as obtained from aerial photography, 1949-1974 (from Everts, DeWall, and Czerniak, 1980)

Cumulative rates of shoreline change derived from the 1962 to 1972 profile data are shown in Figure 2.8.3-4. These rates are comparable in magnitude to shoreline change rates derived from the 1949 to 1974 aerial photography analysis; however, the annual mean rate of erosion for Ludlam Island was slightly higher at 2.5 m/yr. (8.2 ft/yr). Yearly changes in sand volume along Ludlam Island varied from a gain of 7.3 m^3/m (2.9 yd^3/ft) in the 1964-65 period to a loss of 11.5 m^3/m (4.6 yd^3/ft) in the 1966-67 time period. Net yearly sand volume changes over the interval from 1962 to 1972 averaged -2.81 m^3/m-yr. (-1.12 yd^3/ft-yr) which equates to a loss of 30,585 m^3/yr. (40,000 yd^3/yr.) above MSL for the entire island.

Farrell, et al. (various reports 1991-1995). As part of the NJ Beach Profile Network, one beach profile line is monitored routinely in Strathmere and four lines are monitored in Sea Isle City (Figure 2.8.3-5). These profile lines were surveyed annually in the fall from 1986 through 1994 and then again in the spring of 1995. Table 2.8.3-1 shows computed beach volume changes for each of the profiles since the monitoring program began (1986-1993) in addition to the volume changes found in the latest analysis period (1993-1995). The following paragraphs summarize changes along the profiles in the study area as analyzed by Farrell et al. (1994, 1995).

Table 2.8.3-1 Beach Volume Changes for Ludlam Island
(from Farrell, et al. 1995)

Profile Station	1986-1993 (m^3/m)	Fall 1993 to Fall 1994 (m^3/m)	Fall 1994 to Spring 1995 (m^3/m)
121 (Strathmere, (Williams Rd.)	-174.3	57.0	-115.5
120 (Sea Isle, 1st Ave.)	-55.7	-21.9	142.3
119 (Sea Isle, 25th Ave.)	44.0	-48.7	26.7
118 (Sea Isle, 57th Ave.)	5.8	-38.6	-1.6
117 (Sea Isle, 80th Ave.)	82.1	-59.2	-26.6

1 m^3 = 1.31 yd^3

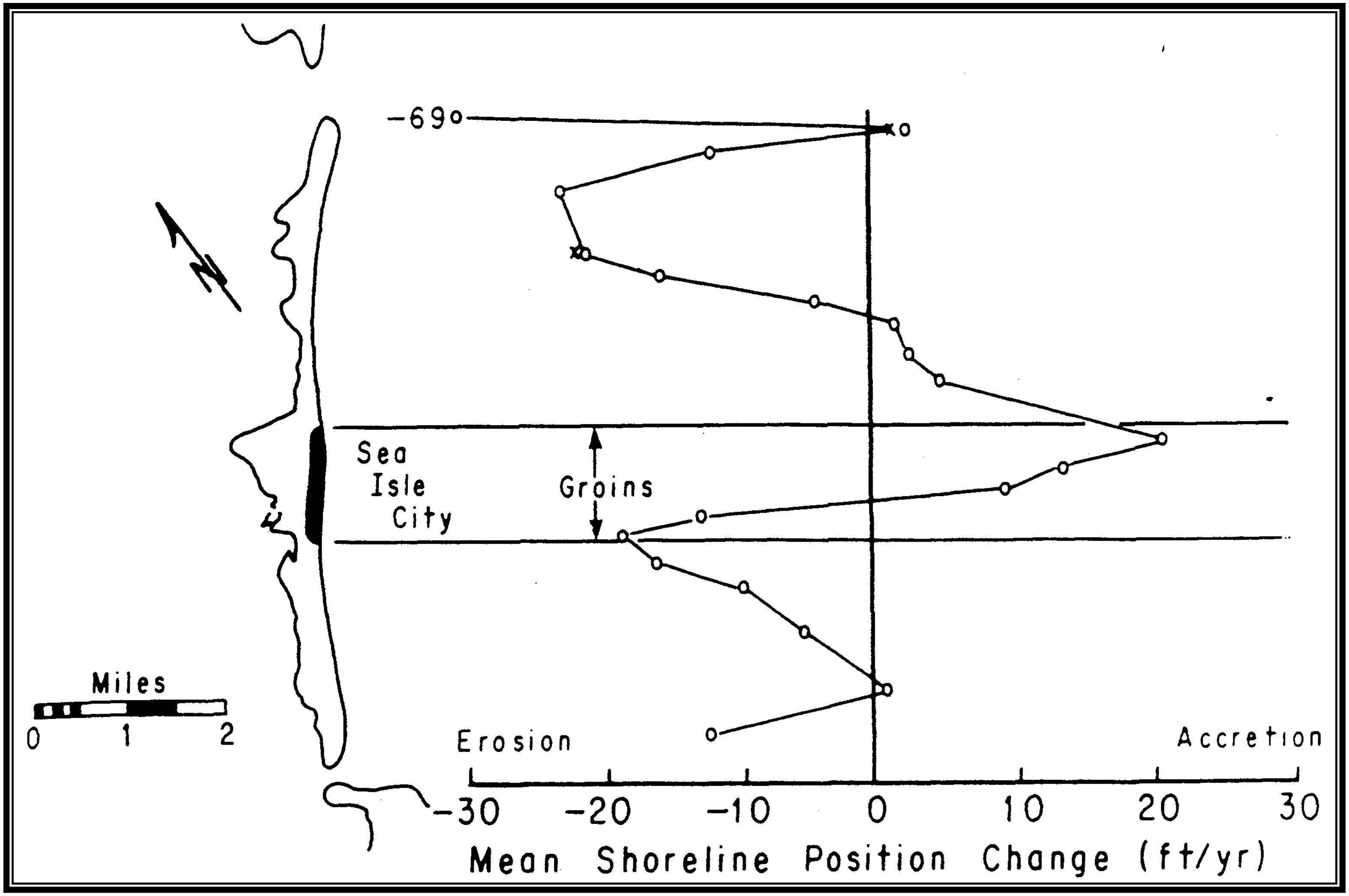

Figure 2.8-8 **Yearly Change in Shoreline Position on Ludlam Beach, 1962-1972, as obtained from survey data** (from Everts, DeWall, and Czerniak, 1980)

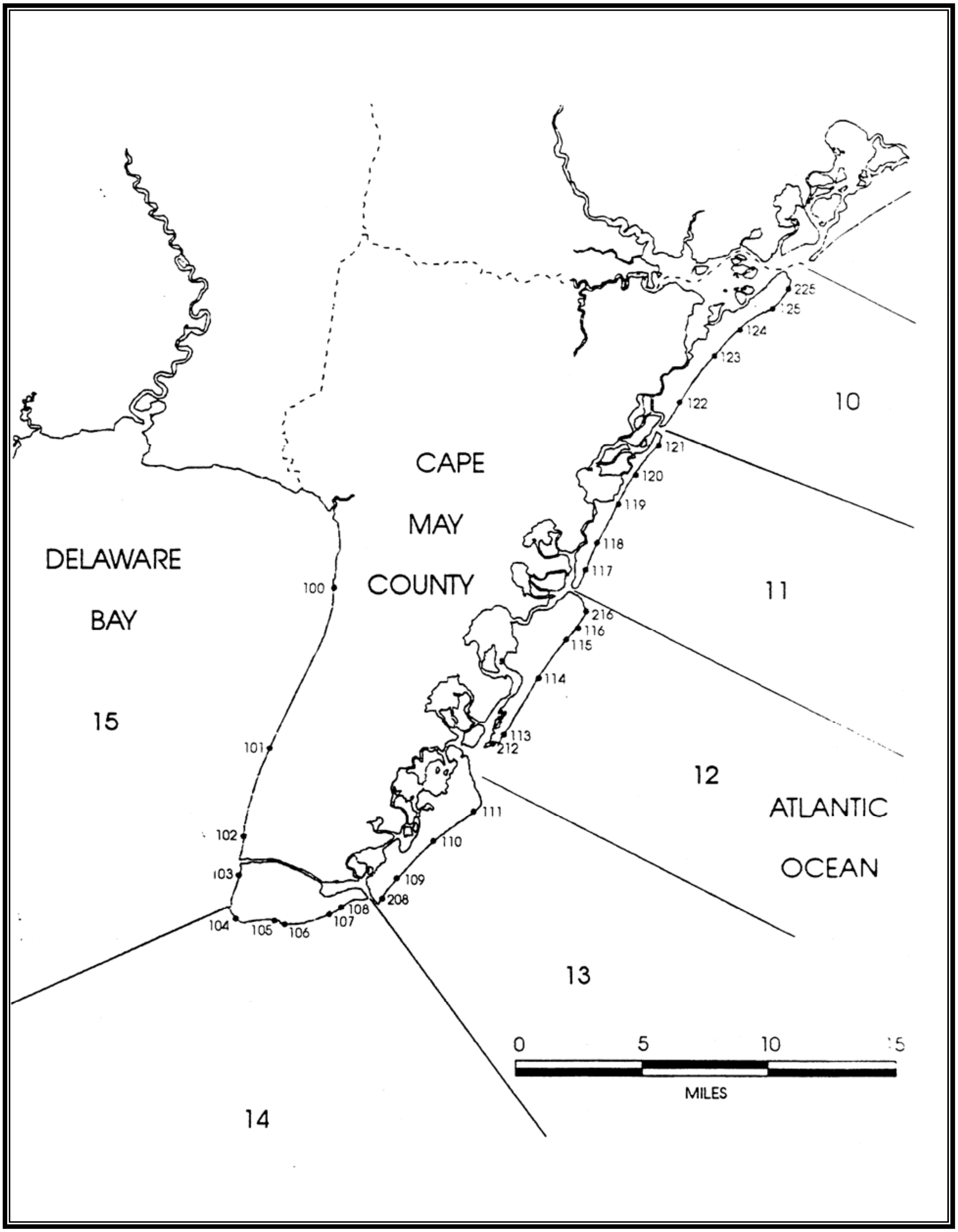

Figure 2.8-9 Location of NJ Beach Profile Network Survey Lines (from Farrell et al. 1995).

Profile #121, located at Williams Road in Strathmere, is significantly influenced by changes in the configuration of Corson Inlet. Between 1986 and 1990, this beach was accretional. Some shoreline erosion occurred between 1990 and 1991; then significant erosion occurred as a result of the storms in 1991 and 1992. According to Farrell, et al. (1994), the shoreline eroded 56 m (184 ft) between 1986 and 1993 for a rate of 8 m/yr. (26 ft/yr). Between 1993 and 1995, substantial erosion of the beach occurred at this location after a period of minor accretion (Figure 2.8.3-6).

Profile #120, at 1st Avenue in Sea Isle City, was relatively stable between 1986 and 1991. The October 1991 storm caused significant erosion and the December 1992 storm breached the dune system. Between Fall 1993 and Spring 1995, the profile lost 25.4 m^3/m (10.11 yd^3/ft) of sand, in spite of a Summer/Fall 1994 effort to reconstruct an I-5 gravel-cored dune along 600 m of the road (Figure 2.8.3-7).

Profile #119, located at 25th Avenue in Sea Isle City, showed an accretional trend between 1986 and 1993 with a gain of approximately 9 m (30 ft). The dune and beachface experienced only minimal changes between 1993 and 1995 (Figure 2.8.3-8).

The shoreline of Profile #118, located at 57th Avenue, remained relatively stable between 1986 and 1991. The 1991 and 1992 storms significantly eroded a portion of the dune and beachface. Between Fall 1993 and Spring 1995, the shoreline eroded approximately 9 m (30 ft) (Figure 2.8.3-9).

Although the storms of 1991 and 1992 eroded the profile in the vicinity of Profile #117, the overall change between 1986 and 1993 was approximately 24 m (79 ft) of shoreline accretion. A beach nourishment operation in 1992 contributed to this accretion. The beach was again nourished in Fall 1993 following construction of two low profile groins at 82nd and 88th Streets. Survey data shows that some of this material has moved offshore along the profile, but the beachface remained relatively stable (Figure 2.8.3-10).

Great Egg Harbor Inlet to Townsends Inlet Reconnaissance Study (1996). A qualitative analysis was done using digital shoreline change maps prepared for the State of New Jersey Historical Shoreline Map Series (Farrell et al. 1989). Transects corresponding to CERC Profile Lines 3, 5, 10, 13, 18 (see Figure 2.8.3-1) were designated on the digital maps and shoreline change trends were evaluated (Table 2.8.3-2).

Table 2.8.3-2 Shoreline Change Trends for Ludlam Island from Great Egg to Townsends Reconnaissance Study

(- Is Erosion, + Is Accretion, S Is Stable)

	Profile 3	Profile 5	Profile 10	Profile 13	Profile 18
1836/42-1879/85	-	-	-	S	+
1879/85-1899	+	-	S	-	+
1899-1932/36	-	S	-	S	-
1932/36-1951/53	S	-	S	--------	+
1951/53-1971	-	-	S	-------	-
1971-1977	+	-	S	+	-
1977-1986	+	+	-	-	+

Substantial fluctuations of erosion and accretion occur on the transect lines closest to Corson Inlet (Profile 3) and Townsends Inlet (Profile 18). A consistent erosional trend is evident for Profile 5 in Strathmere, although the shoreline was slightly accretional between 1977 and 1986 (beach fill operation occurred in 1984). The shoreline along Profile 10 was relatively stable through time, although significant erosional trends occurred from 1836/42 to 1879/85 and from 1977 to 1986. Alternating periods of erosion and accretion are evident on Profile Line 13 (near 40th Street in Sea Isle City), with a fairly significant period of erosion between 1977 and 1986. Note that beach fills occurred in southern Sea Isle City in 1978 and 1984.

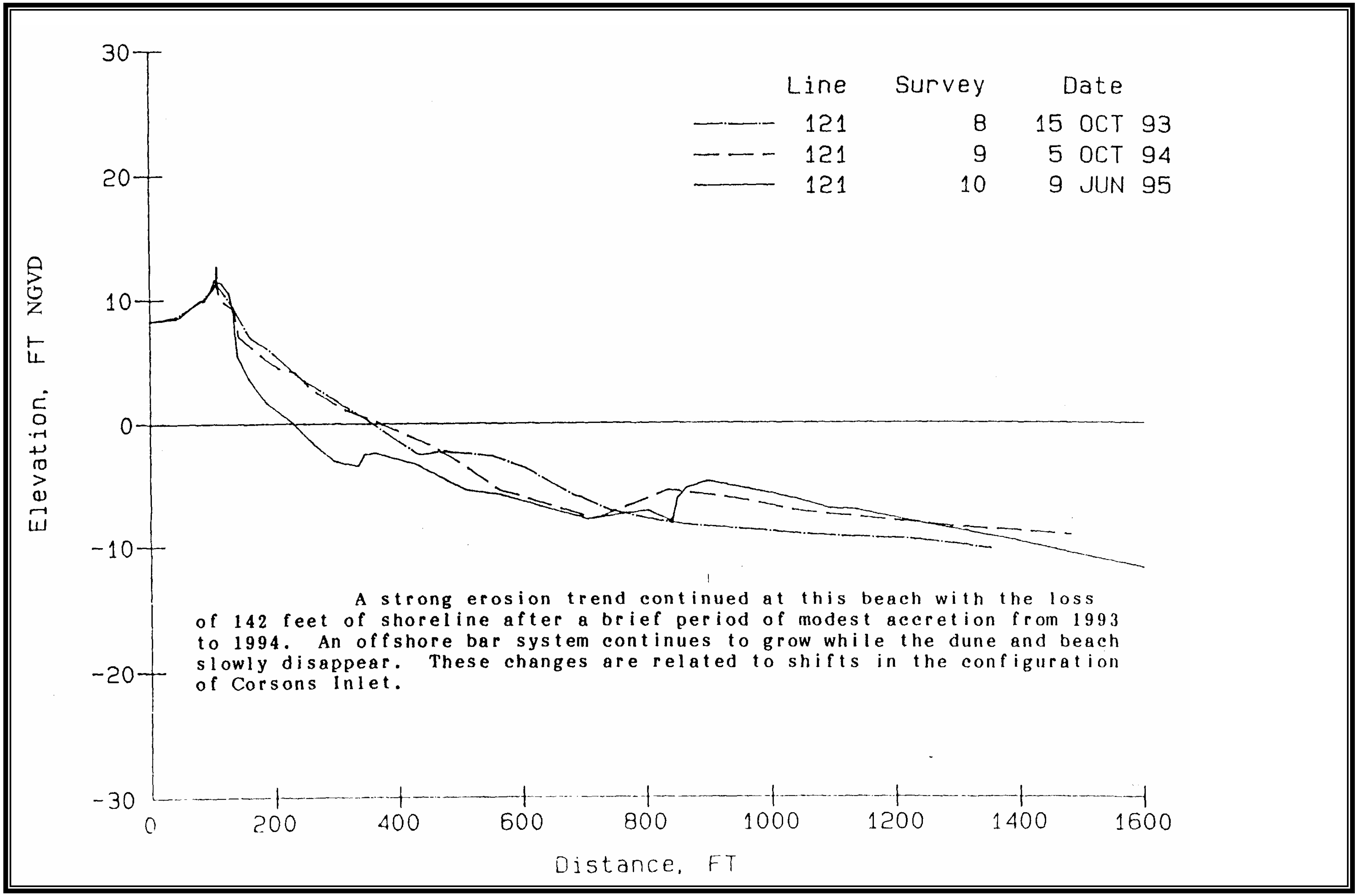

Figure 2.8-10 **NJ Beach Profile Network Line #121, Strathmere, Williams Road**
(from Farrell, et al. 1995)

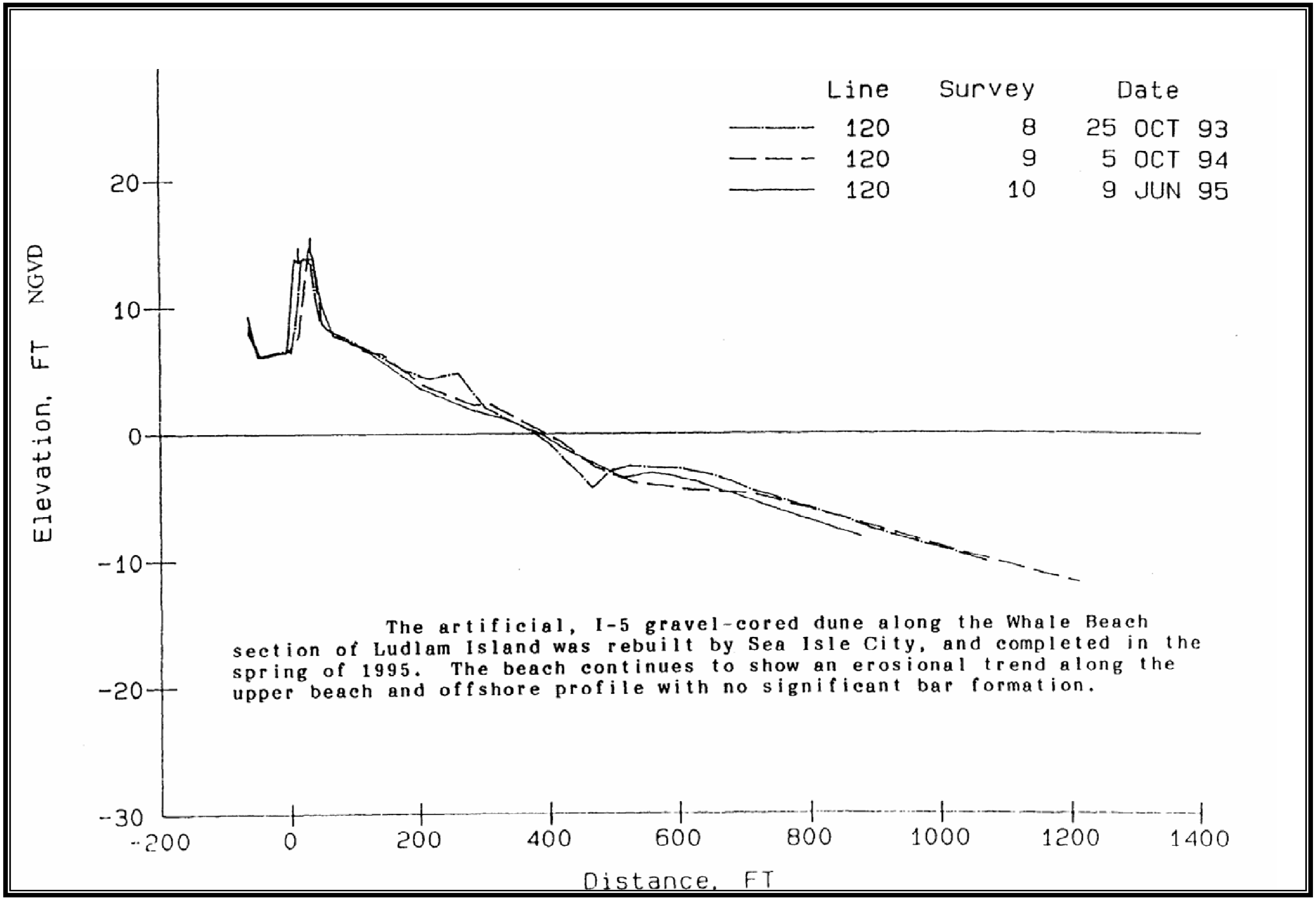

Figure 2.8-11 NJ Beach Profile Network Line #120, 1st Street, Sea Isle City (from Farrell, et al. 1995)

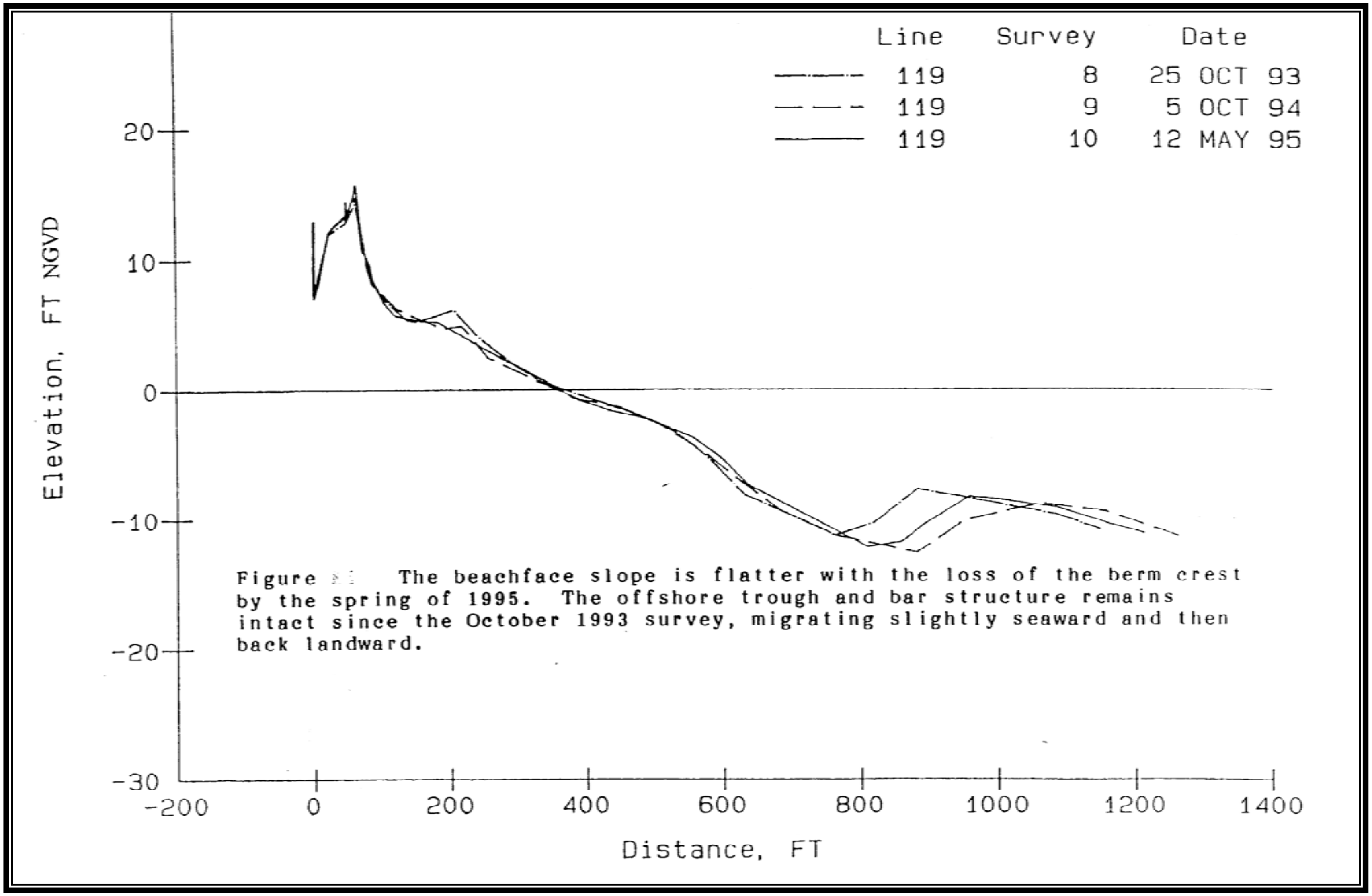

Figure 2.8-12 **NJ Beach Profile Network Line #119, 25th Street, Sea Isle City**
(from Farrell, et al. 1995)

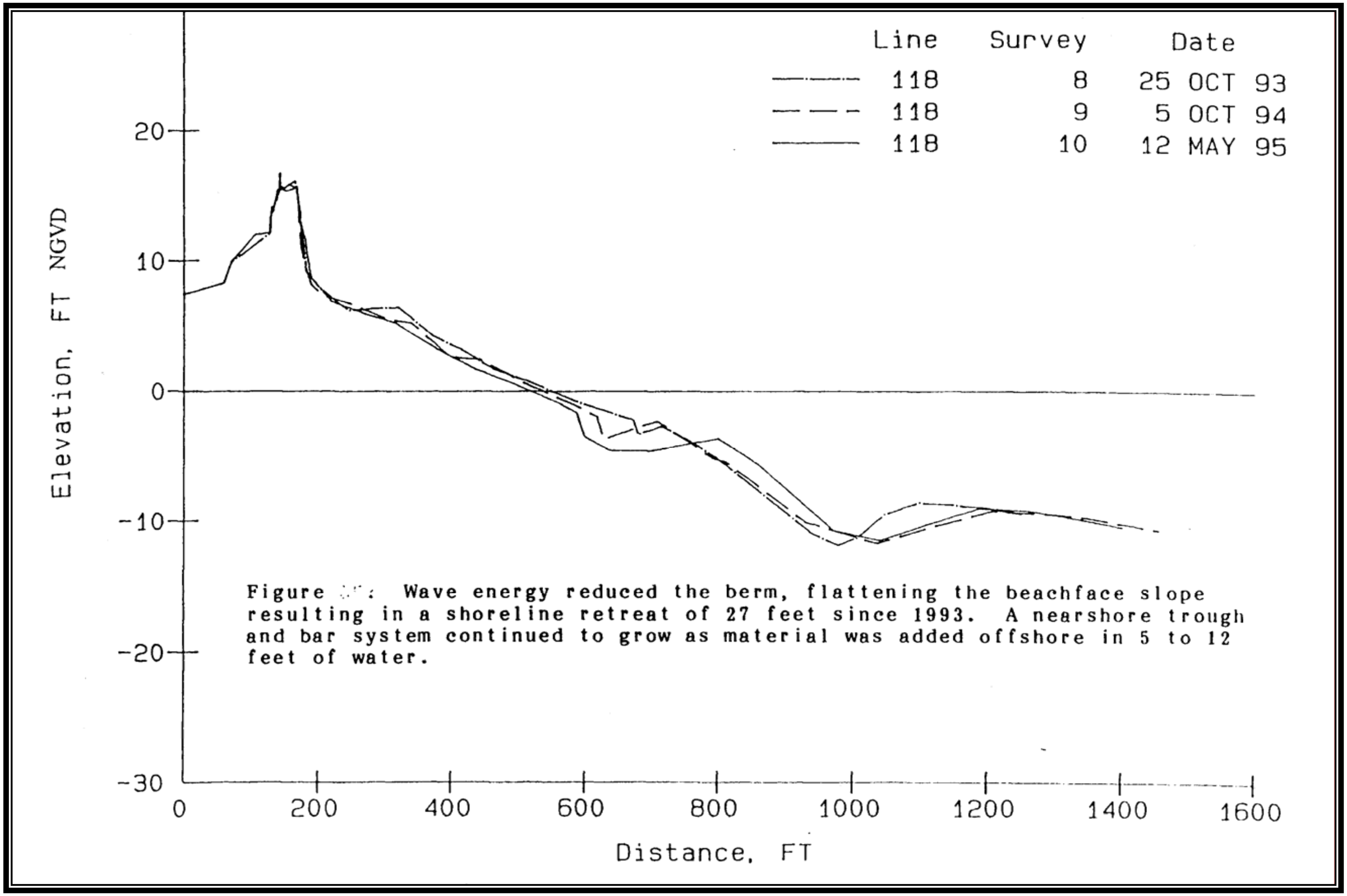

Figure 2.8-13 NJ Beach Profile Network Line #118 57th Street, Sea Isle City
(from Farrell, et al. 1995)

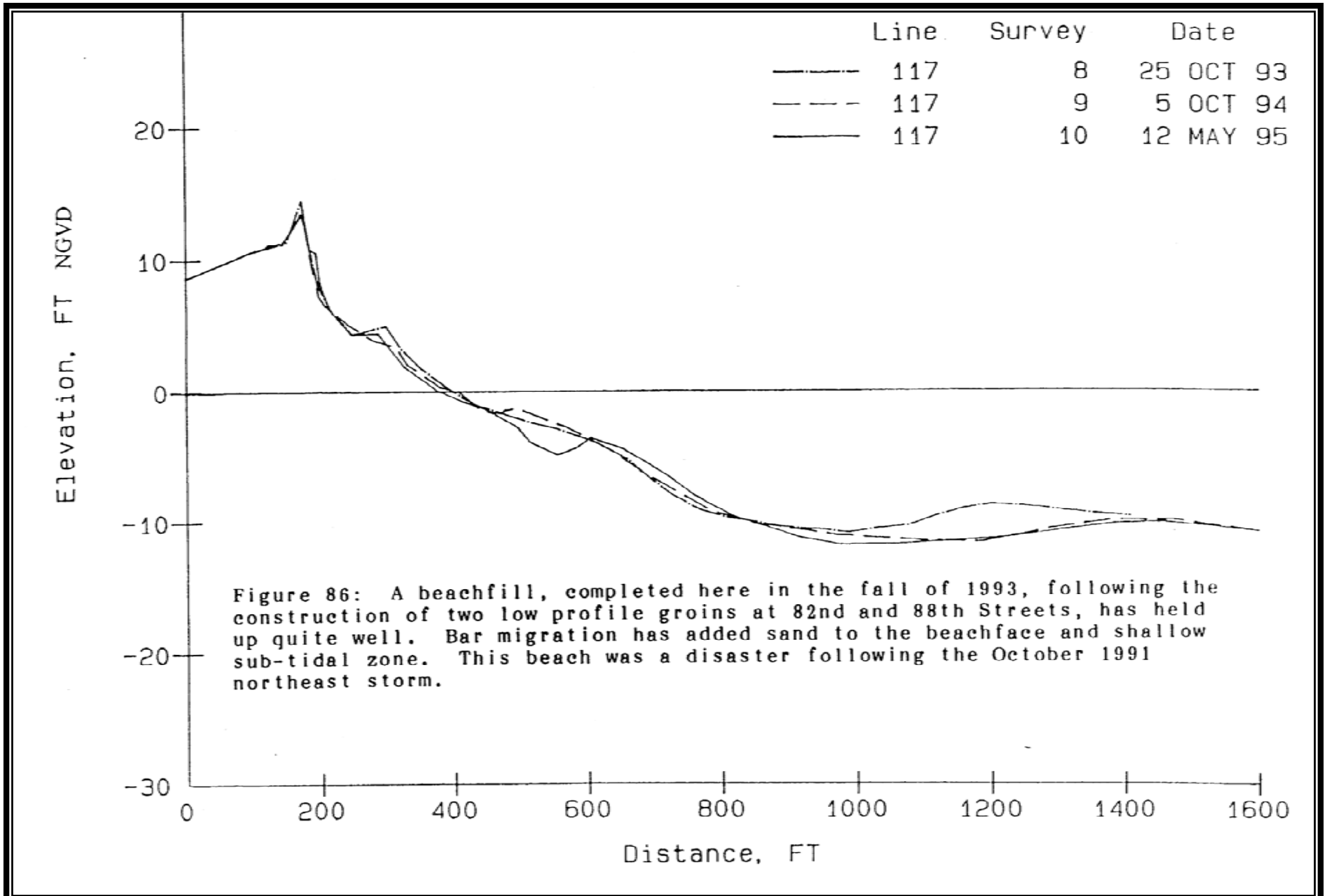

Figure 2.8-14 NJ Beach Profile Network Line #117 80th Street, Sea Isle City
(from Farrell, et al. 1995)

2.8.4 Historical Shoreline Change Analysis For Ludlam Island

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 March 1997 MHW shoreline obtained from digital photogrammetry that was obtained as part of the study. All the shorelines can be seen in Figure 2.8.4-1. 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: 1932/36-1971, 1971-1977, 1977-1986, and 1986-1997. Shoreline change rates were also computed for the time periods of: 1932/36-1997, 1971-1997, and 1977-1997.

The shoreline change analysis involved rotating and translating each digital shoreline to a user-defined coordinate system grid. The grid ran alongshore for 3,176 m (10,421 ft) to Townsends Inlet from a specified origin defined just to the north of Seaview Street near Corson Inlet and extended seaward 610 m (2,000 ft) from Ocean Drive (Figure 2.8.4-2). The digital shorelines were segmented into discrete compartments alongshore on the grid that had varied spacing (Figure 2.8.4-3). Factors that influenced spacing were groin locations on the island, location of shoreline points, and limits of shoreline data. 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 (See Engineering Appendix D, Section 2). A linear "straight-line" fit of the mean shoreline positions from compartment to compartment was used to determine a shoreline change rate for Ludlam Island.

The analysis was performed initially assuming the presence of six beachfills placed between the years of 1978 to 1997. A separate analysis was performed by subtracting out the beachfills to better represent natural trends and make it comparable with other historic rates for the area. The methodology used to account for beachfills was the same as previously described in Section 2.8.2. Shoreline change rates were computed for individual historic periods and then relative to 1997 with the six beachfills in-place and with the six beachfills subtracted out. Results are summarized in Engineering Appendix D, Section 2.

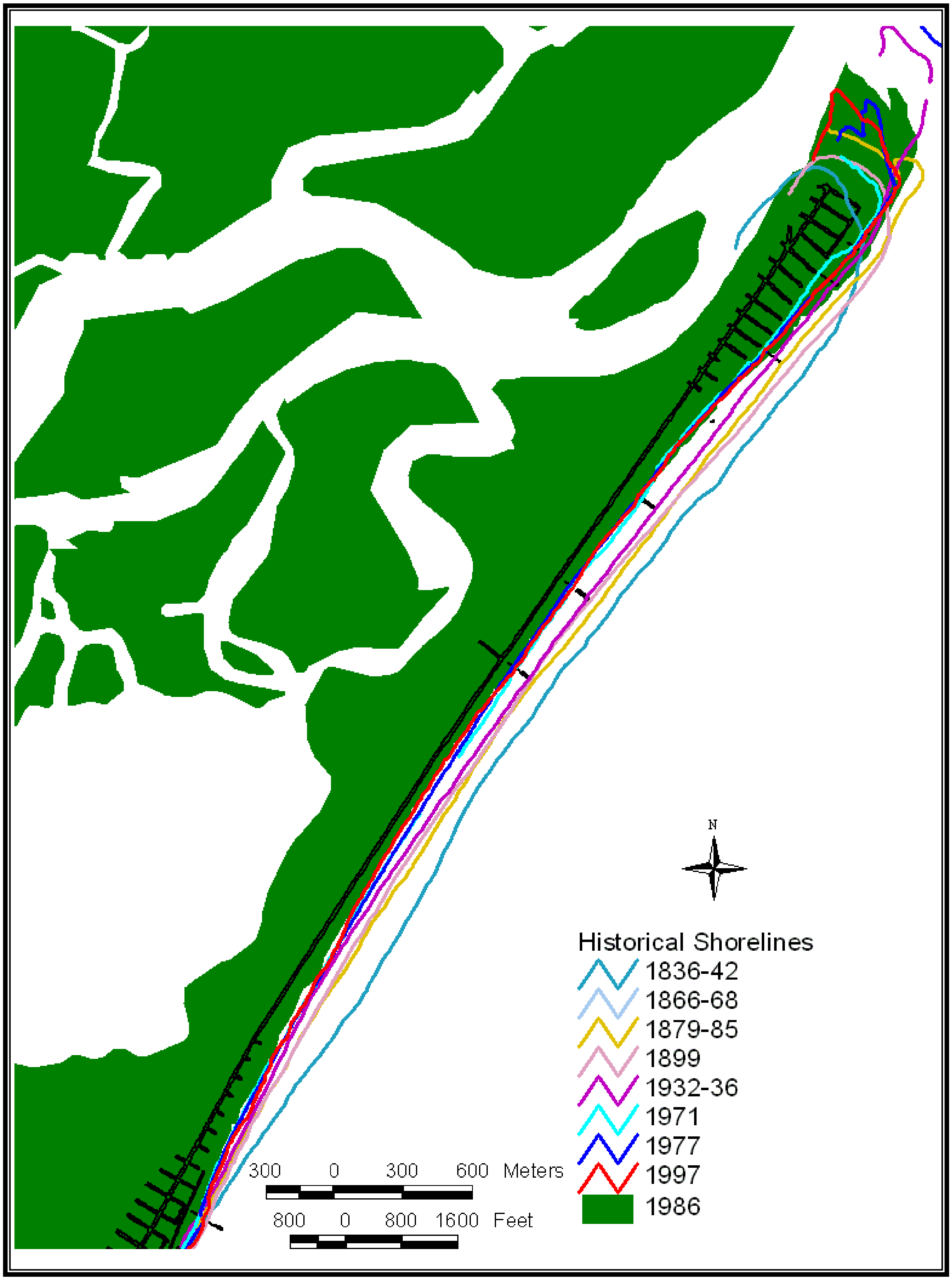

Figure 2.8-15 Shoreline Change Map for Ludlam Island
(data provided by Farrell et al, 1989 and 1997 Digital Photogrammetry)

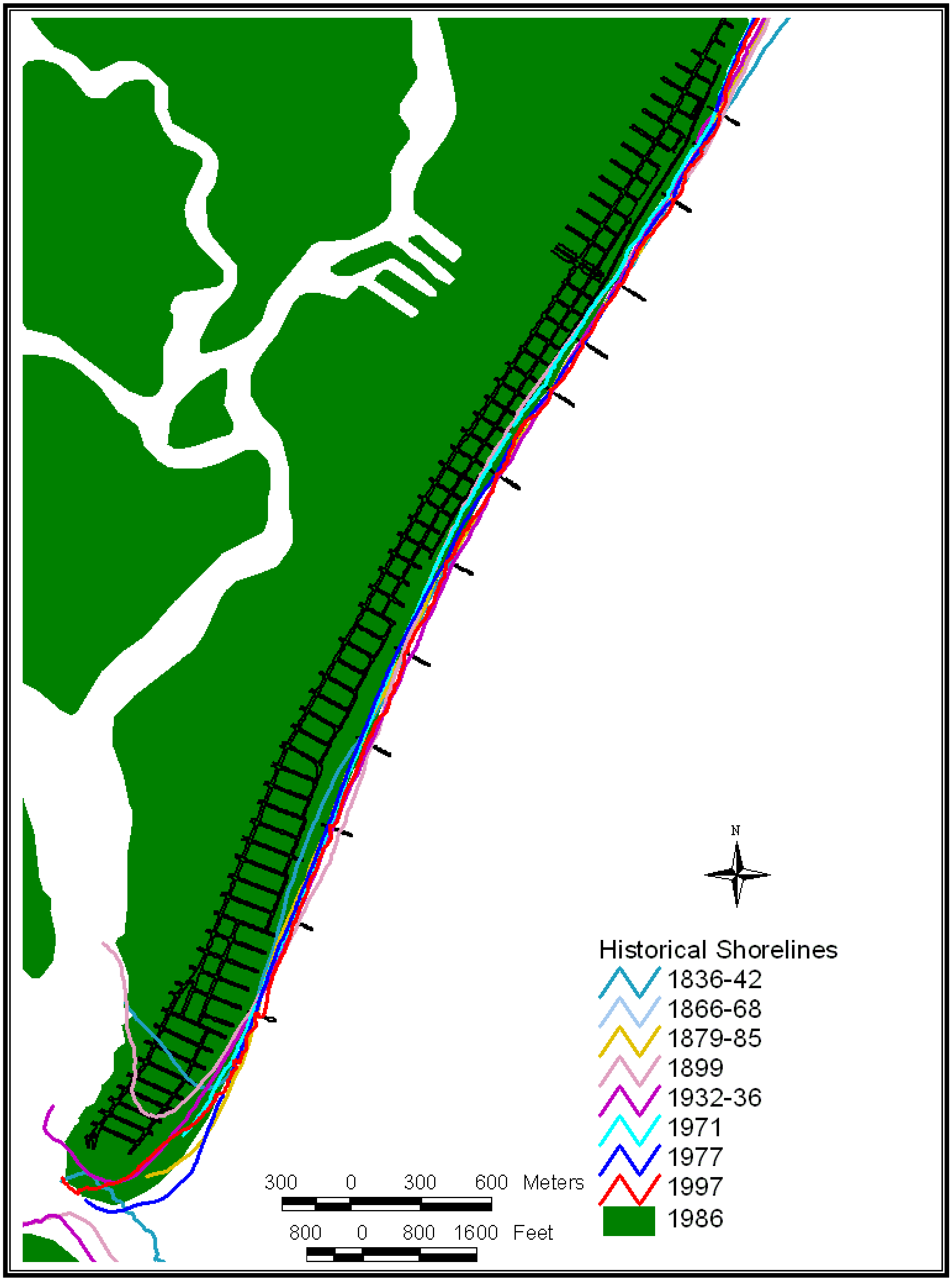

Figure 2.8.4-1 (Cont) Shoreline Change Map for Ludlam Island

(data provided by Farrell et al, 1989 and 1997 Digital Photogrammetry)

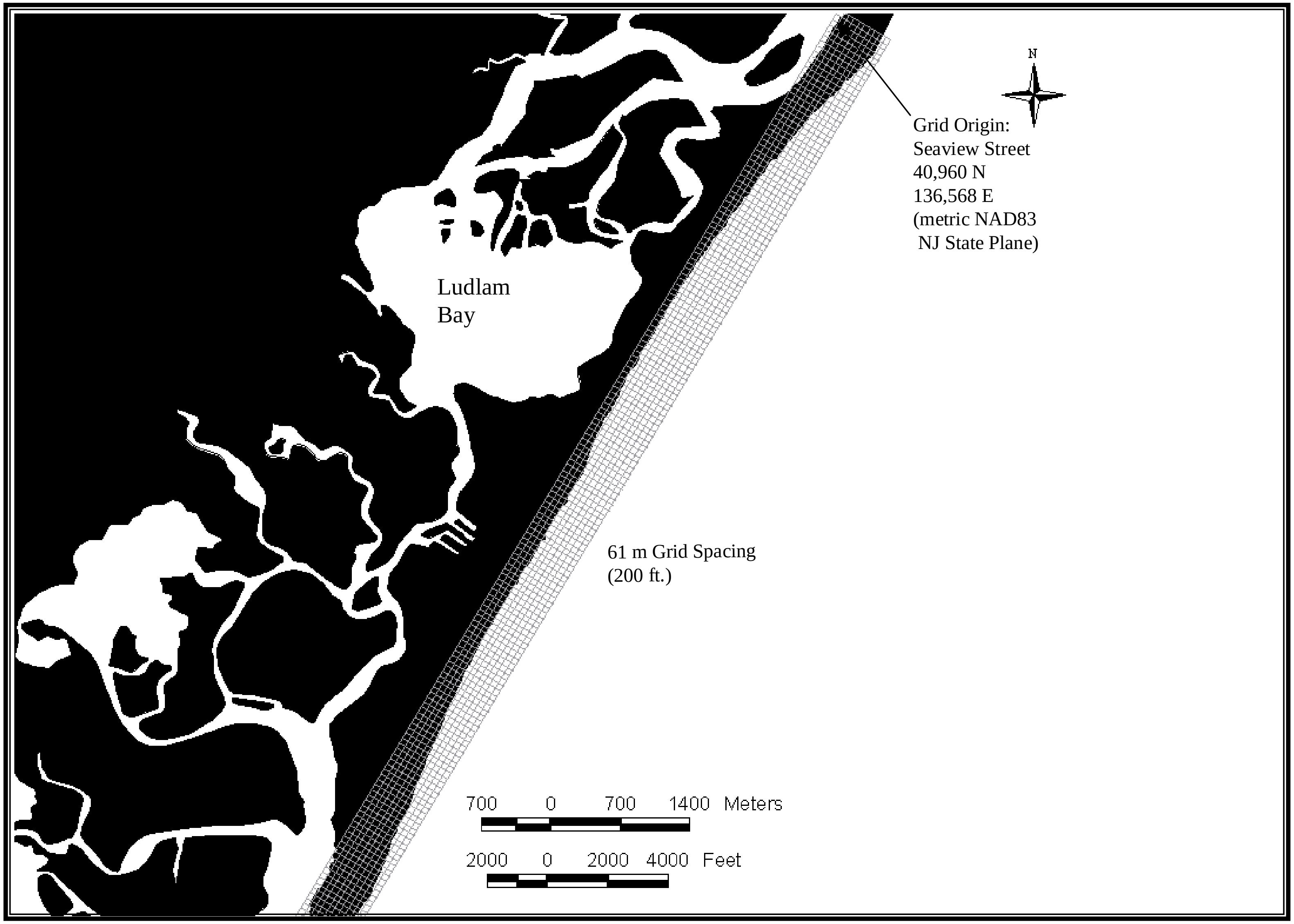

Figure 2.8-16 Shoreline Change Grid for Ludlam Island.

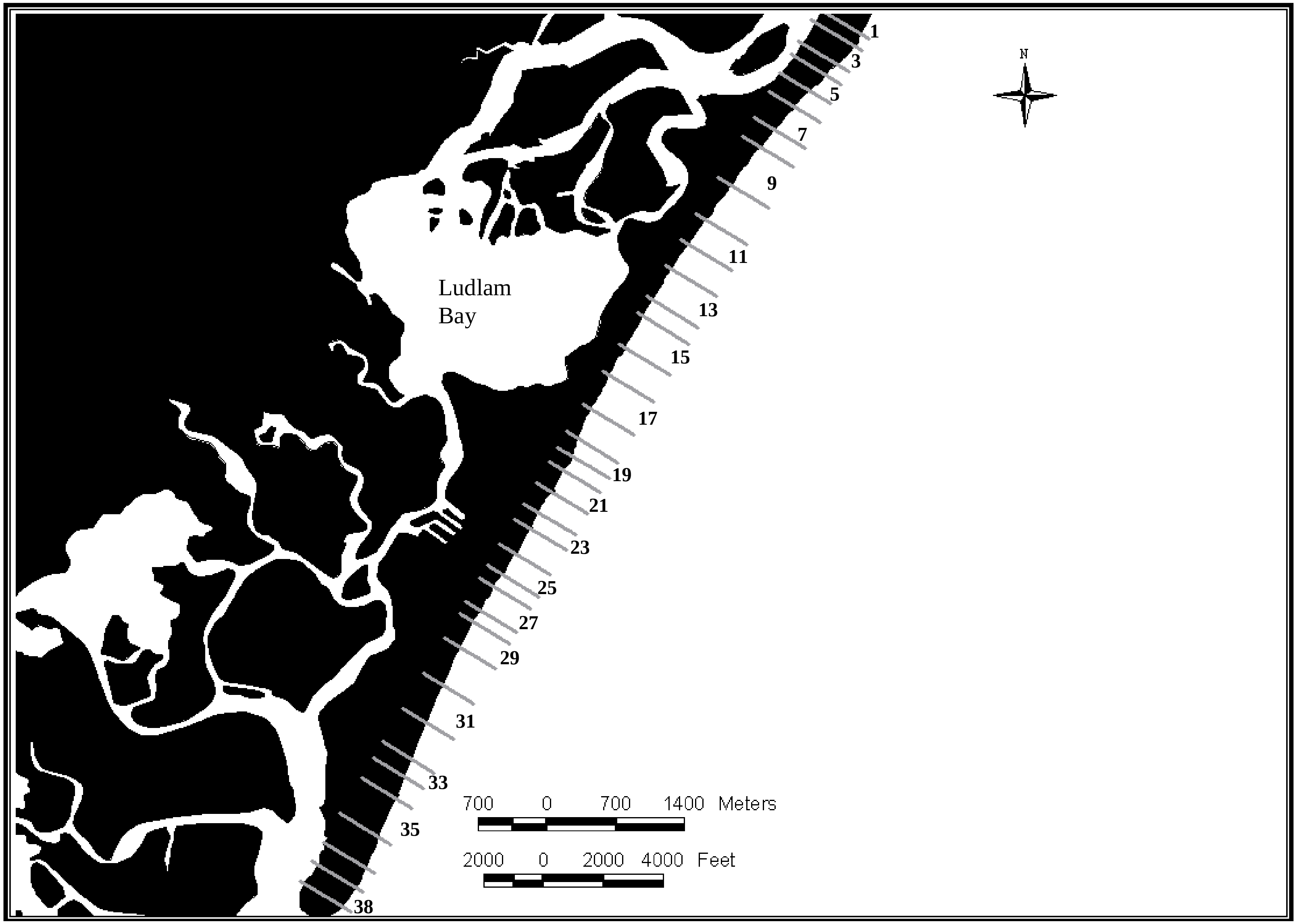

Figure 2.8-17 **Shoreline Change Compartments for Ludlam Island**

A weighted average of each compartment within the Ludlam Island cells was done as shown in Tables 2.8.4-1 and 2.8.4-2. Shoreline change rates are based on the 1997 shoreline for Ludlam Island on a cell by cell basis with and without the beachfills in-place, respectively. . Cell delineation was based on physical and socio-economic conditions and will be referred to again in subsequent sections of this report.

Table 2.8.4-1 Shoreline Change Rates (Meters/Year) for Each Cell Based on 1997 Shoreline for Ludlam Island with Beachfills In-Place

(+ Accretion, - Erosion, NaN - Insufficient Data)

Cell	Length (m)	1932-1997	1971-1997	1977-1997	1986-1997
LI1 (Seaview-Whittier)	2245	-0.13	1.45	-0.01	-4.83
LI2 (Whittier-Sherman)	1782	-0.53	1.06	0.37	-2.63
LI2A (Sherman-Hamilton)	2472	-1.25	0.52	0.23	-1.21
LI3 (Hamilton-13th Street)	6860	-1.34	-0.73	-0.28	0.39
LI4 (13th-29th St)	4598	-0.51	-0.02	0.14	1.87
LI4N (29th-JFK Blvd)	3376	0.14	0.90	0.74	3.05
LI5 (JFK-52nd)	3183	-0.08	1.37	0.41	1.47
LI4S (52nd-57th)	1394	-0.29	1.87	1.16	0.96
LI5B (57th-75th)	4675	-0.27	1.41	1.73	1.18
LI6 (75th-88th)	4004	0.43	0.71	0.45	0.79
LI6B (88th-93rd)	758	0.73	-1.10	-7.41	-8.27

1 m = 3.28 ft

Table 2.8.4-2 Shoreline Change Rates (Meters/Year) for Each Cell Based on 1997 Shoreline for Ludlam Island Beachfills Subtracted Out

(+ Accretion, - Erosion, NaN - Insufficient Data)

Cell	Length (m)	1932-1997	1971-1997	1977-1997	1986-1997
LI 1	2245	-0.37	1.09	0.13	-0.88
LI 2	1782	-1.02	0.31	0.66	5.41
LI 2A	2472	-1.73	-0.23	0.53	6.82
LI 3	6860	-1.55	-1.06	-0.15	3.91
LI 4	4598	-0.51	-0.02	0.14	1.87
LI 4N	3376	0.14	0.90	0.74	3.05
LI 5	3183	-0.15	1.26	0.44	2.39
LI 4S	1394	-0.42	1.68	1.23	3.07
LI 5B	4675	-0.50	0.98	1.67	4.10
LI 6	4004	-0.12	-0.98	-1.43	0.16
LI 6B	758	0.38	-3.54	-8.93	-9.91

1 meter = 3.28 ft

2.9 Inlet Processes at Great Egg Harbor Inlet

2.9.1 Historical Inlet Bathymetry

A history of general inlet geometry change for Great Egg Harbor Inlet from 1891 to 1984 is available in "A Summary Document for the Use and Interpretation of the Historical Inlet Bathymetry Change Maps for the State of New Jersey," (Farrell, et. al., 1989). Bathymetric maps from 1891, 1904, 1937, 1949, 1962, and 1984 were analyzed in this report. Figure 2.9.1-1 shows the historic shorelines for the immediate Great Egg Harbor Inlet vicinity.

Prior to 1891 and any shore protection structures, Great Egg Harbor Inlet behaved as a short-period, double inlet system; however, no bathymetric maps were available to document this morphology. Since 1891, the inlet has behaved as a classic, single channel system where the main channel migrates back and forth through the ebb-tidal delta. The variation in extreme channel positions has alternately benefited the northern shoreline of Longport and the southern shoreline of Ocean City.

The following paragraphs provide a summary of the findings in Farrell, et al. (1989):

1891 Configuration. Total width between shorelines is approximately 760 m (2,493 ft). The deep channel is 43% of the inlet cross-section and the ebb-tidal delta is very large in proportion to the inlet width. The Longport shoreline has its maximum southerly extent and Ocean City has its minimum easterly extent in 1891. The -1.8 m (6 ft) contour encloses a 1270 m (4,167 ft) long, 888 m (2,913 ft) wide deposit of sand, southwest of the inlet's main ocean entrance.

1904 Configuration. Total width between shorelines is 1875 m (6,152 ft) and the channel width is 258 m (846 ft) at the -1.8 m (6 ft) contour. The ratio of main channel width to shoreline opening has decreased to 14%. The main channel depth remains constant at approximately 7.5 m (25 ft). The ocean entrance has moved 900 m (2,953 ft) eastward along the ebb-tidal delta.

1937 Configuration. Total width between shorelines is 1775 m (5,823 ft), while the main channel at the -1.8 m (6 ft) contour is 250 m (820 ft) wide. The width ratio remains at 14%. The shoreline along Longport has continued to erode, coinciding with a major shift in the location of the main channel towards Absecon Island. A reduction in ebb tidal flow along the Ocean City shoreline allowed for accretion along this shoreline.

1949 Configuration. The main channel is now well established on the Longport side of the inlet.

1962 Configuration. Total width between shorelines is 1370 m (4,495 ft) with a channel width at the -1.8 m (6 ft) contour of 355 m (1,165 ft). The channel width percentage of the inlet opening has increased to 26% of the distance between shorelines. The main channel leading to Great Egg Harbor Bay is over 9 m (30 ft) deep. The ocean entrance is at the extreme northeast with the ebb channel opening at 1645 m (5,397 ft) seaward from the end of the Longport terminal groin.

1984 Configuration. The orientation of the main channel has shifted to the southwest from the 1962 position by 635 m (2,083 ft) at the ocean entrance; however, the inner end of the channel near Longport has moved very little.

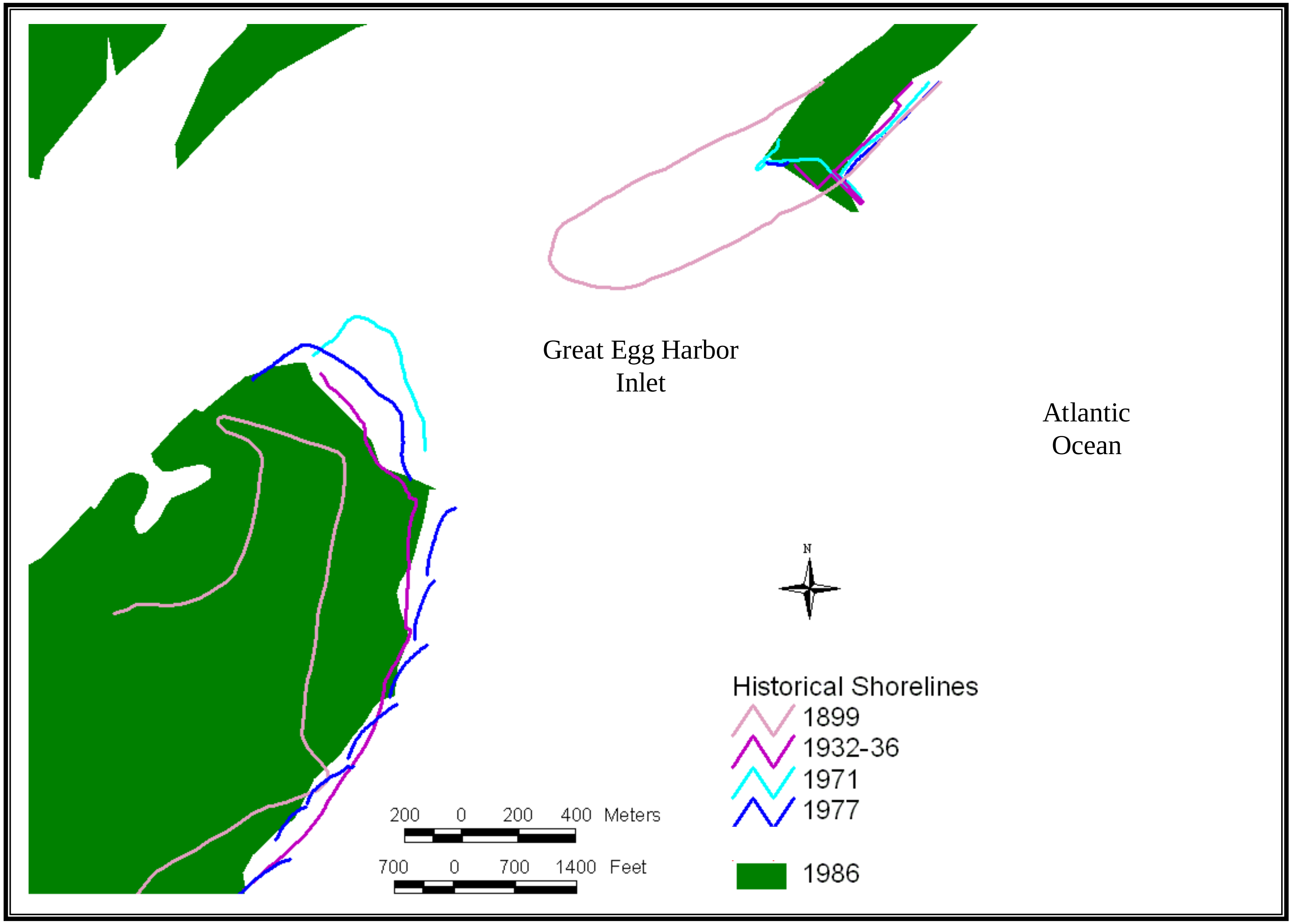

Figure 2.9-1 **Shoreline Change Map for the Great Egg Harbor Inlet Vicinity**
(from Farrell et al., 1989)

2.9.2 Recent Bathymetric Conditions

Bathymetric surveys of Great Egg Harbor Inlet were conducted in March 1995, March 1996, April 1997 and September 1997. These surveys were conducted as part of the routine monitoring program for a Federal beachfill project extending from the inlet to 36th Street in Ocean City. Additionally, pre-and post-surveys of the borrow area were conducted during beach fill events.

In March 1995, two channels were separated by a shoal approximately two-thirds of the way across the inlet (ie., along Range B in Figure 2.7.3-1) going from west to east. The western channel was over 14 m (46 ft) deep in some areas and was relatively wide compared to the narrower eastern channel that had maximum depths of approximately 4 m (13 ft) near Longport. Photo 2.9.2-1 is an aerial mosaic of the inlet in June 1995. Note the dredge working in the borrow area for the Ocean City, NJ beach fill operation.

The monitoring survey of Great Egg Harbor Inlet from April 1997 is shown in Figure 2.9.2-1. From this survey it appears that only one major channel exists in the inlet, passing through approximately the center of the inlet and extending directly out towards the borrow area. Photos 2.9.2-2 and 2.9.2-3 show aerial photography of Great Egg Harbor Inlet from June 1997 and June 1999, respectively. Note the large accretion along the inlet-facing shoreline of Ocean City. The volumetric growth of this area out to the inlet channel has also been evident along several profile lines monitored since 1994. Figure 2.9.2-2 shows profiles along Station –7+01 which is located along the inlet frontage and extends out to the inlet channel.

Photo 2-1 Aerial Photography of Great Egg Harbor Inlet (June 1995)

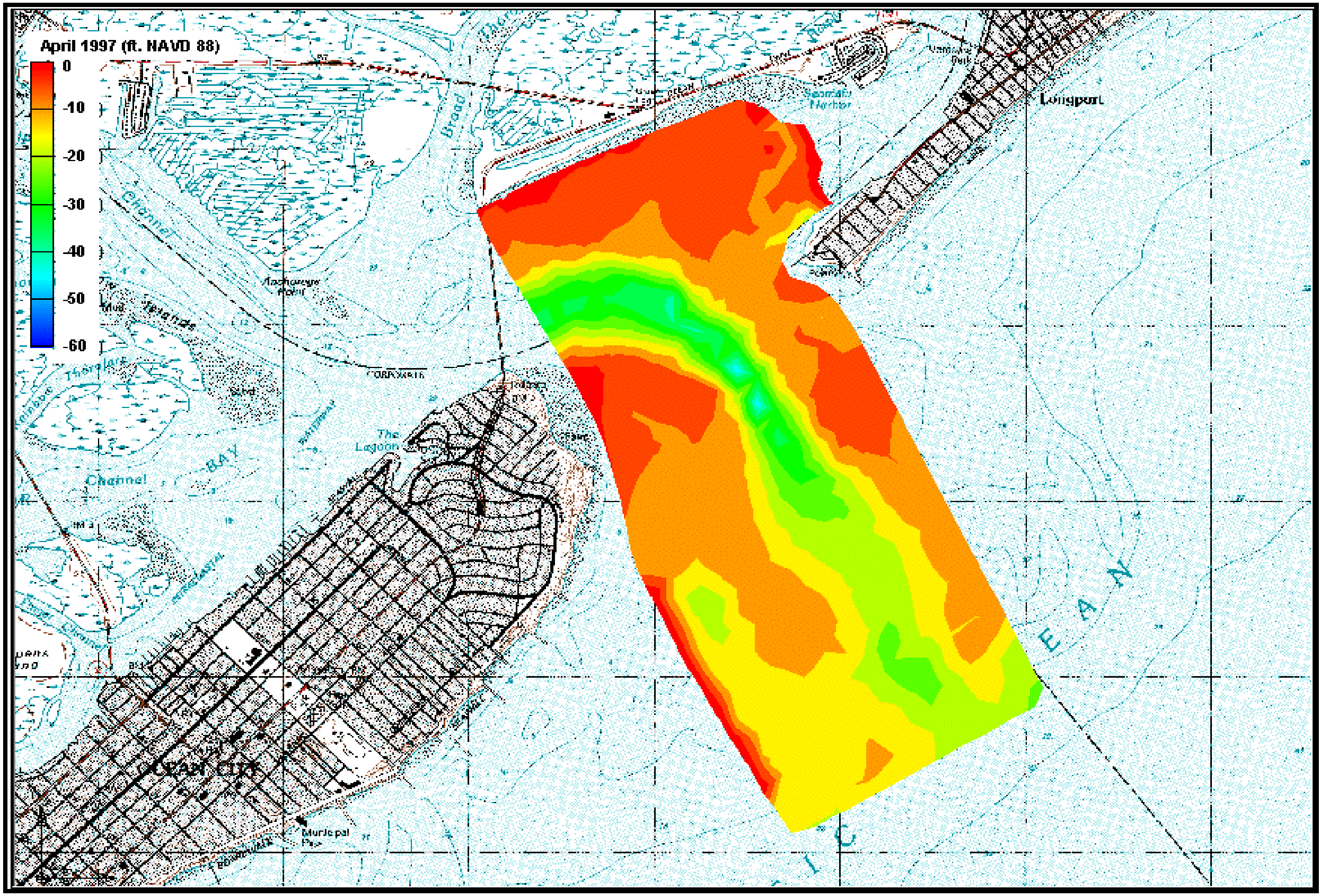

Figure 2.9-2 **Great Egg Harbor Inlet Bathymetry (April 1997)**

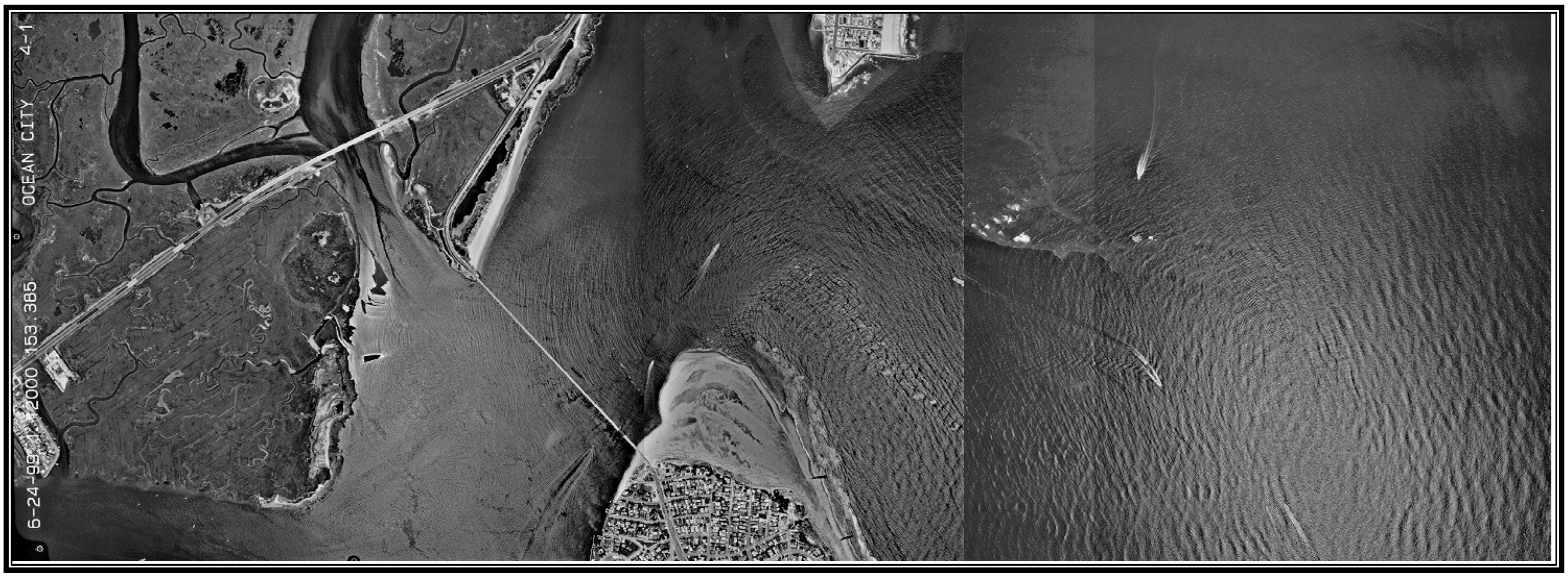

Photo 2-2 **Aerial Photography of Great Egg Harbor Inlet (June 1997)**

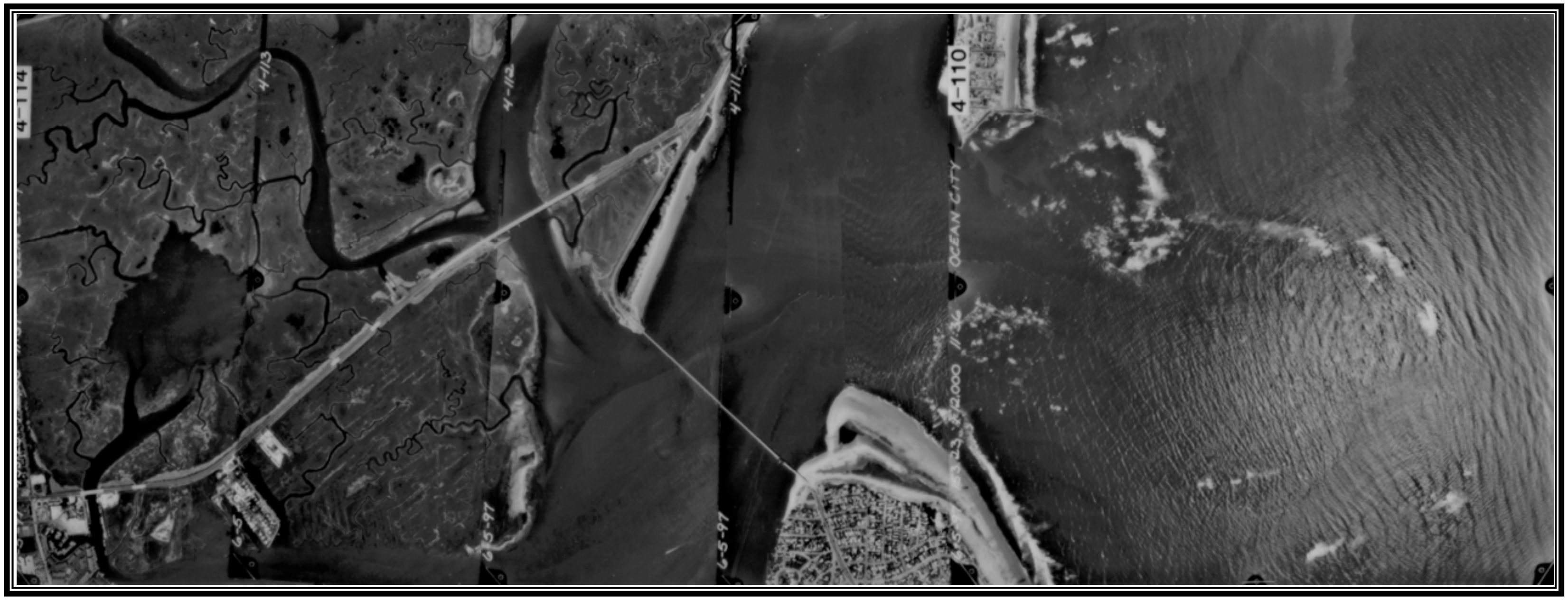

Photo 2-3 **Aerial Photography of Great Egg Harbor Inlet (June 1999)**

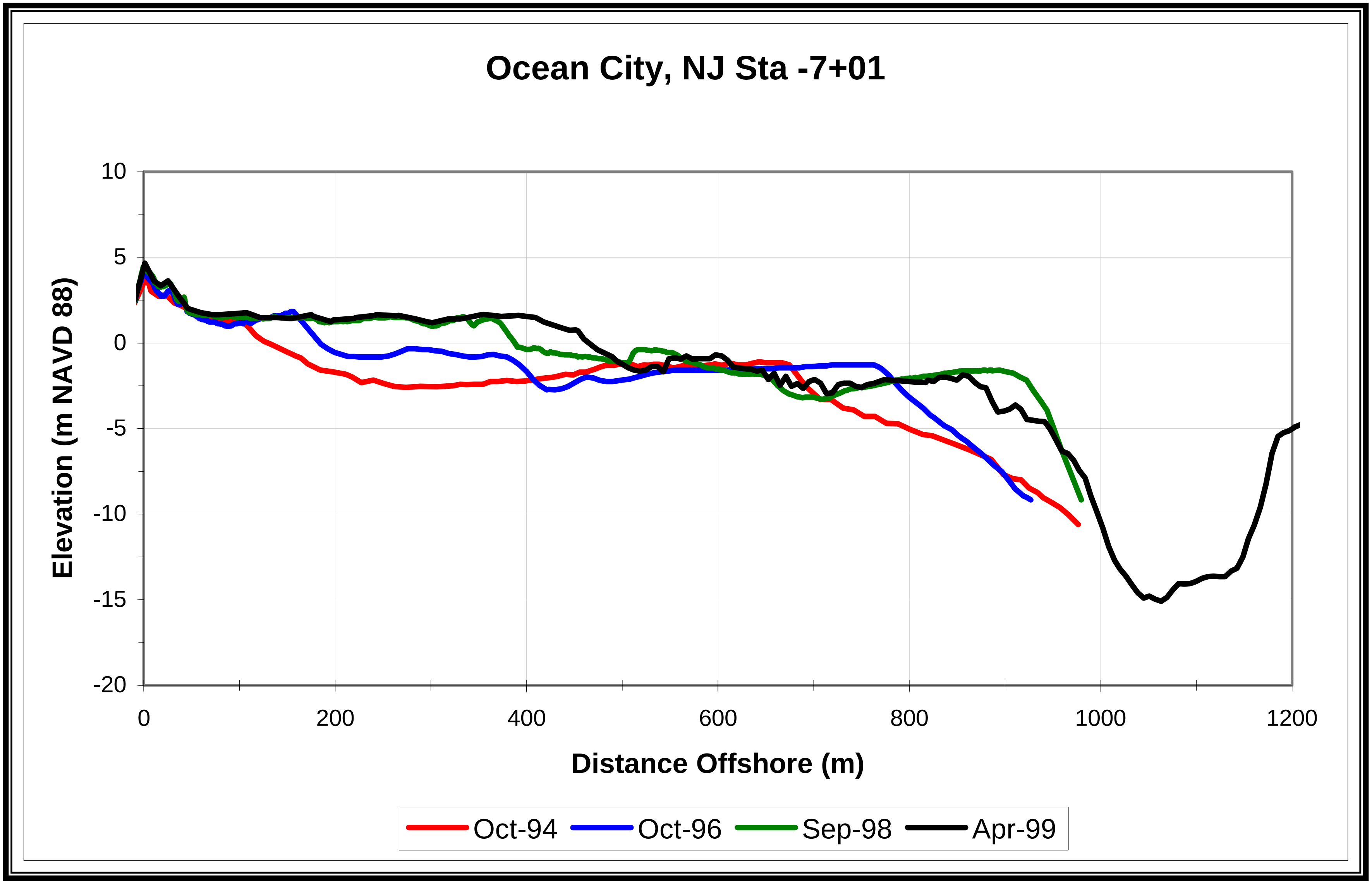

Figure 2.9-3 **Profile line monitored along Great Egg Harbor Inlet (Station –7+01) showing shoreline accretion**

2.10 Inlet Processes at Corson Inlet

2.10.1 Historical Inlet Bathymetry

In order to document historical shoreline change at Corson Inlet, Farrell, et al. (1989) analyzed aerial photography and maps from 1842, 1885, 1899, 1935, 1962, 1971, 1977, and 1986 (Figure 2.10.1-1). The data for the 1842 configuration shows a wide inlet (915 m) with only a minor southern seaward offset of approximately 122 m. Changes since this configuration have been extensive. Inlet breaching in 1885 and subsequent channel migration between 1899 and 1935, and 1962 reduced the inlet's width significantly. Total width of the inlet in 1962 was 342 m. Dramatic channel migration to the southwest between 1962 and 1971 returned the inlet to approximately the 1841 configuration. The largest changes at the inlet occurred during two periods, 1842 to 1855 and 1962 to 1971, both of which were influenced by major storms. From 1971 to 1977, inlet closure resumed. By 1986, the inlet width had narrowed to an extreme value of 190 m.

Changes in shoreline position at Corson Inlet during the period 1949 to 1974 were analyzed by CERC (Everts, DeWall and Czerniak, 1980) as shown in Figure 2.10.1-2. Evaluation of the changes from 1962 to 1971 indicates that the Ocean City shoreline accreted while the Strathmere shoreline eroded on a steady basis with inlet migration from the northeast to the southwest. From 1949 to 1974, Corson Inlet migrated south at a rate of 28.0 m/yr (92 ft/yr), about 4.5 times greater than the long-term northern migration trend. Width changes during this period were highly variable while the migration was nearly constant. The change in position and inlet width was mostly due to erosion of the southern inlet shoreline along Strathmere. The northern inlet shoreline of Ocean City accreted and prograded south at approximately 4.9 m/yr (16 ft/yr).

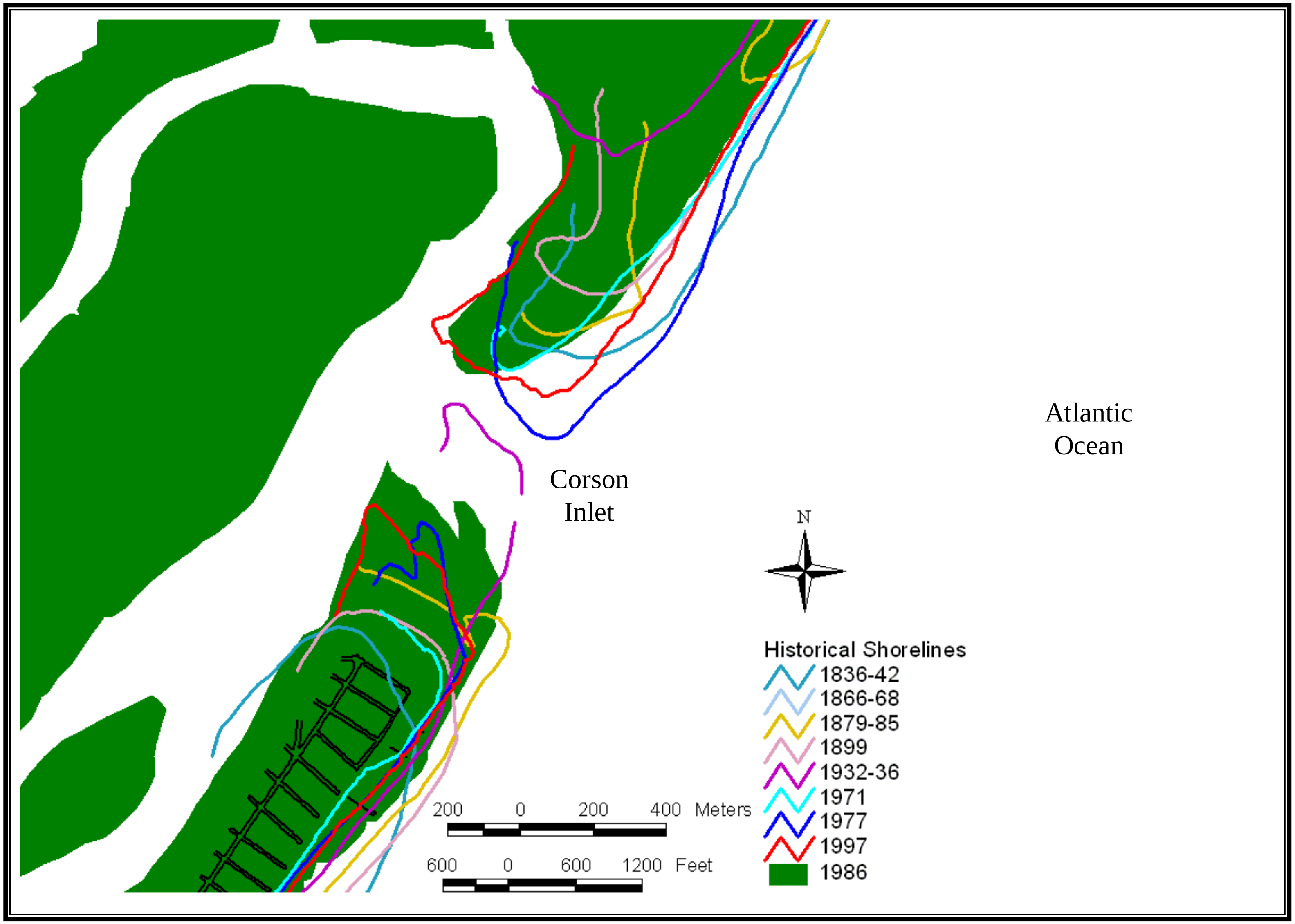

Figure 2.10-1 Shoreline Change Map for the Corson Inlet Vicinity
(from Farrell et al., 1989)

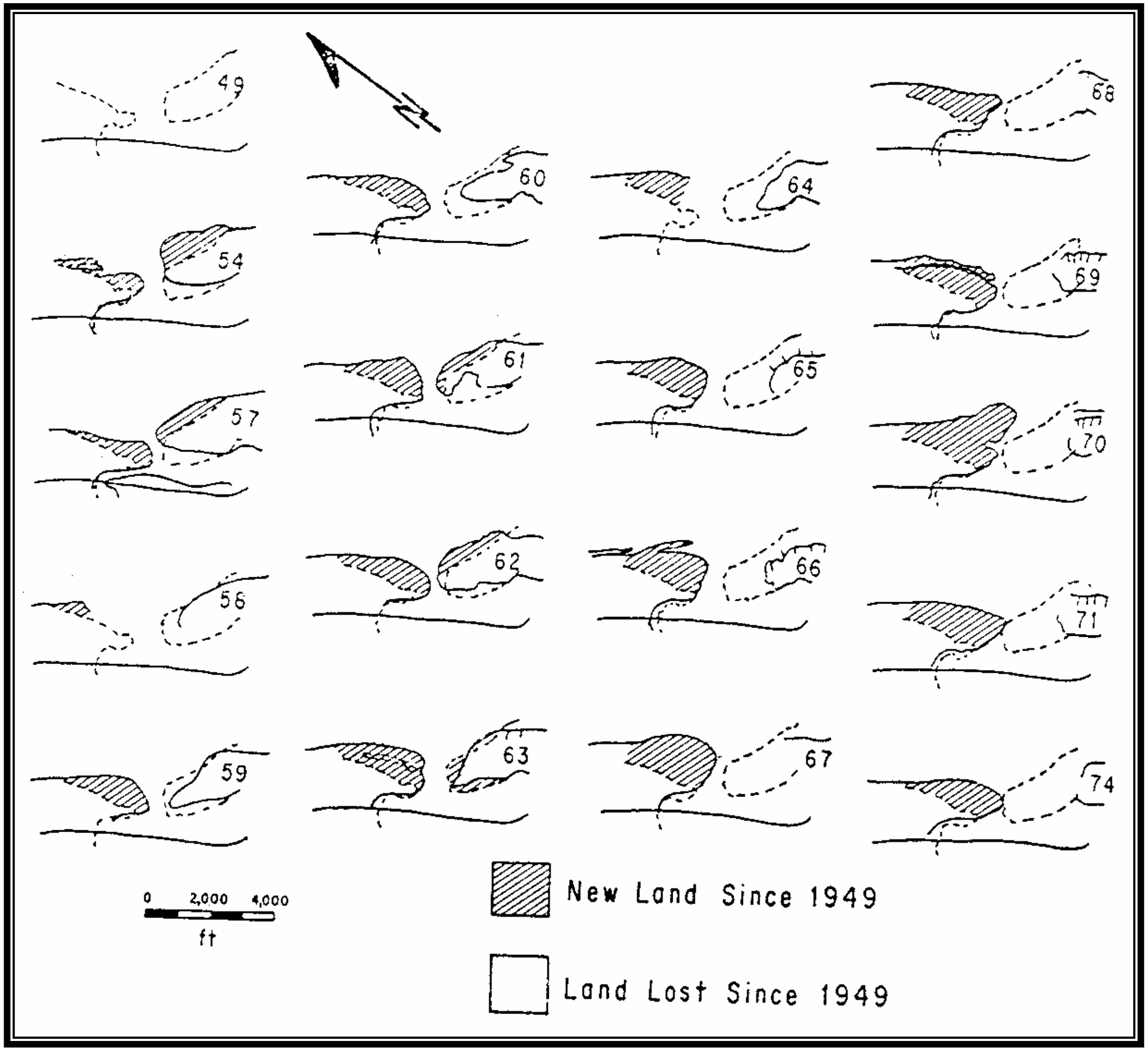

Figure 2.10-2 Shoreline Change at Corson Inlet from 1949 to 1974
(from Everts, DeWall, and Czerrniak, 1980)

2.10.2 Recent Inlet Conditions

Beginning in 1991, quarterly aerial photography of Corson Inlet has been obtained as part of the monitoring program for the existing Federal project at Ocean City. Mosaics of these aerial flights are available at the Philadelphia District. As indicated in Farrell, et al. (1989) the pattern of inlet widening reversed between the mid 1970's and 1986 and the inlet width in 1986 was at an extreme low. The inlet width remained relatively narrow through 1993 (Photo 2.10.2-1).

Photos 2.10.2-2 through 2.10.2-4 show aerial photographs of Corson Inlet in December 1994, September 1995, and January 1996. Note the formation of a second channel on the southern side of the inlet between December 1994 and September 1995 with subsequent erosion of the shoreline near the Strathmere groins. The smaller channel then began to close by the January 1996 photograph accompanied by onshore shoal migration leading to accretion of the Strathmere ocean shoreline. The width of the inlet gradually increased over this time period.

By 1997, a system of small bars and channels was visible on the southern side of Corson Inlet and the inlet shoreline of Strathmere had eroded (Photo 2.10.2-5). The inlet is much wider than 1993 and erosion is evident on the Strathmere shoreline near the northernmost groins.

Note also the relatively large extent of the ebb shoal in the vicinity of Corson’s Inlet State Park. This shoal appears to be growing steadily since approximately 1995, most likely due to the southerly migration of beach fill from Ocean City.

Photos 2.10.2-6 and 2.10.2-7 show the continued trend leading to severe erosion of the Strathmere beaches. Portions of the ebb shoal visible in the photographs are anticipated to eventually migrate onshore and provide some nourishment to the Strathmere shoreline. However, the inlet remains relatively wide and flood tidal currents will continue to erode this shoreline in the inlet’s present configuration.

Bathymetric surveys of Corson Inlet were conducted in May 1998 and May 1999 (Figures 2.10.2-8 and 2.10.2-9 respectively). Note the growth in one year of the ebb shoal to the north and south of the channel.

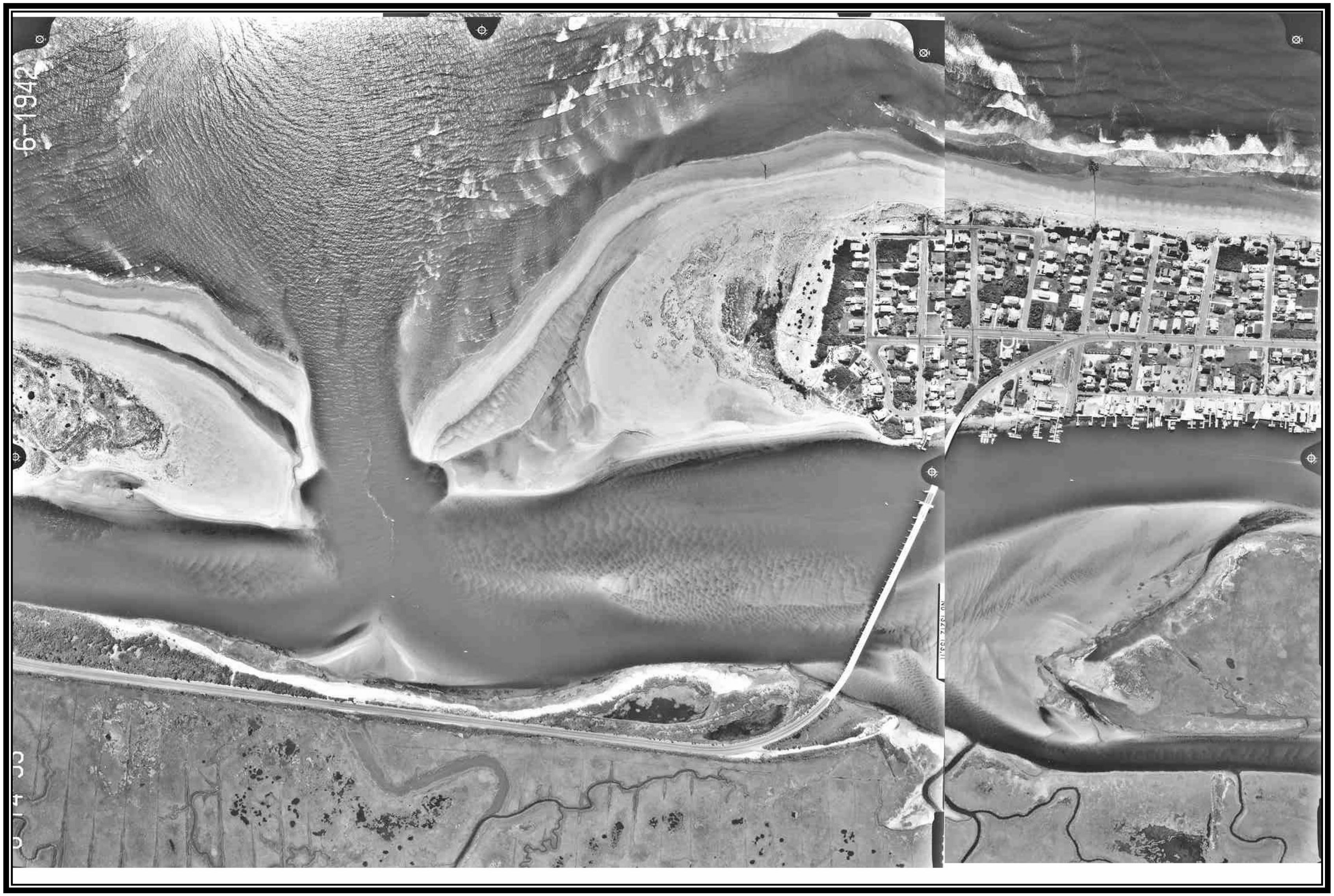

Photo 2-4 Aerial Photography of Corson Inlet (June 1993)

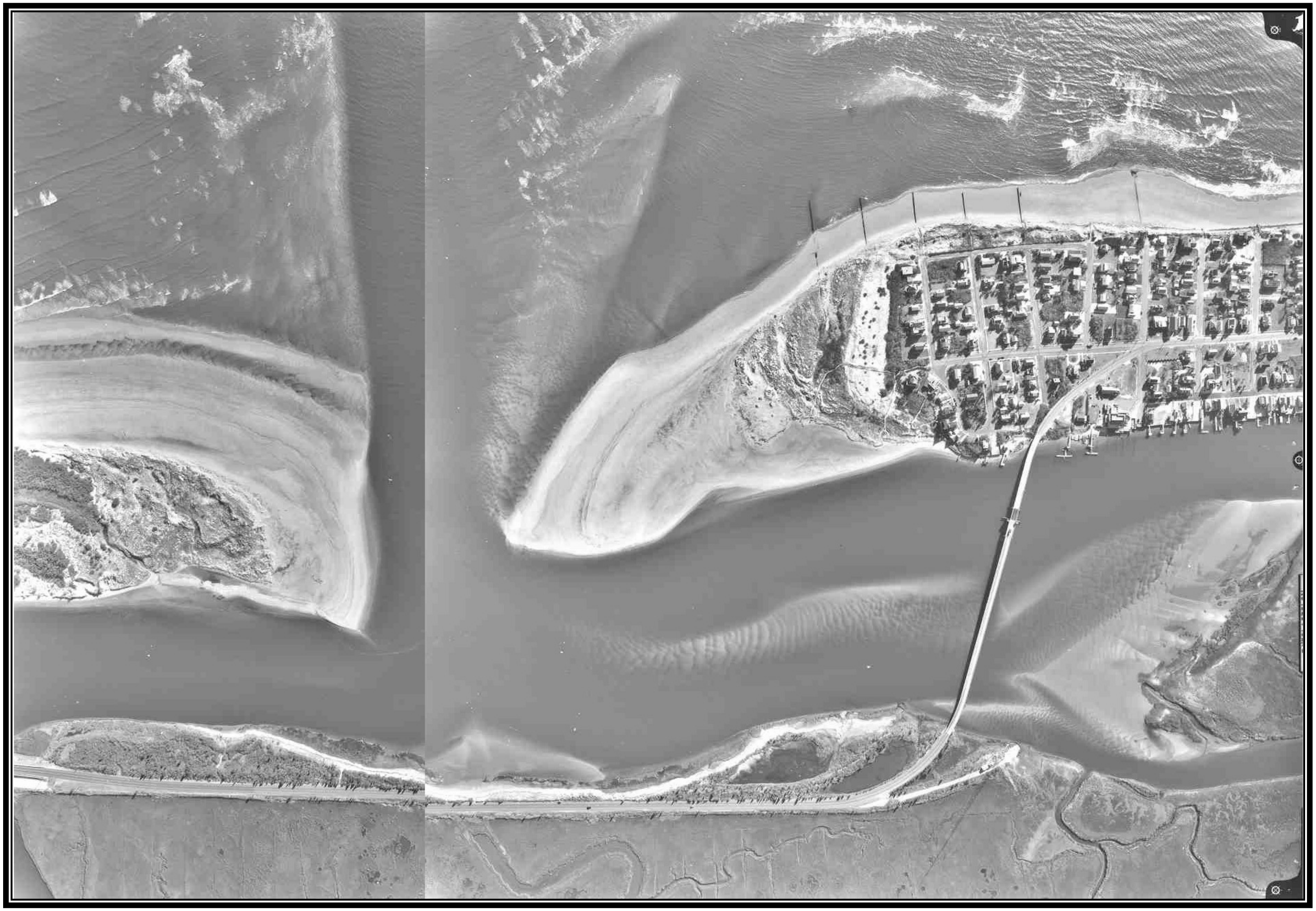

Photo 2-5 Aerial Photography of Corson Inlet (December 1994)

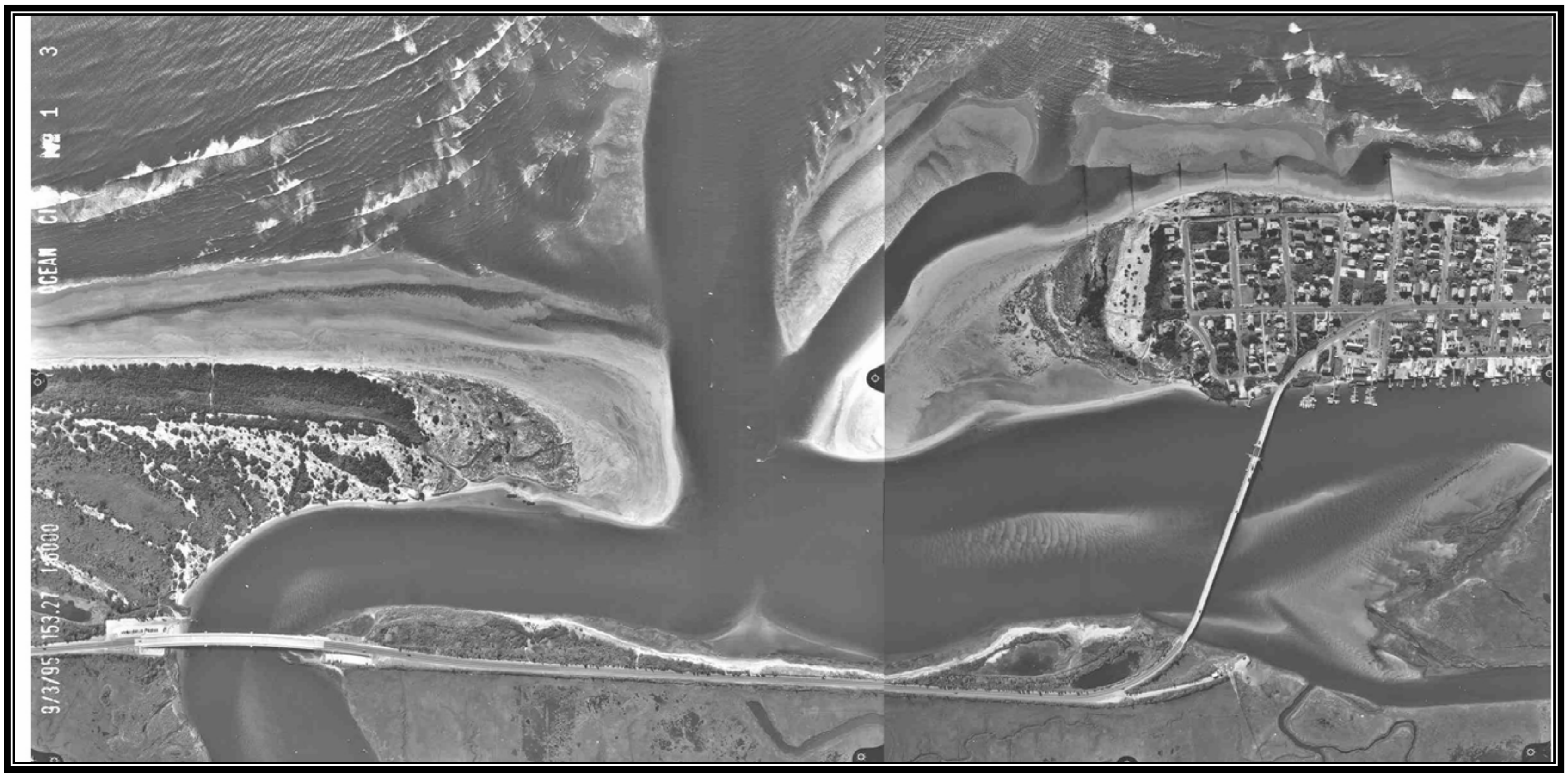

Photo 2-6 Aerial Photography of Corson Inlet (September 1995)

Photo 2-7 Aerial Photography of Corson Inlet (January 1996)

Photo 2-8 Aerial Photography of Corson Inlet (September 1997)

Photo 2-9 Aerial Photography of Corson Inlet (March 1998)

Photo 2-10 Aerial Photography of Corson Inlet (June 1999)

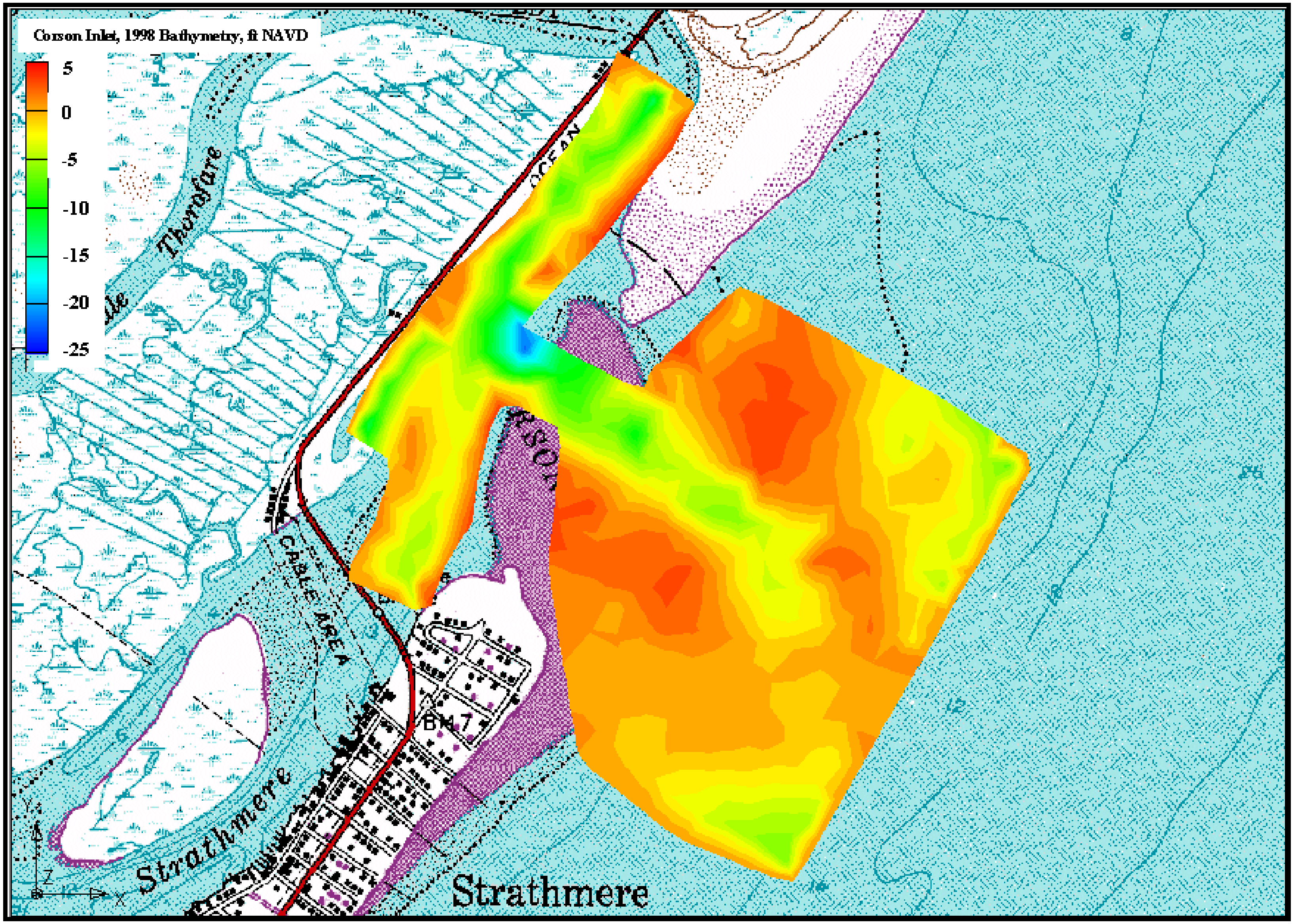

Figure 2.10-3 Corson Inlet Bathymetry (May 1998)

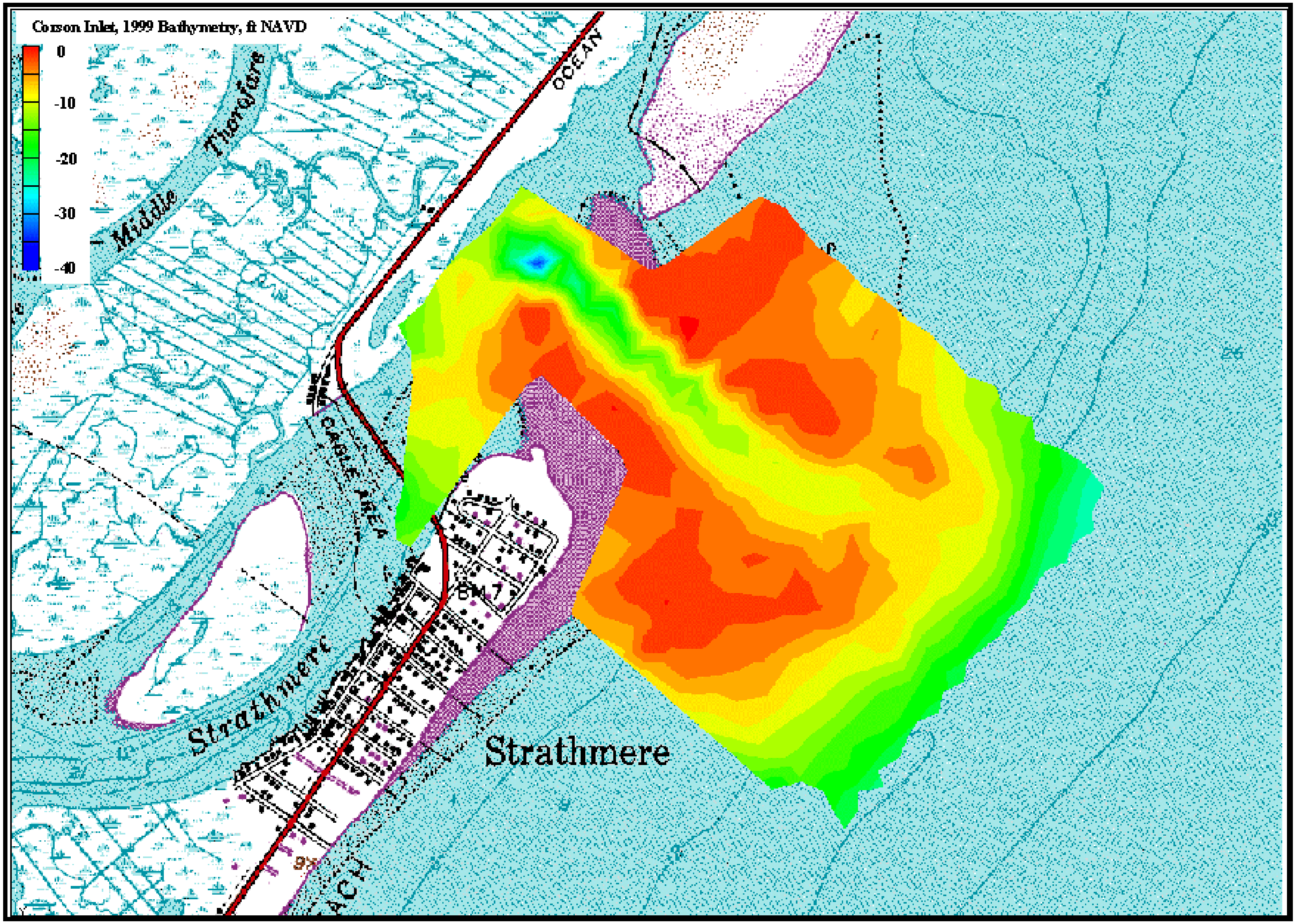

Figure 2.10-4 Corson Inlet Bathymetry (May 1999)

3 PROBLEM IDENTIFICATION

Problems which exist at the study area have been identified through site visits, public, and interagency coordination, review of historical records and reports, aerial photographs, along with beach and offshore surveys. Since a Federal project exists in Ocean City from Seaview Avenue to 36th Street (including tapers), this area was not reevaluated.

The principal water resource problem identified along the study area is storm damage vulnerability associated with wave attack, inundation, and erosion (storm-related and long-term).

3.1 Storm Damage Vulnerability

The principal cause of economic damages along the Atlantic Coast of New Jersey is storms. Storm damage includes wave attack, inundation and storm-induced erosion. Major storms have occurred in September 1944, March 1962, March 1984, September 1985, March 1989, October 1991, January 1992, December 1992, and March 1993.

An accurate assessment of storm damages is difficult to develop for coastal storms. Along the study area, records of historic damages are poor except for the 1962 Northeaster. This storm resulted in damage to 8,467 structures within the entire study area (including northern Ocean City) at a cost of $140,000,000 (1999 dollars).

Storm activity during the 1970's and 1980's was relatively mild and real estate development during this period continued to expand. This has increased the potential for storm damages exceeding the 1962 storm despite strides made in some areas to minimize losses associated with storm damage. Such advances include structural and building code improvements. However, many portions of the developed coast will remain vulnerable due to the proximity of the structures to the beach.

The December 1992 storm produced the second highest water levels recorded at the Atlantic City, NJ, tide gage, resulting in structural damage and extensive beach and dune erosion within the study area. Public property damages for this storm, which qualified for FEMA assistance, totaled $1,300,000 while private insurance claims totaled $12,000,000 according to records provided by the Federal Insurance Administration.

3.1.1 Storm Damage Vulnerability – South End Ocean City, NJ

This area is highly vulnerable to storm damage, where in most sections, only the existing bulkhead offering significant protection from storms. Little or no protective dunes exist for much of the shoreline (Photo 3-1) nor is there a steep beach-face to offer much resistance to storms. High tide shorelines extend almost to the bulkhead in the southern-most portion. Relatively minor storm events cause ocean water to overtop the bulkhead. Many of the houses along the beachfront were constructed at ground level, years ago, when the threat of storm damages was not as great. Due to erosion, these structures now lie in a highly vulnerable position. In response, beachfill was placed by the State of New Jersey and locals along southern Ocean City during the summer of 1995. Since then, storm-related erosion has removed much of this beachfill. Locals estimate a loss of 262,000 cubic meters (345,000 cy) of sand from the storm of February 1998, a relatively minor storm event.

The December 1992 storm caused significant damage, mostly to the South End of Ocean City. Much of the existing dunes were destroyed (Photo 3-2). NJDEP estimated dune loss of approximately 84,000 cubic meters (110,000 cy) at an estimated cost of $1,100,00 to replace. FEMA estimated damages of $465,532 for items such as sand fence and dune grass loss, along with emergency sand dune protection. Private losses for residences were estimated at more than $3,000,000 with damage to about 1,800 homes.

The storm of 1962 caused extensive damage to the South End of Ocean City (Photo 3-3). Many of the existing bulkheads failed during the storm and many homes were totally destroyed by the combined affects of wave action and erosion. Not only were the homes along the shorefront destroyed but even homes located blocks inland. Residents had to be evacuated soon after the storm began. Flooding to unoccupied vacation homes having energized electrical systems resulted in numerous fires, with flooding preventing fire fighting companies from reaching the fire scenes. Damage to Ocean City (including northern portion) was about $90,000,000 (1999 dollars). This included damage to 6,195 structures.

3.1.2 Storm Damage Vulnerability – Gardens Area, Ocean City

The storm damage vulnerability in this area is related to the variable shoreline position. As this area is located along Great Egg Harbor Inlet, the shoreline tends to cycle through periods of accretion and erosion. This area was previously examined in documents mentioned in section 1.5.1.1 of this report. In these reports, the erosion rate at this area was listed as "0 ft/year – no long-term trend; large potential annual variability" and no project was previously recommended for this location.

Currently, a significant dune system and beach width exists at this location (refer back to Photo 1.4-3). However, in 1995, locals placed sand along the 518 meter (1,700 ft) stretch of shoreline due to the relatively small beach width at that time (Photo 3.1-4). Since then, the beach width has expanded significantly. Despite this recent occurrence, local officials are aware of the cyclical nature of the shoreline position and have expressed their concern. Obviously, a reduced beach width will increase the storm damage vulnerability of this location.

3.1.3 Storm Damage Vulnerability- Ludlam Island

Similar to South End Ocean City, Ludlam Island is also highly vulnerable to storm damage due to the critical shoreline position. A minimal beach width exists in many locations with the high-tide line extending to the bulkhead along sections of the island.

In Strathmere, the high tide line extends to a protective bulkhead (Photo 3-5) with storms sending ocean water over this structure, threatening and damaging homes (Photo 3-6). A major storm would cause extensive damage and likely destruction of many residential structures. Recent erosion in the northern-most portion of Strathmere has further increased storm damage vulnerability, necessitating that a small beachfill be placed by the locals in 1999.

In the Whale Beach area, Ocean Drive, a county road connecting Ludlam Island with Ocean City, has historically been overtopped during major storm events. This road is an important evacuation route off of the island with the right-of-way containing utilities. The existing condition has worsened due to the storms of the early 1990's that destroyed most of the protective dunes which existed in this narrow area. During these storms, the roadway was rendered impassable (Photos 3-7 and 3-8 for before and after). A FEMA sponsored dune system was constructed ($240,000) in 1995 (Photo 3-9), but offered minimum protection. In fact, the dunes from 3rd to 6th Streets were destroyed during the January 1996 storm (Photo 3-10), a very minor storm relative to ocean stage. The breaching caused the roadway to be closed for two days and prohibited city crews from gaining access to portions of Ludlam Island. The storm of February 1998 caused extensive erosion which undermined the roadway along Whale Beach. This also resulted in closure of the road for repairs. In response, 1,220 meters (4,000 ft) of geotextile tubes were constructed by Cape May County from approximately 1st to 13th Streets in Sea Isle City (refer back to Photo 1.4-8). These tubes provide protection against minor storms. Major storms would still allow for extreme roadway overtopping, destruction of structures, as well as the possible breaching of this portion of the island. All of these scenarios would severely hamper any rescue efforts needed at Ludlam Island, specifically evacuation of the residents of both Strathmere and Whale Beach.

At Sea Isle City, the promenade/bulkhead extends from 29th to 57th Streets and protects homes from storm damage (Photo 3-11). High tides surge up to this bulkhead which protects an intensely developed area (Photo 3-12). The relatively minor storm of January 1996 left the promenade washed over and buried with sand. A major storm would cause extensive damage and possible destruction of many structures.

Along the Townsends Inlet area of Sea Isle City, severe erosion of almost 10 meters (32 ft) per year since 1986 has removed the beach and protective dunes, leaving this area extremely vulnerable to storm damage (Photo 3-13). A number of projects have been constructed at this location and are documented in 1.5.3.3 of this report. Since 1992, more than $6,000,000 has been spent by the State and locals on an approximately ten-block stretch in this area. The latest project was constructed in 1999, and consisted of a terminal groin followed by a beachfill (Photo 3-14).

Major storm events have caused substantial storm damage to the entire island. The storm of 1962 resulted in the breaching and overtopping of the northern portion of Ludlam Island (Photo 3-15). The breaching resulted in almost the complete destruction of the Whale Beach area and sections of Sea Isle City. Tidal flooding covered nearly the entire island. The prolonged action of high tides and waves leveled most of the island's protective dunes. A total of 2,272 residences were damaged by flooding, with 668 of them suffering structural damage. In Sea Isle City, about 280 structures were completely demolished. Waves 3.6 meters (12 ft) high breached the island on the north from the ocean to the bay. Total flooding and destruction of access roads cut off the island from the mainland for 3 days. Total damage to the island was more than $52,000,000 (1999 dollars). Evacuation of Ludlam Island was necessitated when all public utility systems, including water supply, failed during the storm. Residents had to be removed by helicopters. While some storm protection improvements have been made to the island since the 1962 storm, development has also increased.

The possibility of extensive storm damage along the entire island continues to exist. This has been demonstrated recently by the December 1992 storm. FEMA-eligible damage (utility and public area) was $814,567 while private losses estimates totaled about $2,500,000 according to records provided by the Federal Insurance Administration. NJDEP estimated the loss of 298,000 cu meters (392,000 cy) of sand from the Sea Isle City beach at an estimated cost of $3,900,000 to replace. Dune losses at Sea Isle City were estimated at 211,000 cubic meters (277,000 cy) at an estimated cost of $3,300,000 to rebuild. The storm of January 1996 also caused significant erosion to the remaining beach at Sea Isle City. Locals estimated beach erosion losses at around $3,000,000 to replace.

3.1.3.1 Erosion at Corson's Inlet State Park

Recently, erosion has affected the Ludlam Island portion of Corson's Inlet State Park (refer back to Photo 1.4-6). The park superintendent has indicated that about 12 hectares (30 acres) have been lost since 1998. This erosion is now threatening structures in Strathmere, necessitating a beachfill in 1999 by locals. Recent history has shown this area to be relatively stable. Observing long-term historical trends, this erosion condition will likely reverse at some point. A detailed analysis of the inlet processes and adjacent shorelines is presented in section 2.10 of this report.

Photo 3-1 South End Ocean City, NJ (looking northeast).
Note lack of dunes and proximity of high water line.

Photo 3-2 Ocean City, NJ (40th Street) during 12/14/92 storm.

Photo 3-3 Ocean City, NJ (vic. 34th Street). Storm of March 1962.

Photo 3-4 **Ocean City, NJ (43rd Street). Storm of March 1962.**

Photo 3-5 Ocean City, NJ (54th Street). Storm of March 1962.

Photo 3-6 Gardens Area, Ocean City, NJ - 8/30/95

Photo 3-7 Strathmere, NJ - 12/24/94.
Overtopping of bulkhead during minor storm event

Photo 3-8 Strathmere, NJ, - 2000

Photo 3-9 Whale Beach area, Sea Isle City, NJ - 7/25/89.
Structures shown on beach were experimental shore protection devices, since removed.

Photo 3-10 Whale Beach area, Sea Isle City, NJ, storm of 12/14/92.

Photo 3-11 Whale Beach area, Sea Isle City, NJ - 8/30/95.
Condition following FEMA dune project. (destroyed 1/8/96)

Photo 3-12 Whale Beach area, Sea Isle City, NJ - 2/96.
FEMA-sponsored dunes eroded away by storms

Photo 3-13 Sea Isle City, NJ – promenade area, vic 50th Street – 2/98.

Photo 3-14 Sea Isle City, NJ (49th Street) - 8/30/95.

Photo 3-15 Sea Isle City, NJ (92nd Street) - 11/97

Photo 3-16 Townsends Inlet area of Sea Isle City, NJ – 10/25/99.

Photo 3-17 Strathmere, Upper Township, NJ. Storm of 1962.

Photo 3-18 Strathmere, Upper Township, NJ. Storm of 1962.

Photo 3-19 Whale Beach area, Ludlam Island NJ. Storm of 1962.

Photo 3-20 Sea Isle City, NJ. Storm of 1962.

Photo 3-21 Sea Isle City (44th Street), NJ. Storm of 1962.

Photo 3-22 Sea Isle City (46th Street), NJ. Storm of 1962.

Photo 3-23 Sea Isle City (60th Street), NJ. Storm of 1962.

Photo 3-24 Sea Isle City (95th Street), NJ. Storm of 1962.

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4 WITHOUT-PROJECT ANALYSIS

4.1 Hydraulic Analysis

4.1.1 Storm Erosion, Inundation and Wave Attack Analyses

Storm erosion, inundation and wave attack analyses were conducted for the South End Ocean City and Ludlam for the without-project condition, which is a projection of existing conditions in the base year (2005). These results will then be compared to analyses conducted using selected alternatives for the with project conditions.

4.1.2 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 0.9 m wave or a velocity flow that overtops the profile crest by 0.9 m 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 0.9 m. 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.

4.1.3 Modeling Storm-induced Erosion

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

The USACE has developed, released and adopted the numerical storm-erosion model SBEACH (Storm induced BEAch CHange) for use in field offices (Rosati, et al., 1993). SBEACH is available via a user interface for the personal computer or through the Coastal Modeling System (CMS) (Cialone et al., 1992). The model can also be downloaded from the USACE's Coastal and Hydraulic Laboratory's internet website. Comprehensive descriptions of development, testing, and application of the model are contained in Reports 1 and 2 of the SBEACH series (Larson and Kraus 1989; Larson, Kraus, and Byrnes 1990).

4.1.4 Overview of SBEACH Methodology

SBEACH32 Version 2.0 (Windows version) was used in this analysis. SBEACH is a geomorphic-based two-dimensional model that simulates beach profile change, including the formation and movement of major morphologic features such as longshore bars, troughs, and berms, under varying storm waves and water levels (Rosati, et al. 1993). SBEACH has significant capabilities that make it useful for quantitative and qualitative investigation of short-term, beach profile response to storms. However, since SBEACH is based on cross-shore processes, there are shortcomings when used in areas having significant longshore transport.

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

4.1.5 SBEACH Calibration

Calibration refers to the procedure of reproducing with SBEACH the change in profile shape produced by an actual storm. Due to the empirical foundation of SBEACH and the natural variability that occurs along the beach during storms, the model should be calibrated using data from beach profiles surveyed before and after storms at the project coast or a similar coast. The calibration procedure involves iterative adjustments of controlling simulation parameters until agreement is obtained between measured and simulated profiles.

The best profile data set for model calibration along the study area consisted of USACE profile surveys taken at Ocean City, NJ prior to and just after the December 1992 storm. Shoreline configuration, grain size, and coastal processes at Ocean City are similar to those for Ludlam Island, therefore, calibration using this well-documented pre- and post-storm data is considered sound. Additionally, a wave hindcast of the December 1992 storm (Andrews Miller, 1993) was prepared and water level data for the storm was recorded at the Atlantic City tide gage. Initial calibration simulations produced insufficient erosion when compared to the post-storm profile data. With CERC's assistance, minor modifications were made to the SBEACH program to allow for factors particular to the southern New Jersey coastline. Final calibration using the Ocean City profile lines was satisfactorily completed and controlling simulation parameters were determined as follows:

$K = 2.5e^{-6}\ m^4/N$
$EPS = 0.005\ m^2/sec$
LAMM = 0.50
BMAX = 20 deg
$D_{50} = 0.24$

where K is the empirical transport rate coefficient, EPS is the transport rate coefficient for the slope dependent term, LAMM is the transport rate decay coefficient multiplier, BMAX is the maximum profile slope prior to avalanching, and D_{50} is the effective grain size. For the study area, the variable BMAX was increased to 45 deg in the SBEACH version used in this analysis. The value of D_{50} was varied with each representative profile area.

4.1.6 Development of Input Data for Storm Erosion Modeling

Transects were selected depicting a representative shoreline, structure, backshore configuration, and upland development conditions for various reaches in the study area. For each reach, storm erosion and inundation were computed and reported relative to a designated baseline. Input data was developed for South End Ocean City and Ludlam Island as follows.

4.1.7 Profile Data

Profile input data was developed from the onshore/offshore survey data collected for both South End Ocean City and Ludlam Island in September 1997. Cross sections of representative beach profile lines can be seen in Figures 4.1.7-1 to 4.1.7-12. The profile line names correspond to the cells that they represent. Cell delineation was based on physical and socio-economic characteristics. The cell limits are shown in Figure 4.1.7-13 and described in Table 4.1.7-1. Each profile was extended landward approximately 450 to 500 m, using digital photogrammetry to allow for erosion and inundation computations into the community.

Based on the analysis described in Sections 2.8.2 and 2.8.4, shoreline change trends were evaluated and existing conditions at the base year were determined for each cell. With the exception of LI3 and LI6B, the September 1997 profile data is considered representative of existing conditions in all cells. For cell LI3, an erosion rate of -0.9 m/yr (-3 ft/yr) was assumed and applied to develop the base year condition. For cell LI6B, the base year condition was assumed to be the post-fill profile following construction of the terminal groin in 1999.

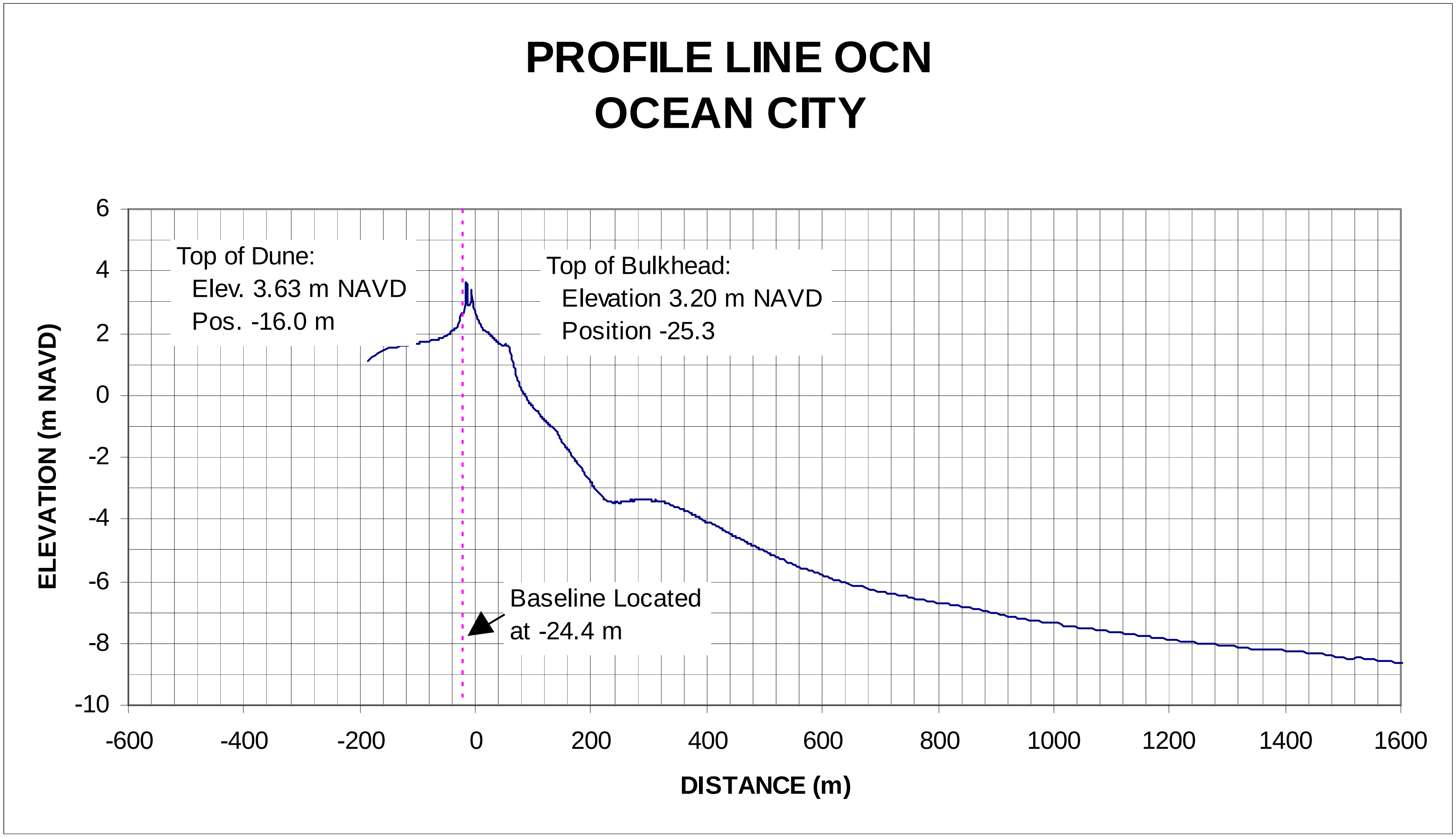


Figure 4.1-1 **Profile Line OCN, South End Ocean City.**

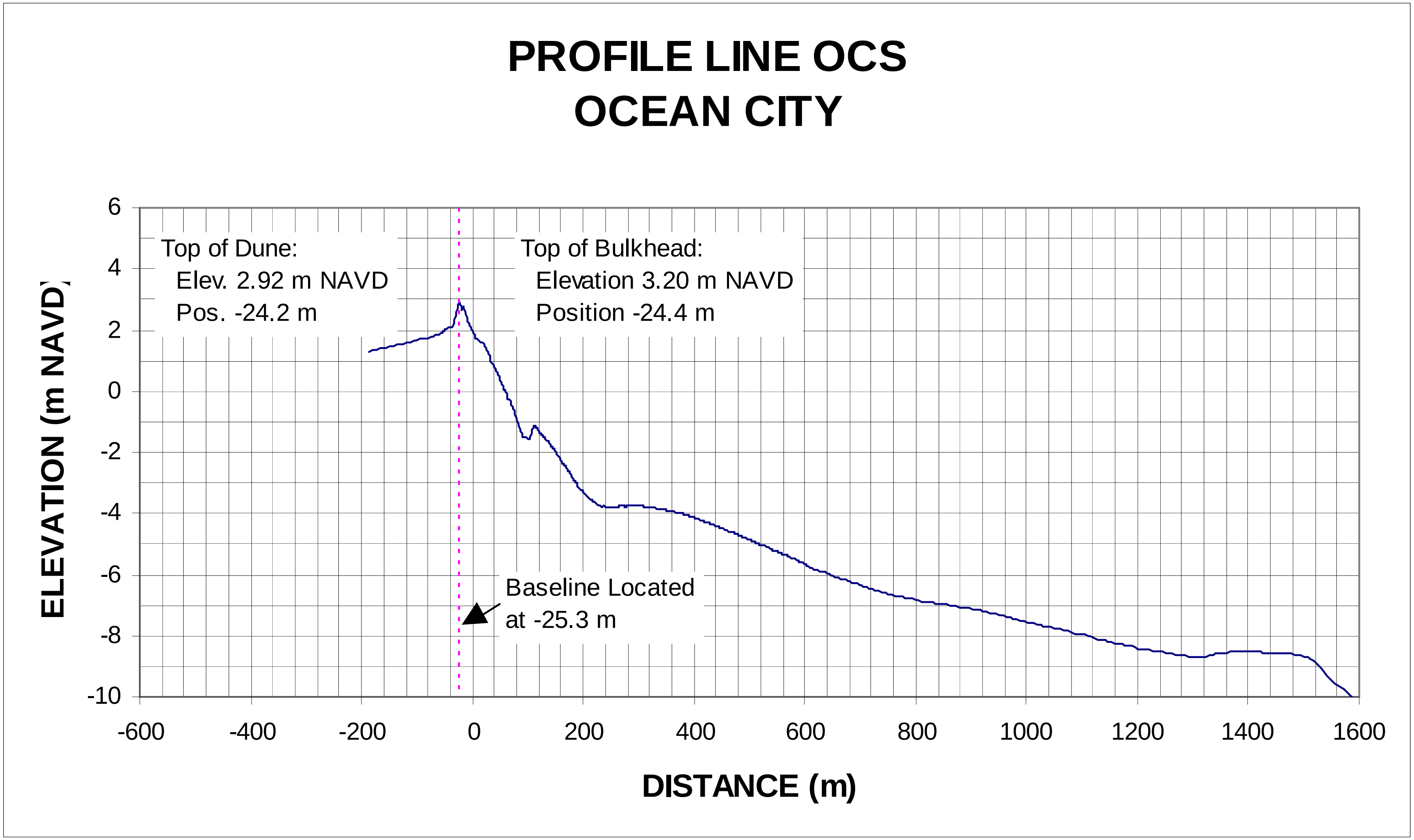


Figure 4.1-2 **Profile Line OCS, South End Ocean City.**

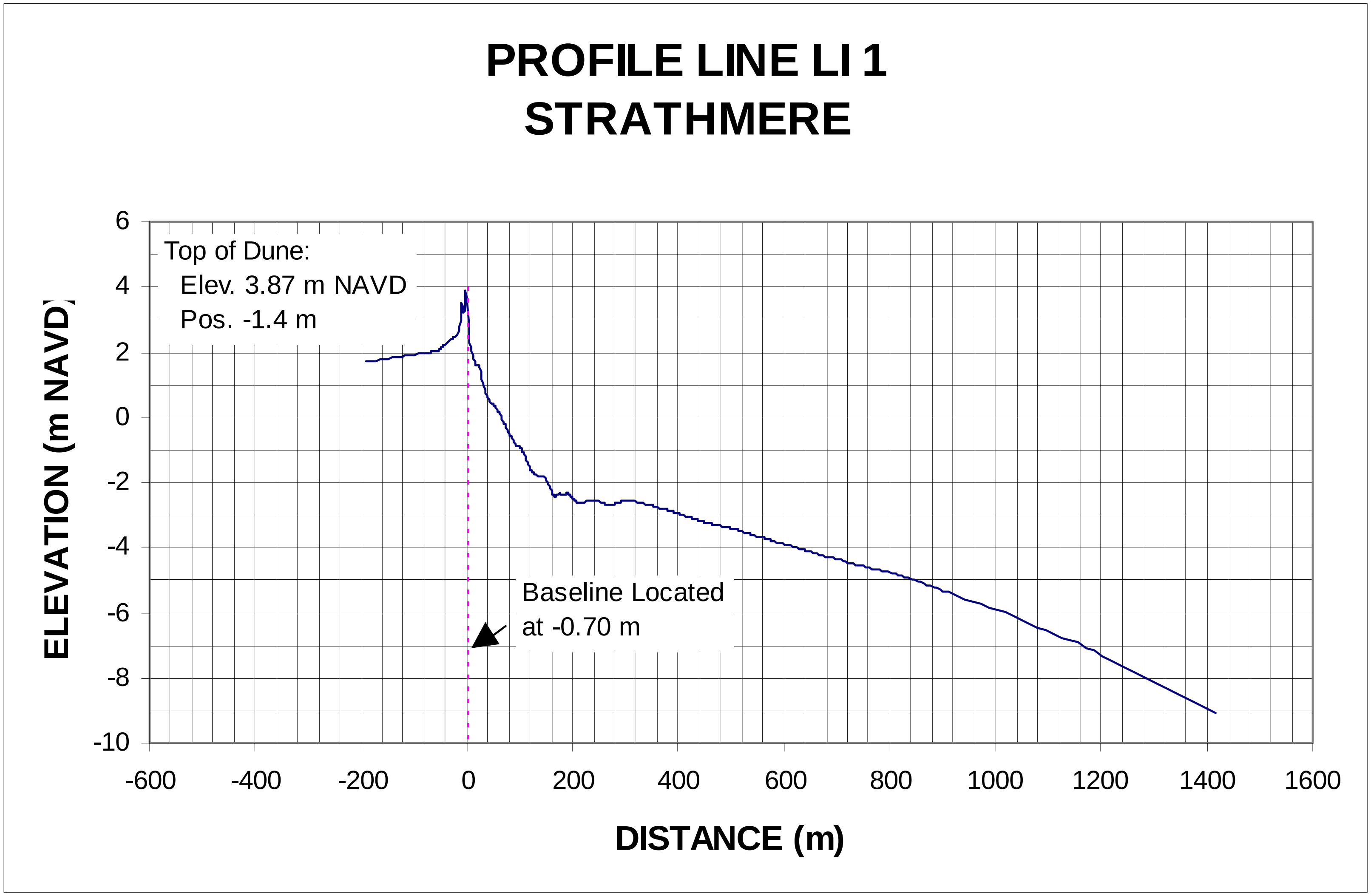


Figure 4.1-3 **Profile Line LI1, Strathmere**

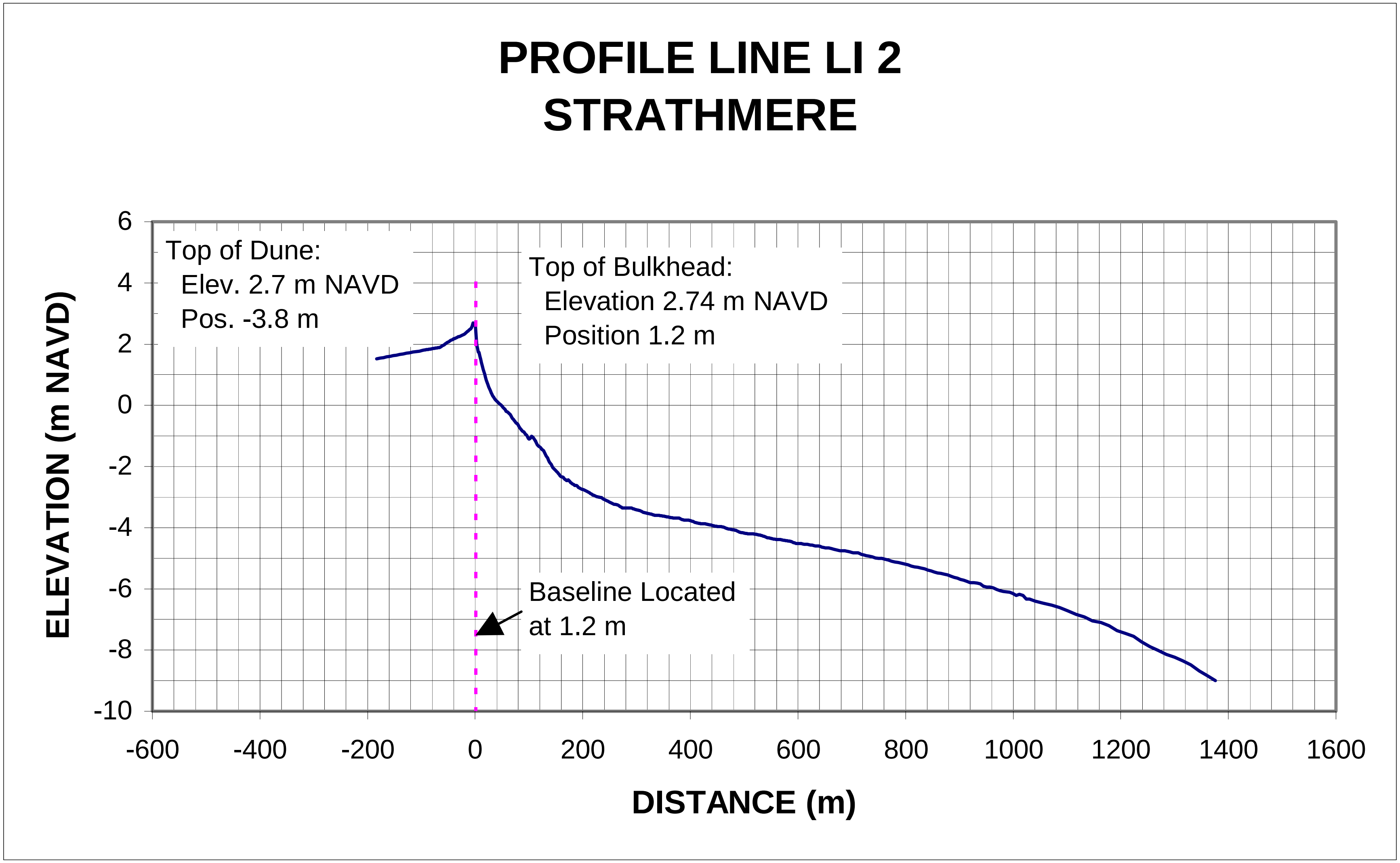


Figure 4.1-4 **Profile Line LI2, Strathmere.**

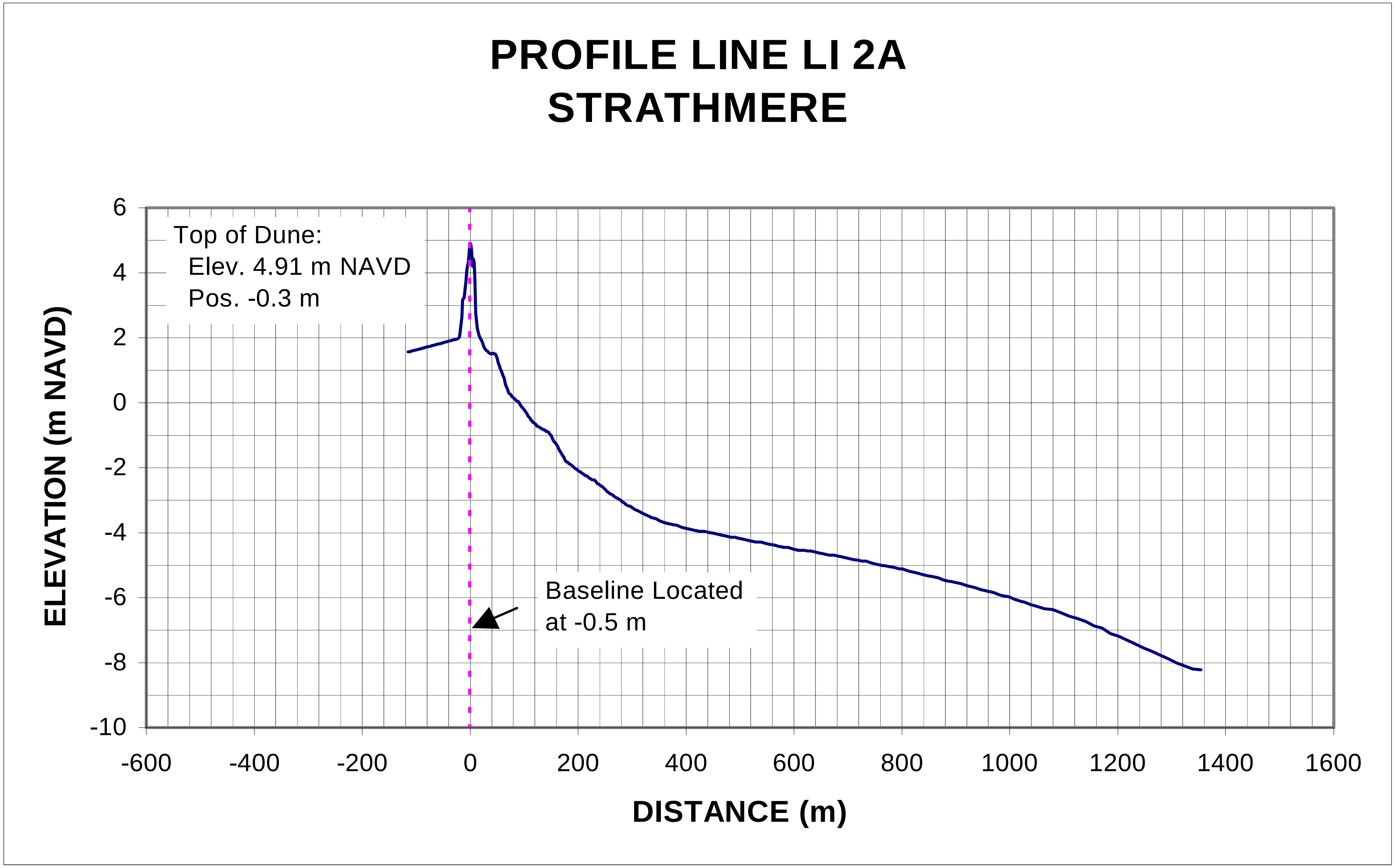


Figure 4.1-5 **Profile Line LI2A, Strathmere.**

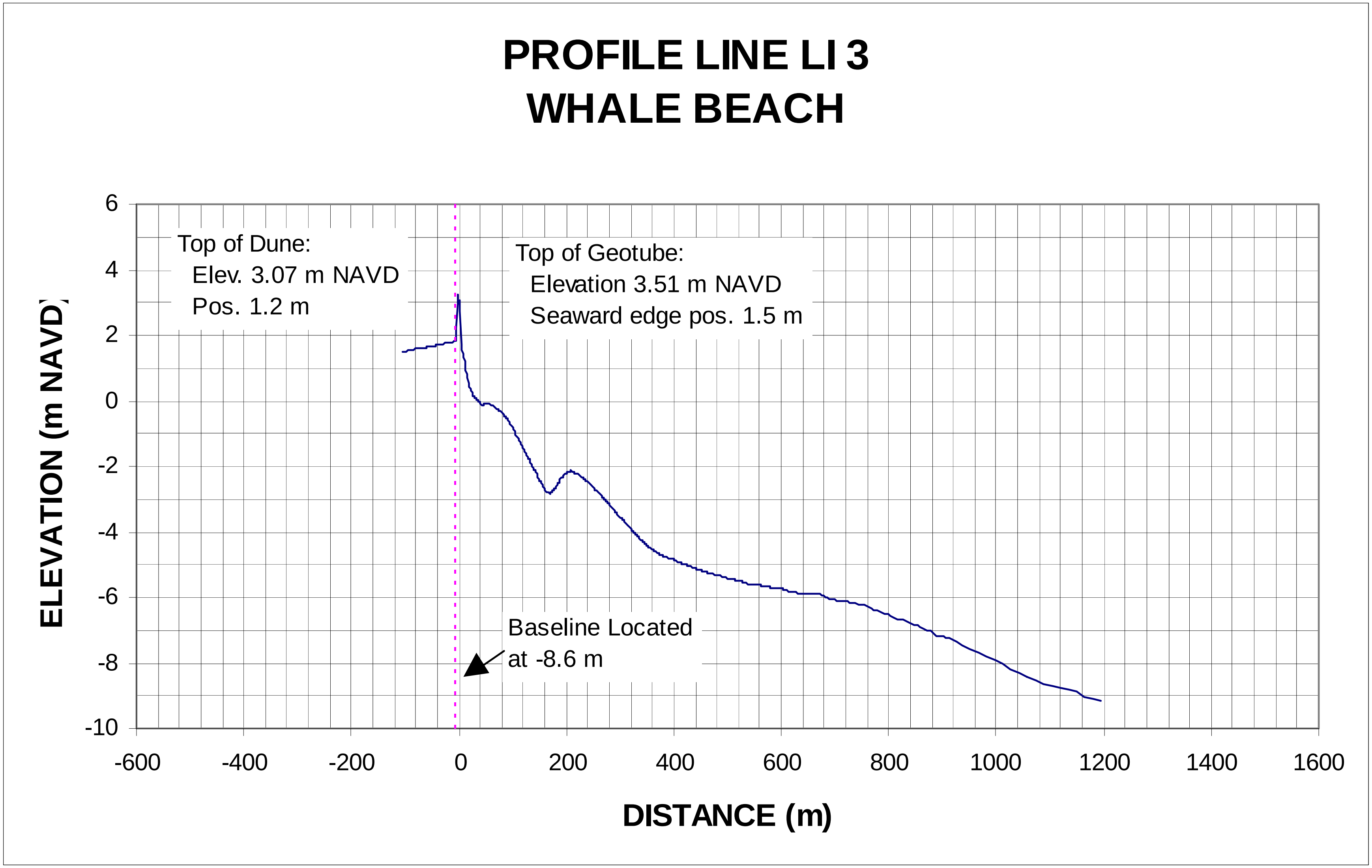


Figure 4.1-6 **Profile Line LI3, Whale Beach area.**

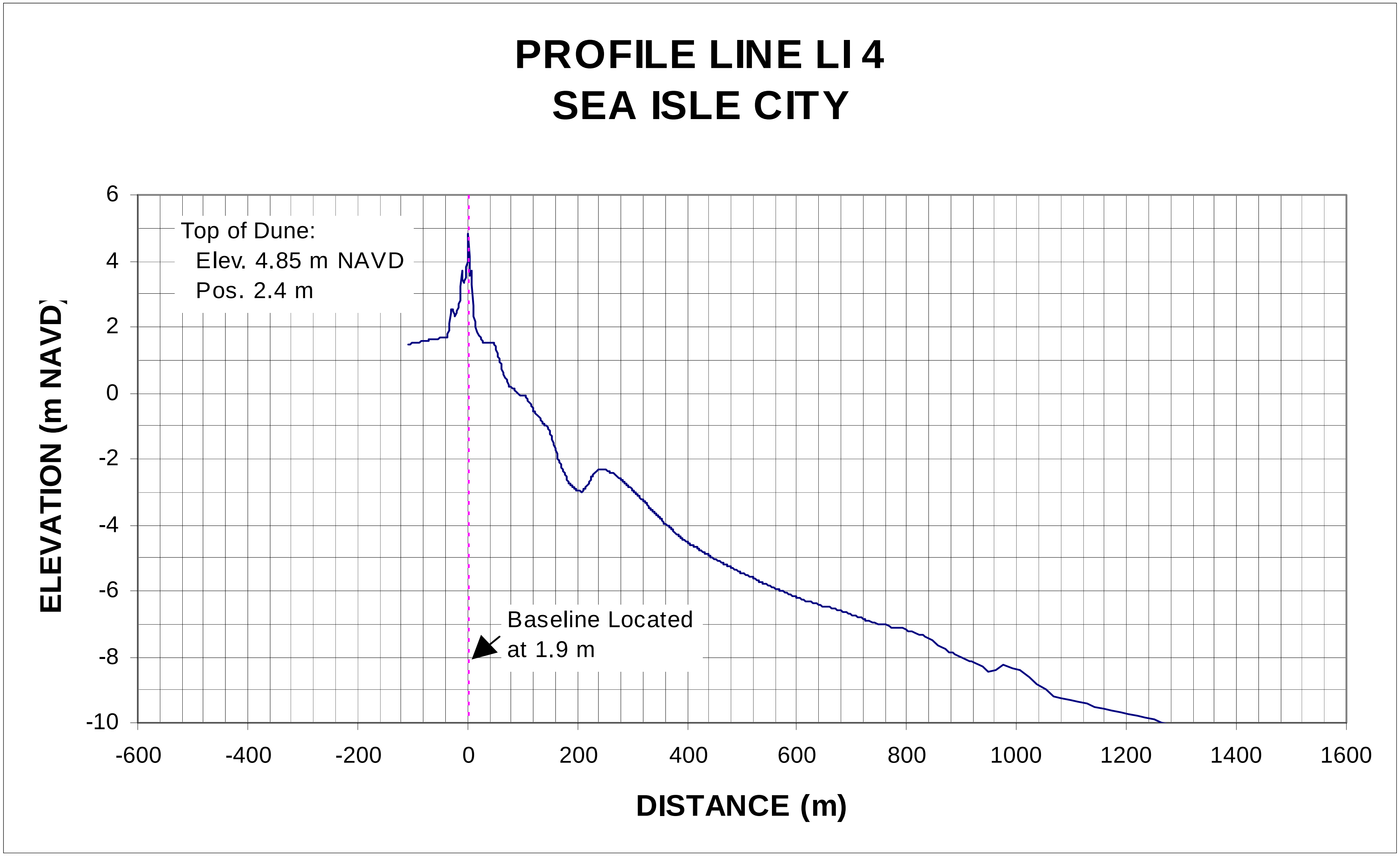


Figure 4.1-7 **Profile Line LI4, Sea Isle City**

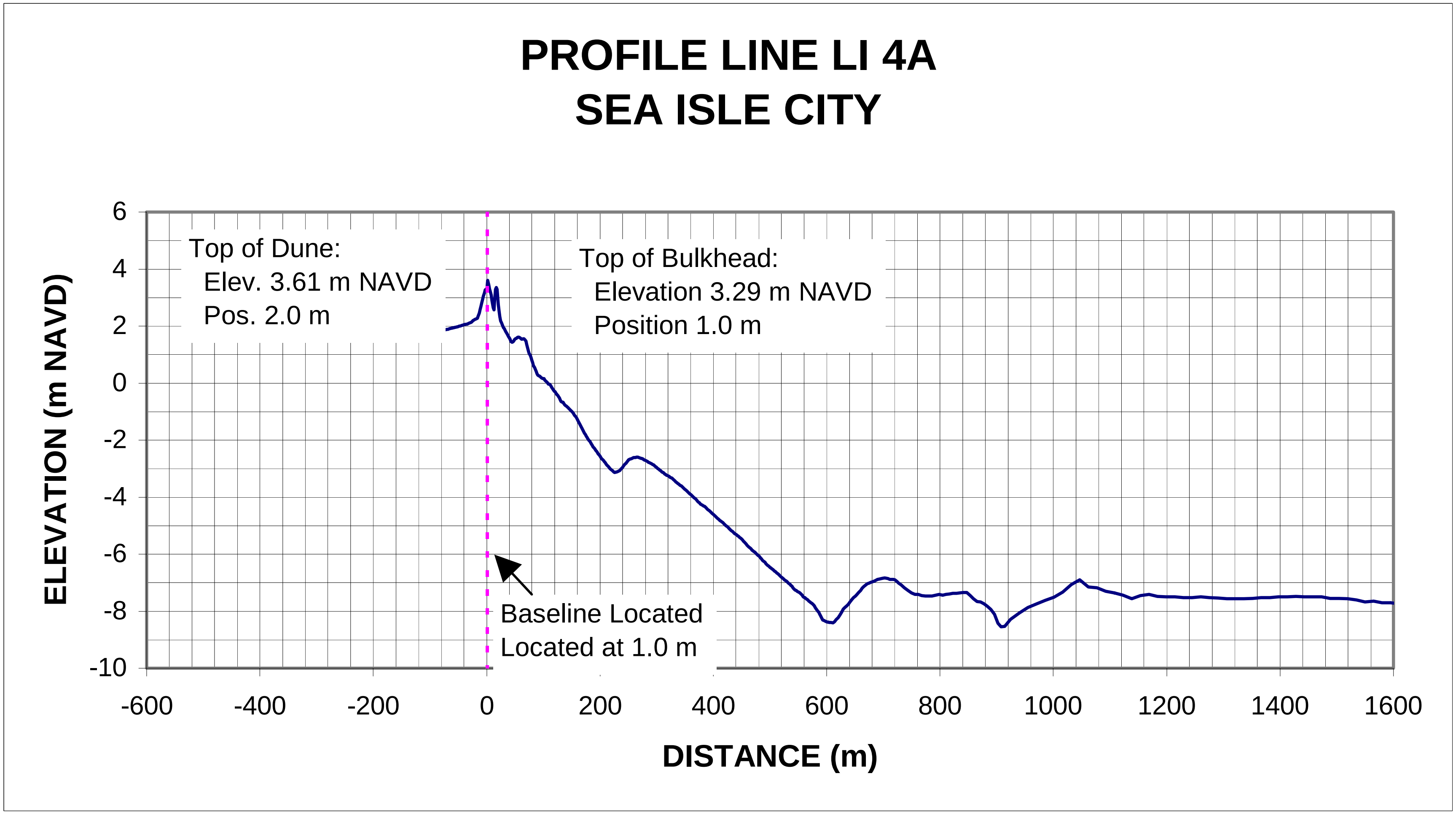


Figure 4.1-8 **Profile Line LI4A, Sea Isle City.**

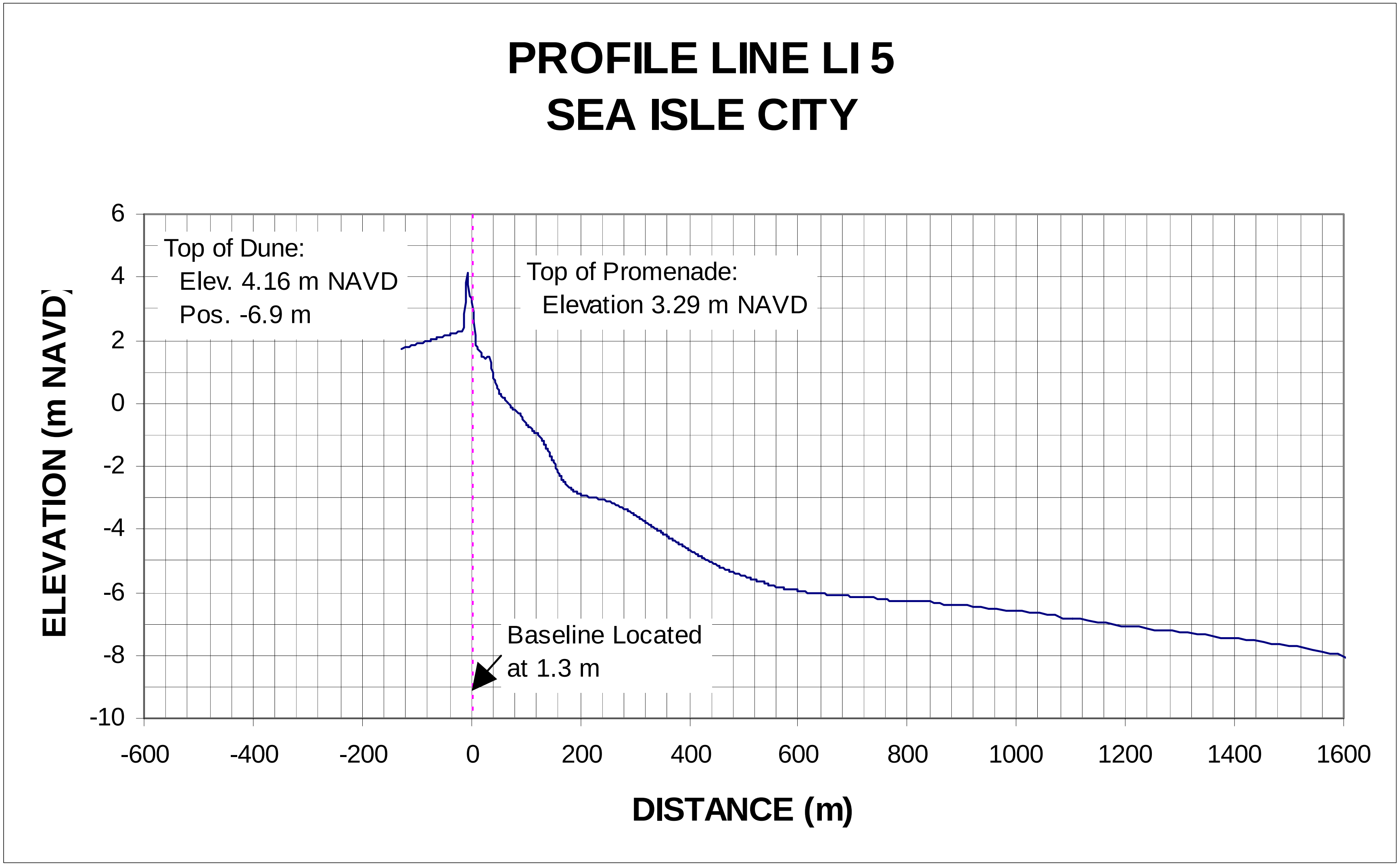


Figure 4.1-9 **Profile Line LI5, Sea Isle City.**

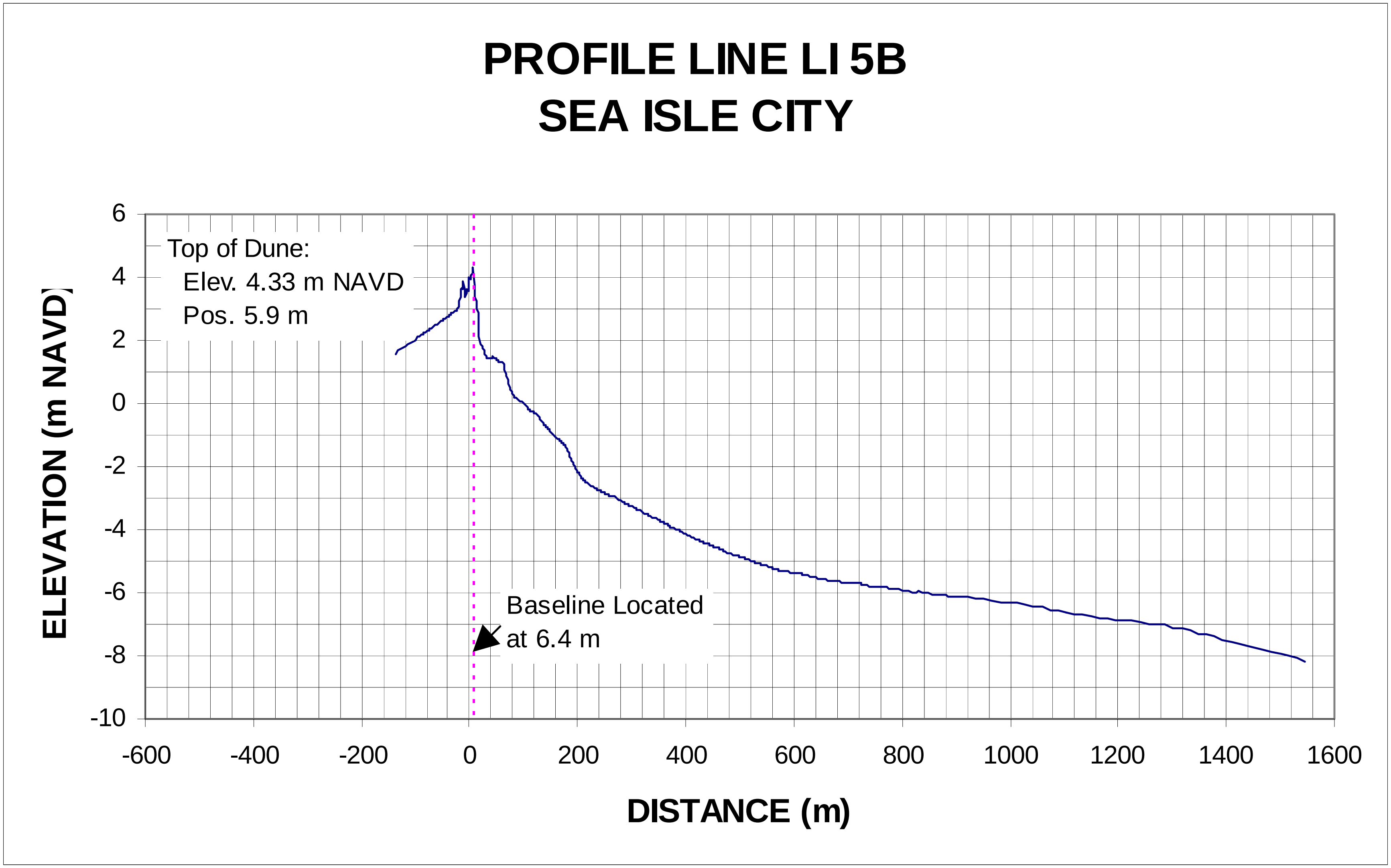


Figure 4.1-10 Profile Line LI5B, Sea Isle City.

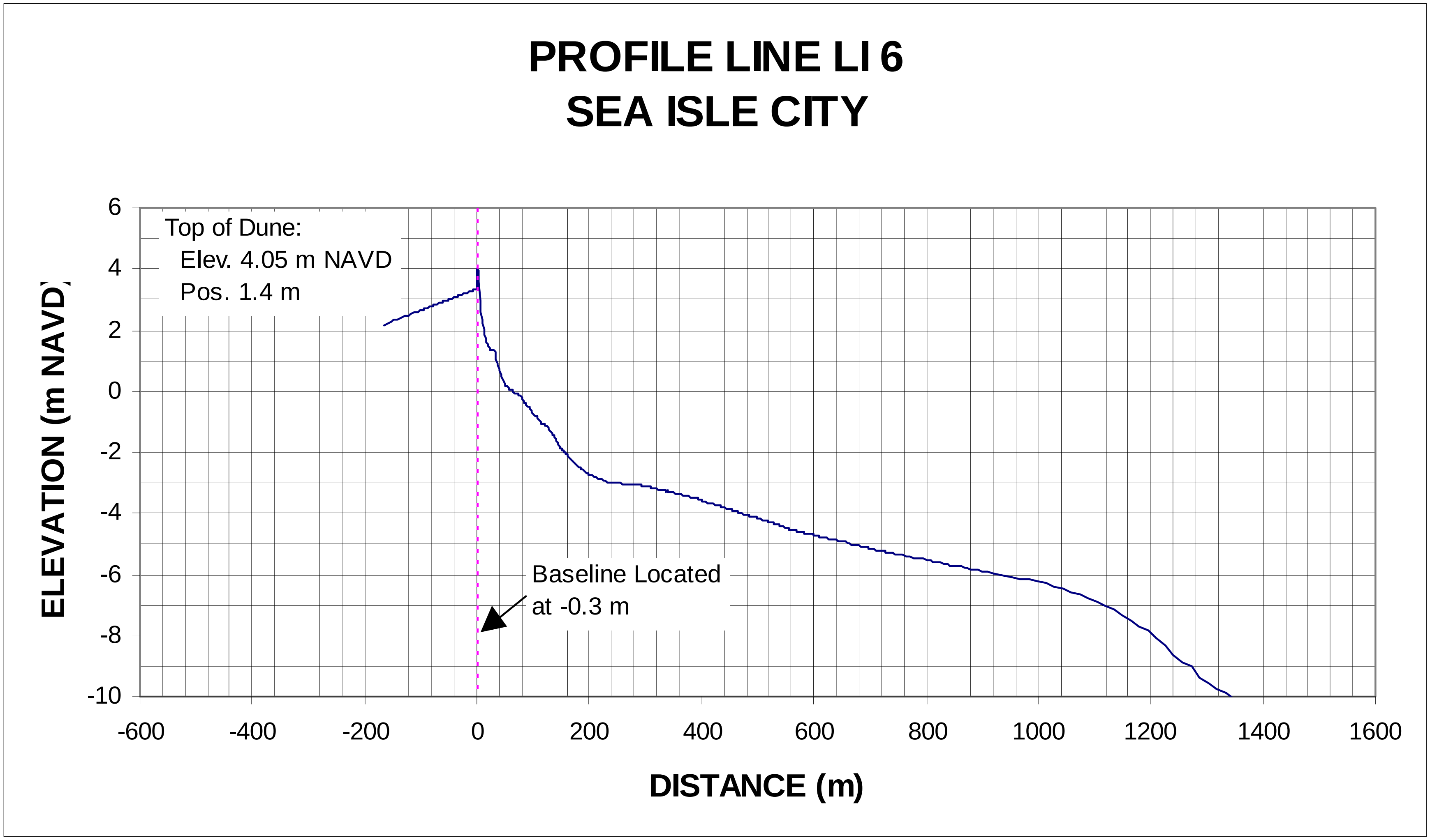


Figure 4.1-11 Profile Line LI 6, Sea Isle City.

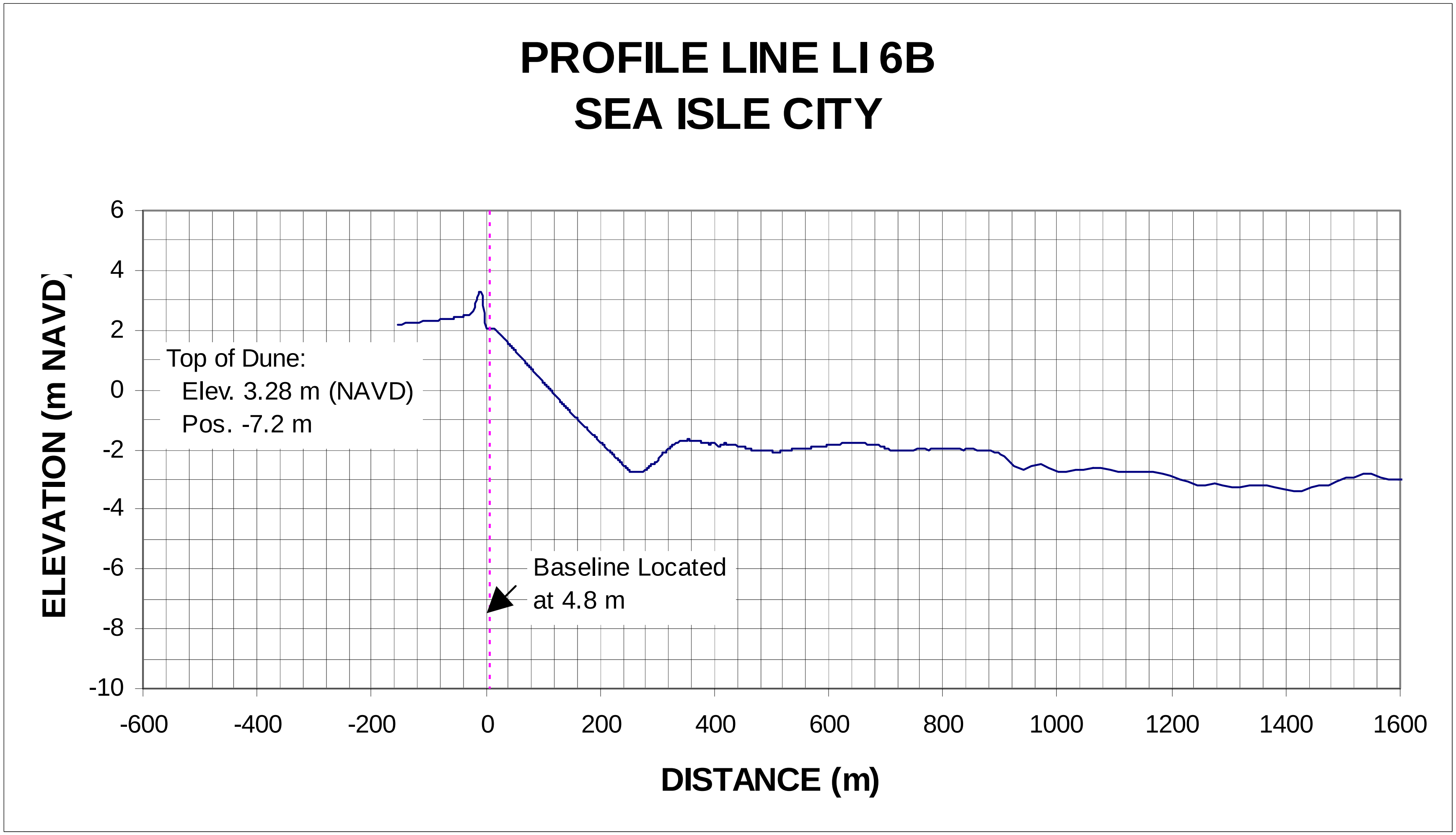


Figure 4.1-12 Profile Line LI 6B, Sea Isle City

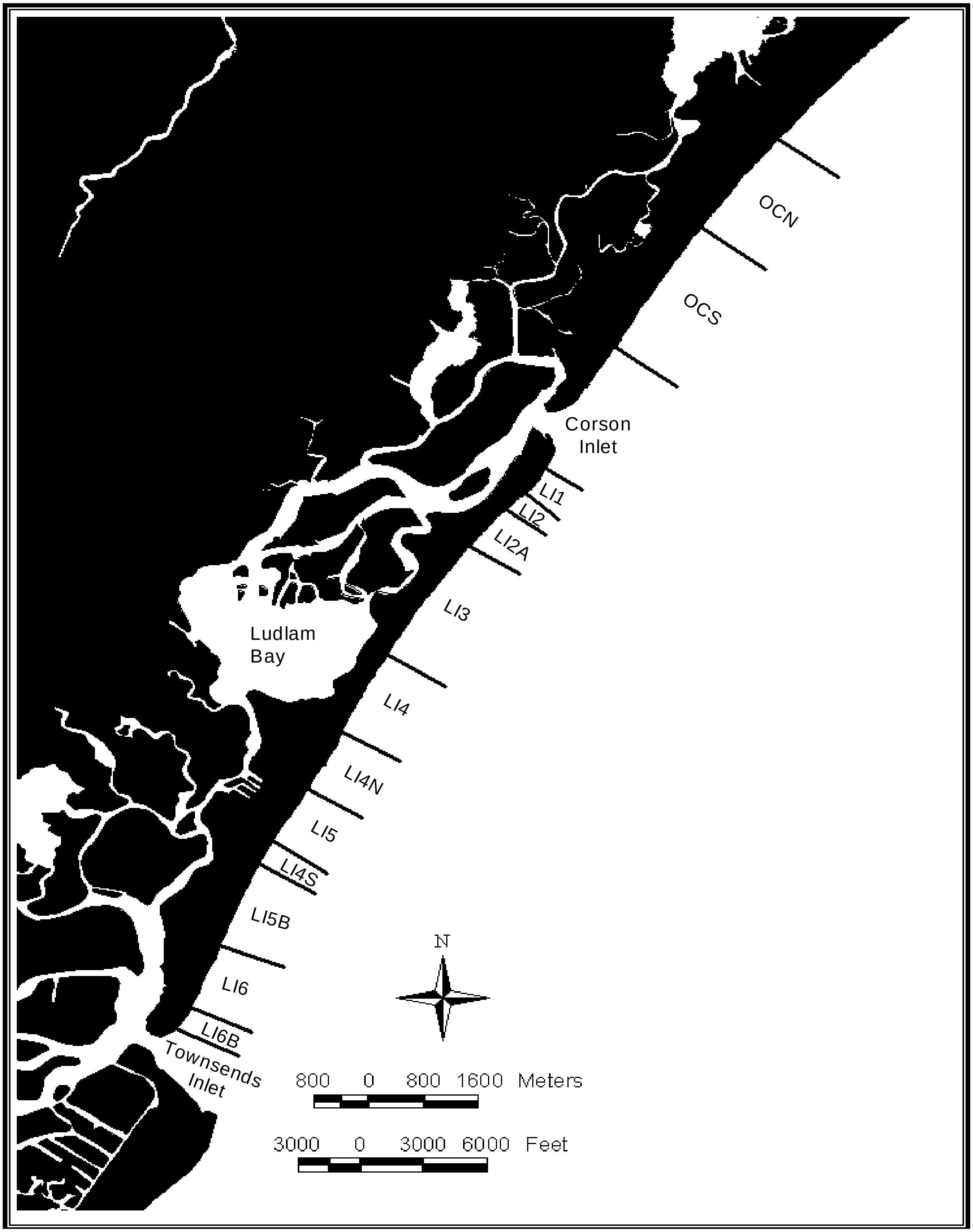


Figure 4.1-13 Cell Boundaries
Note: Profile line "LI4A" was used to represent cells LI4N and LI4S.

Table 4.1.7-1 Cell Descriptions

Cell	Length		Location
	meters	feet	
South End Ocean City			
OCN	1800	5905	Vic 36th St to 46th St
OCS	2292	7519	46th St to 59th St
Ludlam Island			
LI1	478	1569	Strathmere – Seaview to Whittier
LI2	392	1287	Strathmere – Whittier to Sherman
LI2A	785	2576	Strathmere – Sherman to Hamilton
LI3	2090	6858	Whale Beach – Hamilton to approx 13th St
LI4	1406	4613	Sea Isle City – approx 13th to 29th St
LI4N	1035	3395	Sea Isle City –29th St to JFK Blvd
LI5	966	3170	Sea Isle City - JFK Blvd to 52nd St
LI4S	429	1408	Sea Isle City - 52nd St to 57th St
LI5B	1433	4701	Sea Isle City – 57th St to 75th St
LI6	1066	3496	Sea Isle City – 75th to 88th St
LI6B	427	1400	Sea Isle City – 88th to 93rd St.

4.1.8 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. Portions of South End Ocean City, Strathmere and Sea Isle City are fronted with some type of bulkhead or seawall. These structures were accounted for by inputting their locations along the profile along with appropriate failure criteria by waves, water levels, and profile scour. In Sea Isle City, the promenade was allowed to fail as a bulkhead. Section 4.1.12 describes the without project storm analysis results relative to these structures.

4.1.9 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 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 5-, 10-, 20-, 50-, 100-, 200-, and 500-yr frequency events were developed for each of the Ocean City and Ludlam Island study areas as part of the wave hindcast conducted by OCTI. The Gumbel distribution (Fisher-Tippett Type I) was used.

4.1.10 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 nor by the wave height or period alone, but by the combination of these parameters that produces offshore transport.

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

4.1.11 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 1998 were listed in a previous section on water levels (Table 2.7.5-2). 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.

4.1.12 Storm Erosion Simulations

The SBEACH model was applied to predict storm-induced erosion for the Ocean City and Ludlam Island study areas. All representative storm events were run against the pre-storm profiles shown in Figures 4.1.7-1 to 4.1.7-12. 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 profiles based on SBEACH predicted retreat are provided in Figures 4.1.12-1 through 4.1.12-4.

Portions of the shoreline are structured with some type of bulkhead and are represented by profiles OCS, OCN, LI2, LI4A and LI5. In order for storm erosion to affect the community, the bulkhead or 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. For the without-project condition, model simulations resulted in failure of the bulkhead by excessive water elevation at the 50-year storm event for Profiles OCS and LI2 and the 100-year storm for Profiles OCN, LI4A and LI5.

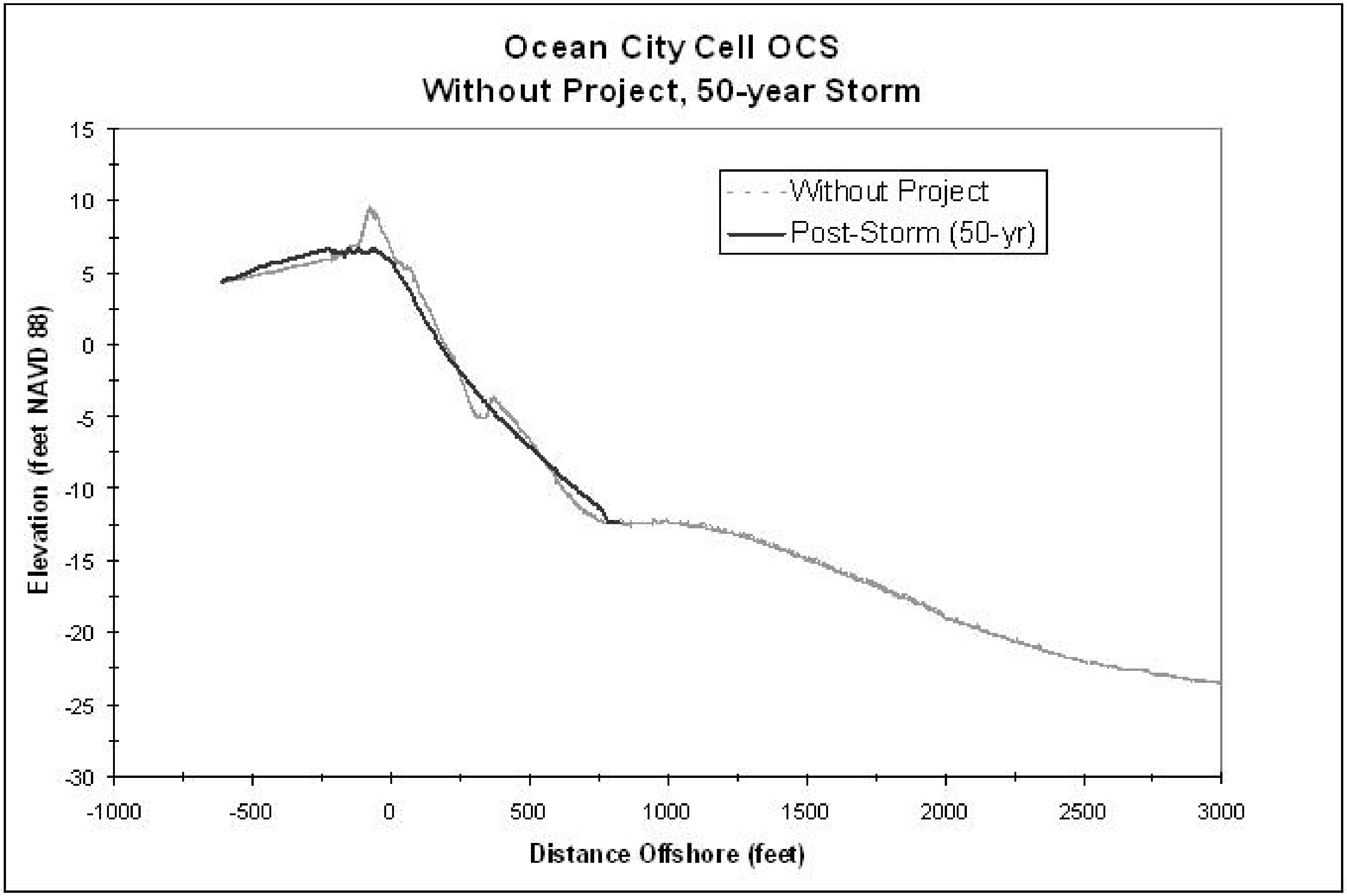


Figure 4.1-14 Pre-storm and post-storm profiles: South End Ocean City, OCS, 50-yr Storm.

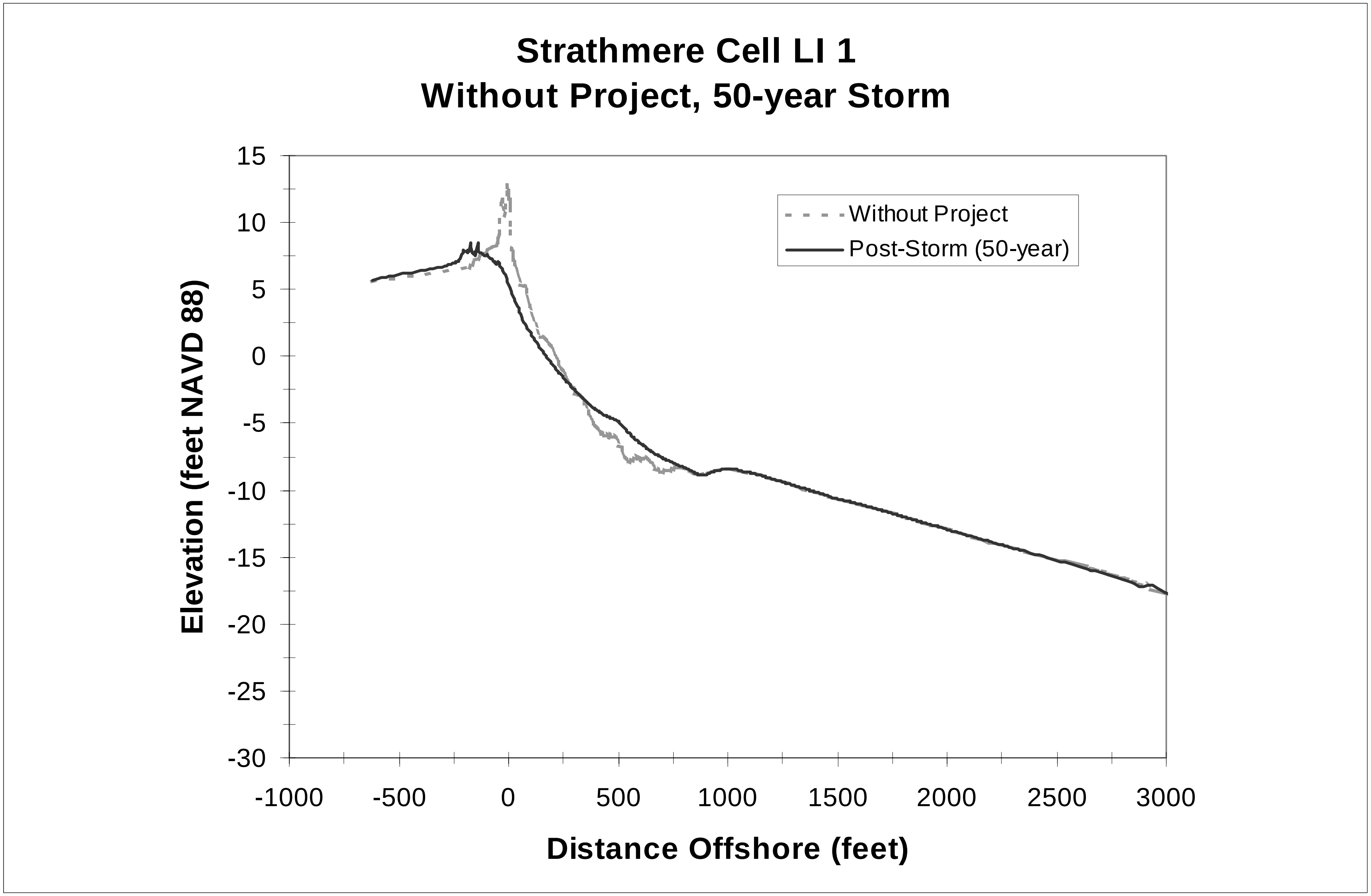


Figure 4.1-15 Pre-storm and post-storm profiles: Strathmere, LI1, 50-yr storm

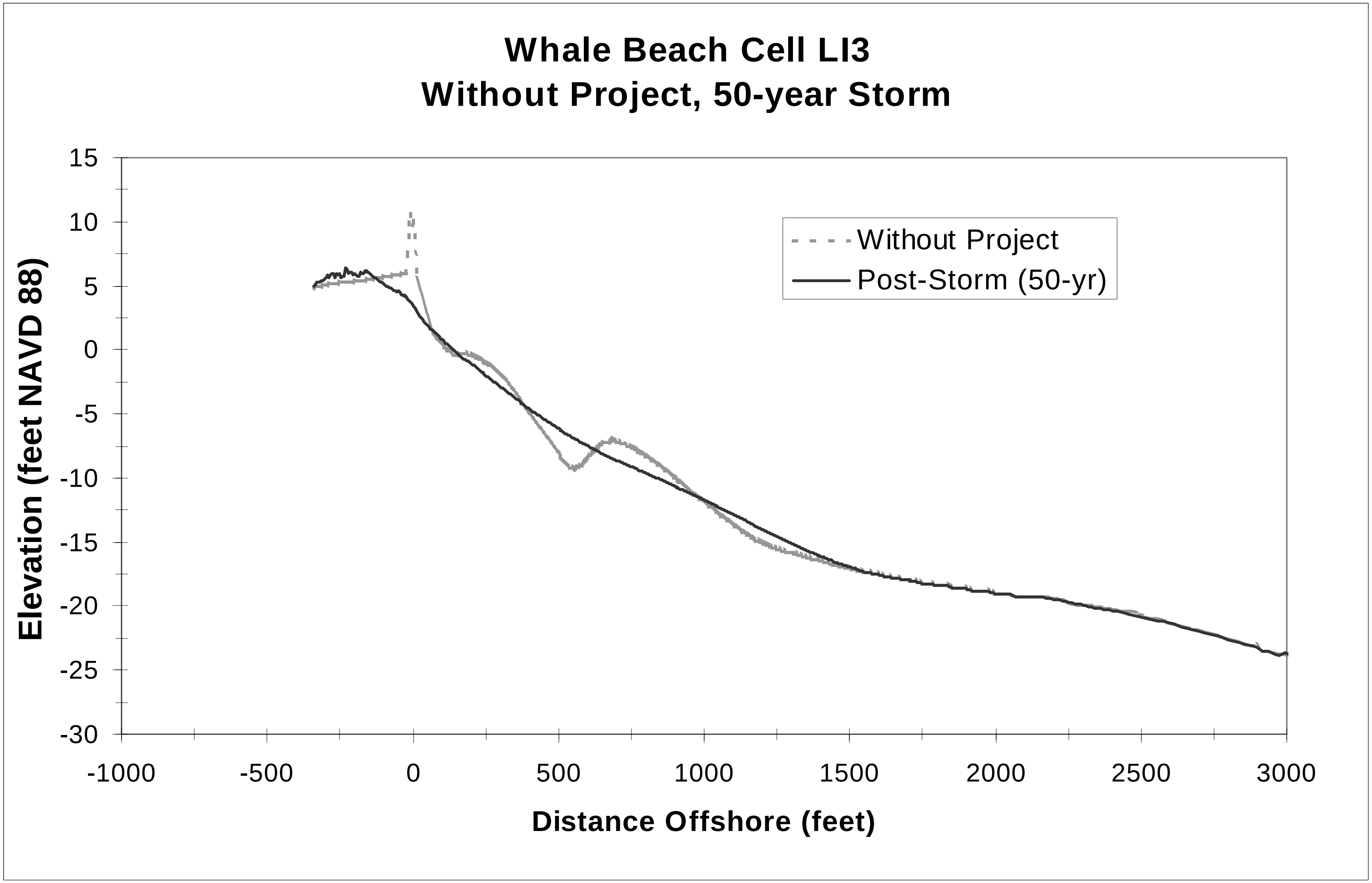


Figure 4.1-16 Pre-storm and post-storm profiles: Whale Beach, LI3, 50-yr storm

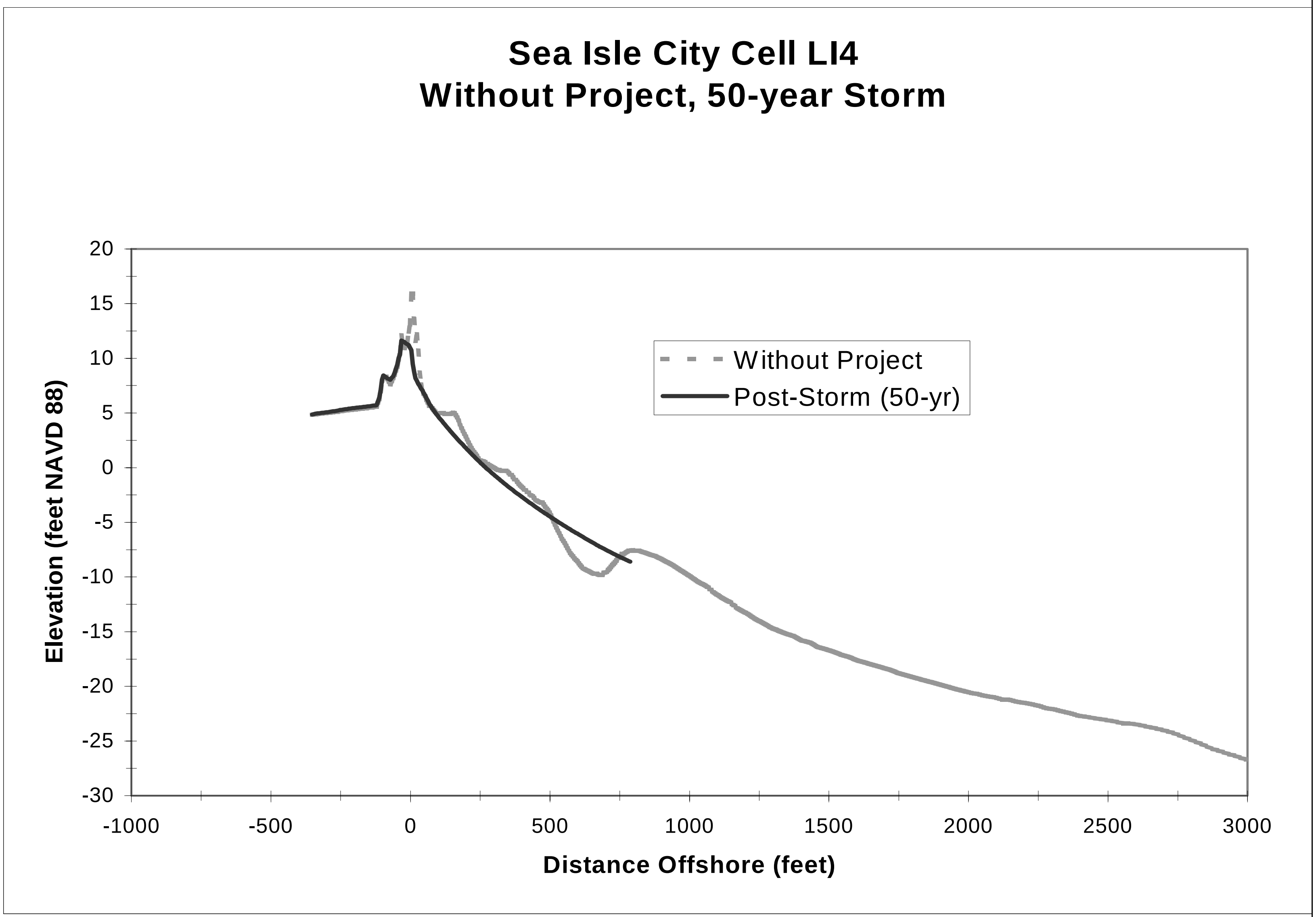


Figure 4.1-17 Pre-storm and post-storm profiles: Sea Isle City, LI4, 50-yr storm.

4.1.13 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 historical or hypothetical 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 Tables 4.1.13-1 and 4.1.13-2. Predicted shoreline erosion positions are reported relative to the designated baseline. The locations of the baseline for each cell are shown on Figures 4.1.7-1 through 4.1.7-12. For OCN, OCS, LI2, and LI4N and LI4S, the baseline lies at the top of the bulkhead. For LI3, the line lies along the seaward side of the road. For LI5, the line lies on the seaward side of the promenade. For LI1, LI4, LI5B, LI6, and LI6B it lies along the approximate centerline of the dune system. In Tables 4.1.13-1 and 4.1.13-2, zero erosion into the community is reported until bulkhead failure occurs and/or erosion encroaches landward of the designated baseline. These erosion values are used as input to the economic model that ultimately computes storm damages associated with storm-related erosion.

Table 4.1.13-1 Storm Erosion Analysis Predicted Shoreline Erosion Positions - South End Ocean City
(m, measured landward from baseline)

Profile/Storm Event	5-year	10-year	20-year	50-year	100-year	200-year	500-year
OCN	0	0	0	0	14	18	20
OCS	0	0	0	21	24	26	27

Table 4.1.13-2 Storm Erosion Analysis Predicted Shoreline Erosion Positions Ludlam Island

(m, measured positive landward from baseline)

Profile/Storm Event	5-year	10-year	20-year	50-year	100-year	200-year	500-year
LI1	12	14	14	29	38	43	50
LI2	0	0	0	46	47	52	53
LI2A	0	0	0	2	15	17	18
LI3*	0	0	0	27	29	31	32
LI4	0	0	0	5	34	35	37
LI4A	0	0	0	0	12	14	15
LI5	0	0	0	0	21	26	32
LI5B	0	0	0	2	31	49	52
LI6	0	5	6	15	34	49	61
LI6B	9	12	18	24	27	29	31

*LI3 with geotextile tubes in place; seaward edge at –11 m from baseline.

4.1.14 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 each beach profile for each hindcasted event. The wave runup and wave setup values were used, along with the eroded beach elevations, to determine inland water surface profiles, inland wave characteristics, and volumes of eroded material which in turn were used to assess economic damages.

4.1.15 Inundation/Wave Attack Methodology

The inland wave attack and inundation methodology used in this project is based upon FEMA guidelines for coastal flooding analysis. The procedure divides possible storm conditions into four cases as described below and shown in Figures 4.1.15-1 through 4.1.15-4. In this feasibility analysis, Case 1 was modified slightly by decaying the wave setup at 0.30 m (1 ft) vertical to approximately 76 m (250 ft) horizontal distance landward.

- Case 1 (shown in Figure 4.1.15-1): 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 0.30 m (1 ft) vertical drop per 305 m (1000 ft) of horizontal distance (modified for this study to a decay of 0.3m each 76m) 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 2 (shown in Figure 4.1.15-2): The top of the dune is above the maximum water level, with wave runup greater than 0.91 m (3 ft) above the dune crest elevation. In this case, the runup depth at the crest is limited to 0.91 m (3 ft), the water depth decays to 0.61 m (2 ft) over first 15.2 m (50 ft) landward of the crest, and stays at 0.61 m (2 ft) until intersecting the bay water level. The wave height is limited to 0.78 times the water depth.

- Case 3 (shown in Figure 4.1.15-3): The top of the dune is above the maximum water level, with wave runup exceeding but still less than 0.91 m (3 ft) above the dune crest elevation. In this case, the depth at the dune crest is the calculated runup depth, which decays to 0.30 m (1 ft) over the first 15.2 m (50 ft) landward of the crest, and stays at 0.30 m (1 ft) until it intersects the bay water level. The wave height is limited to 0.78 times the water depth.

- Case 4 (shown in Figure 4.1.15-4): 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.

The output from the SBEACH modeling at each of the profile lines and 7 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 photogrammetry and quad sheets and bay elevations were used as specified above. The bulkheads located in the project area reduce 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 intervals in which the protective structures will fail for each area were determined previously in conjunction with the erosion analysis.

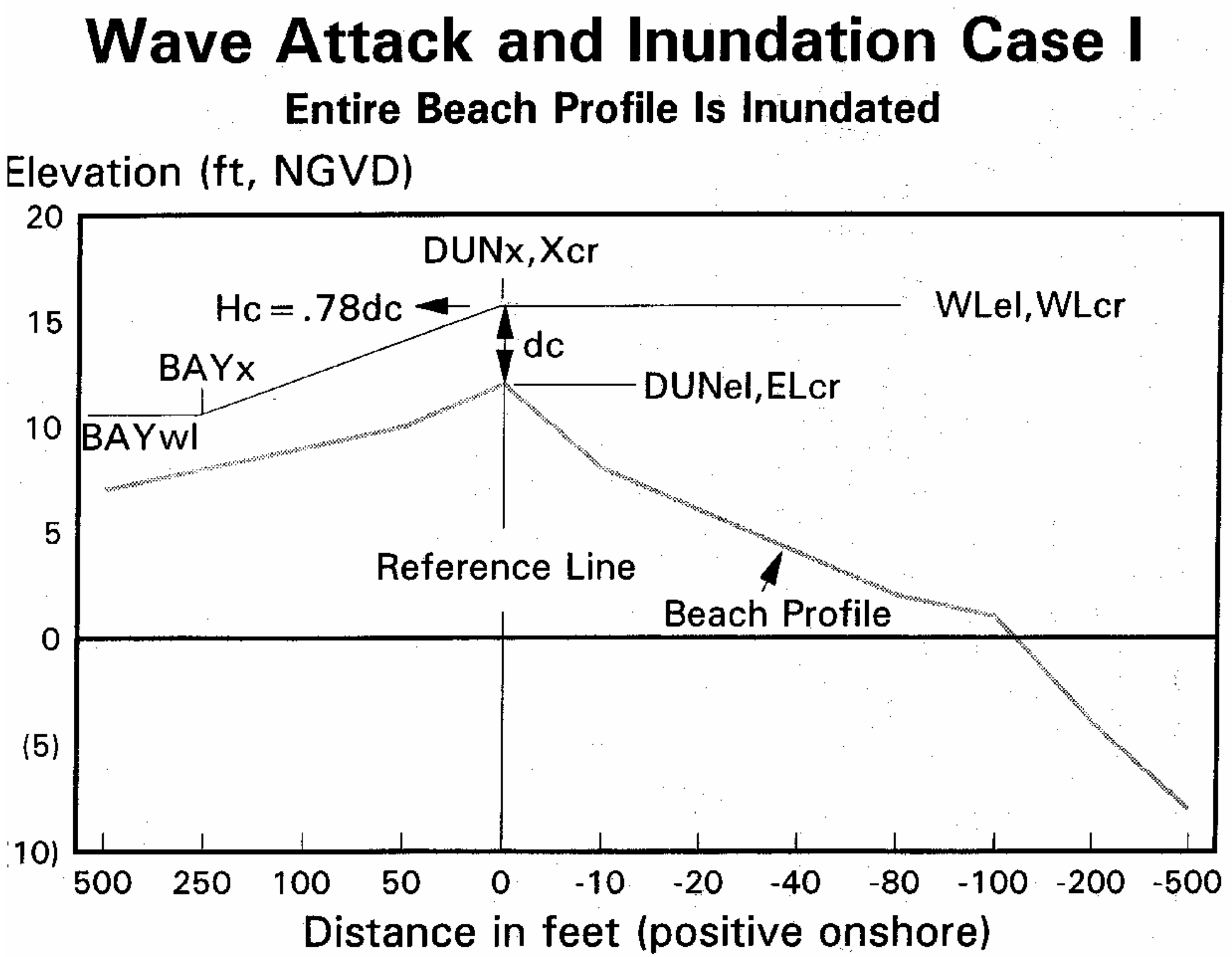


Figure 4.1-18 Case 1: Total Inundation

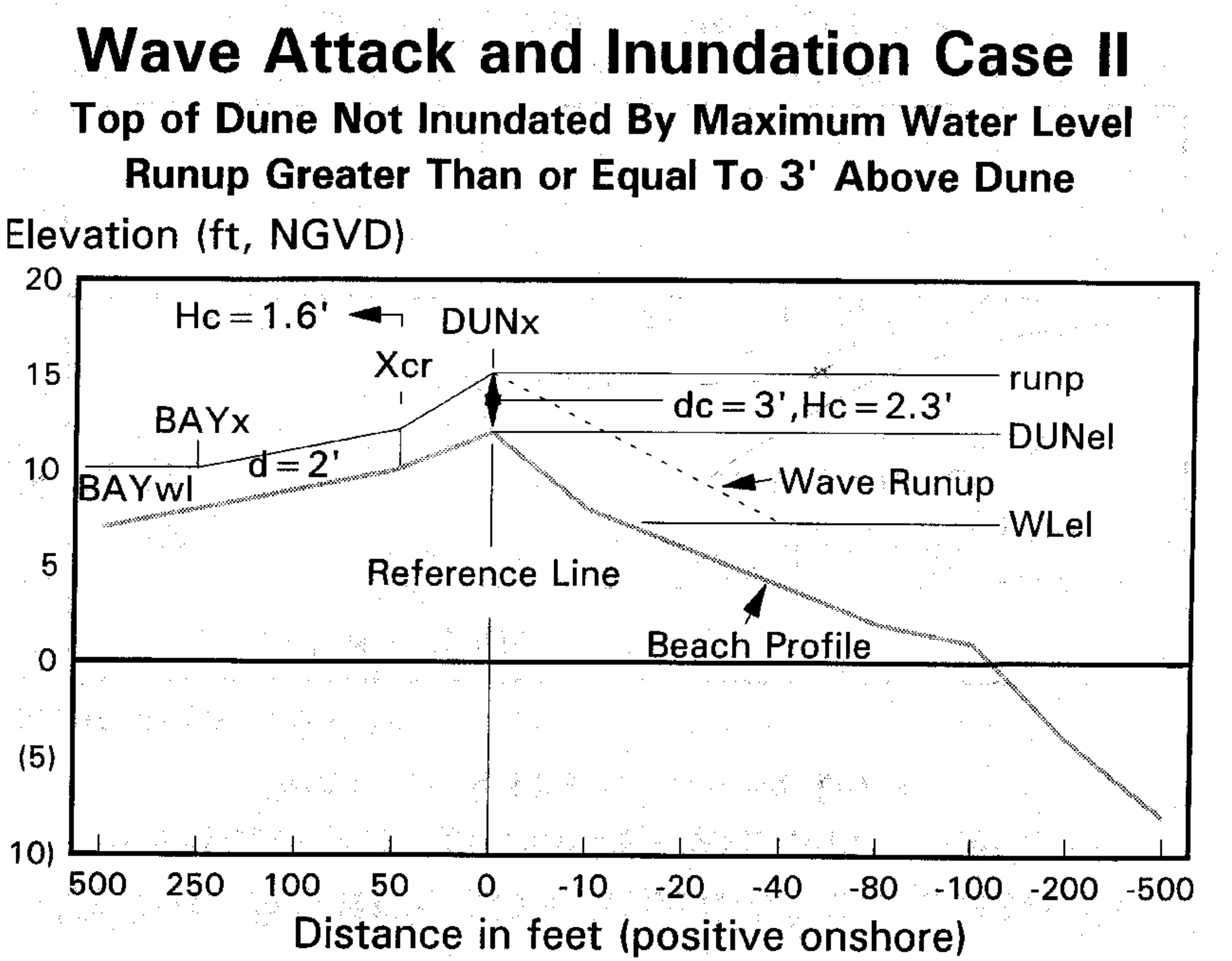


Figure 4.1-19 Case 2: Runup Greater than or Equal to 3 Feet Above Dune.

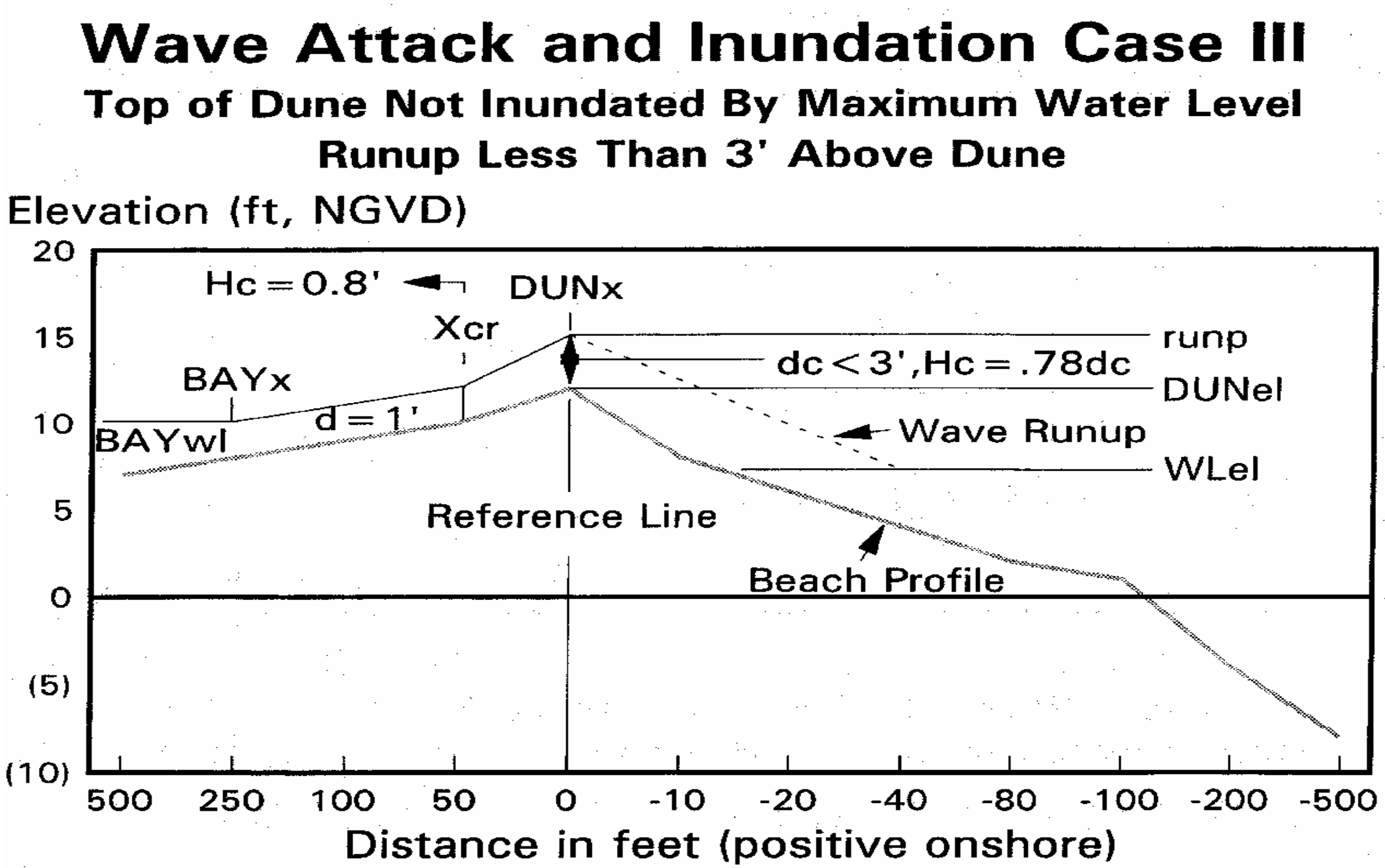


Figure 4.1-20 Case 3: Runup Less than 3 feet

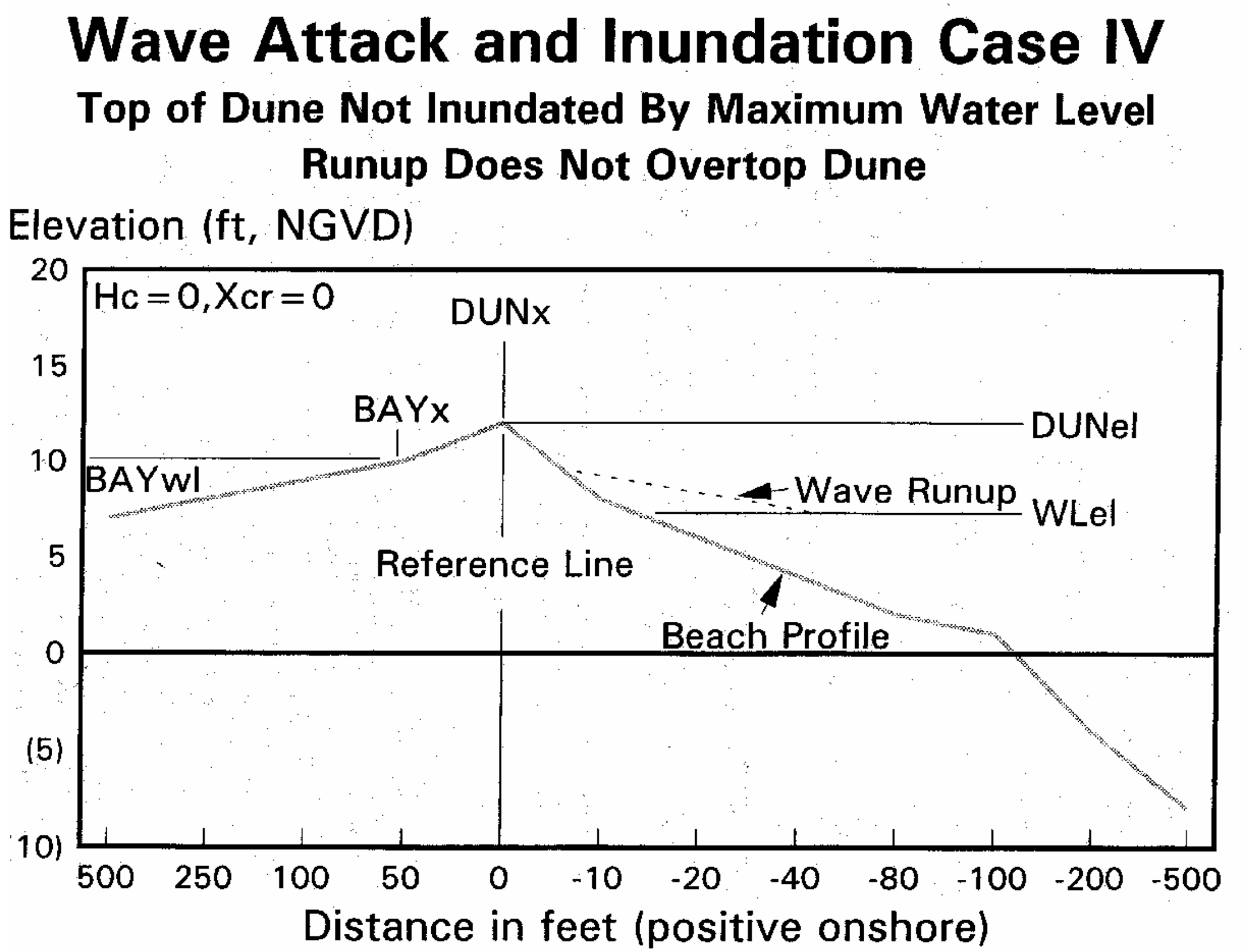


Figure 4.1-21 Case 4: Runup does not overtop dune/no inundation over dune

4.1.16 Back Bay Flooding

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

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

The model conducted for this study included Corson, Townsends, and Hereford Inlets. Figure 4.1.16-1 depicts the channels that were modeled. A total of 84 cross-sections or nodes were input to describe the system. Depth soundings for each cross section were interpolated from the National Oceanic Atmospheric Administration (NOAA) Nautical Chart for Little Egg Harbor to Cape May. The model was calibrated to predicted tides for Corson Inlet and various other locations within the system. Predicted stages for 5 through 500-year storms were then used to drive the model. Model results indicated differences on the order of 0.1 m between ocean and back bay stages for each storm. Therefore, it is assumed that water levels along the back bay shorelines are not damped and are in-phase with the ocean water levels and the bay stage-frequency curve used in the inland inundation analysis is as shown in Figure 2.7.5-1.

4.1.17 Without-Project Inundation and Wave Attack Results

Computed inundation and wave attack results in modified COSTDAM model format for each of the respective profile lines are provided in Engineering Appendix D. Storm erosion results are also shown in the tables.

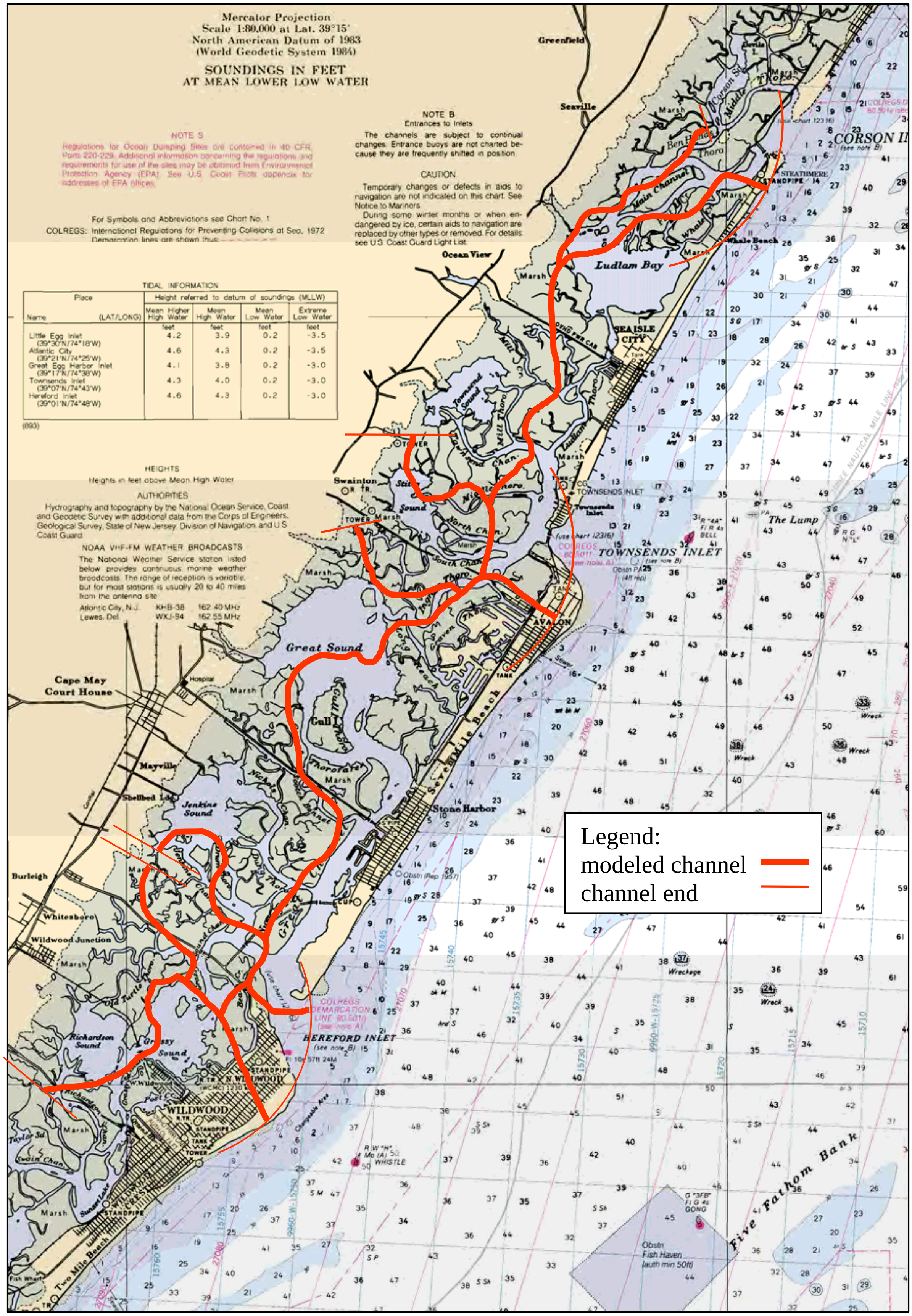


Figure 4.1-22 DYNLET model area

4.2 Without-Project Economic Analysis

4.2.1 Area of Analysis

For summary damage assessment purposes, the study area was separated into two areas, South End Ocean City and Ludlam Island. For analysis purposes, the areas were also broken down in cells identical to those identified previously in section 4.1.7. Figure 4.1.7-13 and Table 4.1.7-1 displays the cell delineation.

4.2.2 Conditions

An October 1998 price level, 50-year period of analysis, and a base year of 2005 were used in the economic analysis. The values of costs and benefits were converted to an annual equivalent time basis using a 6.875% discount rate as applicable to public works projects. All methodology used was consistent with other recently completed USACE storm damage reduction feasibility studies along the New Jersey coast.

4.2.3 Structure Inventory

During the summer of 1998, over 1,250 structures within the delineated study area were inventoried and evaluated for existing conditions (structure and foundation type, first floor elevation). In general, this included structures up to about one block inland from the beach. The Marshall and Swift, Residential and Commercial Estimator was used to estimate the value of each structure. This value is calculated using the replacement cost less depreciation (using an October 1998 price level). Per USACE regulations, the structural value used in this study is the lesser of this value compared to the market value of the structure. As expected, the market value of the structures was always greater and therefore not used. The content value estimate of each structure used was 40%[6] of the structural value.

Information was also obtained for existing infrastructure such as public utilities and roadways.

4.2.4 Storm Damage Methodology and Categories

"Without-project" condition damages were calculated for seven frequency storm events (5, 10, 20, 50, 100, 200 and 500 year events) for erosion, wave and inundation damage to structures, infrastructure and "improved property".

Storm damage calculations to the 1,250 inventoried structures 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 which contains the database information of each structure. A "control" file, generated from the

[6] Engineering Regulation 1105-2-100 allows up to a 50% structure to content value without the use of a survey. The value used was based on past experience with similar, approved feasibility studies, as well as socio-economic and demographic data.

SBEACH model runs as described in section 4.1.3, contains the hydraulic profiles used to characterize the wave, erosion, and inundation mechanisms.

COSTDAM first checks if a structure has been damaged by wave attack based on the relationship between the structure's first floor elevation and the total water elevation that sustains a wave. Next, COSTDAM checks for erosion damage at a structure. Finally, COSTDAM calculates inundation damages if the water elevation is higher than the first floor elevation based on Federal Insurance Administration (FIA) depth-damage curves adjusted for increased saltwater damagability. To avoid double counting, if damage occurs by more than one mechanism, COSTDAM takes the maximum damage of any one given mechanism (wave, erosion, or inundation).

More detailed information regarding the damage category calculations are as follows:

4.2.4.1 Erosion Damages

To determine damage due to storm erosion, the distance between the reference line (normally a bulkhead or dune line) and the front and back walls of each structure were measured from the planimetric mapping and input into the structure file.

Examining the results from the SBEACH model run, if the structure is not on a pile foundation, it was assumed that a structure is destroyed at the point that the land below the structure is eroded halfway through the structure. If the structure is on piles, erosion needs to retreat entirely through the footprint before total damage is claimed. Before total failure for both foundation types, the percent damage claimed is equal to the proportion of erosion under the structure's footprint compared to the total footprint required for 100% damage.

This structure failure point methodology used is the approved “Wilmington District” methodology. Design and coastal engineers have endorsed the validity of the storm erosion and failure mechanism used in COSTDAM. The assumption that damage claimed is equal to the proportion of erosion under the structure’s footprint (for pile structures) prior to total destruction is a determination that was made based on engineering judgment.

Infrastructure damages in this analysis are defined as costs or damages incurred or borne by either local, state, or utility entities attributed to the localized nature of storm frequencies that do not involve damages to housing or building structures. This includes roads and utilities. For Ludlam Island, specifically Sea Isle City, this includes the promenade. Infrastructure damage was assessed by estimating the value of the infrastructure from the baseline to the 500 year erosion outline of the study area. This was then annualized using the HEC Expected Average Annual Damage (EAD) program.

Damage to the land that the structures are on (henceforth called “improved property”) was also calculated. The cost of filling/restoring the improved property is based on a typical lot for the different depths, widths and cubic yards of erosion produced by storms. The improved property value was determined by comparing market value of near shore property to the cost of simply filling in the eroded land for reutilization. The cost of filling/restoring the eroded improved property was determined to be the cheaper of the two, and was used to estimate total damages.

4.2.4.2 Wave and Inundation Damages

A structure is considered damaged by a wave when there is sufficient force in the total water elevation to destroy a structure. Partial wave damages are not calculated; instead the structure is subject to inundation damages. A flood can potentially cause damages to property and their 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.

Depth damage curves were used to estimate the damage to structures. The distinguishing characteristics of these curves were foundation type and the number of stories in the structure. For commercial structures, the business activity was also a distinguishing factor.

4.2.4.3 Detour Costs

As a result of storms, the main road through Ludlam Island is historically prone to failure along the Whale Beach area. While locals have placed geotextile tubes, closure of this road due to significant storm events will still be likely. There are costs associated with closure of this road during time needed for repair as an alternate detour route is used. The original route as well as the most likely alternate route was measured to determine additional mileage and time due to traffic rerouting. The alternate route measures 26 kilometers (16 miles) for a duration of 21 minutes, whereas the original route measures 6 kilometers (4 miles) at 5 minutes based on an estimated annual vehicle use of about 864,000 over the Corson Inlet Bridge, (source:Cape May County Bridge Commission), or 2,361 vehicles on an average daily basis. The additional detour mileage is 19 kilometers (12 miles), for an additional time of 16 minutes. The original route which makes use of the Corson Inlet Bridge has a road toll of $0.50; the alternate route which makes use of the Garden State Parkway has a toll of $0.35.

Detour costs are composed of two categories; additional operating costs and delay costs. Estimates of the average vehicle variable operating expense were obtained from the American Automobile Association and the American Automobile Manufacturer's Association for expenditures for a common intermediate size vehicle. For the five year period of 1995 to 1999 the average variable cost is about 10.5 cents per mile. This is the amount for expenditure for gas and oil, maintenance, and tires. It is an estimate of mileage-sensitive expenditure on driving. The additional operating cost due to the additional detour miles, adjusted for the difference in tolls, is about $2,600 per day.

In addition to operating costs, there is also an opportunity cost per vehicle. Work trips were based on a one person per vehicle occupancy. The value of time saved is represented as a percentage of hourly family income of the driver. The percentage used, 67.1%, is an average for work trips, social/recreational, other trips and vacations as per ER-1105-100 "Value of Time

Saved by Trip Length and Purpose". The average hourly income was based on the county average of $23.15 (Oct. 1999 p/l), which on an hourly basis results in a calculated opportunity cost of about $15.50 per hour per vehicle. The delay cost equates to about $9,700 per day.

The additional cost due to the detour route is about $12,300 per day. Based on historic incidences the number of days of road closure was estimated for each storm frequency and then annualized based on the probability of occurrence. The threshold for "no detour" delays is the 20-year frequency storm event. Although some road damage would be experienced at that event, it is not until beyond that storm frequency event that a detour would be expected. Beyond that, frequency estimates were made for road closure and detour. For example, based on a 50-year storm, the detour would be effective for 77 days, resulting in a detour cost of about $951,000; a 100-year storm would have a cost of about a million dollars resulting from an eighty-one day detour. The expected average annual without-project detour cost due was calculated to be $37,000.

4.2.5 Without-Project Condition Damages Summary

The without-project conditions were computed based on the hydrologic profiles and housing characteristics of the cells. Tables 4.2.5-1 and 4.2.5-2 display the cumulative structure distribution by frequency and storm zone per cell for combined residential and commercial structures. Of the 1,250 structures inventoried, there are a total of 551 structures in the 500 yr. storm zone for South End Ocean City and 709 for Ludlam Island.

Table 4.2.5-1 Structures by Damage Category/Frequency - South End Ocean City

Storm Event[7]	Erosion	Inundation	Wave	Total
5 yr	0	0	0	0
10 yr	0	16	0	16
20 yr	0	16	0	16
50 yr	71	38	151	260
100 yr	60	34	443	537
200 yr	17	12	521	550
500 yr	0	0	551	551

Table 4.2.5-2 Structures by Damage Category/Frequency - Ludlam Island

Storm Event	Erosion	Inundation	Wave	Total
5 yr	2	1	0	3
10 yr	2	25	0	27
20 yr	5	42	0	47
50 yr	59	79	64	202
100 yr	142	110	337	589
200 yr	111	46	514	671
500 yr	60	17	632	709

Tables 4.2.5-3 and 4.2.5-4 display the expected average annual damage to structures by cell and damage mechanism for South End Ocean City and Ludlam Island respectively. Totals also include $81,000 for South End Ocean City and $343,000 for Ludlam Island of annualized damages due to back-bay flooding during storm events, which this study does not address. Since only shoreline structures were inventoried in this study, actual back-bay flooding damages would naturally be greater if all structures were inventoried and included in the storm model runs.

Table 4.2.5-3 Average Annual Damages to Structures by Category - South End Ocean City

[7] Another method of presenting this storm event frequency data is:

5 year storm event = 20% probability of a storm of this magnitude or greater occurring in a given year
10 year = 10%
20 year = 5%
50 year = 2%
100 year = 1%
200 year = 0.5%
500 year = 0.2%.

Cell	Erosion	Inundation	Wave	Total
OCN (36th-46th St)	$39,000	$224,000	$1,411,000	**$1,674,000**
OCS (46th-59th St)	$607,000	$353,000	$2,430,000	**$3,390,000**
South End Ocean City Total	**$646,000**	**$577,000**	**$3,841,000**	**$5,064,000**
% of damages	**13%**	**11%**	**76%**	

Table 4.2.5-4 Average Annual Damages to Structures by Category - Ludlam Island

Cell	Erosion	Inundation	Wave	Total
LI1 (Seaview-Whittier)	$109,000	$76,000	$104,000	**289,000**
LI2 (Whittier-Sherman)	$72,000	$66,000	$139,000	**$277,000**
LI2A (Sherman-Hamilton)	$8,000	$9,000	$56,000	**$73,000**
LI3 (Hamilton-13th Street)	$61,000	$17,000	$307,000	**$385,000**
LI4 (13th-29th St)	$25,000	$27,000	$198,000	**$250,000**
LI4N (29th-JFK Blvd)	$2,000	$468,000	$753,000	**$1,223,000**
LI5 (JFK-52nd)	$43,000	$32,000	$781,000	**$856,000**
LI4S (52nd-57th)	$0	$59,000	$110,000	**$169,000**
LI5B (57th-75th)	$179,000	$7,000	$106,000	**$292,000**
LI6 (75th-88th)	$204,000	$217,000	$199,000	**$620,000**
LI6B (88th-93rd)	$29,000	$66,000	$147,000	**$242,000**
Ludlam Island Total	**$732,000**	**$1,044,000**	**$2,900,000**	**$4,676,000**
% of damages	**16%**	**22%**	**62%**	

The above results were compared with FEMA records showing actual insurance claims following the December 1992 storm. This showed comparable results between the model runs and actual storm damages.

Tables 4.2.5-5 and 4.2.5-6 shows infrastructure and "improved property" damages (described in section 4.2.4.1) for South End Ocean City and Ludlam Island.

Table 4.2.5-5 Infrastructure and Improved Property Damages – South End Ocean City

Cell	Infrastructure	Improved Property	Total
OCN	$3,000	$6,000	**$9,000**
OCS	$41,000	$18,000	**$59,000**
Total	**$44,000**	**$24,000**	**$68,000**

Table 4.2.5-6 Infrastructure and Improved Property - Ludlam Island

Cell	Infrastructure	Improved Property	Total
LI1	$13,000	$6,000	**$19,000**
LI2	$12,000	$4,000	**$16,000**
LI2A	$1,000	$1,000	**$2,000**
LI3	$60,000	$11,000	**$71,000**
LI4	$17,000	$16,000	**$33,000**
LI4N	$7,000	$3,000	**$10,000**
LI5	$12,000	$7,000	**$19,000**
LI4S	$4,000	$2,000	**$6,000**
LI5B	$7,000	$15,000	**$22,000**
LI6	$10,000	$28,000	**$38,000**
LI6B	$0	$7,000	**$7,000**
Total	**$143,000**	**$100,000**	**$243,000**

A summary of all above damage categories are shown in the following tables:

Table 4.2.5-7 Summary of Average Annual Without-Project Damages - South End Ocean City

Cell	Structural Damage	Infrastructure	Improved Property	Total
OCN (36th-46th St)	$1,674,000	$3,000	$6,000	**$1,683,000**
OCS (46th-59th St)	$3,390,000	$41,000	$18,000	**$3,449,000**
South End Ocean City Total	**$5,064,000**	**$44,000**	**$24,000**	**$5,132,000**

Table 4.2.5-8 Summary of Average Annual Without-Project Damages - Ludlam Island

Cell	Structural Damage	Infrastructure	Improved Property	Total
LI1 (Seaview-Whittier)	$289,000	$13,000	$6,000	**$308,000**
LI2 (Whittier-Sherman)	$277,000	$12,000	$4,000	**$293,000**
LI2A (Sherman-Hamilton)	$73,000	$1,000	$1,000	**$75,000**
LI3 (Hamilton-13th Street)	$385,000	$60,000	$11,000	**$456,000**
LI4 (13th-29th St)	$250,000	$17,000	$16,000	**$283,000**
LI4N (29th-JFK Blvd)	$1,223,000	$7,000	$3,000	**$1,233,000**
LI5 (JFK-52nd)	$856,000	$12,000	$7,000	**$875,000**
LI4S (52nd-57th)	$169,000	$4,000	$2,000	**$175,000**
LI5B (57th-75th)	$292,000	$7,000	$15,000	**$314,000**
LI6 (75th-88th)	$620,000	$10,000	$28,000	**$658,000**
LI6B (88th-93rd)	$242,000	$0	$7,000	**$249,000**
Ludlam Island Subtotal	**$4,676,000**	**$143,000**	**$100,000**	**$4,919,000**
Detour Costs				**$37,000**
Ludlam Island Total	**$4,676,000**	**$143,000**	**$100,000**	**$4,956,000**

4.2.6 Local Costs

As detailed in sections 1.5.3 and 1.6 of this report, the State of New Jersey and local communities have been active in providing storm damage protection measures. In the absence of a Federal project, similar costs to maintain the project area would need to continue. The State of New Jersey and local communities have historically "held the line" as needed. New Jersey has a $25 million fund for shore protection protects, not including additional funding for emergency situations.

For South End Ocean City, a beachfill was placed in 1995 and 2000 and will very likely need to continue in both cost and frequency. Thus, in the absence of a Federal project, the average annual local costs foregone over the 50-year period of analysis for South End Ocean City were calculated to be $440,000.

In the case of Ludlam Island, historical data easily demonstrates the state and local commitment to maintaining the island. Locals have paid for their share or shore protection projects by floating bonds for high cost projects or using budget surplus for smaller projects. For instance, the state and City of Sea Isle City spent more than $6 million since 1992 on a ten-block stretch in the southern portion of Sea Isle City. However, other than the exception of expenditures in the Whale Beach area, there is no recent existing pattern of expenditures that parallel the situation found in South End Ocean City. Predicted future local costs for Ludlam Island were based on historical and predicted local projects and detailed in Table 6.3.2-1. According to this analysis, the average annual local costs for Ludlam Island were calculated to be $1,285,000.

The following table details how local costs were calculated. In column 1, a significant portion of the local costs is based on the historical response to the storm of 1984, less than a 20-year stage frequency event. Therefore, adding 22[8] years to this date would bring us to 2006, 2026, and 2046. Column 2 is based on proposed plans by the City of Sea Isle and documented in written correspondence between the city engineer and NAP. These plans would need to be constructed by the locals if the selected Federal plan is not implemented. It should be noted that this number could be increased by more than $4 million based on the proposed groin construction in Whale Beach. Column 3 is an estimate of the beachfill requirements needed in the Whale Beach area (Cell LI3) in lieu of a Federal project. This number is very conservative and is simply based on the need to respond to the long-term erosion rate of three feet per year, basically "holding the line." Column 4 estimates the major nourishment costs required for two cells in along Ludlam Island which are conservatively estimated to occur in years 2026 and 2046.

[8] Adding 20 years would have been prior to the project base year, and therefore would not have been counted in the analysis.

Table 4.2.6-1 Estimated Future Local Costs - Ludlam Island

Cell	(1) Historical Storm Damage Fills[9] (all 1984$ unless noted)	(2) Plans[10] (current $)	(3) Estimate of beachfill needed due to long-term erosion[11]	(4) Estimate of major nourishment due to storm events[12]	Local Costs Determination Calculation
LI1 (Seaview to Whittier)	$436,809	Before base year (by NJDEP)			Based on column 1 at years 2006, 2026, and 2046.
LI2 (Whittier to Sherman)	$358, 221	Same as previous			Same as previous
LI2B (Sherman to Hamilton)	$716,909	Same as previous			Same as previous
LI3 (Hamilton to 13th Street)	$988,061	$1,984,590	$542,808		Based on column 2 at 2006, column 1 at years 2026 and 2046, and column 3 every 5 years starting at year 2010.
LI4 (13th to 29th)		$2,767,764		$1,400,000	Based on column 2 at 2005 and column 4 at years 2026 and 2046.
LI4N (29th to JFK (41st))		$324,000		$1,430,000	Based on column 2 at 2005 and column 4 at years 2026 and 2046.
LI5 (41st to 52nd)	$475,198	$1,270,500			Based on column 2 at 2005, then add column 1 at 2026 and 2046.
LI4S (52nd to 57th)	$499,476	$278,250			Same as previous
LI5B (57th to 75th)	$1,667,144				Based on column 1 at year 2006 then 2026, and 2046.
LI6 (75th to 88th)	$1,010,683				Same as previous
LI6B (88th to 93rd)	$33,397 (1985) $480,940 (1987)				Same as previous

4.2.7 Unquantified Damages

4.2.7.1 Emergency Costs

In addition to the cost of restoring building and infrastructure after a storm event, there is the cost of emergency protective measure and debris clearance that can be taken into account. For the most frequent storm events, this has traditionally involved removal of sand from streets and repair of any dune walkovers. These costs are relatively minor compared to structural

[9] Based on information contained in Table 1.5.3.3-1 and 1.5.3.2-1 of feasibility report.

[10] Based on information provided by Sea Isle City.

[11] Based on sand volumes needed to offset the effects long-tern erosion rate of 3 feet per year

[12] Based on quantities calculated by CENAP.

damage, and it is likely most of these measures would be still be required even with a storm damage reduction protection. Therefore, they were not quantified.

4.2.7.2 Loss of Human Life

As a result of the March 1962 storm, in Cape May County, 545 people suffered minor injuries and 127 suffered major injuries. With the advances in tracking meterological events, advanced warning systems, and the creation and use of evacuation routes in coastal communities, the potential for loss of human life due to flooding or coastal storm events has been significantly reduced. However, the potential for loss of human life still exists.

5 PLAN FORMULATION

This section describes the formulation procedure and results for the Great Egg Harbor Inlet to Townsends Inlet Feasibility Study. The plan formulation process involved the establishment of plan formulation rationale, identification and screening of potential alternatives, and the evaluation of detailed plans responsive to the identified problems and needs. Information is provided on the criteria used in the formulation process, the presentation of the procedures followed in evaluating various alternatives, and the subsequent designation of the selected plan(s).

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 Considered
Cycle 2 - Secondary Screening of Solutions Considered
Cycle 3 - Final Screening and Optimization of the Selected Alternative Solutions

By analyzing the alternative solutions in this manner, the solution that best fits the planning objectives and constraints can be formulated in a logical and efficient manner.

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 areas are located adjacent to the study area:

- *New Jersey Shore Protection Study, Townsends Inlet to Cape May Inlet Feasibility Study, Final Feasibility Report, March 1997*
- *New Jersey Shore Protection Study, Brigantine Inlet to Great Egg Harbor Inlet, Absecon Island Interim Study, Final Feasibility Report, August 1996*
- *General Design Memorandum and Final Supplemental Environmental Impact Statement, Great Egg Harbor Inlet to Peck Beach-Ocean City, NJ, 1990*

Cycle 1 - Initial Screening of Solutions Considered

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.

Without undertaking an in-depth analysis, the goal of the cycle 1 analysis was to screen out those alternatives which obviously do not fulfill the needs of the study area or are inappropriate due to other factors such as having a low level of suitability for the area. Judgements were made about each alternative based on knowledge gained from researching past reports, the professional experience of each study team member and other CENAP personnel. In addition, input from the non-Federal sponsor, NJDEP, concerning the effectiveness of alternatives was considered as well as input from local officials and organizations.

There were two general categories of solutions that were initially considered for implementation in the study area, namely, non-structural measures and structural measures. Non-structural measures are those which 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 the storm damage mechanisms. Typically, specific non-structural solutions include: regulation of any future development (setback limits, building elevation restrictions etc.), and permanent abandonment or evacuation of the study area. These latter options are usually not feasible due to the level of development or economic base of a region.

Structural measures are those which protect property. Some of these alternatives are used to provide protection against potential storm damage or act to impede or otherwise interfere with erosive processes. These typical structural alternatives consist of seawalls, bulkheads, revetments, breakwaters, groins and beach/dune fill. In general, seawalls, bulkheads and revetments are shore parallel structures used to retain fill and/or reduce direct wave attack on the backshore. Breakwaters are also shore parallel structures usually constructed of stone/rubble and placed offshore to absorb incoming wave energy. Groins (sometimes incorrectly referred to as "jetties" by locals), on the other hand, are shore perpendicular structures used to interrupt the long shore sediment transport to hold sand on the beach. Beach/dune fill is the actual placement of sand from a borrow source on the beach to provide a larger berm/dune. Of these structural alternatives, seawalls, bulkheads, revetments, breakwaters and groins are typically expensive to construct and may conflict with the natural ecosystem and are not usually favored by environmental or regulatory agencies. The beach/dune fill option, however, is usually less expensive and is more environmentally favorable since it is most closely related to the natural beach environment. However due to existing erosion (both long-term and storm-induced), long-term periodic nourishment is normally required over the project life. (It should be noted that the beach/dune fill option has been the main feature of the selected plans for all recent Philadelphia District storm damage reduction feasibility studies in both New Jersey and Delaware.)

Cycle 2 – Second Level Screening of Solutions Considered

The purpose of cycle 2 was to further narrow down the number of alternatives for consideration in cycle 3. Only those alternatives that were suitable in terms of the engineering, environmental, social and economic impacts remained after the completion of cycle 2

Cycle 3 - Final Screening and Optimization of the Selected Alternative Solutions

The cycle 1 and cycle 2 screening process eliminated many of the potential alternative measures. The alternatives examined in this cycle had detailed analysis performed which included designs, model runs, and costs, etc to determine the selected plan. A 50-year period of analysis was used with an October 1998 price level, and a 6.875% discount rate.

The selected plan is determined solely on cost-effectiveness by comparing the benefits expected to be derived by the proposed alternatives and their estimated costs. The selected plan is the one with the greatest amount of net benefits (benefits minus costs). Plan selection is not accomplished with the goal of providing a specific level of protection from storm events (i.e. 50-year frequency event).

5.1 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 statues, 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.

After an evaluation of the existing conditions within the study area, coupled with coordination with other federal, state, and local governments, agencies, and organizations, existing problems were organized so that general objectives and subsequent detailed solutions could be developed in an effective and efficient manner. Each of the problems will be evaluated separately, using the three-cycle plan formulation process.

The problems and objectives in the study area were identified as follows:

I. *PROBLEM:* *Storm Damage to South End Ocean City*

CAUSE: *Wave attack, inundation, and erosion*

OBJECTIVE: *Reduce storm damage caused by wave attack, inundation, and erosion*

II. *PROBLEM:* *Storm Damage to Gardens area of Ocean City*

CAUSE: *Wave attack, inundation, and erosion*

OBJECTIVE: *Reduce storm damage caused by wave attack, inundation, and erosion*

III. *PROBLEM:* *Storm Damage to Ludlam Island*

CAUSE: *Wave attack, inundation, and erosion*

OBJECTIVE: *Reduce storm damage caused by wave attack, inundation, and erosion*

5.2 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.

5.2.1 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 2.7 of this report.

5.2.2 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.

5.2.3 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.

5.2.4 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 compliment, 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.

5.2.5 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.

5.2.6 Additional Considerations

Alternatives were developed and considered that would accomplish the following:

a) Combine naturally with the physical characteristics of the existing ecosystem

b) Be in accordance with desires and guidelines expressed by various Federal, state and local agencies and organizations

c) Integrate with other related programs in the study area

d) Be implementable with respect to the financial capabilities of the non-federal sponsor

e) Minimize, where possible, long-term Federal expenditures

5.3 Plan Formulation - South End Ocean City

<u>Problem</u>: *Storm damage to South End Ocean City*
<u>Cause</u>: *Wave attack, inundation, and erosion*
<u>Objective:</u> *Reduce storm damage caused by wave attack, inundation, and erosion.*

5.3.1 South End Ocean City: Cycle 1 Initial Screening of Alternatives

A. <u>No Action Alternative</u>: This is synonymous with the without-project condition. The no action alternative is used to compare the effects of alternative plans. It consists of both the baseline and expected future conditions, assuming no Federal involvement.

<u>Non-Structural Alternatives:</u>

B. Permanent evacuation from areas subject to storm damage
C. Regulation of future development

<u>Structural Alternatives:</u>

D. Berm restoration
E. Dune restoration
F. Geotextile tubes
G. Berm and dune restoration
H. Berm and dune restoration using structural reinforcement (geotextile tubes etc.)
I. Groin field
J. Berm and dune restoration with groin field
K. Berm and dune using structural reinforcement and groin field
L. Increase height of existing bulkhead
M. Offshore detached breakwater
N. Berm and dune restoration with offshore detached breakwater
O. Perched beach
P. Offshore submerged feeder berm
Q. Beach dewatering

A. <u>No Action</u>. This alternative involves no measures to provide storm protection. The potential without-project damages discussed in section 4 of this report would most likely be realized.

B. <u>Permanent Evacuation from Areas Subject to Storm Damage</u>. Permanent evacuation of existing developed areas subject to storm damage involves the 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 areas subject to storm damage are either demolished or relocated to another site. The level of development at Ocean City would make this measure expensive. The cost of long-term shore protection to this area is probably low compared to the cost of permanent evacuation of the residences. Ocean City contains many structures that house year-round residents. Additionally, permanent evacuation would probably meet with strong opposition from these locals. This alternative was not considered in Cycle 2.

C. Regulation of Future Development. Regulation or land use controls could be enacted through codes, ordinances, or other regulations to minimize the impact of erosion on lands which could be developed in the future. Such regulations are traditionally the responsibility of State and local governments. There currently are regulations in place to control future development and reduce susceptibility to damage such as CAFRA (Coastal Area Facility Review Act) 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 Ocean City. Therefore additional regulation to prevent new development would have little impact. This alternative was not considered in Cycle 2.

D. Berm restoration. This alternative involves the placement of beachfill material (sand), directly onto the existing beach in order to widen and stabilize 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 pushes the wave breaker zone and inundation profile seaward and provides sacrificial sediment during storms. It also incidentally provides beach habitat for species like the piping plover. Normally, the beach requires future additional sand placement (periodic nourishment), on a periodic basis so that the required design is maintained. The existing Federal beachfill project located in the northern portion of Ocean City consists of this option. This alternative was considered in Cycle 2.

E. Dune restoration. Involves using sand to construct dunes to a desired height and width. This would add significant protection from overtopping during storm events. However, without a significant berm to protect it, the dune becomes very vulnerable and ineffective during significant storm events as it is susceptible to erosion and wave impact. This alternative was not considered in the Cycle 2 formulation.

F. Geotextile tubes. This alternative consists of the use of sand-filled geotextile tubes. The advantage over a traditional sand dune is that during storm events the tubes may provide greater protection since the tubes would not erode as easily as a sand dune. This would also reduce the amount of long-term periodic sand placement needed to maintain the dune. Failure of the geotextile tube dune would instead likely be due scour. The tubes would also need to be covered with sand for aesthetic reasons. This alternative has recently been constructed on Ludlam Island, both in the Whale Beach area and the Townsends Inlet area. Due to the lack of a beach berm fronting the tubes at the Townsends Inlet location, the structural stability of the tubes has been compromised through constant wave and tidal influences. Therefore, the use of geotextile tubes as a dune would likely be more effective in combination with a berm (existing or constructed). This alternative was not further examined in the Cycle 2 formulation but was combined with a berm and dune alternative.

G. Berm and dune restoration. This alternative is a combination of D and E. This alternative provides a high level of storm protection and merges favorably with the existing environment and has been shown in recent Philadelphia District studies to be the most effective and cost efficient in terms of providing protection from storms. Therefore, this alternative was included in the Cycle 2 formulation.

H. Berm and dune restoration with structural reinforcement. Combination of previous alternatives. Structural reinforcement such as geotextile tubes, Tensar® mattresses, etc. could be placed either inside or fronting the dunes. Depending on placement location, structural reinforcement may provide greater protection under certain conditions. Stability during high wave environments is questionable. It needs to be determined whether the added costs of the reinforcement is worth the additional benefits. This alternative was included in the Cycle 2 formulation.

I. Groin field. Eighteen, mostly timber groins, exist south of 36th Street in Ocean City. 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 some of the littoral drift. A properly designed groin field will reduce erosion and therefore effectively reduce long-term erosion and the need for periodic nourishment of a beachfill. However, a groin field will not provide protection from storm surge unless combined with a properly designed beach restoration and/or additional structure specifically designed for storm surge protection. Therefore, this alternative was not considered further in Cycle 2 but was combined with a berm and dune alternative.

J. Berm & dune restoration w\groin field (stone or geotextile tubes). Combination of prior alternatives. This alternative was further examined in the Cycle 2 formulation.

K. Berm and dune restoration with structural reinforcements and groin field. Combination of prior alternatives. Provides highest level of storm protection and erosion control with same concerns. Initial costs will be high. This alternative was further examined in the Cycle 2 formulation.

L. Increase height of existing bulkhead. This alternative consists of increasing the height of the existing bulkhead to provide additional protection from inundation and wave attack. Both the modification of the existing bulkhead or the replacement of the entire bulkhead with one of a greater height would not likely be cost-effective either. For these reasons, this alternative was not examined further in Cycle 2 plan formulation.

M. Offshore detached breakwaters. An offshore detached breakwater is a structure which reduces the wave energy impacting the shoreline thus reducing erosion. This option could reduce wave impact on the shoreline, depending on placement. In many cases, the offshore detached breakwater is a series of rubble mound structures that are visible from the beach during low tide periods. Since an offshore detached breakwater does not protect against storm surge or provide a protective berm, an initial beachfill is probably required.

This option could reduce wave impact on the most vulnerable areas of the shoreline, depending on placement. The breakwater alternative has many problems: constructability, aesthetics, safety, and cost. Since construction of the breakwater must be done entirely from the ocean, all stone must be brought in on barges and all equipment used must be secured to jack-up barges. There is the additional difficulty of working in an open ocean environment. For these reasons, the cost to construct an offshore breakwater would be quite high and therefore was not considered in Cycle 2.

N. Berm & dune restoration w\offshore detached breakwater. Combination of prior alternatives, see concerns listed previously. Berm/dune combo would provide storm protection. Breakwater may be able to reduce erosion and therefore future periodic nourishment quantities. Cost must be offset by reduced future nourishment. However, at this location, this alternative would not likely be cost-effective. Therefore, this alternative was not included in the Cycle 2 formulation.

O. Perched beach. This alternative is similar to the “berm restoration” alternative listed above except it provides a submerged structure which is used to support the offshore end of the placed beachfill. This eliminates the outer part of the beach profile near its closure with the ocean bottom and therefore, the actual amount of fill material to be placed is less than in a typical beachfill. The submerged structure would act in the same way as a natural bar formed offshore during storm events creating a "perched beach" with a wider berm. The main problem with this alternative is that the angled swell scours in front of and behind the offshore structure resulting in the need for heavy maintenance. In addition, any interception of littoral drift will cause erosion downcoast, even if only temporarily. Perched beaches are not usually designed for high wave energy open ocean coastlines and wouldn’t be very effective in this area due to the dynamic wave, current, and tidal influences. By its very design, perched beaches do not follow foreshore beach slopes which are characteristically gentle along the southern New Jersey shore. Due to these factors and the potential danger posed by the structures to recreational bathers, this alternative was not considered in Cycle 2.

P. Offshore submerged feeder berm. Potentially high costs associated with onshore placement have led to the development of alternate less expensive methods of beach nourishment. One such method is nearshore berm placement. In some areas, nearshore berms can reduce wave damage and provide sand to the littoral system with a cost as little as half that of onshore placement (Allison and Pollock, 1993 and McLellan et. al, 1990).

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, and wave velocity must be within proper ratios (Hands and Allison, 1991). Long term sediment transport trends, both longshore and cross-shore, must also be examined. The berm placement site must be a proper distance downdrift of an inlet or jetty to reduce the tendency of the sediment to return to the inlet or be caught by the jetty (McLellan et. al, 1990). Wave and current conditions at Ocean City make success of this alternative unlikely. Therefore, this alternative was not considered in the Cycle 2 formulation.

Q. 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. Erosion is diminished by beach dewatering due to the discontinuity in the water table and the draining sand, and due to the intergranular pressure and stability which occurs because of the vertical downward flow of water. Accretion is promoted because the sediment laden swash is absorbed by the dewatered sand, causing a deposition of new sand on the foreshore slope.

This alternative requires an initial beachfill placement along with the installation of pipes underneath the beach. Frequent maintenance of the system is also required. Costs would have to be offset by reduced future nourishment requirements. Life cycle costs for a 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.

A summary of the Cycle 1 formulation process is as follows:

Table 5.3.1-1 Cycle 1 Screening Results: South End Ocean City

OBJECTIVE: REDUCE STORM DAMAGE TO SOUTH END OCEAN CITY				
Possible Solutions	**Technical**	**Meet Objective?**	**Relative**	**Further**

	Appropriateness	Erosion Protection	Inundation Protection	Wave Attack Protection	Cost	Consideration in Cycle 2
No action	No	No	No	No		No
Permanent evacuation	No	No	No	No	High	No
Regulation of future Development	Development already regulated	No	No	No	Low	No
Berm restoration	Yes	Yes	Partial	Partial	Moderate	Yes
Dune restoration	Yes	No	Yes	Yes	Low	No
Geotextile tubes	Yes	Partial	Partial	Partial	Low	No
Berm and dune restoration	Yes	Yes	Yes	Yes	Moderate	Yes
Berm and dune restoration with structural reinforcement	Yes	Yes	Yes	Yes	Moderate	Yes
Groin field	Yes	Yes	No	No	Moderate	No
Berm & dune w/groin field	Yes	Yes	Yes	Yes	Moderate	Yes
Berm & dune restoration w/structural reinforcement/groin field.	Yes	Yes	Yes	Yes	Moderate	Yes
Increase height of existing bulkhead	Yes	No	Yes	Yes	Moderate to high	No
Offshore detached breakwater	No	Partial	No	Partial	Low	No
Berm & dune restoration w\offshore detached breakwater	No	Yes	Yes	Yes	Moderate	No
Perched beach	Partial	Partial	No	Partial	High	No
Offshore submerged feeder berm	Partial	Partial	No	Partial	Low	No
Beach dewatering	No	Partial	No	Partial	Moderate	No

Table 5.3.1-2 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 temporary adverse 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 alternative, where the construction of groins would have permanent adverse impacts (MAP) on shellfish such as surfclams. This is because they 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.

A list of abbreviations for the following table is as follows:

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

Table 5.3.1-2 Comparative Environmental Impact Analysis of Cycle 1 Alternatives: South End Ocean City

Alternative	Affected Area(s)	Resource Categories													
		Air Quality	Topography and Soils	Ground-water	Hydro-dynamics	Water Quality	Wetlands	Terrestrial Ecology	Aquatic Ecology			Endangered Species	Cultural Resources	Socio-economics	Aesthetics
									Soft-Bottom Benthic Organisms	Fisheries					
										Shellfish	Finfish				
A. 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
B. 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
C. 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
D. 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
E. 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
F. Geotextile Tubes	Beach/Nearshore	MAT	MBP	NE	NE	MAT	NE	MAT	MAT	MAT	MAT	NE*	NE	BP	MAP
	Offshore	MAT	MAP	NE	NE	MAT	N/A	N/A	MAT	MAT	MAT	NE*	NE		NE
G. 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
H. Berm and Dune Restoration Using Structural Reinforcement	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
I. Groin field	Beach/Nearshore	MAT	BP	NE	BP	MAT	NE	BP	MAP	MAP/MBP	BP	NE*	NE	BP	MAP or MBP
	Offshore	NE	NE	NE	NE	NE	N/A	N/A	NE	NE	NE	NE	NE		NE
J. 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
K. Berm and Dune Using Structural Reinforcement and 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	BE	MAT	N/A	N/A	AT	AT	AT	NE*	NE		NE
L. Increase Height of Existing Bulkhead	Beach/Nearshore	MAT	NE	NE	NE	NE	NE	MAP	NE	NE	NE	NE*	NE	BP	AP
	Offshore	NE	NE	NE	NE	NE	NE	N/A	NE	NE	NE	NE	NE		NE
M. Offshore Detached Breakwater	Beach/Nearshore	MAT	BP	NE	BP	MAT	NE	NE	MAP	MAP/MBP	BP	NE	NE	BP	AP
	Offshore	NE	NE	NE	NE	NE	N/A	N/A	NE	NE	NE	NE	NE		NE
N. 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
O. Perched Beach	Beach/Nearshore	MAT	AP	NE	U	MAT	NE	MAT/BP	AT	AT	AT	NE*	NE	BP	NE
	Offshore	MAT	MAP	NE	NE	MAT	N/A	N/A	AT	AT	AT	NE*	NE		NE
P. 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
Q. 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

5.3.2 South End Ocean City: Cycle 2 – Second Level Screening of Solutions Considered

The purpose of Cycle 2 was to further narrow down the number of alternatives for consideration in Cycle 3. Only those alternatives that are practical, in terms of the engineering, environmental, social and economic impacts remained after the completion of Cycle 2.

Results of the Cycle 2 formulation process are as follows:

Table 5.3.2-1 Cycle 2 Screening Results: South End Ocean City

OBJECTIVE: REDUCE STORM DAMAGE TO SOUTH END OCEAN CITY							
Possible Solutions	**Design Considerations**	**Environmental Considerations**	**Social Considerations**	**Relative Costs**	**Potential to Meet Objective**	**Further Consideration in Cycle 3?**	**Remarks**
Berm restoration	Similar in size to existing Federal project (107 meters/350 ft). Minimum 45 meter (150 ft) beach width for piping plovers.	Temporary loss of benthic habitat in borrow areas. Burial of benthic organisms in placement area. Combines well with existing environment. Provides piping plover habitat.	Acceptable. Provides additional recreational beach area.	Moderate to high to provide desired inundation and wave attack protection.	Moderate.	Yes	Adverse environmental impacts can be minimized through coordination with agencies. This also applies to all following alternatives.
Berm and dune restoration	Recon plan dune height 3.9 m (12.8 ft). Min beach width for piping plovers as previous.	Same as previous. Added habitat from dune planting.	Same as previous. Dune height may impair view of beach/ocean from homes.	Moderate	High	Yes	Proved most cost-effective in other recent District studies along NJ coast.
Berm and dune restoration with structural reinforcement.	Same as previous.	Same as previous. Concerns over non-biodegradeable material used.	Same as previous Probably acceptable if geotextile tubes covered.	Moderate	High	Yes	Added benefit of reinforcement/stabilization would need to be cost-effective.
Berm & dune restoration w/groin field	Berm/dune similar as above. Replace/ rehab/extend existing groins.	Same as berm/dune. Gain rocky habitat Possible 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.
Berm & dune restoration w/structural reinforcement/groin field.	Same as previous.	Same as previous.	Same as previous.	Moderate	High	Yes	Combination of prior alternatives.

Table 5.3.2-2 Comparative Environmental Impact Analysis of Cycle 2 Alternatives: South End Ocean City

Resource Categories	Berm Restoration	Berm and Dune Restoration	Berm and Dune Restoration w/ Structural Reinforcement	Berm and Dune Restoration w/Groin Field	Berm & dune restoration w/structural reinforcement/groin field
Air Quality	Emissions discharges from dredge and construction equipment would result in localized and temporary air quality degradation in the vicinity of the construction.	Same as berm restoration.	Same as berm and dune restoration with a minor incremental increase in emissions to build structural reinforcement.	Same as berm and dune restoration with a minor incremental increase in emissions to build groins.	Same as berm and dune restoration with a an incremental increase in emissions to build groins and structural reinforcement.
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. **Offshore:** Same as berm and dune 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 and dune restoration.	**Beach/Nearshore**: Combination of all Cycle 2 alternatives. **Offshore:** Combination of all Cycle 2 alternatives
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 and dune restoration **Offshore:** Same as berm and dune restoration.	**Beach/Nearshore**: Same as berm and dune restoration **Offshore:** Same as berm and dune restoration.	**Beach/Nearshore**: Combination of all Cycle 2 alternatives **Offshore:** Combination of all Cycle 2 alternatives
Hydrodynamics	**Beach/Nearshore**: Only negligible effects are expected on nearshore transport and beach runup. 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**: Same as berm restoration. **Offshore:** Same as berm and dune 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 and dune restoration.	**Beach/Nearshore**: Combination of all Cycle 2 alternatives **Offshore:** Same as berm and dune restoration.
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 and dune restoration.	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Same as berm and dune restoration.	**Beach/Nearshore**: Combination of all Cycle 2 alternatives **Offshore:** Combination of all Cycle 2 alternatives
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 and dune restoration. **Offshore:** Not applicable.	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Not applicable.	**Beach/Nearshore**: Combination of all Cycle 2 alternatives **Offshore:** Not applicable.
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 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**: Same as berm and dune restoration. **Offshore:** Not applicable.	**Beach/Nearshore**: Combination of all Cycle 2 alternatives **Offshore:** Not applicable

Resource Categories	Berm Restoration	Berm and Dune Restoration	Berm and Dune Restoration w/ Structural Reinforcement	Berm and Dune Restoration w/Groin Field	Berm & dune restoration w/structural reinforcement/groin field
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. **Offshore:** Same as berm and dune restoration	**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**: Same as berm and dune restoration **Offshore:** Same as berm and dune restoration
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 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:** Same as berm and dune restoration. **Offshore:** Same as berm and dune 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 and dune restoration.	**Beach/Nearshore**: Same as berm and dune restoration with groin field. **Offshore:** Same as berm and dune restoration
Shellfish and Essential Fish Habitat Resources	**Beach/Nearshore**: Shellfish resources in the nearshore such as surfclams and blue mussels would become buried during beachfill placement. Recruitment and recolonization is expected shortly after construction is completed. **Offshore:** Dredging would initially eliminate any commercial surfclam stocks that are mature enough to reproduce, however, recruitment is expected to occur shortly after cessation of dredging, provided that similar substrate and environmental conditions exist in the post-dredge environment in the borrow site.	**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. **Offshore:** Same as berm and dune restoration.	**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**: Same as berm and dune restoration w/ groinfield **Offshore:** Same as berm and dune restoration w/ groinfield
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. **Offshore:** Same as berm and dune 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 and dune restoration.	**Beach/Nearshore**: Same as berm and dune restoration w/ groinfield **Offshore:** Same as berm and dune restoration w/ groinfield

Resource Categories	Berm Restoration	Berm and Dune Restoration	Berm and Dune Restoration w/ Structural Reinforcement	Berm and Dune Restoration w/Groin Field	Berm & dune restoration w/structural reinforcement/groin field
Endangered Species	**Beach/Nearshore**: Potential impacts to State and Federally 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 and dune restoration.	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Same as berm and dune restoration.	**Beach/Nearshore**: Same as berm and dune restoration **Offshore:** Same as berm and dune restoration w/ groinfield
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 and dune restoration.	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Same as berm and dune restoration.	**Beach/Nearshore**: Same as berm and dune restoration w/ groinfield **Offshore:** Same as berm and dune restoration w/ groinfield
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 a reinforcement structure may be unsightly if it is left exposed. **Offshore:** Same as berm and dune 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 and dune restoration.	**Beach/Nearshore**: Combination of all four alternatives. **Offshore:** Same as berm and dune restoration.

5.3.3 South End Ocean City: Final Screening and Optimization

The purpose of the cycle 3 plan formulation was to conduct a detailed analysis of the alternatives that have progressed through the prior two cycles of plan formulation. Detailed costs were developed so that a selected plan could be determined. The alternatives that were analyzed in this cycle were as follows:

- Berm restoration
- Berm and dune restoration
- Berm and dune restoration with structural reinforcement
- Berm and dune restoration w/groin field
- Berm & dune restoration w/structural reinforcement/groin field.

Due to the number of alternatives that were analyzed, costs that were assumed relatively constant for all plans (such as real estate costs) or relatively low-cost (sand fence, dune grass) were not included in the formulation as they would not have affected the relative determination of the "selected plan". All associated costs were included in the "selected plan", shown later in this report.

5.3.3.1 Design Parameters

In Cycle 3, the berm/dune each nourishment alternatives required optimization of the design parameters. In developing these parameters, the existing conditions in the study area and accepted coastal engineering practices were reviewed. Listed below are the boundary conditions utilized to construct a logical methodology used to efficiently identify the optimum plan.

Berm Elevation. Tides, waves, and beach slope determine the natural berm elevation. If the berm is too high, scarping may occur, if too low, ponding of water and temporary flooding may occur when a ridge forms at the seaward edge. The existing berm elevations in the study area vary between +1.7 m (5.5 ft) to +2.1 m (7 ft) NAVD88. The 1995 South End beachfill elevation was at +2.2 m (7.25ft) NAVD88 while the existing Federal beachfill project equals +2.7 m (8.75 ft). It was determined that a constructable template which closely matches the prevailing natural berm height in the study area should be +2.1 m (7 ft) NAVD88. This elevation was used for all designs.

Beachfill Slope. The slope of the design berm is based on historical profiles and the average slope of the berm, both onshore and offshore. The existing foreshore slope ranges from 1:30 to 1:25, therefore the foreshore slope for all alternatives was set to match the existing down to the Mean Low Water elevation. Below the mean low water line the slope follows that of the existing profile to the point where the design berm meets the existing profile.

Berm Width. An interval between successive berm widths was used for modeling purposes. In general, this interval was set wide enough to discern significant differences in costs and benefits between alternatives but not so great that the NED plan could not be accurately determined. An interval of 50 feet (15 meter) has been used successfully in previous feasibility studies. This analysis used a 20 meter (65 feet) interval. Due to the nesting of piping plovers (an endangered species) consideration was also given to maximum and minimum widths to support nesting. USFWS estimated beach (seaward toe of dune to Mean High Water) for piping plovers to range from 45m (150 ft) minimum to about 91m (300 ft) maximum. Taking into account the foreshore slopes, this translates into a maximum berm width of about 50 meters (165 ft) while the minimum berm width for piping plovers would only need to be about 2 meters (7 ft). Since this minimum is less than the existing berm width, meeting this requirement would not be a concern.

With one exception, the largest design berm width analyzed was based on the largest berm width for piping plovers 50 meters (165 feet). The smallest berm width analyzed was set at the minimum average existing berm width, 30 meters (100').

Design Baseline. A design baseline was established along the ocean frontage of the project study area in order to determine the alignment of the proposed beach restoration alternatives. This baseline was set at the existing bulkhead.

Dune Height (NAVD88). As with berm width, an interval between successive dune heights was used for modeling purposes. This interval was set wide enough to discern significant differences in costs and benefits between alternatives but not so great that the NED plan could not be accurately determined. The interval used was 0.6 meters (2 ft). The largest design dune height used, +5.1 meters (16.8 ft), was based on the determination where the additional costs were greater than the additional benefits captured. The lowest design dune height evaluated, +3.3 meters (10.8 ft), was just above the height of the existing bulkhead +3.2 meters (10.5 ft).

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 southern New Jersey coast. This dune configuration was patterned after designs by Joseph M. Caldwell, a USACE engineer. The "Caldwell Section" was used to design protection of coasts 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 5H: 1V, which was determined to be the optimum condition based on native sand grain size, and the grain size of sand to be obtained from offshore borrow areas. Dune width (at crest) was set at 7.6 meters (25 ft).

Design Beachfill Quantities. Quantities for each alternative were calculated by superimposing the proposed design templates on the existing beach survey cross sections. Average end area methods were used to compute the volumes.

Periodic Nourishment Volumes. In order to maintain the design template periodic sand nourishment is needed, otherwise the design profile would erode. This nourishment volume is considered sacrificial and protects the design template. At the end of the nourishment cycle, the design beach profile remains

A higher nourishment cycle duration brings a corresponding decrease in the annualized cost of beachfill 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. Experience with existing Philadelphia District beachfill projects also suggests placing smaller nourishment volumes on a 2-5 year cycle to maximize the residence time of the beachfill. For South End Ocean City, a nourishment cycle of 3 years was used. This is the same frequency as existing Federal beachfill project in Ocean City, thereby resulting in unit cost reduction.

For the plan formulation analysis, the nourishment volume was computed based on long-term erosion and diffusion. The diffusion component therefore caused the rate to vary depending on the berm width. Periodic sand nourishment cycle was estimated at 3 years, same as the existing Federal project in Ocean City. Advanced nourishment was also placed with the initial fill and an overfill factor of 1.15 was applied during the cost estimating calculations. The borrow source location used was M3 (see Figure 2.2.11-1). Nourishment volumes are listed in tables that follow.

5.3.3.2 Berm Restoration

While recent Philadelphia District studies have all shown that this alternative is not as cost-effective as berm and dune restoration, both the existing Federal beachfill project at the northern portion of Ocean City and the 1995 local project at the South End were berm restoration plans, therefore, this alternative was analyzed. The following table summarizes considerations were used in the development of the berm restoration alternatives.

Component	Remarks
Berm Width[13]	Existing averages about 30.5 meters (100 ft). 1995 South End beachfill varied from about 36.6 m (120 ft) to 64 m (210 ft) from 36th to 40thSt. and about 30.5 m (100 ft) from 41st St. south to 59th St. (Length measured from bulkhead to MHW was 82 meters (270'). Existing Federal beachfill varies with minimum width of 30 m (100'). It measures at about 100 m (330') at 34th St. According to USFWS, for piping plovers, max beach (seaward toe of dune extending down to MHW) width should range between about 91 m (300') max and 45 m (150 ft) min. Therefore, berm width (seaward toe of dune to berm crest) should be less than about 46 m (150 ft) as slope.
Berm Elevation (NAVD88)	Existing = +1.7 m (5.5 ft) to +2.1 m (7 ft) 1995 South End beachfill = +2.2 m (7.25ft) Fed project = +2.7 m (8.75 ft)
Beachfill Slope	Existing =1:30 to 1:25

Two berm restoration configurations were analyzed. Results from SBEACH and COSTDAM model runs were as follows:

[13] Measured from existing bulkhead to berm crest unless noted.

South End Ocean City
Storm Damage Reduction by Alternative
Berm Restoration Alternatives
October 1998 Price level - 6.875% Discount Rate

Alternative Name	**Description** **(bulkhead to berm crest)**	**Avg. Annual Damages***	**Avg. Annual Damage Reduction Benefits**	**% Damage Reduction**	**Initial Quantity (cu meters)**	**Periodic Nourishment (cu meters)**	**Avg Annual Costs**	**Net Benefits**
Without-Project	*30m (100')*	*$5,132,000*						
B350	107m (350')	$2,577,000	$2,555,000	49.8%	4,247,000	867,000	$6,056,000	-$3,501,000
B165	50m (165')	$4,265,000	$867, 000	16.9%	735,000	347,000	$2,110,000	-$1,243,000

*Includes damage to structures, infrastructure, and cost of fill

As expected, results showed negative net benefits for both alternatives, either due to the large annual costs associated with B350 or the small damage reduction offered by B165. Compared to the without-project condition, neither alternative shifted the storm event that caused the bulkhead failure from the 50-year frequency event.

More detailed information regarding damage reduction per damage category can be found on the following table. This table does not include cost of fill or infrastructure damages, since they are relatively minor when compared to damage to structures.

South End Ocean City
Storm Damage Reduction to Structures by Category
Berm Restoration Alternatives
October 1998 Price level - 6.875% Discount Rate

Alternative Name	**Avg. Annual Damages**			**Total**
	Erosion	**Inundation**	**Wave**	
Without-Project.	*$646,000*	*$577,000*	*$3,841,000*	*$5,064,000*
B350	$3,000	$381,000	$2,181,000	$2,565,000
B165	$448,000	$603,000	$3,169,000	$4,220,000

From the above table, it can be observed that B350 provided significant protection against erosion damages, while B165 provided little. However, not much damage reduction occurred in the greatest damage category, wave damage.

5.3.3.3 Berm and Dune Restoration

As mentioned previously, this alternative has been found to be the "selected plan" in recent Philadelphia District feasibility studies in nearby shore communities. The following tables show component information and a matrix of alternatives that were analyzed.

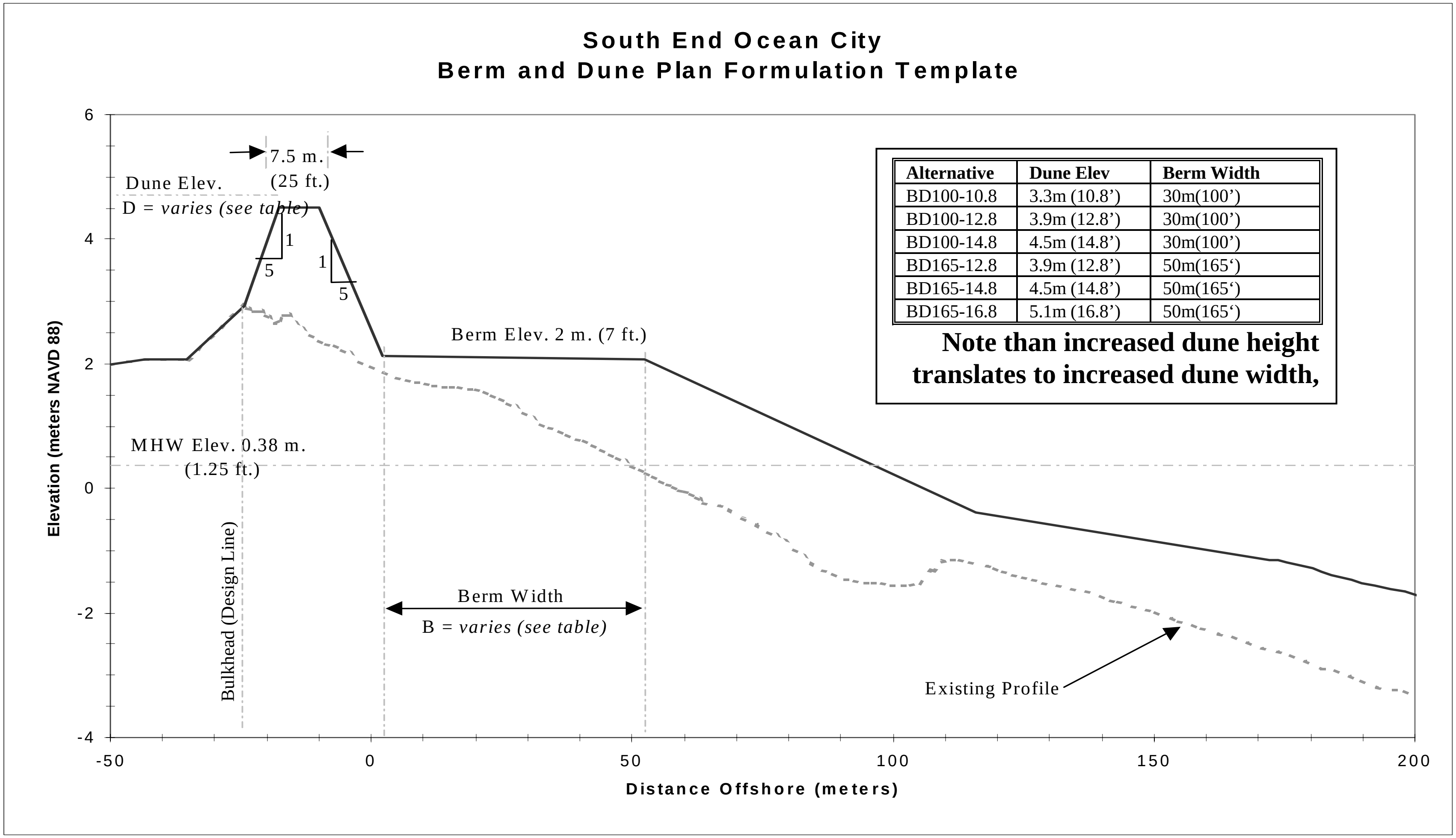
Component	Dimension	Remarks
Berm Elevation (NAVD 88)	+2.1m (7.0 ft)	Recon study plan = +2.2 m (7.2 ft) Existing = +1.7 m (5.5 ft) to +2.1 m (7 ft) Federal beachfill project = +2.7 m (8.75 ft) 1995 South End beachfill =+2.2 m (7.25ft)
Beachfill Slope	Approximates existing	Existing = 1:30 to 1:25
Berm Width	Varies	Existing averages about 30.5 meters (100 ft). Recon study plan = 30.8 meters (100 ft) 1995 South End beachfill varied from about 36.6 m (120 ft) to 64 m (210 ft) from 36th to 40thSt. and about 30.5 m (100 ft) from 41st St. south to 59th St. (Length measured from bulkhead to MHW was 82 meters (270 ft). Existing Federal beachfill varies with minimum width of 30 m (100'). It measures at about 100 m (330') at 34th St. According to USFWS, for piping plovers, max beach (seaward toe of dune extending down to MHW) width should range between about 91 m (300') max and 45 m (150 ft) min. Therefore, berm width (seaward toe of dune to berm crest) should be less than about 46 m (150 ft) as slope.
Dune Height (NAVD88)	Varies	Varies. Existing dune crest elevation of 36th to 49th St dune system varies mostly between +3.0 meters and +3.2 meters (10.0 and 10.5 ft), with several elevations as high as +3.5 m (11.5 ft) and as low as +2.8 m (9.0 ft). A somewhat narrower dune system extends from 49th to 59th St. The crest elevation of this system varies mostly between +2.7 (9.0 ft) and +3.2 m (10.5 ft) with elevations as high as +4.3 m (14.0 ft) and as low as +2.5 m (8.0 ft).
Dune Width	7.6 m (25')	Standard Caldwell section width
Dune Side Slopes	1:5	Standard Caldwell section slopes
Dune offset for maintenance	0	

South End Ocean City
Matrix of Berm and Dune Alternatives

Dune Elevation (NAVD88)	30 meters* (100ft)	50 meters** (165ft)
3.3 meters (10.8 ft) (Existing bulkhead/dune height=3.2 m)	BD100-10.8	
3.9 meters (12.8 ft)	BD100-12.8	BD165-12.8
4.5 meters (14.8 ft)	BD100-14.8	BD165-14.8
5.1meters (16.8 ft)		BD165-16.8

*Average existing berm width.
**Max berm width for piping plovers which nest in area

The following figure presents a graphical representation of the alternatives that were analyzed:



Alternative	Dune Elev	Berm Width
BD100-10.8	3.3m (10.8')	30m(100')
BD100-12.8	3.9m (12.8')	30m(100')
BD100-14.8	4.5m (14.8')	30m(100')
BD165-12.8	3.9m (12.8')	50m(165')
BD165-14.8	4.5m (14.8')	50m(165')
BD165-16.8	5.1m (16.8')	50m(165')

Results from SBEACH and COSTDAM model runs are shown on the following table[14].

South End Ocean City
Berm and Dune Restoration Alternatives
Storm Damage to Structures by Category
October 1998 Price level - 6.875% Discount Rate

Alternative Name	**Avg. Annual Damages**			**Total**
	Erosion	**Inundation**	**Wave**	
Without-Project	*$646,000*	*$577,000*	*$3,841,000*	*$5,064,000*
BD100-10.8	$151,000	$825,000	$2,417,000	$3,394,000
BD100-12.8	$2,000	$267,000	$2,164,000	$2,433,000
BD100-14.8	$0	$173,000	$2,151,000	$2,324,000
BD165-12.8	$2,000	$183,000	$2,139,000	$2,324,000
BD165-14.8	$0	$119,000	$1,246,000	$1,365,000
BD165-16.8	$0	$77,000	$1,250,000	$1,327,000

Trends were as follows:

Erosion Damage

- All alternatives showed significant erosion damage reduction.

This was accounted for by the fact that initial structural damages due to erosion only accounted for about 13% of the without-project damages. Since only a few structures were subject to erosion damages, simply eliminating these few structures from erosion damages would cause the high damage reduction rate. In addition, the nature of the damage mechanism is that once the bulkhead fails, wave and inundation damages would impact the structure before erosion.

Inundation Damage

- Holding berm width constant, inundation damages decreased with increasing dune height
- Holding dune height constant, inundation damages decreased with increasing berm width

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[14] This table does not include cost of fill or infrastructure damages, since they are relatively minor when compared to damage to structures.

This damage mechanism accounted for about 11% of the without-project damages. Without-project damages occur significantly at the 50-year frequency event at cell OCN and the 10 year frequency event at cell OCS. Most plans would prevent damage up to the 50 year frequency event. As the damages are pushed to the higher intensity but lower frequency storms (50 year or greater), damages become numerically less significant when annualized.

Wave Damage

- Holding berm width constant, wave damages decreased with increasing dune height. Alternatives BD165-14.8 and BD 165-16.8 provided significantly greater damage reduction.
- Holding dune height constant, wave damages decreased with increasing berm width. Alternatives BD165-14.8 and BD 165-16.8 provided significantly greater damage reduction.

Wave damage counted for about 76% of the without-project damages. Unlike erosion or inundation, wave damage is either "all or nothing". The structure is either unaffected or totally destroyed. This could give way to large increases in damage reduction between some alternatives. In addition, those structures not being destroyed by wave attack could experience significant inundation damages due to damage category shifting. Without-project damages occur significantly at the 100 year frequency event at cell OCN and the 50 year frequency event at cell OCS. Alternatives prevent damage up to at least the 100 year frequency event.

Bulkhead Failure

The model runs also indicated that, with the exception of BD100-10.8, all alternatives would shift bulkhead failure to at least the 200-year frequency event. General trends showed that raising the dune height moves bulkhead failure to lower frequency storm events, while berm width changes did not change the bulkhead failure storm frequency.

Net benefits for each plan are shown.

South End Ocean City

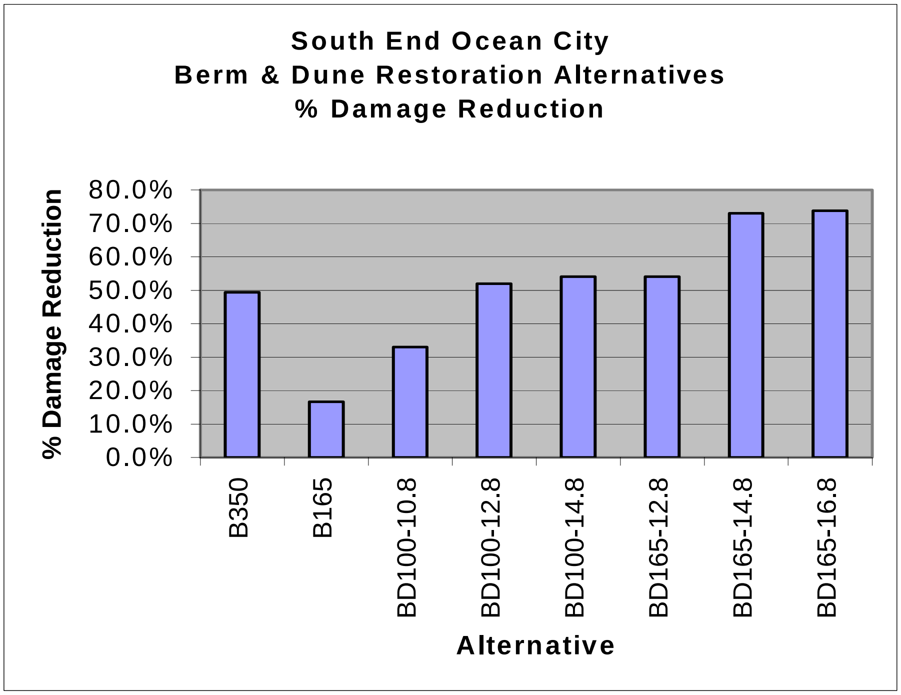
Berm and Dune Restoration Alternatives
Storm Damage Reduction Benefits
October 1998 Price level - 6.875% Discount Rate

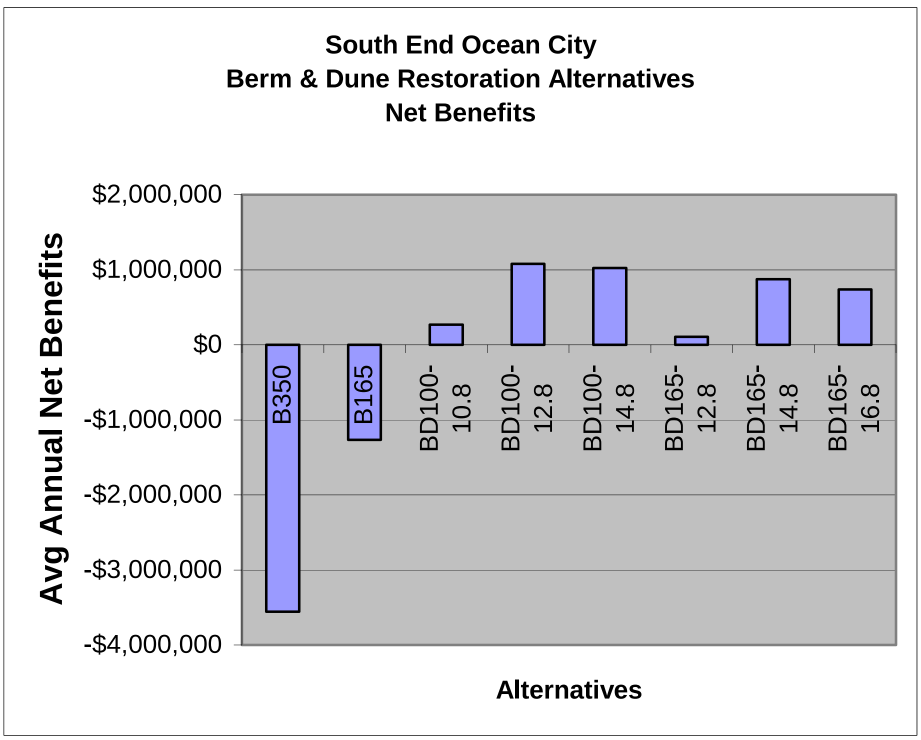
Alternative Name	Description		Avg. Annual Damages*	Avg. Annual Damage Reduction Benefits	% Damage Reduction	Sand Quantity (cu meters)		Avg. Annual Costs	Net Benefits
	Dune Height (meters NAVD 88)	Avg. Berm Width (meters)				Initial	Periodic Nourishment		
Without-Project	*N/A*	*30 (100 ft)*	*$5,132,000*						
BD100-10.8	3.3 (10.8 ft)	30 (100 ft)	$3,420,000	$1,712,000	33.4%	676,000	266,000	$1,402,000	$310,000
BD100-12.8	3.9 (12.8 ft)	30 (100 ft)	$2,442,000	$2,690,000	52.4%	912,000	266,000	$1,554,000	$1,136,000
BD100-14.8	4.5 (14.8 ft)	30 (100 ft)	$2,328,000	$2,804,000	54.6%	1,220,000	266,000	$1,717,000	$1,087,000
BD165-12.8	3.9 (12.8 ft)	50 (165 ft)	$2,332,000	$2,800,000	54.6%	1,739,000	347,000	$2,634,000	$166,000
BD165-14.8	4.5 (14.8 ft)	50 (165 ft)	$1,369,000	$3,763,000	73.3%	2,061,000	347,000	$2,825,000	$938,000
BD165-16.8	5.1 (16.8 ft)	50 (165 ft)	$1,331,000	$3,801,000	74.1%	2,410,000	347,000	$2,998,000	$803,000

*Includes damage to structures, infrastructure, and cost of fill

Dune Elevation (NAVD88)	30 meters* (100ft)	50 meters** (165ft)
3.3 meters (10.8’) (Existing bulkhead/dune height=3.2m) Net benefits	BD100-10.8 $310,000	
3.9 meters (12.8’) Net benefits	**BD100-12.8** **$1,136,000**	BD165-12.8 $166,000
4.5 meters (14.8’) Net benefits	BD100-14.8 $1,087,000	BD165-14.8 $938,000
5.1meters (16.8’) Net benefits		BD165-16.8 $803,000

*Average existing berm width
**Max width for piping plovers which nest in area





*Berm only alternatives B350 and B165 are shown for comparison reasons.

As expected, the berm/dune alternatives performed much better than the "berm only" plans. Increasing the berm and dune component magnitude generally provided greater damage reduction. However, larger costs for the "bigger" plans generally caused their net benefits to decease.

As seen from the tables and charts above. The analysis showed the BD100-12.8 alternative demonstrated the greatest net benefits. The following table shows a comparison of damage mechanisms between the without and the BD100-12.8 alternative.

Cell	Plan	Storm Frequency							
		2 yr	5 yr	10 yr	20 yr	50 yr	100 yr	200 yr	500 yr
OCN	W/O Proj	---	---	---	---	IN	BF, E, WD	---	---
	BD100-12.8	---	---	---	---	IN	WD	BF, E	---
OCS	W/O Proj	---	---	IN	---	BF, E, WD	---	---	---
	BD100-12.8	---	---	---	---	IN	WD	BF, E	---

BF-Bulkhead failure, WD-Wave Damage, IN-Inundation Damage, E-Erosion Damage

5.3.3.4 Berm and dune restoration with structural reinforcement

Consideration was given to the use of structural dune reinforcement to possibly provide a more cost-effective solution compared with berm and dune restoration alternative (BD100-12.8). Geotextile tubes provide protection in certain shoreline applications and are relatively inexpensive, costing around $100 per linear foot. Other types of dune reinforcement have not been widely used locally with consistent success and therefore were not considered.

Geotextile tubes used in oceanfront applications are sand filled structures constructed of permeable geosynthetic material. The size of geotextile tube varies depending on the application, but those constructed parallel to the shoreline as protection need to be large, in order to adequately resist wave forces.

The configuration of geotextile tubes typically includes a primary tube, an anchor tube, and a scour apron. Geotextile tubes are constructed by pumping a sand/seawater slurry into prefabricated tubes. The tubes are laid empty on top of the scour apron. The slurry is pumped through the top of the tube through special openings to accommodate the pump. The water component of the slurry drains through the permeable tube material, leaving the sand inside. The scour apron is used to direct the water excreted from the tube away so during construction, the sand at the base of the tube is not eroded; this scour apron remains after the tubes are filled. The anchor tube is smaller and is placed in front of the primary tube. It is constructed in the same manner as the primary tube. Its function, along with the scour apron, is to prevent erosion of sand beneath the primary geotextile tube so that it remains stable. Scour is the most likely cause of failure.

As a final step, the geotextile tubes should be covered with sand and maintained for sacrificial purposes and for aesthetic appearance. Erosion of sand fronting geotextile tubes typically occurs in a vertical scarp on the seaward side of the tubes (unless an adequate beach exists). This will result in the scour apron "digging in" at the base of the dunes providing a non-erodible permeable base over which sand will come and go. If left exposed to sunlight, the geosynthetic material that geotextile tubes are constructed of may become damaged from long-term exposure to ultraviolet light. The sand could be lost from the tube at which point the geosynthetic and plastic material become more susceptible to the forces of wind and water and can shred. Therefore, in order to maintain geotextile tubes properly, at some point replacement of sand cover becomes necessary. This can pose a maintenance problem if beach nourishment cycles are too far apart. If left exposed, they are especially aesthetically unpleasing in a developed environment such as South End Ocean City.

The possible benefits which could accrue from the placement of geotextile tubes are from:

1. Reduction in storm damage (wave, inundation) due to increased stability of the dune
2. Reduction of dune reconstruction costs following major storm events costs, since theoretically the geotextile tubes should maintain more of the dune than unconfined sand.

It is difficult to accurately quantify the benefits of the geotextile tubes in this type of analyses, since they can not be directly modeled using SBEACH. However, examination of the storm analysis model results indicated that for alternative BD100-12.8, the 200-year frequency storm is the first event which substantially impacts the dune. Therefore, until that storm event, the geotextile tubes would provide no additional benefits from either storm damage reduction or from the reduction of dune reconstruction costs following storm events. At the 200-year frequency event, enough storm erosion has occurred where the existing bulkhead would fail. As the bulkhead is much more resistant to failure that the geotextile tubes, it can easily be assumed that the geotextile tubes also fail due to storm damage erosion at the 200-year frequency storm event. Therefore, since tubes would neither provide any additional protection nor to maintain the dune, this alternative was not found to be cost-effective.

5.3.3.5 Berm and dune restoration w/groin field

Further consideration was given for either the construction of additional groins or the modification of the existing groins in South End Ocean City.

Groins control the rate of longshore sediment transport through a project area and can reduce the rate of sediment lost to downdrift beaches. When designed properly, they are effective in stabilizing beaches and reducing nourishment rates where sediment is lost by alongshore movement. The reduction of nourishment rates would lessen or possibly even eliminate long-term Federal commitment of funds, a priority of the current Administration. A method to compare life cycle costs for a groin system is to estimate annual costs of the system in-place (which includes the initial construction, periodic sand nourishment for the reach with the groins and maintenance) against the annual cost of stabilizing the beach by periodic sand nourishment alone.

Fill losses due to longshore transport processes can be reduced by placing groins near to or at the ends of a project (Dean and Yoo, 1993). Groins used for this purpose are usually referred to as "terminal groins" and can increase the longevity of a nourishment project by minimizing transport out of the project area into adjacent areas. Concerns normally arise over the negative impacts to a downdrift beach due to the reduced alongshore sand transport and subsequent downdrift erosion which may occur.

Recent feasibility studies by the Philadelphia District have investigated the cost-effectiveness of groins. Groin construction was not found to be cost-effective in any of these cases. The relatively high initial costs (around $2,500 per foot) compared to the reduced sand nourishment savings were not found to be cost-effective.

Therefore, based on the anticipated lack of substantial benefits and the relatively high cost of groin construction/modification, it was determined that this alternative would not be cost-effective.

5.3.3.6 Berm & dune restoration w/structural reinforcement/groin field

Since this was a combination of the previous analyses, there was no need to reanalyze. This alternative would not have more net benefits than the berm and dune restoration plan only.

5.4 Plan Formulation - Gardens Area of Ocean City

Problem: *Storm Damage to Gardens area of Ocean City*
Cause: *Wave attack, inundation, and erosion*
Objective: *Reduce storm damage caused by wave attack, inundation, and erosion*

As discussed previously in section 3.1.2, storm damage vulnerability in this area is related to the cyclical nature of Great Egg Harbor Inlet and the variability of the shoreline position along the inlet. Historically, the variation in channel positions has alternately benefited the northern inlet shoreline of Longport and the southern shoreline of Ocean City.

This area was previously evaluated in documents mentioned in section 1.5.1.1, most recently in the *Plan Reevaluation and Scheme Selection (Technical Review Meeting NO. 1), Great Egg Harbor Inlet to Peck Beach - Ocean City, NJ (1988).* This document included a "no action analysis" in which a quantitative prediction of shoreline position was made for the area. The shoreline analysis concluded that there was no long-term trend of erosion, however large cyclical variations in the shoreline position could be expected. Beach profile data collected in 1955, 1963, 1965 and 1984, along with aerial photographic data accumulated from 1949 to 1974 form the database used in analysis.

As part of monitoring program of the Federal project in Ocean City, inlet bathymetric data, quarterly aerial photography and semi-annual beach profile data has been collected in this area since 1994. Recent bathymetric surveys show that only one major channel exists in the inlet, passing through approximately the center of the inlet and extending directly out towards the Federal borrow area. Although there was some variability in the Great Egg Harbor Inlet shoreline of Ocean City in 1994 and 1995, the shoreline has accreted steadily and substantially since 1995. An ongoing analysis of the monitoring data indicates that a portion of the Federal fill has migrated into the Gardens area. This trend is expected to continue, therefore, the shoreline in this area should continue to accrete or remain relatively stable. With continued removal of material from the borrow area and placement of fill in northern Ocean City, the location of the main channel should also remain relatively stable.

Two possible storm damage reduction alternatives were considered for the Gardens area on a qualitative level:

A. Extension of the existing Federal beachfill project
B. Construction of a bulkhead or seawall along the inlet frontage

In general, placement of beachfill material along an inlet shoreline is typically not a feasible alternative for storm protection. If the inlet channel migrates close to the inlet frontage, the beachfill material would likely be swept into the channel by tidal currents. This trend has occurred historically where the main channel of Great Egg Harbor Inlet has a greater influence on the inlet shoreline of Ocean City. However, as described above, the present inlet shoreline and dune system is substantial and is expected to continue to accrete or remain stable.

Constructing a bulkhead or seawall along the inlet frontage was also considered. Costs were assumed to be about $2,500 per foot along the 1,700 feet frontage. It would be unlikely that the $4,250,000 initial costs would be justified based on the relatively small number of structures that would likely be damaged from the inlet side. It should also be noted that there are indications that a bulkhead already exists along the frontage, buried under the substantial existing dunes, however its existence or condition has not been confirmed.

For the reasons discussed, it was determined that no Federal solution for this area would be recommended.

5.5 Plan Formulation - Ludlam Island

Problem: *Storm damage to Ludlam Island*
Cause: *Wave attack, inundation, and erosion*
Objective: *Reduce storm damage by wave attack, inundation, and erosion*

5.5.1 Ludlam Island: Cycle 1 Initial Screening of Alternatives

A. No Action Alternative: This is synonymous with the without-project condition. The no action alternative is used to compare the effects of alternative plans. It consists of both the baseline and expected future conditions, assuming no Federal involvement.

Non-Structural Alternatives:

B. No action
C. Permanent evacuation from areas subject to storm damage
D. Regulation of future development

Structural Alternatives:

E. Berm restoration
F. Dune restoration
G. Geotextile tubes
H. Berm and dune restoration
I. Berm and dune restoration using structural reinforcement (geotextile tubes etc.)
J. Groin field
K. Berm and dune restoration with groin field
L. Berm and dune using structural reinforcement and groin field
M. Bulkhead/seawall
N. Offshore detached breakwater
O. Berm and dune restoration with offshore detached breakwater
P. Perched beach
Q. Offshore submerged feeder berm
R. Beach dewatering

A. No Action. This alternative involves no measures to provide storm protection. The potential without-project damages discussed in section 4 of this report would most likely be realized.

B. Permanent Evacuation from Areas Subject to Storm Damage. Permanent evacuation of existing developed areas subject to storm damage involves the 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 areas subject to storm damage are either demolished or relocated to another site. The level of development present along most of Ludlam Island would make this measure expensive. The cost of long-term shore protection to this area is probably low compared to the cost of permanent evacuation of the residences. Ludlam Island contains many structures that house year-round residents. Additionally, permanent evacuation would probably meet with strong opposition from these locals. However, the Whale Beach area is sparsely developed and this alternative may be cost-effective at this location only. Therefore, this alternative was considered in cycle 2 for the Whale Beach area only.

C. Regulation of Future Development. Regulation or land use controls could be enacted through codes, ordinances, or other regulations to minimize the impact of erosion on lands which could be developed in the future. Such regulations are traditionally the responsibility of State and local governments. There currently are regulations in place to control future development and reduce susceptibility to damage such as CAFRA (Coastal Area Facility Review Act) 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. With the exception of the Whale Beach area (where development is already significantly regulated), there is virtually no oceanfront that is not developed in Ludlam Island. Therefore additional regulation to prevent new development would have little impact. This alternative was not considered in cycle 2.

D. Berm restoration. This alternative involves the placement of beachfill material (sand), directly onto the existing beach in order to widen and stabilize 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 pushes the wave breaker zone and inundation profile seaward and provides sacrificial sediment during storms. It also incidentally provides beach habitat for species like the piping plover. Normally, the beach requires future additional sand placement (periodic nourishment), on a periodic basis so that the required design is maintained. This alternative was further considered in cycle 2.

R. Dune restoration. Involves using sand to construct dunes to a desired height and width. This would add significant protection from overtopping during storm events. However, without a significant berm to protect it, this option becomes very vulnerable and ineffective during significant storm events as it is susceptible to erosion and wave impact. Therefore, this alternative was not considered in the cycle 2 formulation.

E. Geotextile tubes. This alternative consists of the use of sand-filled geotextile tubes. The advantage over a traditional sand dune is that during storm events the tubes may provide greater protection since the tubes would not erode as a sand dune. This should also reduce the amount of long-term periodic sand placement needed to maintain the dune. Failure of the geotextile tube dune would likely be due to scour. A cost-benefit analysis would be needed to evaluate the advantages of using tubes. The tubes would also need to be covered with sand for aesthetic reasons. This alternative has recently been constructed on Ludlam Island, both in the Whale Beach area and the Townsends Inlet area. Due to lack of a beach berm fronting the tubes at the Townsends Inlet location, the structural stability of the tubes has been compromised through constant wave and tidal influences. Therefore, the use of geotextile tubes would likely be more effective in combination with a berm (existing or constructed) and dune, as in the Whale Beach area. This alternative was not further examined in the cycle 2 formulation but was combined with a berm and dune alternative.

F. Berm and dune restoration. This alternative is a combination of D and E. This alternative provides a high level of storm protection and merges favorably with the existing environment and has been shown in recent Philadelphia District studies to be the most effective and cost efficient in terms of providing protection from storms. Therefore, this alternative was included in the cycle 2 formulation

G. Berm and dune restoration using structural reinforcement. Combination of previous alternatives. Structural reinforcement such as geotextile tubes, Tensar® mattresses etc could be placed either inside or fronting the dunes. Depending on placement location, structural reinforcement may provide greater protection under certain conditions. Stability during high wave environments is questionable. It needs to be determined whether the added costs of the reinforcement is worth the additional benefits. This alternative was included in the cycle 2 formulation.

H. 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 some of the littoral drift. Thirty-nine groins exist on Ludlam Island, with 5 more proposed for the Whale Beach area. It seems that groins exist or are planned at the most appropriate locations. However, modification of these groins might prove cost-effective. A properly designed groin field will reduce erosion and therefore effectively reduce long-term erosion and the need for periodic nourishment of a beachfill. However, a groin field will not provide protection from storm surge unless combined with a properly designed beach restoration and/or and additional structure specifically designed for storm surge protection. Therefore, this alternative will not be considered further in cycle 2 but was combined with a berm and dune alternative.

I. Berm & dune restoration w\groin field (stone or geotextile tubes). Combination of prior alternatives. This alternative was further examined in the cycle 2 formulation.

J. Berm and dune creation with structural reinforcements and groin field. Combination of prior alternatives. Provides highest level of storm protection and erosion control with same concerns. Initial costs will be high. This alternative was further examined in the cycle 2 formulation.

K. Bulkhead/seawall. A bulkhead protects upland areas from erosion and storm damage. A bulkhead exists along most of Strathmere and a portion of Sea Isle City. While the bulkhead will protect upland areas, beach restoration in some of the narrower berm areas would be required to limit erosion in front of the bulkhead and provide additional protection to upland areas. Since a bulkhead does not interact with the littoral transport, it will not reduce nourishment cycles as a groin field would. This alternative would also reduce inundation damages.

   A seawall serves the same purpose of a bulkhead but is constructed of stone or concrete and is generally larger in size. This alternative also has a high cost. There is also an academic debate regarding whether a seawall actually induces erosion of sand from the beach face.

   This alternative was examined further in cycle 2 plan formulation.

L. Offshore detached breakwaters. An offshore detached breakwater is a structure which reduces the wave energy impacting the shoreline thus reducing erosion. This option could reduce wave impact on the shoreline, depending on placement. In many cases, the offshore detached breakwater is a series of rubble mound structures that are visible from the beach during low tide periods. Since an offshore detached breakwater does not protect against storm surge or provide a protective berm, an initial beachfill is probably required.

This option could reduce wave impact on the most vulnerable areas of the shoreline, depending on placement. The breakwater alternative has many problems: constructability, aesthetics, safety, and cost. Since construction of the breakwater must be done entirely from the ocean, all stone must be brought in on barges and all equipment used must be secured to jack-up barges. There is the additional difficulty of working in an open ocean environment. A series of submerged breakwaters were placed off of the Whale Beach area in 1989. Due to inadequate foundation conditions, these structures failed and were removed.

For these reasons, the cost to construct an offshore breakwater would be quite high and therefore was not considered in cycle 2.

M. <u>Berm & dune restoration w\offshore detached breakwater.</u> Combination of prior alternatives, see concerns listed previously. Berm/dune combo would provide storm protection. Breakwater may be able to reduce erosion and therefore future periodic nourishment quantities. Cost must be offset by reduced future nourishment. However, at this location, this alternative would not likely be cost-effective. Therefore, this alternative was not included in the cycle 2 formulation.

N. <u>Perched beach.</u> This alternative is similar to the "berm restoration" alternative listed above except it provides a submerged structure which is used to support the offshore end of the placed beachfill. This eliminates the outer part of the beach profile near its closure with the ocean bottom and therefore, the actual amount of fill material to be placed is less than in a typical beachfill. The submerged structure would act in the same way as a natural bar formed offshore during storm events creating a "perched beach" with a wider berm. The main problem with this alternative is that the angled swell scours in front of and behind the offshore structure resulting in the need for heavy maintenance. In addition, any interception of littoral drift will cause erosion downcast, even if only temporarily. Perched beaches are not usually designed for high wave energy open ocean coastlines and wouldn't be very effective in this area due to the dynamic wave, current, and tidal influences. By its very design, perched beaches do not follow foreshore beach slopes which are characteristically gentle along the southern New Jersey shoreline. Due to these factors and the potential danger posed by the structures to recreational bathers, this alternative was not considered in cycle 2.

O. <u>Offshore submerged feeder berm.</u> Potentially high costs associated with onshore placement have led to the development of alternate less expensive methods of beach nourishment. One such method is nearshore berm placement. In some areas, nearshore berms can reduce wave damage and provide sand to the littoral system with a cost as little as half that of onshore placement (Allison and Pollock, 1993 and McLellan et. al, 1990).

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, and wave velocity must be within proper ratios (Hands and Allison, 1991). Long term sediment transport trends, both longshore and cross-shore, must also be examined. The berm placement site must be a proper distance downdrift of an inlet or jetty to reduce the tendency of the sediment to return to the inlet or be caught by the jetty (McLellan et. al, 1990). Wave and current conditions at Ludlam Island make success of this alternative unlikely. Therefore, this alternative was not considered in the cycle 2 formulation.

Q. 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. Erosion is diminished by beach dewatering due to the discontinuity in the water table and the draining sand, and due to the intergranular pressure and stability which occurs because of the vertical downward flow of water. Accretion is promoted because the sediment laden swash is absorbed by the dewatered sand, causing a deposition of new sand on the foreshore slope.

This alternative requires an initial beachfill placement along with installation of pipes underneath the beach. Frequent maintenance of the system is also required. Costs would have to be offset by reduced future nourishment requirements. Life cycle costs for a large-scale implementation are unknown. Technology and performance is still unproven for an open ocean coastal. Therefore, this alternative was not considered in the cycle 2 formulation.

A summary of the Cycle 1 formulation process is as follows:

Table 5.5.1-1 Cycle 1 Screening Results: Ludlam Island

OBJECTIVE*: *REDUCE STORM DAMAGE TO LUDLAM ISLAND						
Possible Solutions	**Technical Appropriateness**	**Meet Objective?**			**Relative Cost**	**Further Consideration in Cycle 2**
		Erosion Protection	**Inundation Protection**	**Wave Attack Protection**		

No action	No	No	No	No		No
Permanent evacuation	Yes, at Whale beach area only.	No	No	No	High	Yes
Regulation of future Development	Development already regulated	No	No	No	Low	No
Berm restoration	Yes	Yes	Partial	Partial	Moderate	Yes
Dune restoration	Yes	No	Yes	Yes	Low	No
Geotextile tube	Yes	Partial	Partial	Partial	Low	No
Berm and dune restoration	Yes	Yes	Yes	Yes	Moderate	Yes
Berm and dune with structural dune reinforcement	Yes	Yes	Yes	Yes	Moderate	Yes
Groin field	Yes (in certain areas)	Yes	No	No	Moderate	No
Berm & dune w/groin field	Yes	Yes	Yes	Yes	Moderate	Yes
Berm & dune w/structural reinforcement and groin field.	Yes	Yes	Yes	Yes	Moderate	Yes
Bulkhead/seawall	Yes	Partial (property, not beach)	Yes	Yes	High	Yes
Offshore detached breakwater	No	Partial	No	Partial	Low	No
Berm & dune restoration w\offshore detached breakwater	No	Yes	Yes	Yes	Moderate	No
Perched beach	Partial	Partial	No	Partial	High	No
Offshore submerged feeder berm	Partial	Partial	No	Partial	Low	No
Beach dewatering	No	Partial	No	Partial	Moderate	No

Table 5.5.1-2 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 temporary adverse 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 alternative, where the construction of groins would have permanent adverse impacts (MAP) on shellfish such as surfclams. This is because they 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.

A list of abbreviations for the following table is as follows:

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

Table 5.5.1-2 Comparative Environmental Impact Analysis of Cycle 1 Alternatives: Ludlam Island

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				
A. 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
B. 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
C. 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
D. 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
E. 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
F. Geotextile Tubes	Beach/Nearshore	MAT	MBP	NE	NE	MAT	NE	MAT	MAT	MAT	MAT	NE*	NE	BP	MAP
	Offshore	MAT	MAP	NE	NE	MAT	N/A	N/A	MAT	MAT	MAT	NE*	NE		NE
G. 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
H. Berm and Dune Restoration Using Structural Reinforcement	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
I. Groinfield	Beach/Nearshore	MAT	BP	NE	BP	MAT	NE	BP	MAP	MAP/MBP	BP	NE*	NE	BP	MAP or MBP
	Offshore	NE	NE	NE	NE	NE	N/A	N/A	NE	NE	NE	NE	NE		NE
J. Berm and Dune Restoration w/ Groinfield	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
K. Berm and Dune Using Structural Reinforcement and Groinfield	Beach/Nearshore	MAT	SBP	NE	BP	MAT	NE	MAT/BP	MAP	MAP/MBP	BP	NE*	NE	SBP	MAT/BP
	Offshore	MAT	MAP	NE	BE	MAT	N/A	N/A	AT	AT	AT	NE*	NE		NE
L. Bulkhead or Seawall (includes some nourishment)	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
M. Offshore Detached Breakwater	Beach/Nearshore	MAT	BP	NE	BP	MAT	NE	NE	MAP	MAP/MBP	BP	NE	NE	BP	AP
	Offshore	NE	NE	NE	NE	NE	N/A	N/A	NE	NE	NE	NE	NE		NE
N. 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
O. Perched Beach	Beach/Nearshore	MAT	AP	NE	U	MAT	NE	MAT/BP	AT	AT	AT	NE*	NE	BP	NE
	Offshore	MAT	MAP	NE	NE	MAT	N/A	N/A	AT	AT	AT	NE*	NE		NE
P. 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
Q. 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

5.5.2 Ludlam Island: Cycle 2 – Second Level Screening of Solutions Considered

The purpose of cycle 2 was to further narrow down the number of alternatives for consideration in cycle 3. Only those alternatives that are practical, in terms of the engineering, environmental, social and economic impacts remained after the completion of cycle 2.

Results of the cycle 2 formulation process are as follows:

Table 5.5.2-1 Cycle 2 Screening Results: Ludlam Island

OBJECTIVE: REDUCE STORM DAMAGE TO LUDLAM ISLAND							
Possible Solutions	**Design Considerations**	**Environmental Considerations**	**Social Considerations**	**Relative Costs**	**Potential to Meet Objective**	**Further Consideration in Cycle 3?**	**Remarks**
Permanent Evacuation		Favorable	Not likely supported by residents.	High.	High	Yes	Feasible at Whale Beach area.
Berm restoration	Min 45 m (150 ft) max 91 m (300 ft) beach width for piping plovers.	Temporary loss of benthic habitat in borrow areas. Burial of benthic organisms in placement area. Combines well with existing environment. Provides piping plover habitat.	Acceptable. Provides additional recreational beach area.	Moderate to high to provide desired inundation and wave attack protection.	Moderate	Yes	Adverse environmental impacts can be minimized w/coordination with agencies. This alternative did not perform well when compared to the berm and dune alternatives analyzed for South End Ocean City.
Geotextile tubes	Similar as those presently existing in Whale Beach.	Would not provide habitat for piping plovers.	None	Low	Moderate	No	Erosion would eventually scour out foundation and tube would fail if no protective berm.
Berm & dune restoration	Recon study plan dune height = 3.9 m (12.8 ft). Min 45 m/max 91 m (150/300 ft) beach width for piping plovers.	Same as berm alternative. Added habitat from dunes.	Same as berm alternative. Dune height may impair view of beach from homes.	Moderate	High	Yes	Provides high level of protection. Proved most cost-effective in other recent CENAP studies along NJ coast.
Berm and dune using structural dune reinforcement (geotextile tube).	Same as previous.	Same as previous. Concerns over non-biodegradeable reinforcement	Same as previous. Probably acceptable if geotextile tubes covered.	Moderate	High	Yes	Added benefit of reinforcement/stabilization would need to be cost-effective.

OBJECTIVE: REDUCE STORM DAMAGE TO LUDLAM ISLAND							
Possible Solutions	**Design Considerations**	**Environmental Considerations**	**Social Considerations**	**Relative Costs**	**Potential to Meet Objective**	**Further Consideration in Cycle 3?**	**Remarks**
Berm & dune w/ groin field	5 low-profile groins already proposed for Whale Beach area.	Same as berm/dune. Gain of rocky habitat (if stone groins). Possible negative impact on downdrift beaches. Burial of benthic organisms in placement area.	Probably acceptable. Groins used as fishing areas.	Moderate	High	Yes	Groin construction costs would have to be offset by savings from reduced period nourishment.
Bulkhead/Seawall	Similar to existing	Hardened structures not favored by environmental agencies. Won't provide or protect bird nesting habitat.	Seawall probably not aesthetically acceptable.	High	Moderate	No	
Berm & dune using structural reinforcement/groin field.	Similar as previous.	Similar as previous.	Similar as previous.	Moderate	High	Yes	Combination of prior alternatives.

Table 5.5.2-2 Comparative Environmental Impact Analysis of Cycle 2 Alternatives: Ludlam Island

Resource Categories	Permanent Evacuation	Berm Restoration	Geotextile Tubes	Berm and Dune Restoration	Berm and Dune Restoration w/ Structural Reinforcement	Berm and Dune Restoration w/Groin Field	Bulkhead/Seawall	Berm & dune restoration w/structural reinforcement/ groin field
Air Quality	May have minor or negligible beneficial impact on air quality due to decrease in population density and structures in the area after evacuation is completed.	Emissions discharges from dredge and construction equipment would result in localized and temporary air quality degradation in the vicinity of construction .	Same as berm restoration.	Same as berm restoration.	Same as berm and dune restoration with a minor incremental increase in emissions to build structural reinforcement.	Same as berm and dune restoration with a minor incremental increase in emissions to build groins.	Emissions discharges from construction equipment would be minor and temporary during the duration of construction activities.	Same as berm and dune restoration with a an incremental increase in emissions to build groins and structural reinforcement.
Topography and Soils	**Beach/Nearshore:** Beach would be allowed to erode significantly reducing beach width and profile. **Offshore:** No effect.	**Beach/Nearshore**: Impacts on beach topography would be beneficial by providing a consistent stable beach profile during the project life. Beach berm elevation would be raised by a few feet over existing profile. Sand fill would be compatible with existing beach sand. **Offshore:** Long-term changes in borrow site bathymetry are expected from impacts associated with deepening through dredging.	**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**: 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. **Offshore:** Same as berm and dune 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 and dune restoration.	**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.	**Beach/Nearshore**: Combination of all Cycle 2 alternatives. **Offshore:** Combination of all Cycle 2 alternatives
Ground-water	**Beach/Nearshore:** No effect. **Offshore:** No effect.	**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 and dune restoration **Offshore:** Same as berm and dune restoration.	**Beach/Nearshore**: Same as berm and dune restoration **Offshore:** Same as berm and dune restoration.	**Beach/Nearshore**: No effect. **Offshore:** No effect.	**Beach/Nearshore**: Combination of all Cycle 2 alternatives **Offshore:** Combination of all Cycle 2 alternatives
Hydrodynamics	**Beach/Nearshore:** Beach would be allowed to erode significantly reducing beach width and profile. Tides and currents would not be affected. **Offshore:** No effect.	**Beach/Nearshore**: Only negligible effects are expected on nearshore transport and beach runup. Intertidal zone would be displaced seaward. **Offshore:** Only negligible effects are expected on wave climate.	**Beach/Nearshore:** No effect. **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 and dune 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 and dune 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.	**Beach/Nearshore**: Combination of all Cycle 2 alternatives **Offshore:** Same as berm and dune restoration.

Resource Categories	Permanent Evacuation	Berm Restoration	Geotextile Tubes	Berm and Dune Restoration	Berm and Dune Restoration w/ Structural Reinforcement	Berm and Dune Restoration w/Groin Field	Bulkhead/Seawall	Berm & dune restoration w/structural reinforcement/ groin field
Water Quality	**Beach/Nearshore:** No effect. **Offshore:** No effect.	**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 restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Same as berm and dune restoration.	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Same as berm and dune restoration.	**Beach/Nearshore:** No effect. **Offshore:** No effect.	**Beach/Nearshore**: Combination of all Cycle 2 alternatives **Offshore:** Combination of all Cycle 2 alternatives
Wetlands	**Beach/Nearshore:** No effect, however, in the long-term, continued erosion may degrade salt marsh wetlands to the west by continued sand overwash resulting from storms. **Offshore:** No effect.	**Beach/Nearshore**: No vegetated wetlands would be affected within the project impact area. **Offshore:** Not applicable.	**Beach/Nearshore**: Same as berm restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore**: Same as berm restoration. **Offshore:** Not applicable.	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Not applicable.	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Not applicable.	**Beach/Nearshore:** No effect. **Offshore:** No effect.	**Beach/Nearshore**: Combination of all Cycle 2 alternatives **Offshore:** Not applicable.
Terrestrial Ecology	**Beach/Nearshore:** Removal of structures and development would improve terrestrial habitat, however, continued erosion may jeopardize terrestrial habitat. **Offshore:** Not applicable.	**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:** 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**: 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**: Same as berm and dune restoration. **Offshore:** Not applicable.	**Beach/Nearshore:** Bulkhead or seawall may reduce terrestrial habitat diversity for the upper beach and dune area. **Offshore:** Not applicable.	**Beach/Nearshore**: Combination of all Cycle 2 alternatives **Offshore:** Not applicable
Soft-bottom Benthic Organisms	**Beach/Nearshore:** No effect. **Offshore:** No effect.	**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:** Impacts would be minimal since most of the fill placement and construction would occur on the upper beach. **Offshore**: Same as berm restoration, but on a smaller scale.	**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. **Offshore:** Same as berm and dune restoration	**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:** No effect. **Offshore:** No effect.	**Beach/Nearshore**: Same as berm and dune restoration **Offshore:** Same as berm and dune restoration

Resource Categories	Permanent Evacuation	Berm Restoration	Geotextile Tubes	Berm and Dune Restoration	Berm and Dune Restoration w/ Structural Reinforcement	Berm and Dune Restoration w/Groin Field	Bulkhead/Seawall	Berm & dune restoration w/structural reinforcement/ groin field
Rocky Hard Bottom Organisms	**Beach/Nearshore:** No effect. **Offshore:** No effect.	**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 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:** No effect. **Offshore:** No effect.	**Beach/Nearshore:** Same as berm restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore:** Same as berm and dune restoration. **Offshore:** Same as berm and dune 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 and dune restoration.	**Beach/Nearshore:** No effect. **Offshore:** No effect.	**Beach/Nearshore**: Same as berm and dune restoration with groin field. **Offshore:** Same as berm and dune restoration
Shellfish and Essential Fish Habitat Resources	**Beach/Nearshore:** No effect. **Offshore:** No effect.	**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:** Impacts would be minimal since most of the fill placement and construction would occur on the upper beach. **Offshore:** Same as berm restoration, but on a smaller scale.	**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. **Offshore:** Same as berm and dune restoration.	**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:** No effect. **Offshore:** No effect.	**Beach/Nearshore**: Same as berm and dune restoration w/ groinfield **Offshore:** Same as berm and dune restoration w/ groinfield

Resource Categories	Permanent Evacuation	Berm Restoration	Geotextile Tubes	Berm and Dune Restoration	Berm and Dune Restoration w/ Structural Reinforcement	Berm and Dune Restoration w/Groin Field	Bulkhead/Seawall	Berm & dune restoration w/structural reinforcement/ groin field
Finfish and Essential Fish Habitat Resources	**Beach/Nearshore:** No effect. **Offshore:** No effect.	**Beach/Nearshore**: Most highly mobile finfish would be able to avoid beachfill placement area during construction. Turbidity generated could clog gills and inhibit respiration and adversely affect sight feeders. Burial of benthic community may temporarily disrupt food chain in impacted area. **Offshore:** Most highly mobile finfish would be able to avoid the dredging intake during dredging. Turbidity generated could clog gills and inhibit respiration and adversely affect sight feeders. Loss of benthic community may temporarily disrupt food chain in impacted area.	**Beach/Nearshore:** Impacts would be minimal since most of the fill placement and construction would occur on the upper beach. **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:** Same as berm and dune 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 and dune restoration.	**Beach/Nearshore:** No effect. **Offshore:** No effect.	**Beach/Nearshore**: Same as berm and dune restoration w/ groinfield **Offshore:** Same as berm and dune restoration w/ groinfield
Endangered Species	**Beach Nearshore:** Removal of structures and development from beachfront may improve habitat for threatened and endangered shorebirds. **Offshore:** No effect.	**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 restoration. **Offshore:** Same as berm restoration.	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Same as berm and dune restoration.	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Same as berm and dune restoration.	**Beach/Nearshore:** Same as berm and dune restoration. **Offshore:** No effect.	**Beach/Nearshore**: Same as berm and dune restoration **Offshore:** Same as berm and dune restoration w/ groinfield
Cultural Resources	**Beach/Nearshore:** No effect. **Offshore:** No effect.	**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:** No effect. **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:** Same as berm and dune restoration.	**Beach/Nearshore**: Same as berm and dune restoration. **Offshore:** Same as berm and dune restoration.	**Beach/Nearshore:** No effect. **Offshore:** No effect.	**Beach/Nearshore**: Same as berm and dune restoration w/ groinfield **Offshore:** Same as berm and dune restoration w/ groinfield

Resource Categories	Permanent Evacuation	Berm Restoration	Geotextile Tubes	Berm and Dune Restoration	Berm and Dune Restoration w/ Structural Reinforcement	Berm and Dune Restoration w/Groin Field	Bulkhead/Seawall	Berm & dune restoration w/structural reinforcement/ groin field
Aesthetics	**Beach/Nearshore:** May improve aesthetics by restoring affected area back to a more natural condition. **Offshore:** No effect.	**Beach/Nearshore**: Temporary adverse impacts on sight and smell due to construction activities (equipment, earth moving, initial color of sand, sulfide gas) would disappear upon cessation of construction. A wider, more stable beach in the impact area may have long-term beneficial impacts on aesthetics in maintaining the integrity of the area. **Offshore:** Dredge equipment working offshore may appear unsightly during construction and periodic nourishment.	**Beach/Nearshore:** A dune with a geotextile tube core may inhibit ocean views of some properties. Potential for exposure of geotextile tube core, which may be considered unsighhtly. **Offshore:** Same as berm restoration.	**Beach/Nearshore**: Same as berm restoration except that a dune may impact some ocean views. **Offshore:** Same as berm restoration.	**Beach/Nearshore**: Same as berm and dune restoration except that a reinforcement structure may be unsightly if it is left exposed. **Offshore:** Same as berm and dune 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 and dune restoration.	**Beach/Nearshore:** Hardened structures such as bulkheads and seawalls would have adverse aesthetic impacts because of their unnatural appearance. **Offshore:** No effect.	**Beach/Nearshore**: Combination of all four alternatives. **Offshore:** Same as berm and dune restoration.

5.5.3 Ludlam Island: Cycle 3 – Final Screening and Optimization

The purpose of the cycle 3 plan formulation was to conduct a detailed analysis of the alternatives that have progressed through the prior two cycles of plan formulation. Detailed costs were developed so that a selected plan could be determined. The alternatives that were analyzed in this cycle were as follows:

- Berm restoration
- Berm and dune restoration
- Berm and dune restoration with structural reinforcement
- Berm and dune restoration w/groin field
- Berm & dune restoration w/structural reinforcement/groin field.
- Permanent Evacuation (Whale Beach area only)

Due to the number of alternatives that were analyzed, costs that were assumed relatively constant for all plans (such as real estate costs) or relatively low-cost (sand fence, dune grass) were not included in the formulation as they would not have affected the relative determination of the "selected plan". Also, cost of fill and infrastructure benefits were only quantified for the selected plan, as previous analyses have shown these benefits not to affect the relative determination of the "selected plan. All associated costs were included in the "selected plan", shown later in this report.

5.5.3.1 Design Parameters

In Cycle 3, the berm/dune each nourishment alternative required optimization of the design parameters. In developing these parameters, the existing conditions in the study area and accepted coastal engineering practices were reviewed. Listed below are the boundary conditions utilized to construct a logical methodology used to efficiently identify the optimum plan.

Berm Elevation (NAVD88). Tides, waves, and beach slope determine the natural berm elevation. If the berm is too high, scarping may occur, if too low, ponding of water and temporary flooding may occur when a ridge forms at the seaward edge. The existing berm elevations in the study area vary between +1.5 m (5 ft) in Strathmere to +2.1 (6.8 ft) for Sea Isle City. It was determined that a constructable template which closely matches the prevailing natural berm height in the study area should be +1.8 m (6 ft). This elevation was used for all designs.

Beachfill Slope. The slope of the design berm is based on historical profiles and the average slope of the berm, both onshore and offshore. The existing foreshore slope ranges from 1:50 to 1:30, therefore the foreshore slope for all alternatives was set to match the existing down to the Mean Low Water elevation. Below the mean low water line the slope follows that of the existing profile to the point where the design berm meets the existing profile.

Berm Width. An interval between successive berm widths was used for modeling purposes. In general, this interval was set wide enough to discern significant differences in costs and benefits between alternatives but not so great that the NED plan could not be accurately determined. An interval of 50 feet (15 meter) was used. This interval has been successfully in previous feasibility studies.

Due to the nesting of piping plovers (an endangered species) consideration was also given to maximum and minimum widths to support nesting. USFWS estimated beach (seaward toe of dune to Mean High Water) for piping plovers to range from 45m (150 ft) minimum to about 91m (300 ft) maximum. Taking into account the foreshore slopes, for most locations along Ludlam Island, this translates into a maximum berm width of about 76 meters (250 ft) while the minimum berm width for piping plovers would only need to be about 2 meters (7 ft). Since this minimum is less than the existing berm width, meeting this requirement would not be a concern.

The largest design berm width analyzed was 30 meters (100 feet) based on the determination where the additional were greater than additional benefits captured. The smallest berm width analyzed was set at the minimum average existing berm width, 15 meters (50').

Design Baseline. A design baseline was established along the ocean frontage of the project study area in order to determine the alignment of the proposed beach restoration alternatives. This baseline was set at the existing bulkhead or the centerline of the existing dune if no bulkhead was present.

Dune Height (NAVD88). As with berm width, an interval between successive dune heights was used for modeling purposes. This interval was set wide enough to discern significant differences in costs and benefits between alternatives but not so great that the NED plan could not be accurately determined. The interval used was 0.6 meters (2 ft). The largest design dune height used was +5.1 meters (16.8 ft). The lowest design dune height evaluated, +3.9 meters (12.8 ft), was less than a foot above the height of the existing promenade in Sea Isle City +3.7 meters (12.0 ft).

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 southern New Jersey coast. This dune configuration was patterned after designs by Joseph M. Caldwell, a USACE engineer. The "Caldwell Section" was used to design protection of coasts 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 5H: 1V, 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 width (at crest) was set at 7.6 meters (25 ft).

Design Beachfill Quantities. Quantities for each alternative were calculated by superimposing the proposed design templates on the existing beach survey cross sections. Average end area methods were used to compute the volumes.

Periodic Nourishment Volumes. In order to maintain the design template periodic sand nourishment is needed, otherwise the design profile would erode. This nourishment volume is considered sacrificial and protects the design template. At the end of the nourishment cycle, the design beach profile remains

A higher nourishment cycle duration brings a corresponding decrease in the annualized cost of beachfill 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.

For the plan formulation analysis, the nourishment volume was computed based on long-term erosion and diffusion. The diffusion component therefore caused the rate to vary depending on the berm width. Periodic sand nourishment cycle was estimated at 5 years, same as the existing Federal project in Ocean City. Advanced nourishment was also placed with the initial fill and an overfill factor of 1.15 was applied during the cost estimating calculations. The borrow source locations used were L3, L1, and C1 (see Figure 2.2.11-1). Nourishment volumes are listed in tables that follow.

5.5.3.2 Berm Restoration

5.5.3.3 Berm and Dune Restoration

As shown in the previous analysis for South End Ocean City, berm restoration was not shown to be cost-effective, especially when compared to berm and dune restoration. However, berm restoration alternatives were still considered and analyzed for Ludlam Island. For comparison reasons, the berm and berm and dune restoration alternatives were analyzed concurrently.

While South End Ocean City is virtually homogenous with regard to the shoreline features, the existing conditions along Ludlam Island vary. Therefore, to determine the most-efficient possible plan for the entire length of Ludlam Island, sections or reaches were analyzed separately. Specifically, cells LI1-LI2A, LI3, and LI4-LI6 (refer back to Section 1 for photos and maps). The most cost-effective plans were then combined along the entire length of Ludlam Island.

Cell	Length		Location
	meters	feet	
		Ludlam Island	
LI1	478	1569	Strathmere – Seaview to Whittier
LI2	392	1287	Strathmere – Whittier to Sherman
LI2A	785	2576	Strathmere – Sherman to Hamilton
LI3	2090	6858	Whale Beach area – Hamilton to approx 13th St
LI4	1406	4613	Sea Isle City – approx 13th to 29th St
LI4N	1035	3395	Sea Isle City –29th St to JFK Blvd
LI5	966	3170	Sea Isle City - JFK Blvd to 52nd St
LI4S	429	1408	Sea Isle City - 52nd St to 57th St
LI5B	1433	4701	Sea Isle City – 57th St to 75th St
LI6	1066	3496	Sea Isle City – 75th to 88th St
LI6B	427	1400	Sea Isle City – 88th to 93rd St.

Some berm and dune configurations were not analyzed in all areas of Ludlam Island as trends indicated that they would not be more cost-effective. In addition, due to the limited amount of structures in Cell LI3[15], effort was not spent running numerous berm and dune configurations since it was obvious that a minimum size would be the most cost-effective.

The following table shows component information, followed by tables showing the matrix of alternatives that were analyzed.

Component	Dimension	Remarks
Berm Elevation (NAVD 88)	+1.8 m (6.0 ft)	Existing = +1.7 m (5.5 ft) Strathmere, to +2.1 m (7 ft) Sea Isle City Recon study plan = +1.1 m (3.8 ft) Strathmere, 2.2 m (7.2 ft) Sea Isle City
Beachfill Slope	Approximates existing	Existing = 1:50 to 1:30
Berm Width	Varies	Existing averages about 15 meters (50 ft). Recon study plan = 30.8 meters (100 ft) According to USFWS, for piping plovers, max beach (seaward toe of dune extending down to MHW) width should range between about 91 m (300') max and 45 m (150 ft) min. Therefore, berm width (seaward toe of dune to berm crest) should be less than about 76 m (250 ft) as slope.
Dune Height (NAVD88)	Varies	A somewhat narrow dune system extends from the Corson Inlet to Tecumesh Ave. The crest elevation of this system varies mostly between +2.7 and +3.6 m (9.0 and 12.0 ft), with elevations as high as +3.7 m (12.0 ft) and as low as +2.5 m (8.0 ft). A fairly substantial dune system extends from south of Sherman Ave. to the southern boundary of Strathmere. The crest elevation of this dune system varies mostly between +3.0 and +3.9 m (10.0 and 13.0 ft) with several elevations as high as +4.8 m (15.5 ft) and as low as +2.8 m (9.0 ft). A timber bulkhead, in poor condition extends from Tecumesh Ave to Sherman Ave, top elevation +2.4m (8.0 ft) In Sea Isle City, a substantial dune system extends from 13th to 29th Sts. The crest elevation of this system varies mostly between +4.0 and +4.3 m (13.0 and 14.0 ft) and with elevations as high as +4.7 (15.5 ft) and as low as +3.7 m (12.0 ft). Existing promenade in Sea Isle City +3.7 meters (12.0 ft).
Dune Width	7.6 m (25')	Standard Caldwell section width
Dune Side Slopes	1:5	Standard Caldwell section slopes
Dune offset for maintenance	0	

[15] It should also be noted that cell LI3 was the only cell on Ludlam Island which showed a long-term erosion rate.

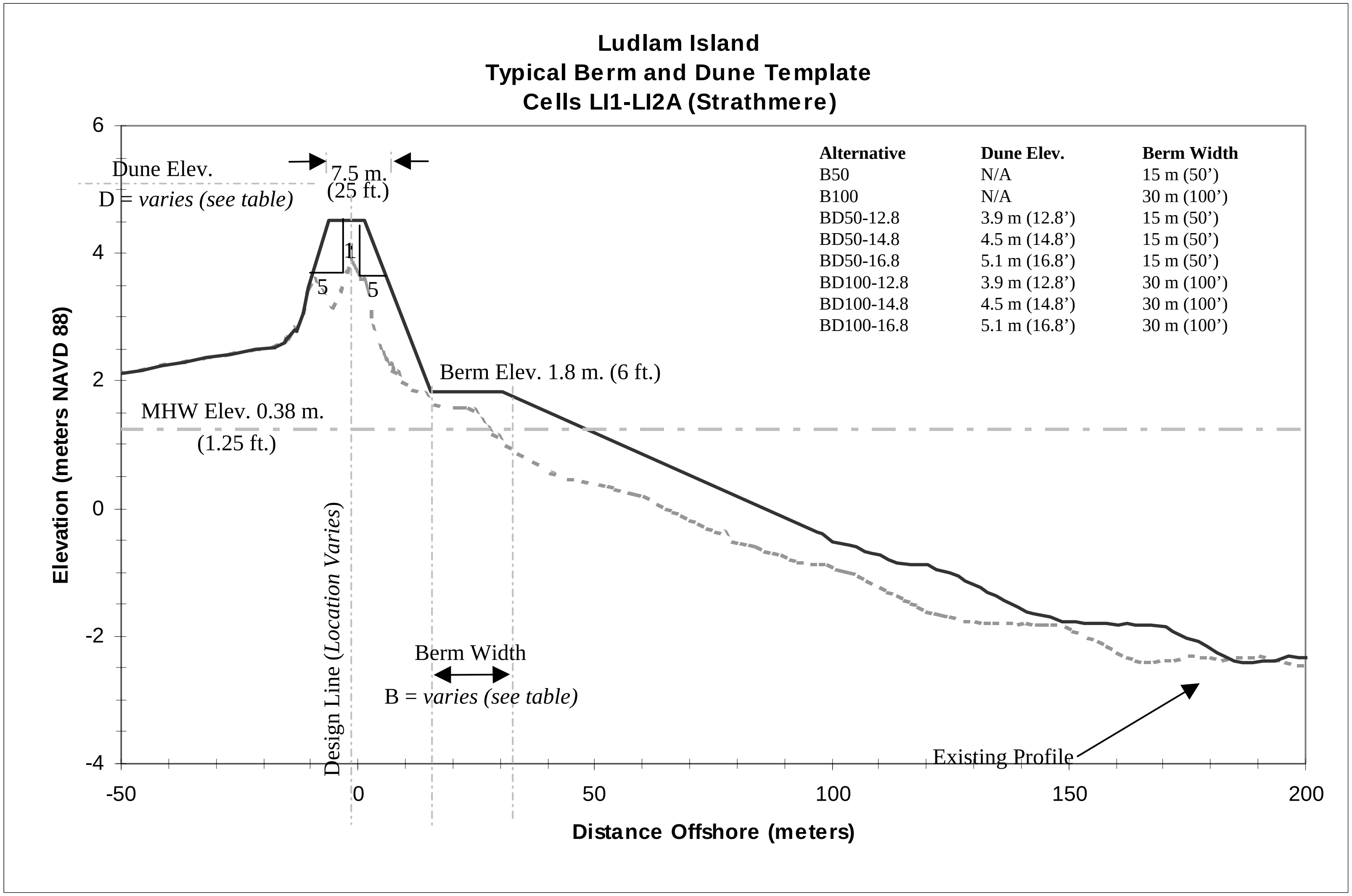
The optimization of berm and dune alternatives was conducted by first conducting an initial screening for the Cells LI1-LI2A (Strathmere).

Ludlam Island
Initial Screening – Cells LI1-LI2A (Strathmere area)
Matrix of Berm and Dune Restoration Alternatives

Dune Elevation (NAVD88)	**Berm width (measured from seaward toe of dune)**	
	15 meters[16] (50ft)	30 meters (100 ft)
No dune	B50*	B100
3.9 meters (12.8 ft)	BD50-12.8	BD100-12.8
4.5 meters (14.8 ft)	BD50-14.8	BD100-14.8
5.1meters (16.8 ft)	BD50-16.8	BD100-16.8

The following figure presents a graphical representation of the alternatives that were analyzed.

[16] Average existing berm width



Cell shown is LI1

Note than increased dune height translates to increased dune width, pushing the berm further seaward and increasing sand quantity.

Results from SBEACH and COSTDAM model runs are shown on the following table[17].

Ludlam Island
Initial Screening – Cells LI1-LI2A (Strathmere area)
Berm and Dune Restoration Alternatives
Storm Damage to Structures by Category
October 1998 Price Level - 6.875% Discount Rate

Alternative Name	**Avg. Annual Damages**			**Total**
	Erosion	**Inundation**	**Wave**	
Without-Project	*$189,000*	*$151,000*	*$299,000*	*$639,000*
B50	$91,000	$72,000	$206,000	$369,000
BD50-12.8	$28,000	$21,000	$140,000	$189,000
BD50-14.8	$11,000	$19,000	$89,000	$119,000
BD50-16.8	$7,000	$29,000	$72,000	$108,000
B100	$82,000	$19,000	$205,000	$306,000
BD100-12.8	$15,000	$18,000	$111,000	$144,000
BD100-14.8	$10,000	$18,000	$89,000	$117,000
BD100-16.8	$5,000	$29,000	$59,000	$93,000

Trends were as follows:

Erosion Damage

- All alternatives showed significant erosion damage reduction. Berm-only alternatives were not as effective as berm and dune alternatives.

Inundation Damage

- All configurations provided significant and, with the exception of B50, a similar amount of damage reduction. No real patterns emerged between alternatives. Slight increases in inundation damages when comparing constant berm width and increasing dune height can be attributed to a shift across damage categories.

Wave Damage

- Holding berm width constant, wave damages decreased with increasing dune height.
- Holding dune height constant, wave damages decreased with increasing berm width.

[17] This table does not include cost of fill or infrastructure damages, since they are relatively minor when compared to damage to structures.

- Berm and dune alternatives provided greater wave damage reduction the berm-only alternatives

Total Damages

- Holding berm width constant, total damages decreased significantly with increasing dune height
- Holding dune height constant, total damages decreased with increasing berm width, tough not a significantly as when dune height was increased

Cell LI2 Bulkhead Failure

The model runs also indicated that all berm and dune alternatives would shift bulkhead failure from the 50-year frequency event to at least the 200-year frequency event. General trends showed that raising the dune height moves bulkhead failure to lower frequency storm events, while berm width changes did not change the bulkhead failure storm frequency. Berm only plans did not affect bulkhead failure.

Benefits to structures for each plan are shown in the following table with alternative BD50-14.8 generating the greatest net benefits among the alternatives.

Local Costs Foregone

As detailed in sections 1.5.3 and 1.6 of this report, the State of New Jersey and local communities have been active in providing storm damage protection measures. Local costs forgone for Ludlam Island were also based on historical and predicted local projects if the selected plan is not constructed. In the absence of the selected plan, these expenditures would continue and are therefore included in the following table. Sections 4.2.6 and 6.4.2 details the information used to determine the estimated local costs foregone for Ludlam Island. Average annual local costs foregone for cells LI1-LI2A were calculated to be $191,000.

Ludlam Island
Initial Screening – Cells LI1-LI2A (Strathmere area)
Berm and Dune Restoration Alternatives
Storm Damage Reduction Benefits to Structures Only
October 1998 Price level - 6.625% Discount Rate

Alternative Name	**Description**		**Avg. Annual Damages***	**Avg. Annual Damage Reduction Benefits**	**% Damage Reduction**	**Sand Quantity (cu meters)**		**Avg. Annual Costs**	**Local Costs Foregone**	**Recreation Benefits[18]**	**Net Benefits**
	Dune Height (meters NAVD 88)	**Avg. Berm Width (meters)**				**Initial**	**Periodic Nourishment**				
Without-Project	*N/A*	*15 (50 ft)*	*$639,000*								
B50	N/A	15 (50 ft)	$369,000	$270,000	42%	210,000	210,000	$791,000	$191,000	$265,000	-$65,000
BD50-12.8	3.9 (12.8 ft)	15 (50 ft)	$189,000	$450,000	70%	291,000	210,000	$833,000	$191,000	$265,000	$73,000
BD50-14.8	4.5 (14.8 ft)	15 (50 ft)	$119,000	$520,000	81%	394,000	210,000	$886,000	$191,000	$265,000	$90,000
BD50-16.8	5.1 (16.8 ft)	15 (50 ft)	$108,000	$531,000	83%	546,000	210,000	$965,000	$191,000	$265,000	$22,000
B100	N/A	30 (100 ft)	$306,000	$333,000	52%	432,000	302,000	$1,098,000	$191,000	$265,000	-$309,000
BD100-12.8	3.9 (12.8 ft)	30 (100 ft)	$144,000	$495,000	78%	510,000	302,000	$1,134,000	$191,000	$265,000	-$183,000
BD100-14.8	4.5 (14.8 ft)	30 (100 ft)	$117,000	$522,000	82%	600,000	302,000	$1,179,000	$191,000	$265,000	-$201,000
BD100-16.8	5.1 (16.8 ft)	30 (100 ft)	$93,000	$546,000	85%	796,000	302,000	$1,280,000	$191,000	$265,000	-$278,000

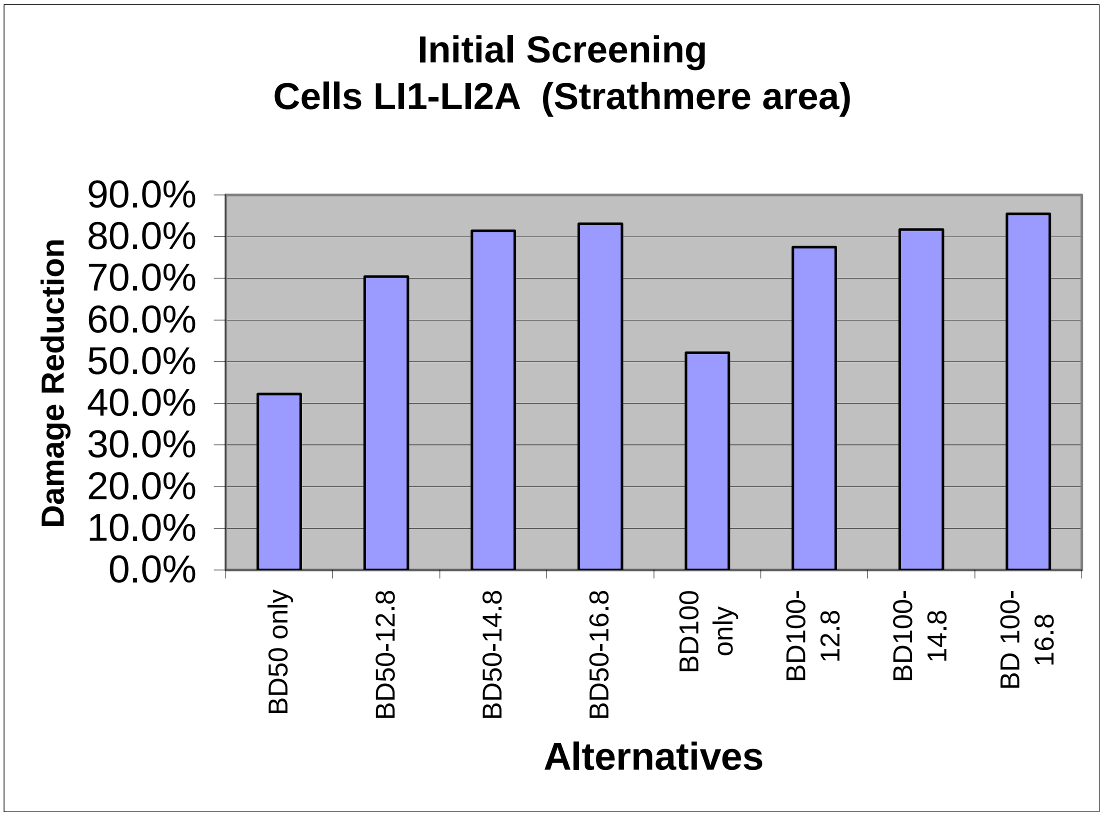
*Does not include damage to infrastructure, and cost of fill

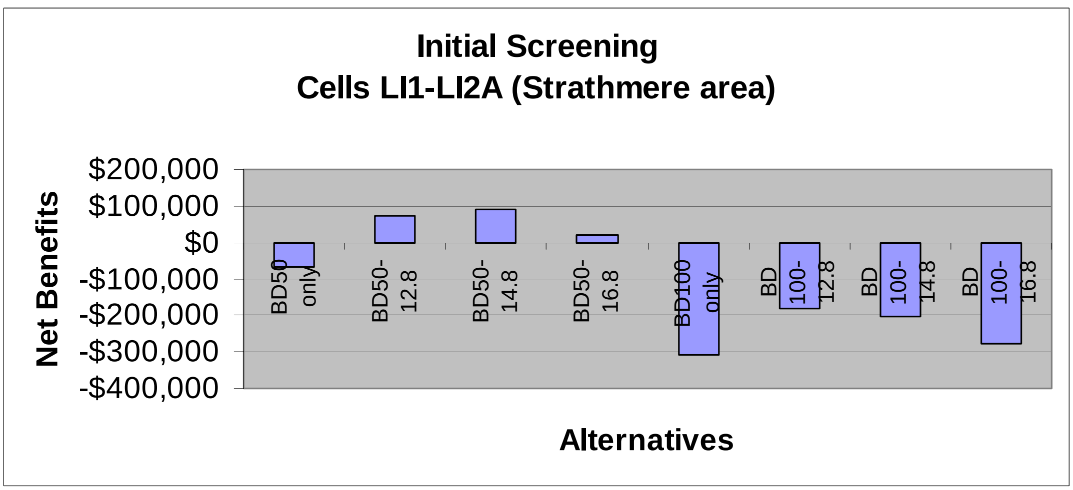
[18] October 1999 price level, see Section 6.4.3 for information regarding this category.

The following table shows the relationship of this alternative to the others.

Dune Elevation (NAVD88)	Berm width (measured from seaward toe of dune)	
	15 meters[19] (50ft)	30 meters (100 ft)
No dune Net benefits	B50 -$65,000	B100 -$309,000
3.9 meters (12.8 ft)* Net benefits	BD50-12.8 $73,000	BD100-12.8 -$183,000
4.5 meters (14.8 ft) Net benefits	**BD50-14.8** **$90,000**	BD100-14.8 -$201,000
5.1meters (16.8 ft) Net benefits	BD50-16.8 $22,000	BD100-16.8 -$278,000

[19] Average existing berm width


Initial Screening
Cells LI1-LI2A (Strathmere area)
Damage Reduction
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
BD50 only
BD50-12.8
BD50-14.8
BD50-16.8
BD100 only
BD100-12.8
BD100-14.8
BD 100-16.8
Alternatives


Initial Screening
Cells LI1-LI2A (Strathmere area)
Net Benefits
$200,000
$100,000
$0
-$100,000
-$200,000
-$300,000
-$400,000
BD50 only
BD50-12.8
BD50-14.8
BD50-16.8
BD100 only
BD 100-12.8
BD 100-14.8
BD 100-16.8
Alternatives

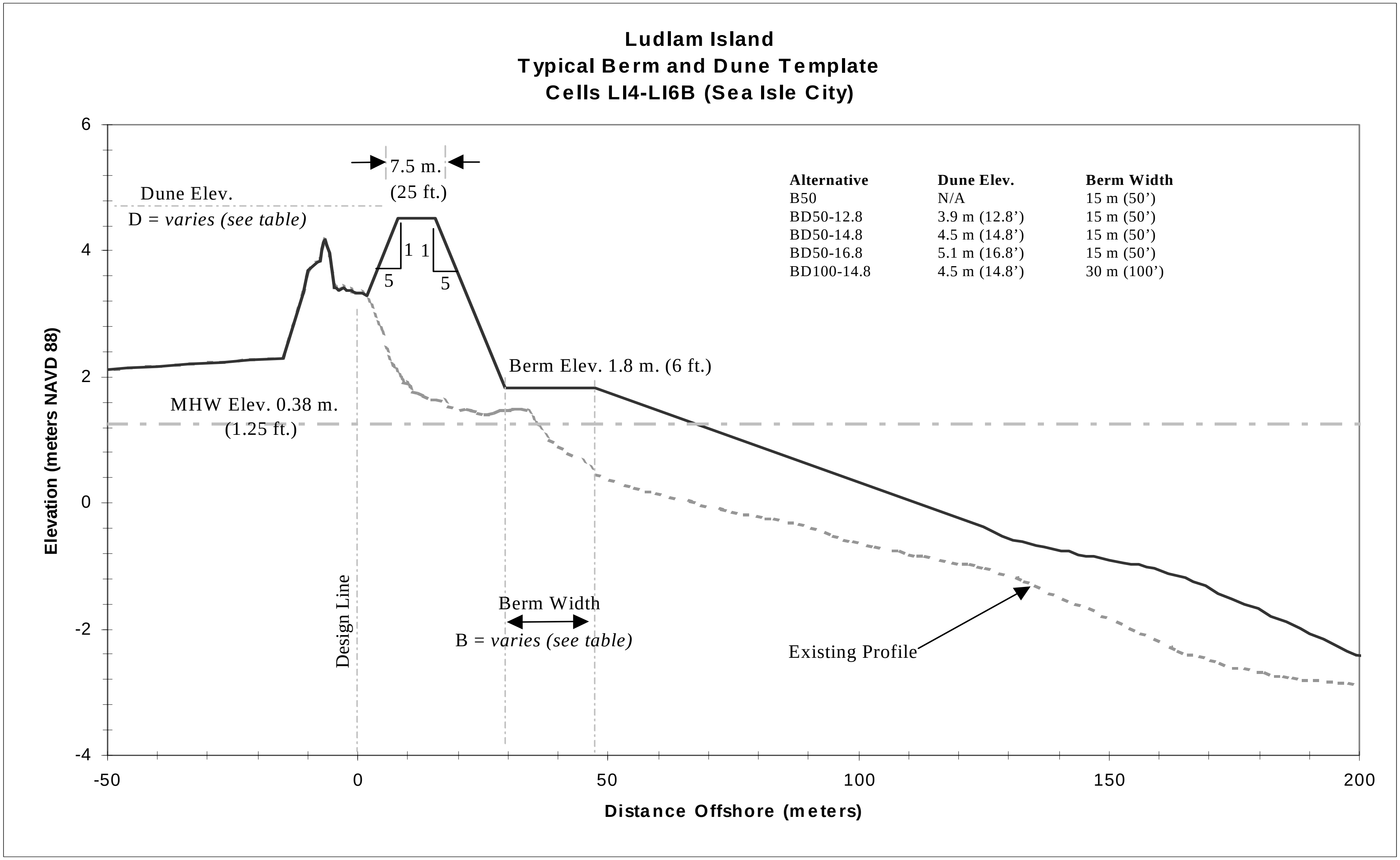
Next, alternatives were analyzed for cells LI4-LI6B, which extends from 29th Street to 93rd Street in Sea Isle City. These alternatives were identical to those analyzed previously for cells LI1 to LI2A with the exception of the omission of alternatives B50, BD100-12.8, and BD100-16.8. It was evident from the previous analysis for cells LI1to LI2A and the patterns that developed for cells LI4to LI6B that any of these three alternatives would not be among the most cost-effective.

Ludlam Island
Initial Screening - Cells LI4-LI6B (29th Street to 93rd Street, Sea Isle City)
Matrix of Berm and Dune Alternatives

Dune Elevation (NAVD88)	**Berm width (measured from seaward toe of dune)**	
	15 meters[20] (50ft)	30 meters (100 ft)
No dune	B50	N/A
3.9 meters (12.8 ft) (Existing promenade = +3.7 meters (12.0 ft))	BD50-12.8	BD100-12.8
4.5 meters (14.8 ft)	BD50-14.8	N/A
5.1meters (16.8 ft)	BD50-16.8	N/A

The following figure presents a graphical representation of the alternatives that were analyzed for Cell LI4-LI6B.

[20] Average existing berm width



Specific cell shown above is LI5

Note than increased dune height translates to increased dune width, pushing the berm further seaward and increasing sand quantity

Results from SBEACH and COSTDAM model runs are shown on the following table[21].

Ludlam Island
Initial Screening – Cells LI4-LI6B (Sea Isle City)
Berm and Dune Restoration Alternatives
Storm Damage to Structures by Category
October 1998 Price Level - 6.625% Discount Rate

Alternative Name	Avg. Annual Damages			Total
	Erosion	Inundation	Wave	
Without-Project	*$482,000*	*$876,000*	*$2,294,000*	*$3,652,000*
B50	$297,000	$311,000	$2,228,000	$2,836,000
BD50-12.8	$241,000	$250,000	$2,194,000	$2,685,000
BD50-14.8	$155,000	$210,000	$1,297,000	$1,662,000
BD50-16.8	$101,000	$215,000	$1,223,000	$1,539,000
BD100-14.8	$120,000	$205,000	$1,295,000	$1,620,000

Trends were as follows:

Erosion Damage

- All alternatives showed significant erosion damage reduction. Damages were reduced with higher dune height and berm width.

Inundation Damage

- All configurations provided significant and, with the exception of B50, a similar amount of damage reduction. In general, inundation damages decreased with increasing dune height. Slight increases in inundation damages when comparing constant berm width and increasing dune height (see BD50-16.8) can be attributed to a shift across damage categories.

Wave Damage

- Holding berm width constant, wave damages decreased with increasing dune height, especially between alternatives BD50-12.8 and BD50-14.8.
- Holding dune height constant, wave damages decreased insignificantly with increasing berm width.

[21] This table does not include cost of fill or infrastructure damages, since they are relatively minor when compared to damage to structures.

- Berm and dune alternatives provided greater wave damage reduction than the berm-only alternatives

Total Damages

- Holding berm width constant, total damages decreased significantly with increasing dune height
- Holding dune height constant, total damages decreased slightly with increasing berm width.

Cell LI4N, LI4S, and LI5 Bulkhead Failure

The model runs also indicated that for cells LI4N and LI4S, all berm and dune alternatives would shift bulkhead failure from the 50-year frequency event to at least the 200-year frequency event. General modeling trends showed that the presence of a dune provides significant protection to the bulkhead and prevents failure of the bulkhead until lower frequency storms.

Increases in berm width only are not as effective of an alternative for preventing bulkhead failure. For the berm only alternative, bulkhead failure was at the 100-year frequency event for cells LI4N&S and LI5. The without-project failure for these cells was at the 50-year frequency event in Cell LI4N&S and the 100-year frequency event for Cell LI5.

Benefits to structures for each plan are shown in the following table.

Ludlam Island
Initial Screening – Cells LI4-LI6B (Sea Isle City)
Berm and Dune Restoration Alternatives
Storm Damage Reduction Benefits to Structures Only
October 1998 Price level - 6.625% Discount Rate

Alternative Name	**Description**		**Avg. Annual Damages***	**Avg. Annual Damage Reduction Benefits**	**% Damage Reduction**	**Sand Quantity (cu meters)**		**Avg. Annual Costs**	**Local Costs Foregone[22]**	**Recreation Benefits[23]**	**Net Benefits**
	Dune Height (meters NAVD 88)	**Avg. Berm Width (meters)**				**Initial**	**Periodic Nourishment**				
Without-Project	*N/A*	*15 (50 ft)*	*$3,652,000*								
B50	N/A	15 (50 ft)	$2,836,000	$816,000	22%	466,000	654,000	$1,889,000	$818,000	$1,210,000	$732,000
BD50-12.8	3.9 (12.8 ft)	15 (50 ft)	$2,685,000	$967,000	27%	695,000	654,000	$2,007,000	$818,000	$1,210,000	$988,000
BD50-14.8	4.5 (14.8 ft)	15 (50 ft)	$1,662,000	$1,990,000	55%	1,083,000	654,000	$2,209,000	$818,000	$1,210,000	$1,808,000
BD50-16.8	5.1 (16.8 ft)	15 (50 ft)	$1,539,000	$2,113,000	58%	1,538,000	654,000	$2,418,000	$818,000	$1,210,000	$1,723,000
BD100-14.8	4.5 (14.8 ft)	30 (100 ft)	$1,620,000	$2,032,000	56%	1,906,000	971,000	$3,216,000	$818,000	$1,210,000	$844,000

*Does not include damage to infrastructure, and cost of fill

[22] Sections 4.2.6 and 6.4.2 of this report details the information used to determine the estimated local costs foregone.
[23] See Section 6.4.3 for information regarding this category.

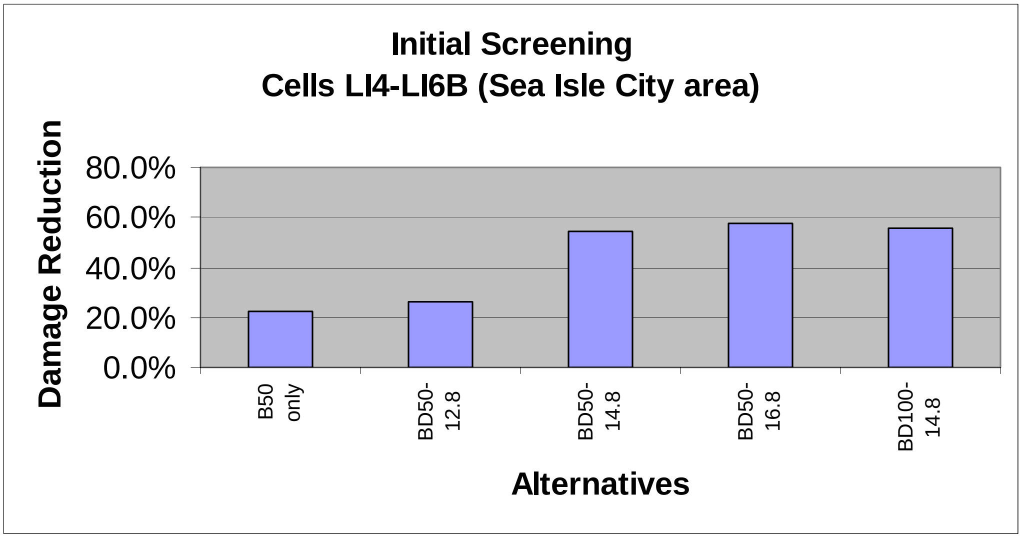
The analysis showed that for cells LI4 to LI6B, that alternative BD50-14.8 produces that greatest net benefits when compared to other berm and dune alternatives considered. This configuration was identical to the plan for cells LI1-LI2A.

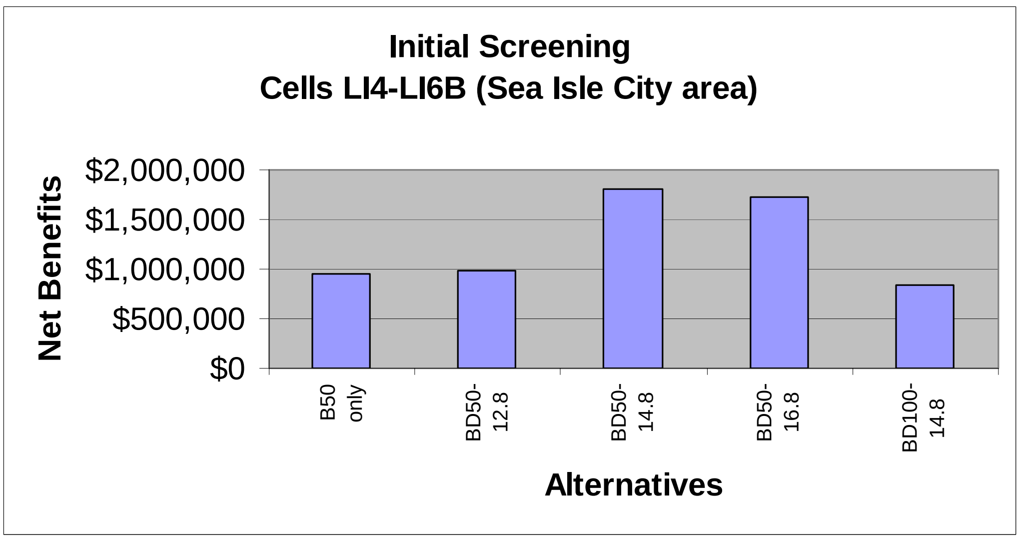
The following table shows the relationship of this alternative to the others.

Dune Elevation (NAVD88)	**Berm width (measured from seaward toe of dune)**	
	15 meters[24] (50ft)	30 meters (100 ft)
No dune Net benefits	B50 $732,000	N/A
3.9 meters (12.8 ft) Net benefits	BD50-12.8 $988,000	N/A
4.5 meters (14.8 ft) Net benefits	**BD50-14.8** **$1,808,000**	BD100-14.8 $844,000
5.1meters (16.8 ft) Net benefits	BD50-16.8 $1,723,000	N/A

Existing promenade = +3.7 meters (12.0 ft)

[24] Average existing berm width





Increasing the berm and dune component magnitude generally provided greater damage reduction. However, larger costs for the "bigger" plans generally caused their net benefits to decease.

Up to this point in the plan formulation, the most cost-effective berm and dune alternative was identified for Cells LI1-LI2A and from Cells LI4 to LI6B and was coincidentally identical (B50-14.8). The remaining cell was Cell LI3 (referred to as the "Whale beach area"), which stretches from Hamilton Avenue in Strathmere to 13th Street in Sea Isle City. This area is narrow and is not densely developed. Therefore, effort was not spent applying numerous berm and dune configurations to this area. It was obvious that a small-scale plan would likely be the most cost-effective.

Two configurations were analyzed. Results can be seen in the following table.

Ludlam Island
Initial Screening – Cell LI3 (Whale Beach area)
Berm and Dune Restoration Alternatives
Storm Damage Reduction Benefits to Structures Only
October 1998 Price level - 6.625% Discount Rate

Alternative Name	Description		Avg. Annual Damages*	Avg. Annual Damage Reduction Benefits	% Damage Reduction	Sand Quantity (cu meters)		Avg. Annual Costs	Local Costs Foregone	Recreation Benefits	Net Benefits
	Dune Height (meters NAVD 88)	Avg. Berm Width (meters)				Initial	Periodic Nourishment				
Without-Project	*N/A*	*15 (50 ft)*	*$385,000*								
BD50-12.8	3.9 (12.8 ft)	15 (50 ft)	$283,000	$102,000	27%	844,000	420,000	$1,581,000	$256,000	$115,000	-$1,108,000
BD50-14.8	4.5 (14.8 ft)	15 (50 ft)	$165,000	$220,000	57%	997,000	420,000	$1,656,000	$256,000	$115,000	-$1,065,000

*Does not include damage to infrastructure, and cost of fill

The analysis did show that for Cell LI3, that alternative BD50-14.8 produces that greatest net benefits when compared to the other berm and dune alternative considered. This configuration was identical to that for Cells LI1-LI2A and Cells LI4. Though the net benefits for Cell LI3 were shown as negative, they did not include infrastructure or cost-of-fill benefits. In addition, unit costs for sand would decrease when combined with beachfill for cells LI1-LI2A and LI4-LI6B.

Regardless, omission of the Whale Beach area would leave, according to coastal geologist Norman P. Psuty of Rutgers University, “the most dangerous stretch of beach in New Jersey”[25] without protection and would also lessen the effectiveness of an adjacent berm and dune project along Ludlam Island. In most, if not all aspects, the island functions as a system and therefore protection measures should address it as such. Otherwise, a “weak link” in the project would not only exist; but is actually being “engineered” or designed into the project.

In addition, the road which runs along this area is a hurricane evacuation route along Cape May County (see figure). In recent history, the February 1998 storm was only a five-year stage frequency event, yet the road was rendered entirely impassable for two days due to ocean water overtopping and erosion. Significant potential for damage to both property and the endangerment of human life exists during storms as alternative evacuation routes (towards Sea Isle City and by way of Ocean City) would likely be cut-off.

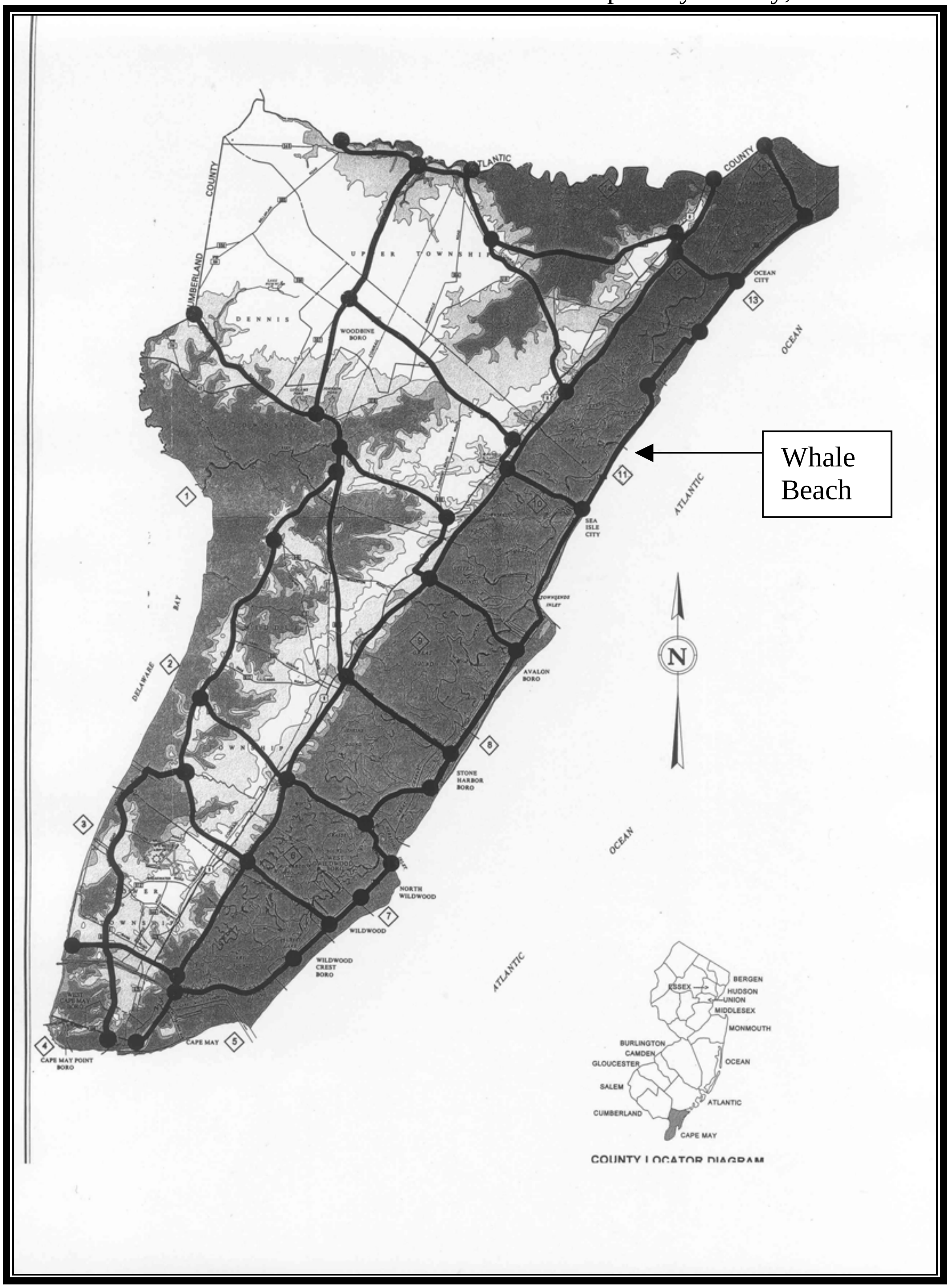
Simply tapering adjacent berm and dune restoration would not be an effective solution. While the use of fill tapers along the entire Whale Beach area instead of the recommended project would reduce costs, the tapers would not provide much, if any storm damage protection.

The purpose of tapers is to stabilize the project and tapering into a “weak” area like Whale Beach would not likely provide stability.

Finally, beach restoration would provide habitat for piping plovers, and endangered species.

[25] Gilbert M. Gaul and Anthony R. Wood, “ A stormy debate over Whale Beach,” *Philadelphia Inquirer*, 14 July 2001, 1(A).

Hurricane Evacuation Routes – Cape May County, NJ



Berm and Dune Plan for entire Ludlam Island

For each section of Ludlam Island analyzed above, the BD50-12.8 alternative demonstrated the greatest net benefits. Therefore, this plan would extend along the entire island. Previously, only damage reduction to structures were included as benefits and other benefit categories such as infrastructure, recreation, and local costs foregone etc. were not. The following table includes these benefits as well as price level updated to October 1999. A detailed description of these benefit categories can be found in Section 6.0 of this report.

Ludlam Island
Berm and Dune Restoration Alternative
Storm Damage Reduction Benefits
October 1999 Price level - 6.625% Discount Rate

Alternative Name	Avg. Annual Damages*	Avg. Annual Storm Damage Reduction Benefits	% Damage Reduction	Recreation Benefits	Local Costs Foregone	Sand Quantity (cu meters)		Avg. Annual Costs	Net Benefits
						Initial	Periodic Nourishment		
Without-Project	*$5,041,000*								
BD50-14.8	$2,102,000	$2,939,000	58%	$1,590,000	$1,298,000	2,525,000	1,335,000	$3,359,000	$2,468,000

*Includes damage to structures, infrastructure, and cost of fill

The following table shows a comparison of when damage mechanisms begin between the without-project and the BD50-14.8 alternative for Ludlam Island.

Plan	Storm Frequency							
	2 yr	5 yr	10 yr	20 yr	50 yr	100 yr	200 yr	500 yr
W/O Proj	---	IN, E	---	---	WD	---	---	---
BD50-14.8	---	---	--	IN*		WD, E	---	---

WD-Wave Damage, IN-Inundation Damage, E-Erosion Damage
*small amount of damage in 10 yr frequency event

5.5.3.4 Berm and dune restoration with structural reinforcement

Consideration was given to the use of structural dune reinforcement to possibly provide a more cost-effective solution compared with berm and dune restoration alternative (BD50-14.8). Geotextile tubes provide protection in certain shoreline applications and are relatively inexpensive, costing around $100 per linear foot. Other types of dune reinforcement have not been widely used locally with consistent success and therefore were not considered.

Geotextile tubes used in oceanfront applications are sand filled structures constructed of permeable geosynthetic material. The size of geotextile tube varies depending on the application, but those constructed parallel to the shoreline as protection need to be large, in order to adequately resist wave forces.

The configuration of geotextile tubes typically includes a primary tube, an anchor tube, and a scour apron. Geotextile tubes are constructed by pumping a sand/seawater slurry into prefabricated tubes. The tubes are laid empty on top of the scour apron. The slurry is pumped through the top of the tube through special openings to accommodate the pump. The water component of the slurry drains through the permeable tube material, leaving the sand inside. The scour apron is used to direct the water excreted from the tube away so during construction, the sand at the base of the tube is not eroded; this scour apron remains after the tubes are filled. The anchor tube is smaller and is placed in front of the primary tube. It is constructed in the same manner as the primary tube. Its function, along with the scour apron, is to prevent erosion of sand beneath the primary geotextile tube so that it remains stable. Scour is the most likely cause of failure.

As a final step, the geotextile tubes should be covered with sand and maintained for sacrificial purposes and for aesthetic appearance. Erosion of sand fronting geotextile tubes typically occurs in a vertical scarp on the seaward side of the tubes (unless an adequate beach exists). This will result in the scour apron "digging in" at the base of the dunes providing a non-erodible permeable base over which sand will come and go. If left exposed to sunlight, the geosynthetic material that geotextile tubes are constructed of may become damaged from long-term exposure to ultraviolet light. The sand could be lost from the tube at which point the geosynthetic and plastic material become more susceptible to the forces of wind and water and can shred. Therefore, in order to maintain geotextile tubes properly, at some point replacement of sand cover becomes necessary. This can pose a maintenance problem if beach nourishment cycles are too far apart. If left exposed, they are especially aesthetically unpleasing in a developed environment such as Ludlam Island.

The possible benefits which could accrue from the placement of geotextile tubes are from:

- Reduction in storm damage (wave, inundation) due to increased stability of the dune
- Reduction of dune reconstruction costs following major storm events costs, since theoretically the geotextile tubes should maintain more of the dune than unconfined sand.

It is difficult to accurately quantify the benefits of the geotextile tubes in this type of analyses, since they cannot be directly modeled using SBEACH. However, examination of the storm analysis model results indicated that for alternative BD50-14.8, with the exception of cell LI3, the 100-year frequency storm is the first event which substantially impacts the dune. Therefore, until that storm event, the geotextile tubes would provide no additional benefits from either storm damage reduction or from the reduction of dune reconstruction costs following storm events. At the 200-year frequency event, enough storm erosion has occurred where the dune and any existing bulkhead would fail. As the bulkhead is much more resistant to failure that the geotextile tubes, it can easily be assumed that the geotextile tubes also fail due to storm damage erosion at the 200-year frequency storm event. Based on this, the tubes are not providing any additional storm protection, nor would they likely contribute to the maintaining of the dune core.

The case is similar for cell LI3, which contains existing geotextile tubes for portion. The 50-year frequency storm is the first event that substantially impacts the dune. Therefore, until that storm event, the geotextile tubes would provide no additional benefits from either storm damage reduction or from the reduction of dune reconstruction costs following storm events. At the 100-year frequency event, enough storm erosion has occurred where the dune and any existing bulkhead would fail. As the bulkhead is much more resistant to failure that the geotextile tubes, it can easily be assumed that the geotextile tubes also fail due to storm damage erosion at the 100-year frequency storm event. Based on this, the tubes are not providing any additional storm protection, nor would they likely contribute to the maintaining of the dune core.

5.5.3.5 Berm and dune restoration w/groin field

Further consideration was given for either the construction of additional groins along Ludlam Island.

Groins control the rate of longshore sediment transport through a project area and can reduce the rate of sediment lost to downdrift beaches. When designed properly, they are effective in stabilizing beaches and reducing nourishment rates where sediment is lost by alongshore movement. The reduction of nourishment rates would lessen or possibly even eliminate long-term Federal commitment of funds, a priority of the current Administration. A method to compare life cycle costs for a groin system is to estimate annual costs of the system in-place (which includes the initial construction, periodic sand nourishment for the reach with the groins and maintenance) against the annual cost of stabilizing the beach by periodic sand nourishment alone.

Fill losses due to longshore transport processes can be reduced by placing groins near to or at the ends of a project (Dean and Yoo, 1993). Groins used for this purpose are usually referred to as "terminal groins" and can increase the longevity of a nourishment project by minimizing transport out of the project area into adjacent areas. Concerns normally arise over the negative impacts to a downdrift beach due to the reduced alongshore sand transport and subsequent downdrift erosion which may occur.

Other recent feasibility studies by the Philadelphia District have also investigated the cost-effectiveness of groins. Groin construction was not found to be cost-effective in any of these cases. The relatively high initial costs (around $2,500 per foot) compared to the reduced sand nourishment savings were not found to be cost-effective.

There are twenty-six existing groins in Ludlam Island, which are described further in section 2.6 of this report. Based on an evaluation of the condition and location of the existing groins, relative coastal processes in the study area (low to moderate longshore transport rates, wave climate and the long-term shoreline erosion rate in the cell LI3), and a proposed NJDEP groin project in the Whale Beach area, it was determined that the construction of additional groins in the Whale Beach area the would be analyzed.

The NJDEP had previously proposed the construction of 5 groins in the Whale Beach area of Sea Isle City. These groins would have been constructed at 6th, 11th, 16th, 21st, and 26th Street and their lengths would vary from 204 meters (670 ft) for streets 6th, 11th, and 16th, to 198 meters (650 ft) for 21st, and 26th Streets.

An analysis was performed using GENESIS (GENEralized Model for SImulating Shoreline Change) to evaluate the effectiveness of extending the existing groin field on Ludlum Island. The GENESIS model simulates long-term shoreline change on an open sandy coast as produced by spatial and temporal differences in wave-driven longshore sediment transport. GENESIS is best used to calculate shoreline change from one equilibrium condition to another, such as in response to structures and/or placement of beachfill. For this study, the model was used to evaluate the effect of additional groins in stabilizing the beach and reducing renourishment requirements for the selected beachfill plan.

The GENESIS model domain included the entire length of Ludlum Island from Corson Inlet to Townsends Inlet. The existing shoreline condition was developed using 1997 shoreline data. Existing groin structures that were modeled included eight groins along the northern end of the domain at Strathmere and 13 groins along the southern half of the domain at Sea Isle City. Wave hindcast information that was previously generated by OCTI was analyzed to develop a representative annual time-history of wave heights and periods for the study area. Using these representative wave conditions, the model was calibrated to match long-term historical trends of annual shoreline erosion and sand transport for Ludlam Island.

The calibrated model was applied using the representative annual wave input to calculate shoreline change over a modeling duration of 5 years, corresponding to the length of the selected renourishment cycle. Several groin alternatives was developed based on a proposed State plan to construct five new groins in the area of Whale Beach. Groin alternatives that were evaluated include a beachfill only plan (no new groins), the proposed State groin plan, and several variations of the State plan involving different groin lengths. Each alternative was modeled to calculate shoreline change over the 5 year renourishment interval. Model results were used to estimate renourishment volumes required to restore the beach to the selected project planform at the end of the 5-yr interval.

Cases modeled were as follows and assumed in combination with the BD50-14.8 alternative:

Case ID	**6th St. Groin (Cell LI3)**	**11th St. Groin (Cell LI3)**	**16th St. Groin (Cell LI4)**	**21st St. Groin (Cell LI4)**	**26th St. Groin (Cell LI4)**
No Groins	--	--	--	--	--
Proposed NJDEP Project	204 m (670 ft)	204 m (670 ft)	204 m (670 ft)	198 m (650 ft)	198 m (650 ft)
Mod. A -15 m (50 ft)	189 m (620 ft)	189 m (620 ft)	189 m (620 ft)	183 m (600 ft)	183 m (600 ft)
Mod. B -30 m (100 ft)	174 m (570 ft)	174 m (570 ft)	174 m (570 ft)	168 m (550 ft)	168 m (550 ft)
Mod. C -46 m (-150 ft)	158 m (520 ft)	158 m (520 ft)	158 m (520 ft)	152 m (500 ft)	152 m (500 ft)
Mod. D -61 m (-200 ft)	143 m (470 ft)	143 m (470 ft)	143 m (470 ft)	137 m (450 ft)	137 m (450 ft)
Mod. E -76 m (-250 ft)	128 m (420 ft)	128 m (420 ft)	128 m (420 ft)	122 m (400 ft)	122 m (400 ft)
Mod. F -91 m (-300 ft)	113 m (370 ft)	113 m (370 ft)	113 m (370 ft)	91 m (350 ft)	91 m (350 ft)
Mod. G (Variable)	158 m (520 ft)	128 m (420 ft)	113 m (370 ft)	137 m (450 ft)	168 m (550 ft)

Applying the nourishment quantities for the BD50-14.8 berm and dune restoration alternative, the results of the modeling are shown in the table below.

Periodic Volume Requirements after first 5 yrs:

Case ID	**Quantity (m^3) Cells LI1-LI2A**	**Quantity (m^3) Cell LI3**	**Quantity (m^3) Cells LI4-LI6B**	**Total Project***
No Groins	235,000 (100%)	420,000 (100%)	680,000 (100%)	1,335,000 (100%)
Proposed NJDEP Project	207,000 (88%)	273,000 (65%)	1,088,000 (160%)	1,568,000 (117%)
Mod. A -15 m (50 ft)	207,000 (88%)	277,000 (66%)	1,027,000 (151%)	1,511,000 (113%)
Mod. B -30 m (100 ft)	207,000 (88%)	277,000 (66%)	959,000 (141%)	1,384,000 (108%)
Mod. C -46 m (-150 ft)	207,000 (88%)	286,000 (68%)	898,000 (132%)	1,394,000 (104%)
Mod. D -61 m (-200 ft)	207,000 (88%)	302,000 (72%)	836,000 (123%)	1,345,000 (101%)
Mod. E -76 m (-250 ft)	207,000 (88%)	332,000 (79%)	782,000 (115%)	1,321,000 (99%)
Mod. F -91 m (-300 ft)	207,000 (88%)	390,000 (93%)	728,000 (107%)	1,325,000 (99%)
Mod. G (Variable)	207,000 (88%)	302,000 (72%)	768,000 (113%)	1,277,000 (96%)

% is compared to "No Groins" Case ID
*****includes tapers at north and south end of Ludlam Island

As shown in the table, cells downdrift of groins (LI4-LI6B) will require an increased nourishment rate as less sand would naturally migrate to that area.

Mod G. shows the greatest reduction in periodic nourishment rate with a reduction of 5%. The cost of the groin construction to achieve this reduction would be as follows

Mod G Groin Location	**Length**	**Approximate Cost Rate ($/ft)**	**Total Cost**
6th St.	520 ft	$2,500	$1,300,000
11th St.	420 ft	$2,500	$1,050,000
16th St.	370 ft	$2,500	$925,000
21st St.	450 ft	$2,500	$1,125,000
26th St	550 ft	$2,500	$1,375,000
		Total	**$5,775,000**

Applying this reduction in periodic nourishment rate and adding the cost of groin construction provides the results.

Ludlam Island
Berm and Dune Restoration Alternative w/Groins
Storm Damage Reduction Benefits
October 1999 Price level - 6.625% Discount Rate

Alternative Name	Avg. Annual Damages*	Avg. Annual Storm Damage Reduction Benefits	% Damage Reduction	Local Costs Foregone	Sand Quantity (cu meters)		Avg. Annual Costs	Net Benefits
					Initial	Periodic Nourishment		
Without-Project	*$5,041,000*							
BD50-14.8	$2,102,000	$2,939,000	58%	$1,298,000	2,525,000	1,335,000	$3,359,000	$878,000
BD50-14.8 with groins (Mod G.)	$2,102,000	$2,939,000	58%	$1,298,000	2,525,000	1,227,000	$3,705,000	$532,000

*Includes damage to structures infrastructure, and cost of fill

As seen in the table above, the addition of the groins would not produce greater net benefits, and therefore option was no longer considered.

5.5.3.6 Berm & dune restoration w/structural reinforcement/groin field

Since this is was a combination of the previous analyses, there was no need to reanalyze. This alternative would not have more net benefits than the berm and dune restoration plan only.

5.5.3.7 Permanent Evacuation (Whale Beach area only)

Due to the relatively low structural density of the Whale Beach area, an analysis was performed to determine the cost-effectiveness of this alternative. It should be noted that even if proven cost-effective, there would likely be strong residential and local governmental opposition to this alternative. In addition, even if the residents were "permanently evacuated" with this alternative, the county road that runs along this reach would very likely be maintained. The road serves as the connection between Strathmere and Sea Isle City and also serves as an evacuation route off of Ludlam Island.

Two scenarios were compared to the BD50-14.8 plan which would extend along the entire island. One would be to permanently evacuate cell LI3 and the other would include cells LI3 and LI4. These alternatives would differ from the plan extending along the entire island as follows:

- Damage to “structures” and “cost of fill” categories decreases since they are removed.
- Since the roadway and other utilities would be maintained, infrastructure damages would not change
- Sand quantities would be eliminated (except for taper quantity) in cells LI3 and LI4. However, periodic nourishment quantities would then increase in other cells due to “sink factor” as sand would migrate to empty cells to achieve equilibrium.
- Permanent evacuation costs (purchase, moving, relocation exp) would be added
- Since locals would not allow portion of island to breach and would still maintain roadway, local costs foregone benefits would be reduced

A market analysis was completed performed in July 1999. This analysis estimated the cost for the permanent evaluation of approximately 150 properties for the Whale Beach area of Ludlam Island, Cape May County, New Jersey. The area inventoried stretches from Sherman Road in Strathmere, to 29th Street in Sea Isle City, Cape May County. Due to the differences in the towns as to kind of structures and area, the analysis provided separate costs for the properties in each. A breakout of the total number of properties, shows approximately 65 are located in Strathmere (Upper Township) and 85 in the City of Sea Isle City.

The Strathmere portion consists primarily of residential structures. The 1990 census indicated a summer population of 4,000 residents and winter population of 100. For 1999, it is estimated that the winter population has increased to 200-300. Some variation exists as to size of the properties, ranging from 0.07 to 0.25 acre lot with a 1-2 story, frame constructed, Single Family Residential (SFR) house. An analysis of the tax records for the 65 properties considered under this option yield a total value of $11,697,000, at an average price of $194,950. Sales in this area have been infrequent. Records show that 8 properties have been sold from 1997 to the present, at an average price of $197,312. All of them sold above their assessed value.

Using the average figure of properties sold, purchase alone of the 65 Strathmere properties at $197,312 each would total approximately $12,825,280. Under P.L 91-646 any property needed to be acquired for project purposes, which is the primary residence of the owner, is entitled to relocation benefits in the amount of $22,500. Given the census statistics provided by the town of Strathmere, a 10% contingency figure used for those (7 owners) potentially eligible to receive this relocation benefit yields a cost of $157,500. Every property owner under P.L. 91-646 would be entitled to moving expenses. The estimated moving cost for this area is approximately $1,000 per home, yielding a total of $65,000. Total cost for purchase of the Strathmere properties and relocation benefits is approximately $13,047,780**.**

The area of Sea Isle City under consideration for this market analysis is a highly developed residential community consisting of approximately 38 SFR properties and 47 condominiums. Recent sales have been brisk. Twenty-three SFR properties, typically consisting of a 1-2 story, frame constructed house, situated on 0.13 of an acre lot, sold at an average of $226,587. The purchase of 38 SFR at this average price would total approximately $8,610,300.

The condominiums presented a more complex picture. They needed to be categorized according to the number of units each contains as shown in the tax records, since each unit is separately owned and deeded. This means that the buyout of these condominiums must be based on a per unit cost, not property (i.e., structure). An analysis of those records showed that approximately 2 properties contain 9 units each; 4 properties contain 4 units each; and 41 properties contain 2 units each. Total units for buyout in these condominiums was 116.

It was not possible to arrive at a single average price per unit for all the condominiums, since the sale price of a unit varies greatly depending on the kind of condominium in which it is found. In the 2-unit condominium, typically consisting of a 2-story, frame constructed house on 0.15 of an acre of land, based on approximately 23 sales in the last 6 months, the average price was $237,626. Since there are 41 such condos in this area, for 82 units that would total a cost of approximately $19,485,330.

For the 4-unit condominium, 7 sales over the last 2 years shows an average price of $171,500. Using this average price, total for 16 units would be approximately $2,744,000.

No recent comps were found for a condominium with more than 4 units. Therefore, based on the assessed value of each unit and adding a 10% contingency to that value, an average per unit cost ranging from $123,750 to $136,000 will be used. Total cost for 18 units would range from approximately $2,228,000 to $2,448,000.

Cost to purchase the 116 condominium units would range from $24,457,330 to $24,677,330. Cost to purchase the 85 Sea Isle properties, condominiums and SFR, would range from $33,067,630 to $33,287,630. As regards the relocation benefits for the Sea Isle City properties, all 154 owners would be eligible for $1,000 moving expenses for a total of $154,000. Using again 10% as a contingency for potential owners (15) who, as permanent residents, would be eligible for $22,500 in relocation benefits that cost would total $337,500. Total cost for purchase of the Sea Isle properties (154 buyouts) is estimated to be approximately $33,559,130 to $33,779,130.

Total cost to purchase the approximately 150 properties (219 buyouts), inclusive of relocation benefits, for the area surveyed ranges from $46,606,910 to $46,826,910 for the area surveyed. Adding a 15% contingency to the purchase price of these properties, increases the total to approximately $53,490,846 to $53,743,346. Administrative costs (including 15% contingency) would add approximately $1,000,000 to the costs.

To compare this alternative with extending the previously selected berm and dune alternative (BD50-14.80) along the entire island required that the above market costs needed to be allocated into cells LI3 and LI4. This is shown in the following tables:

Cell LI3 (Hamilton Ave to 13th Street)							
Structure Type	**# of units**	**Purchase Cost**	**Subtotal Cost**	**Subtotal Cost w/15% contingency**	**Moving costs**	**Relocation Costs**	**Total Costs**
SFR							
Strathmere	65	$197,312	$12,825,280	$14,749,072	$65,000	$157,500	$14,971,572
Sea Isle City	17	$226,587	$3,851,979	$4,429,776	$17,000	$45,000	$4,491,776
2-Unit Condos	12	$237,626	$2,851,512	$3,279,239	$12,000	$22,500	$3,313,739
4-Unit Condos	16	$171,500	$2,744,000	$3,155,600	$16,000	$45,000	$3,216,600
9- Unit Condos	18	$136,000	$2,448,000	$2,815,200	$18,000	$45,000	$2,878,200
						Total (rounded)	$28,872,000
						Admin costs	$54,000
						Total	**$28,926,000**

Cell LI4 (13th Street to 29th Street)							
Structure Type	**# of units**	**Purchase Cost**	**Subtotal Cost**	**Subtotal Cost w/15% contingency**	**Moving costs**	**Relocation Costs**	**Total Costs**
SFR	21	$226,587	$4,758,327	$5,472,076	$21,000	$45,000	$5,538,076
2-Unit Condos	70	$237,626	$16,633,820	$19,128,893	$70,000	$157,500	$19,356,393
						Total (rounded)	$24,894,000
						Admin costs	$46,000
						Total	**$24,940,000**

Applying these numbers to the first costs produced the following results. The results show that both permanent evacuation alternatives would produce less net benefits than extending the berm and dune plan along the entire length of Ludlam.

Ludlam Island
Berm and Dune Restoration Alternative vs. Permanent Evacuation
Storm Damage Reduction Benefits
October 1999 Price level - 6.625% Discount Rate

Alternative Name	**Avg. Annual Damages***	**Avg. Annual Storm Damage Reduction Benefits**	**% Damage Reduction**	**Local Costs Foregone**	**Sand Quantity (cu meters)**		**Avg. Annual Costs**	**Net Benefits**
					Initial	**Periodic Nourishment**		
Without-Project	*$5,041,000*							
BD50-14.8	$2,102,000	$2,939,000	58%	$1,298,000	2,525,000	1,335,000	$3,359,000	$878,000
BD50-14.8 Permanent Evac. in Cell LI3	$1,933,000	$3,108,000	62%	$1,042,000	1,559,000	1,047,000	$4,683,000	-$533,00
BD50-14.8 Permanent Evac. in Cells LI3 and LI4	$1,791,000	$3,350,000	66%	$813,000	1,401,000	854,000	$6,067,000	-$1,904,000

*Includes damage to structures infrastructure, and cost of fill

5.6 Screening of Sand Borrow Sites

5.6.1 Initial Screening of Sand Borrow Sites

There were initially five different candidate offshore sites (L1, L2, M3, M8 and O1) considered to be used as sand borrow sources (Figure 2.3.8-2 and Table 5.6.1-1). Site M8 was eliminated early in the selection process due to it being cost prohibitive because of a previous requirement to pay lease fees on mineral extraction from areas within the outer continental shelf. However, site M8 was then subsequently reconsidered when the lease fees were waived as per a Memorandum of Agreement between the U.S. Army Corps of Engineers and the U.S. Department of the Interior – Minerals Management Service. Site O1 initially showed potential as a viable borrow site, however, further analysis confirmed that it contains unsuitable material due to high clay content in vibrocore samples. Therefore, site O1 was eliminated from further consideration. Site L2 was initially considered due to presence of suitable coarse sands, however, it was eliminated due to habitat considerations and its designation as a N.J. Prime Fishing Area where sand mining is prohibited under NJ 7:7E3.4. This site also received strong objections from NJDEP fisheries agencies. Site M3 was also eliminated due to habitat considerations because it contains prominent relict shoal features, which are considered to be valuable finfish and shellfish habitat. Commercial surfclam densities were low for this site, however, the existing fish habitat features along with strong opposition from NJDEP fisheries agencies were factors for eliminating this site. L1 contains suitable quality sand in sufficient quantities to supply portions of the project area over a 50-year period. L1 did not exhibit any outstanding benthic community features (although it did have higher mean taxa per sample and biomass when compared to other sites at the time). The commercial surfclam densities were highest among other sites measured at the time, however, surfclam densities were lower than the calculated mean value of 7.04 bushels per five-minute tow for nearby NJDEP sample stations 16-25, which are scattered around the vicinity of all of the borrow sites (NJDEP, 1997b). L1 does not exhibit any outstanding habitat features other than its proximity to the "Sea Isle Lump". NJDEP expressed concerns of hydrodynamic effects on the Sea Isle Lump, which prompted this area to be shifted to the east by about 1,000 feet to provide a buffer to the Sea Isle Lump. Therefore, in consideration of all of the factors, Site L1 was considered further as a viable borrow site. Site M8 was also considered further.

Table 5.6.1-1 Initial Screening of Sand Borrow Areas

Area	Size	Mean Grain Size (mm)	Est. Qty. or Capacity of Sandy Material	Biological Resources: General Benthic Parameters: Mean # Taxa per Sample	Biological Resources: General Benthic Parameters: Total Abundance (#/M²)	Biological Resources: General Benthic Parameters: Mean Total Biomass (G/M²)	Biological Resources: Fisheries: Juvenile Surfclam Densities (#/M²)	Biological Resources: Fisheries: Commercial Surfclam Densities (Mean #Bushels/5-Minute Tow) (range is in parenthesis)	Biological Resources: Fisheries: Essential Fish Habitat Considerations	Other Considerations	Consider Site Further?
L1	449 hectares (1,110 acres)	0.28	13,610,000 m³ 17,908,000 yd³	28.85	12,788	2.94	46.8	1.99 (0.02 – 18.82)	Bottom depths vary from 40 – 49 feet, however, site is relatively flat and slopes towards offshore. No prominent shoals or other habitat features are apparent within site. However, site is adjacent to "Sea Isle Lump".	NJDEP expressed concerns regarding site impacts and hydrodynamic changes on adjacent "Sea Isle Lump", which is within Site L2.	Yes, but move eastern edge of site approximately 1,000 feet to the west to avoid edge of "Sea Isle Lump", and extend western edge towards the shore.
L2	262 hectares (648 acres)	0.65	9,180,000 m³ 12,000,000 yd³	NM	NM	NM	NM	NM	Site contains "Sea Isle Lump", which is listed as a Prime Fishing Area where sand mining is prohibited under NJ 7:7E-3.4.	Strong opposition to site utilization by NJDEP due to fisheries concerns.	No
M3	238 hectares (587 acres)	0.29	8,790,000 m³ 11,500,000 yd³	23	13,403	1.81	129.0	0.01 (0.0 – 0.03)	Contains prominent shoal habitat features.	Strong opposition to site utilization by NJDEP.	No
M8	130 hectares (321 acres)	0.25	1,976,000 m³ 2,600,000 yd³	NM	NM	NM	NM	NM	Site appears to be a flat and featureless sandy bottom.	This site was not considered originally due to cost considerations concerning use of outer continental shelf (OCS) sand mineral resources, however, it was reconsidered due to recent waiver on lease fees for sand mining as per agreement between USACE and Minerals Management Service. This site was preliminarily identified as a preferred site by NJDEP. Site will be expanded in size to accommodate sand requirements.	Yes, but a benthic study and commercial surfclam investigation should be performed in secondary screening phase.
N		High % of clay	N/A (Quantity was not estimated based on high clay content)	NM	NM	NM	NM	NM	Site contains shallow linear shoal habitat, which may be attractive to some of the Federally managed species under EFH guidelines.	This site was considered during the Reconnaissance Study, however, subsequent investigations revealed substantial clay lenses within the material.	No, this site was eliminated due to material quality and fish habitat considerations.
O1	122 hectares (302 acres)	High % of clay	N/A (Quantity was not estimated based on high clay content.)	25.11	13,437	1.52	72.0	0.47 (0.0 – 1.26)	Includes tip of marine ridge/shoal.	NJDEP has fisheries concerns, however, finds it least objectionable when compared to L2 and M3. Vibrocore analysis determined that site contains high percentages of clay material in samples.	No, site was eliminated because vibrocore samples indicate that the material may be unsuitable for beach replenishment.

NM = Not measured.

5.6.2 Secondary Screening of Borrow Areas

Five potential sand borrow site locations were evaluated as part of the secondary screening of borrow areas (Figure 2.3.8-2 and Table 5.6.2-1). L1 East is basically L1 from the initial screening, however, it was modified by moving its eastern border approximately 1,000 feet west towards the coast to avoid and minimize any potential hydrodynamic impacts on the "Sea Isle Lump" shoal. L1 West is a new shoreward expansion of L1 East, however, the biological parameters were evaluated separately from L1 East since it was sampled at a different time. These combined areas contain sufficient quality beachfill material for the Ludlam Island portion of the project. L1 East and West both contain relatively low commercial surfclam densities, but have comparatively higher juvenile surfclam densities. Benthic parameters are variable, however, L1 East exhibited the highest benthic biomass among all sites evaluated for this study, however, this was generally low compared to other regional biomass values (Scott et al. 1999). L3 was a new site added during the secondary screening and exhibits suitable quality beachfill material. Biological components reveal an area well within typical ranges for benthic habitats within the area. No unique benthic community is present. The mean surfclam density (1.12 bushels/5-minute tow) was lower than some of the other sites and the calculated mean value of 7.04 bushels per five-minute tow for nearby NJDEP sample stations 16-25, which are scattered around the vicinity of all of the borrow sites (NJDEP, 1997b). A slight sand ridge forms the backbone of this site, however, this feature does not provide the topographic relief or habitat heterogeneity present within the other previously eliminated sites. The remaining sites showed no identifiable patterns to exclude/include sites due to benthic parameters. Site M8 had benthic community and surfclam parameters intermediate of the other sites and does not appear to exhibit any outstanding habitat features that would preclude its use. Corson Inlet Ebb Shoal (C1) site varied the most where benthic parameters such as mean number of taxa, abundance, biomass, and number of juvenile surfclams were much lower than the other sites. The most abundant species in the Corson Inlet Ebb Shoal site was the bivalve, *Donax fossor*, which is characteristic of highly dynamic nearshore habitats. However, the Corson Inlet Ebb Shoal site had the highest commercial/adult surfclam densities of all of the sites compared, but remains lower than the calculated mean value of 7.04 bushels per five-minute tow for nearby NJDEP sample stations 16-25, which are scattered around the vicinity of all of the borrow sites (NJDEP, 1997b).

Based on a number of environmental factors, sand quality and quantity, and location, Sites L1 (east and west combined), L3, M8 and C1 were selected as the proposed borrow sites. By selecting these sites, mitigative measures such as avoidance of higher value fisheries habitat were adopted to integrate environmental quality planning into plan formulation. Measures to further minimize environmental impacts are discussed later in Section 6.

Table 5.6.2-1 Secondary Screening of Sand Borrow Areas

Area	Size	Mean Grain Size (mm)	Est. Qty. or Capacity of Sandy Material	Biological Resources						Other Considerations	Consider Site Further?
				General Benthic Parameters			Fisheries				
				Mean # Taxa per Sample	Total Abun-dance (#/M²)	Mean Total Biomass (G/M²)	Juvenile Surfclam Densities (#/M²)	Commercial Surfclam Densities (Mean #bushels/5-minute tow) (Range is in parenthesis)	Essential Fish Habitat Considerations		
L1 East	449 hectares (1,110 acres)	0.28	9,180,000 m^3 12,200,000 yd^3	28.85	12,788	2.94	46.8	1.99 (0.02 – 18.82)	Bottom depths vary from 40 – 49 feet, however, site is relatively flat and slopes towards offshore. No prominent shoals or other habitat features are apparent within site. However, site is adjacent to "Sea Isle Lump" , which is designated as a Prime Fishing Area.	NJDEP expressed concerns regarding site impacts and hydrodynamic changes on adjacent "Sea Isle Lump", which is within Site L2.	Yes, but move eastern edge of site approximately 1,000 feet to the west to avoid edge of "Sea Isle Lump".
L1 West	327 hectares (807 acres)	0.28		22.4	5,683	1.6	40.9	0.73 (0.0 – 3.8)	Bottom depths vary from 34 – 47 feet, however, site is relatively flat and slopes towards offshore. No prominent shoals or other habitat features are apparent.	NJDEP does not have strong opposition to site utilization, provided inshore "finger" shoal areas are avoided.	Yes
L3	844 hectares (2,085 acres)	0.22	12,620,000 m^3 16,500,000 yd^3	20.2	6,599	3.17	19.9	1.12 (0.0 – 10.7)	A slight ridge with gradual slopes exists within the center of the site. Bottom is sandy with little prominent habitat features. Bottom depths vary from 32 – 50 feet.	No strong opposition to site utilization by NJDEP.	Yes
M8	434 hectares (847 acres)	0.25	4,900,000 m^3 6,500,000 yd^3	21.25	6,180	1.98	22.7	1.03 (0.0 – 5.5)	Site appears to be a flat and featureless sandy bottom, (34 –42 ft depths) with the exception of a small 30 ft. deep shoal along the eastern border of the site.	This site is preferred by NJDEP.	Yes, but avoid small shoal on eastern border of site.
Corson Inlet Ebb Shoal (C1)	82 hectares (202 acres)	0.26	765,000 m^3 1,000,000 yd^3	11.25	5,608	0.82	5.68	3.06 (1.0 – 6.3)	Has highest commercial surfclam densities among all borrow sites considered. Highly dynamic area is expected to be more suited for habitat disturbance associated with dredging. Potential to disrupt seasonal finfish migrations through inlet.	Inlet may provide renewable sand source for periodic nourishment, which could minimize aerial extent of impact on benthic habitat on future periodic nourishment. There are concerns regarding hydrodynamic effects on modifying the inlet system.	Yes

6 SELECTED PLAN

6.1 Identification of the Selected Plan

The National Economic Development Plan (NED) is defined as that plan which maximizes beneficial contributions to the Nation while meeting planning objectives. The design of the selected plan is complete and consistent with Corps criteria as described in the Shore Protection Manual, CETNs and accepted engineering practice. Because design of the selected plan is not technically complex and is essentially complete, additional design work (i.e. Design Memorandum) is not needed except for plans and specifications. The following sections describe the selected plan. The plans for South End Ocean City and Ludlam Island area are described below:

6.1.1 Description of the Selected Plan - South End Ocean City

The selected plan for South End Ocean City consists of a berm and dune utilizing sand obtained from an offshore borrow source. The dune crest will have a top elevation of +3.9 meters (+12.8 ft) NAVD88, a top width of 7.6 meters (25 ft) and side slopes of 1V:5H. Approximately 4,200 meters of sand fence and 80,000 square meters of dune grass will be included for dune stabilization. Dune vegetation will consist of beachgrass and coastal panicgrass which will be planted on the newly constructed dune. Twenty-two dune walkovers for beach access are also included and would be placed directly on the dune. These would consist of treated lumber and average about 53 meters (175 feet) in length and 1 meter (3.5 feet) wide. Sand fence would be placed along the sides for dune protection purposes.

The berm will extend from the seaward toe of the dune for a distance of 30.5 meters (100 feet) at an elevation of 2.1 meters (7.0 ft) NAVD88 before sloping down at 1V:25H to elevation -0.38 meters (-1.25ft) NAVD88. The remainder of the design template parallels the existing profile slope to the depth of closure. The total width from the seaward toe of the dune to Mean High Water (MHW) is 66 meters (218 feet).

The plan extends from 34th Street to 59th Street for a total length of 4,268 meters (14,000 feet or 2.6 miles). Initial sand quantity is 1,218,000 cu meters (1,603,000 cu yds) which includes design fill quantity of 912,000 cu meters (1,192,000 cu yds) plus advanced nourishment of 306,000[26] cu meters (403,000 cu yds). Periodic nourishment of 306,000 cu meters (403,000 cu yds) is scheduled to occur every 3 years synchronized with the existing Federal beachfill project at Ocean City (Great Egg Harbor Inlet to 34th Street). Material would be taken from the borrow source identified in this report as “M8”. Since this borrow source is located just outside the 3 nautical mile boundary, a project-specific Memorandum of Agreement (MOA) will be required with the Minerals Management Service (MMS). Preliminary coordination with MMS has indicated that no problem is anticipated.

Table 6.1.1-1 Summary of Selected Plan Dimensions - South End Ocean City, NJ

[26] Includes overfill factor of 1.15 for borrow area “M8”

Component	Dimensions	Remarks
Berm Elevation	+2.1m (7.0 ft) NAVD 88	Same as existing
Berm Width	30.5 meters (100 feet)	Same as average existing
Distance from seaward toe of dune to Mean High Water (MHW)	66 meters (218 feet)	
Beachfill Slope	1:30 to 1:25	Approximates existing
Dune Height	+3.8 meters (+12.8 ft) NAVD88	Existing bulkhead = 3.3 meters (10.8 ft) NAVD88
Dune Width (at crest)	7.6 m (25')	Standard Caldwell section
Dune Side Slopes	1:5	Standard Caldwell section
Dune offset for maintenance	None	
Length of fill	4,268 meters (14,000 feet or 2.6 miles)	
Initial Sand Quantity	1,218,000 cubic meters (1,603,000 cu yds)	Includes advanced nourishment
Periodic Nourishment	306,000 cubic meters (403,000 cu yds)	3 year cycle
Major Replacement	382,000 cubic meters (503,000 cu yds)	Year 24. Includes periodic nourishment quantity. Same dune grass and sand fence quantities as initial fill.
Taper Section	None	Tapers into groin at 59th Street.
Borrow Source Location	M8	Located outside 3 mile limit. Requires MMS agreement.
Dune Grass	Surface area =79,624 m^2 (857,089 ft^2)	12"x12" spacing
Sand fence	4,092 meters (13,426 feet)	Single row
Outfall Extensions	None	
Dune Cross-overs	22	

Graphical representation of the selected plan are shown in Figures 6.1.1-1 through 6.1.1-7.

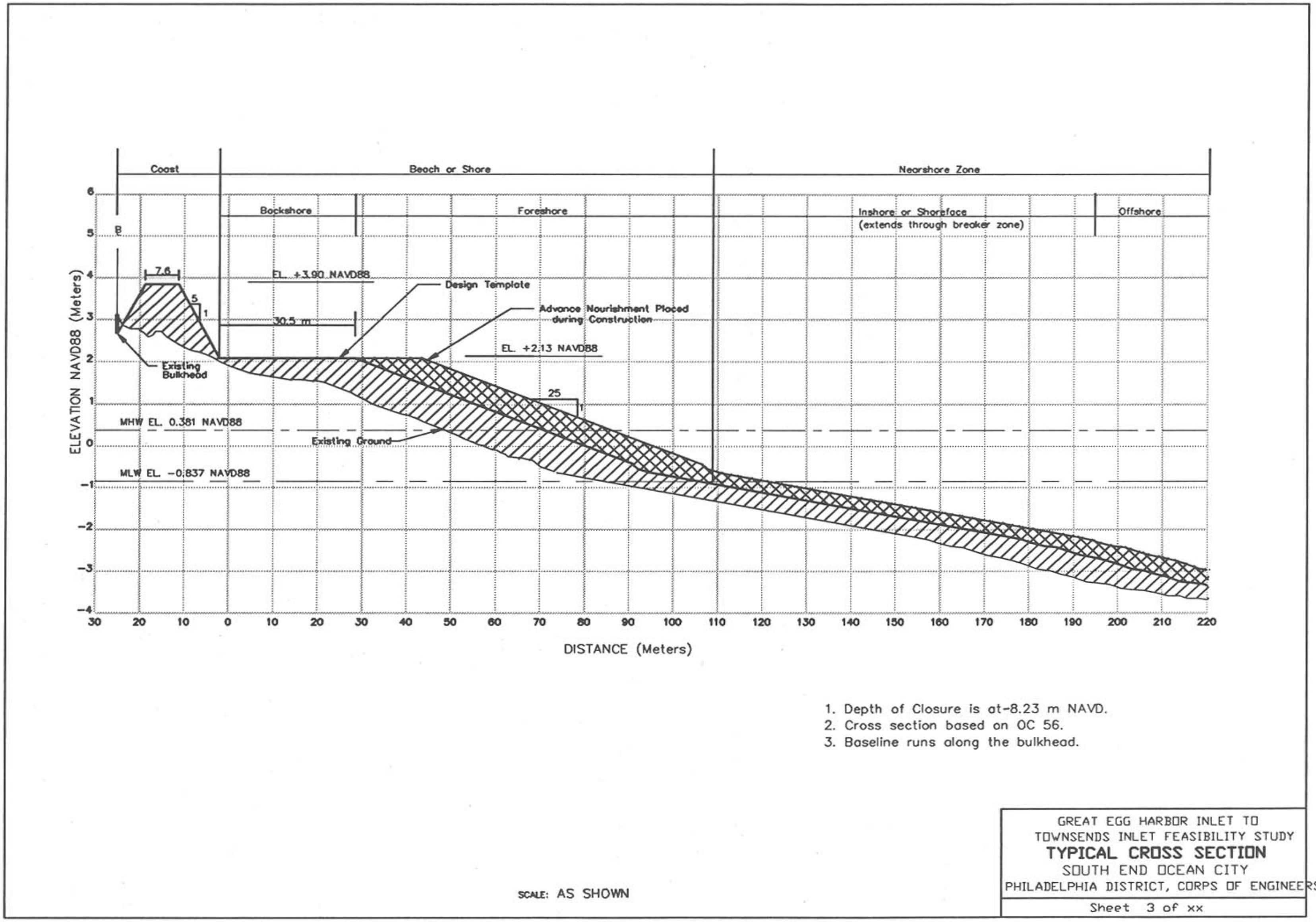


Figure 6.1-1 **Selected Plan for Ocean City, NJ - Typical Design Cross Section, 34th – 59th Street**

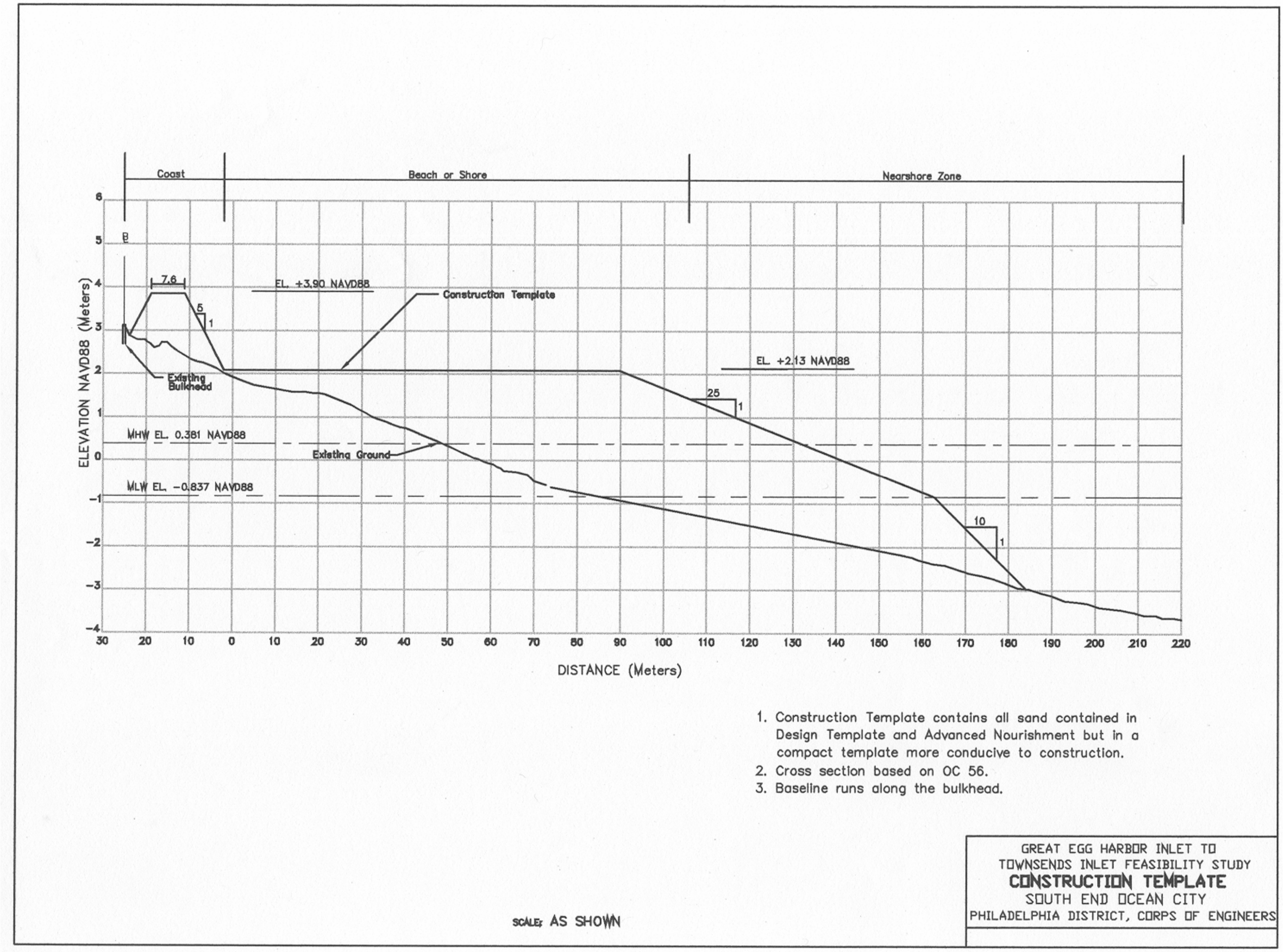


Figure 6.1-2 Selected Plan for Ocean City, NJ - Typical Construction Cross Section, 34th – 59th Street

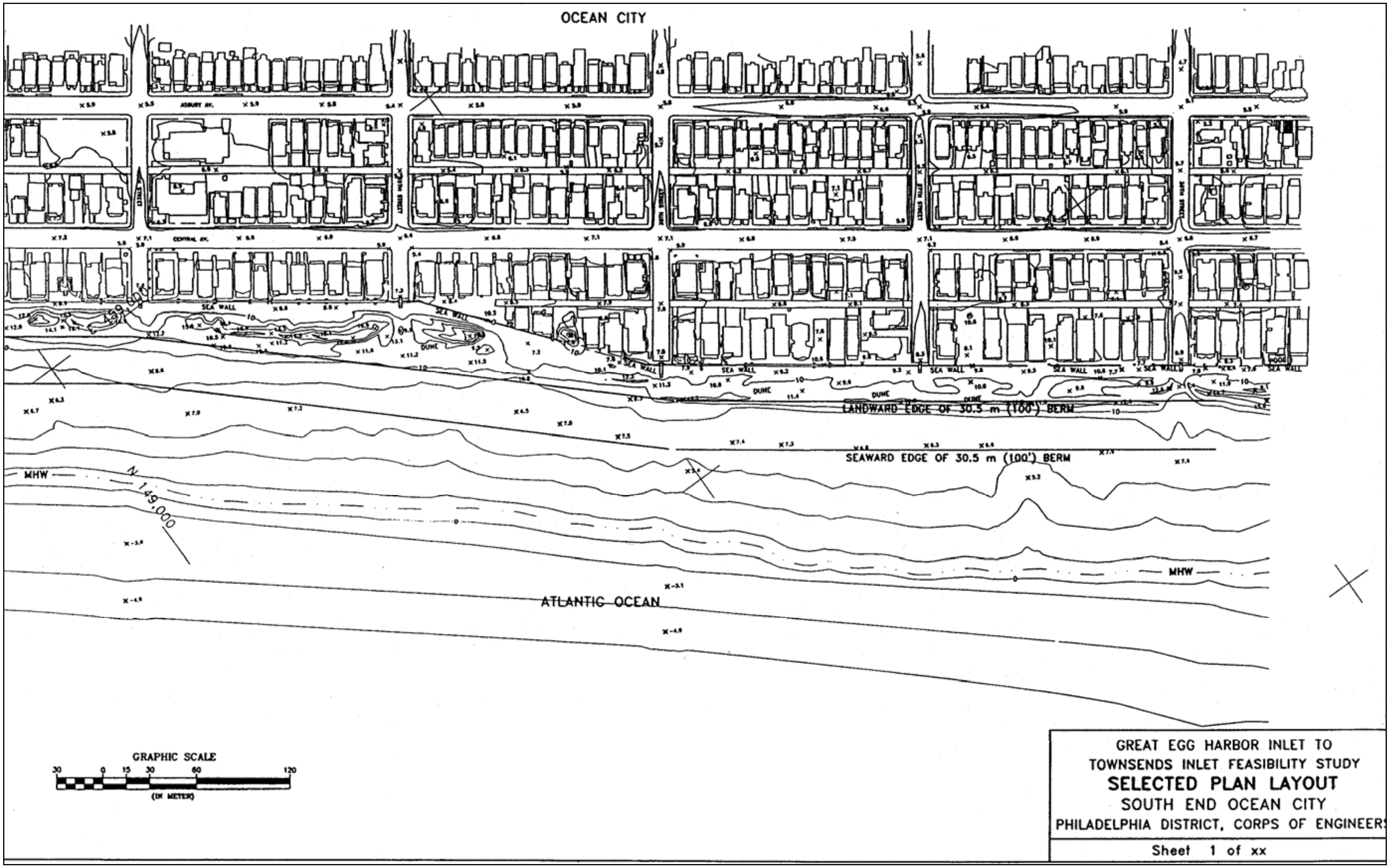


Figure 6.1-3 **Selected Plan Layout for Ocean City, NJ – 36th Street to south of 40th Street**

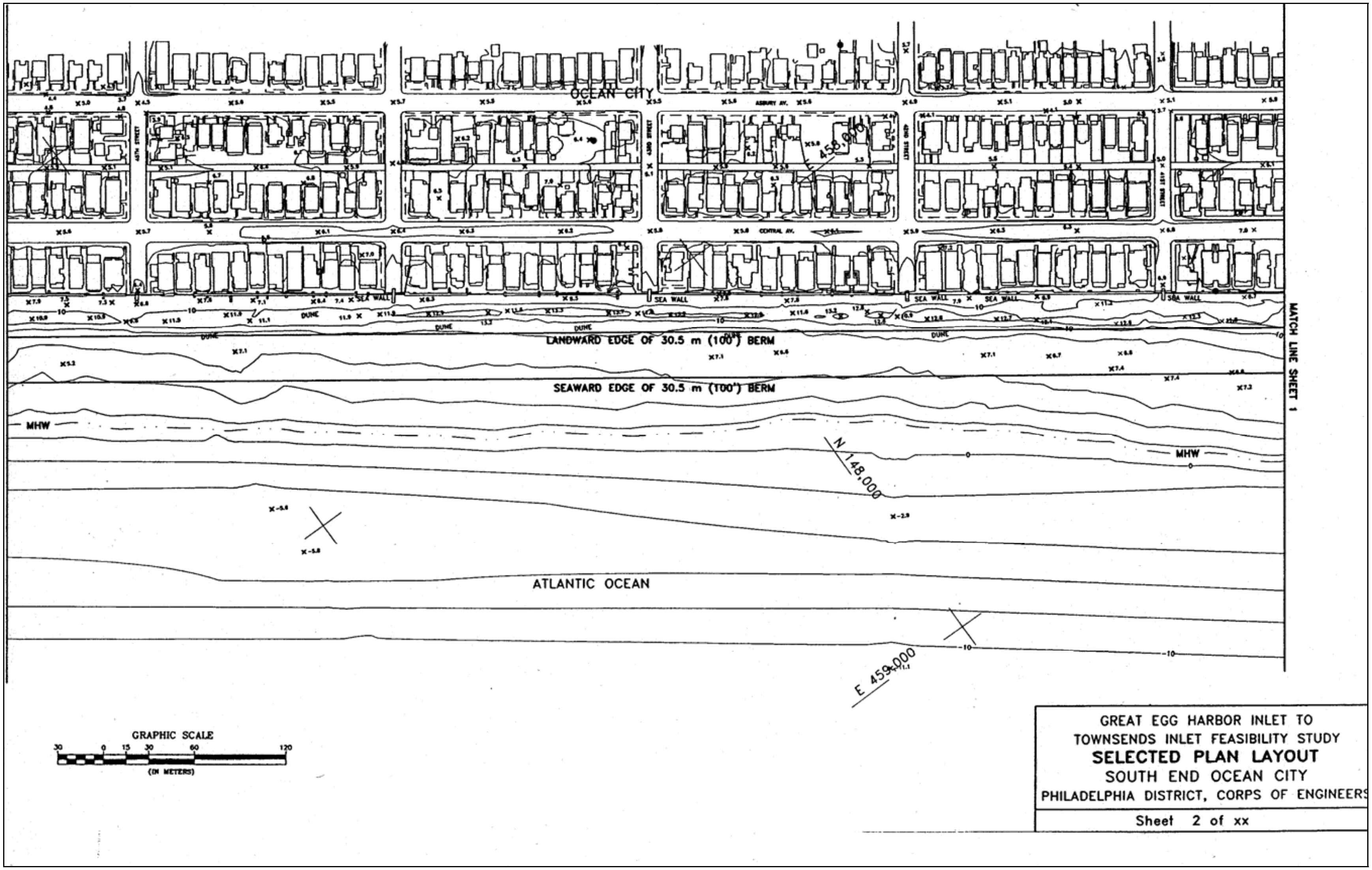


Figure 6.1-4 **Selected Plan Layout for Ocean City, NJ – South of 40th Street to south of 45th Street**

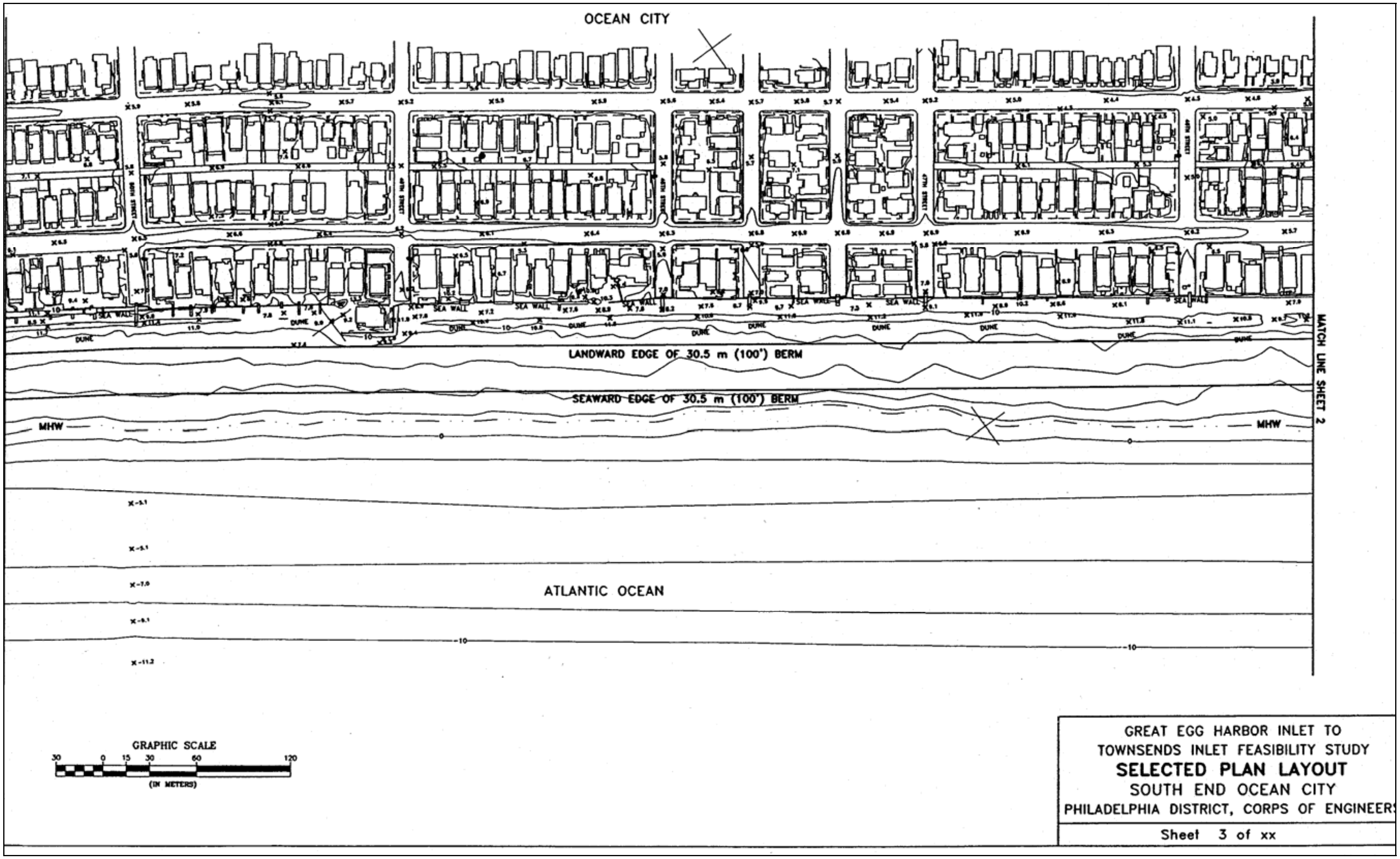


Figure 6.1-5 Selected Plan Layout for Ocean City, NJ – South of 45th Street to south of 50th Street

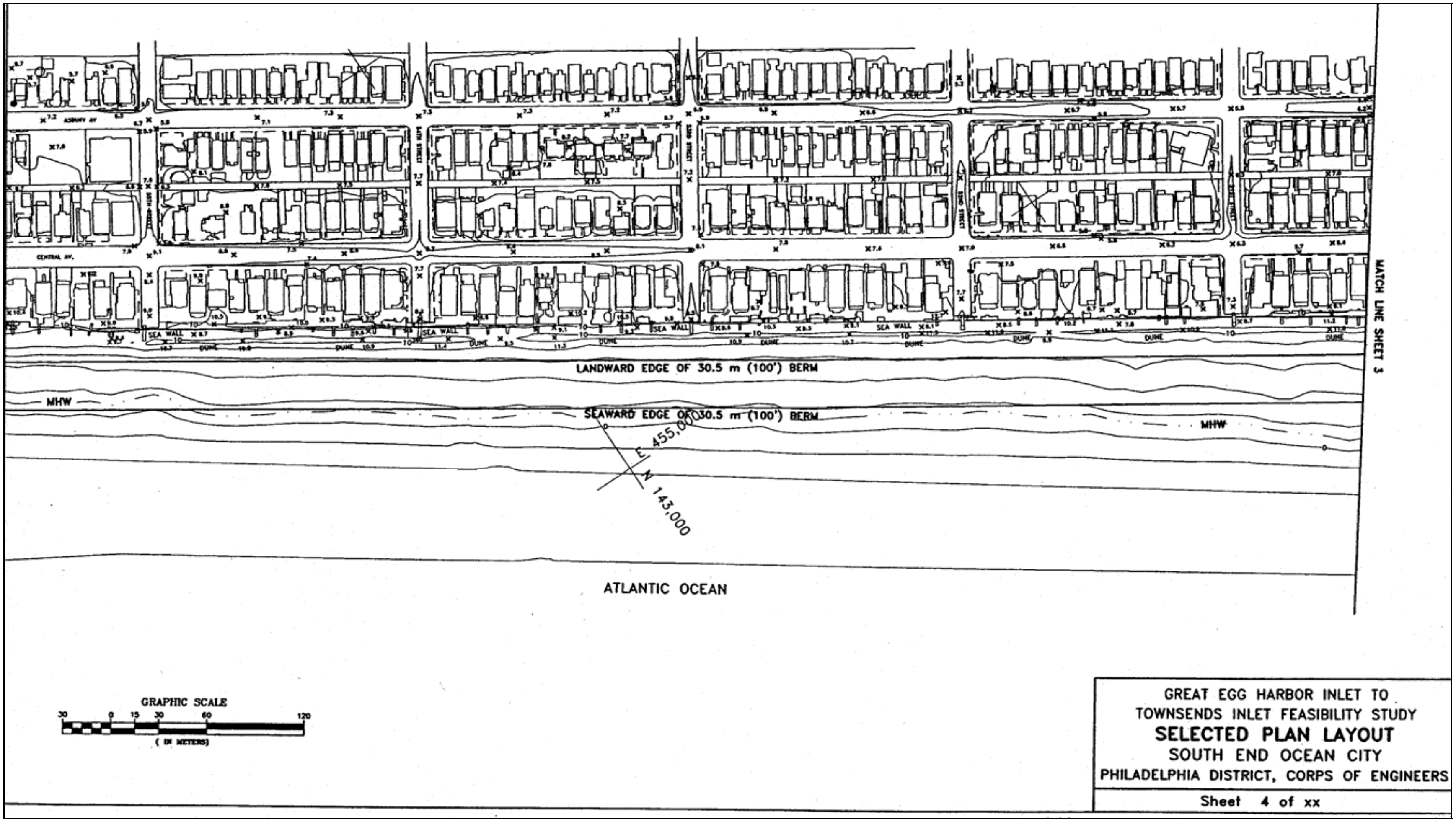


Figure 6.1-6 **Selected Plan Layout for Ocean City, NJ – South of 50th Street to south of 55th Street**

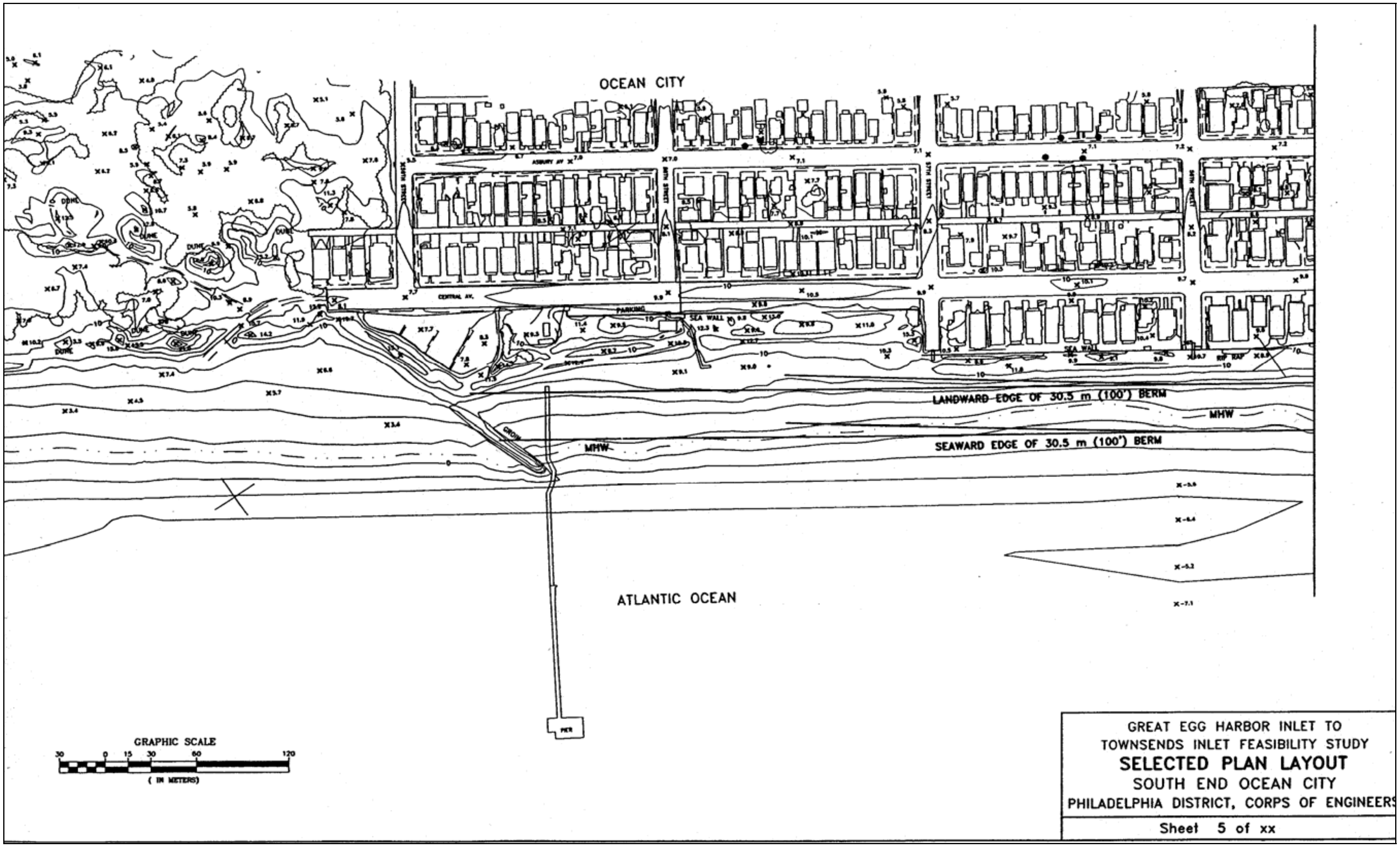


Figure 6.1-7 Selected Plan Layout for Ocean City, NJ – South of 55th Street to 59th Street

6.1.1.1 Periodic Nourishment Requirements.

In order to maintain the integrity of the design beachfill alternatives, periodic sand nourishment must be included in the project design. If periodic nourishment were not performed throughout the life of the project, longshore and cross-shore sediment transport mechanisms, separate from storm induced erosion, would act to erode the design beach. This erosion would reduce the protection from storm damage afforded by the project design. The nourishment quantities are considered sacrificial material which acts to ensure the integrity of the project design. Various coastal processes were analyzed to develop an estimate of the required annual nourishment fill volumes.

The nourishment parameters were developed by: considering background erosion losses using shoreline recession rates developed in the historic shoreline change analysis, losses due to the predicted rate of sea level rise, losses due to storm induced erosion, and "spreading out" losses due to diffusion of the beachfill through longshore transport gradients. The periodic nourishment requirement for the selected plan was computed to be 306,000 m^3 (403,000 $yd.^3$) every three years for South End Ocean City. This quantity includes an overfill factor of 1.15.

6.1.1.2 Major Replacement Requirements.

The periodic nourishment rate described previously includes losses due to storms that have occurred within the analysis period. This includes storms of approximately 50 year return period and more frequent (and therefore lower intensity). However, consideration was also given to project impacts due to less frequent (but greater intensity) storm events. Therefore, major replacement quantities were developed in accordance with Engineering Regulation 1110-2-1407 to identify additional erosional losses from the project due to higher intensity (low frequency) storm events. This methodology has also been used in other recent, approved studies conducted by the Philadelphia District along the coast.

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 economic project life 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 storm frequency event were obtained by interpolating between the 50 and 100-yr frequency events. Water levels and waves were hindcasted 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 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. As a conservative estimate of the necessary major rehabilitation quantity, a volume equal to 60% of the estimated storm eroded volume will require mechanical placement 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 76,000 m^3 (100,000 yd^3) along Ocean City 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 costing purposes. Therefore, for South End Ocean City, the major replacement sand quantity is 306,000+76,000=382,000 cubic meters (503,000 cu yds). Since a high intensity storm would also likely impact the dune grass and sand fence, cost allocations were also made for their possible replacement as these components are important for dune stabilization.

6.1.1.3 Overfill Factor

The overfill factor has been included in the periodic nourishment quantities. For borrow area M8, this factor was calculated to be 1.15.

A detailed explanation of this and related concepts are as follows:

The winnowing out of the finer portion of the beachfill material as a result of wave action is a continually ongoing process that can best be described as "erosional losses." Similar, yet separate from "erosional losses" are "pumping losses." "Pumping losses" occur as a result of placement of the material during construction. Sand is pumped as a slurry and the finer portion of this material is washed away as the water from the slurry drains into the ocean. A "pumping losses" factor is included in the estimation of the initial fill quantity. "Erosional losses" are offset by the inclusion of an overfill factor which is used to estimate the number of volumetric units of borrow material required to produce the equivalent of one volumetric unit of native beach material after natural processes have adjusted the constructed beach to the equilibrium profile. It should be noted that the overfill factor should be used with caution when borrow materials are well sorted, as is the case with the designated borrow site. James (1975) indicates that when the borrow area is better sorted than the beach, there is insufficient material in the grain size distribution, hence, consideration of sorting losses is not required.

It is not necessary to include the overfill factor in addition to the "pumping loss" factor when calculating the initial construction quantity for the proposed project. Due to the inclusion of advance nourishment, the material contained within the "design template," as distinct from the larger "construction template," is effectively isolated from the long term erosion impacts which sort and transport sediment on the exposed face of the active profile. Hence, only the "pumping loss" factor, and not the overfill factor need be applied to the "design template." The Philadelphia District however, maintains the more conservative approach of applying both the overfill factor and the "pumping losses" factor to the periodic nourishment quantity because it is this material that will be subjected to long term erosion losses since it lies in the active wave zone.

The initial construction quantity is based on the cross-section required to construct the "design" profile plus a comparable or larger quantity required to advance the entire active profile out to the "depth of closure." The native beach composite grain size distribution, such as was computed for the study area, includes samples from the sub-aerial beach as well as the submerged portion of the active profile out to closure depth. The initial construction volume, because it is based on the quantity required to advance the entire active profile out to depth of closure, in effect already includes the fraction which is calculated with the overfill factor procedures. In addition, the performance characteristics of the proposed beachfill design takes into account the differences in grain size between the material in the borrow area and the material on the native beach.

6.1.1.4 Project Transition and Tapers.

The project will transition and taper into the existing beach groins located between 58th and 59th Streets**.**

6.1.1.5 Outfall Extensions

There are no outfall extensions required for South End Ocean City.

6.1.2 Description of the Selected Plan – Ludlam Island

The selected plan for Ludlam Island consists of a berm and dune utilizing sand obtained from an offshore borrow source. The dune crest will have a top elevation of +4.5 meters (+14.8

ft) NAVD88, a top width of 7.6 meters (25 ft) and side slopes of 1V:5H. Approximately 11,000 meters (36,000 ft) of sand fence and 282,000 square meters (3,035,000 sq ft) of dune grass will be included for dune stabilization. Dune vegetation will consist of beachgrass and coastal panicgrass which will be planted on the newly constructed dune. One hundred and thirteen dune walkovers are also included and would be placed directly on the dune. These would consist of treated lumber and average about 53 meters (175 feet) in length and 1 meter (3.5 feet) wide. Sand fence would be placed along the sides for dune protection purposes.

The berm width will extend from the seaward toe for a distance of 15 meters (50 ft) at an elevation of 1.8 meters (6.0 ft) NAVD88 before sloping down (varying from 1V:30H to 1V:50H) to elevation –0.38 meters (-1.25 ft) NAVD88. The remainder of the design template parallels the existing profile slope to the depth of closure. The total width from the seaward toe of the dune to Mean High Water (MHW) varies depending upon location from 58 to 87 meters (190 to 285 feet).

The plan extends from 38 meters (125 feet) north of Seaview Avenue in Strathmere to Pleasure Ave (just beyond 93rd Street) in Sea Isle City for a total length of 10,507 meters (6.5 miles). In addition, there is a taper of 224 meters (734 feet) into Corson's Inlet State Park and a taper of 20 meters (66 feet) into the terminal groin south of 93rd Street. Total length of beachfill, including tapers, is 10,751 meters (6.7 miles).

Initial sand quantity is 3,911,000 cu meters (5,146,000 cu yds) which includes design fill quantity of 2,528,000 cu meters (3,326,000 cu yds) plus advanced nourishment of 1,383,000 cu meters[27] (1,820,000 cu yds). Periodic nourishment of 1,383,000 cu meters (1,820,000 cu yds) is scheduled to occur every 5 years. Material would be taken from the borrow sources identified in this report as "L3", "L1", and "C1".

Graphical representation of the selected plan are shown in Figures 6.1.2-1 through 6.1.2-15. More detailed information will be provided as part of a future "plans and specifications" product, which would be used to award the construction contract.

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[27] Includes overfill factors

Table 6.1.2-1 Summary of Selected Plan Dimensions – Ludlam Island, NJ

Component	Dimensions	Remarks
Berm Elevation	+1.8 m (6.0 ft) NAVD 88	Same as existing
Berm Width	15 meters (50 feet)	Same as average existing
Distance from seaward toe of dune to Mean High Water (MHW)	varies depending upon location from 58 to 87 meters (190 to 285 feet)	
Beachfill Slope	1:50 to 1:30	Approximates existing
Dune Height	+4.5 meters (+14.8 ft) NAVD88	Existing promenade in Sea Isle City +3.7 meters (12.0 ft)
Dune Width (at crest)	7.6 m (25’)	Standard Caldwell section
Dune Side Slopes	1:5	Standard Caldwell section
Dune offset for maintenance	None	
Length of fill	10,751 meters (6.7 miles), including tapers	
Initial Sand Quantity	3,911,000 cu meters (5,146,000 cu yds)	Includes advanced nourishment
Periodic Nourishment	1,383,000 cu meters (1,820,000 cu yds)	5 year cycle
Major Replacement	1,600,000 cu meters (2,105,000 cy yds)	Year 25. Includes periodic nourishment quantity. Same dune grass and sand fence quantities as initial fill.
Taper Section	224 meters (734 feet) into Corson’s Inlet State Park and a taper of 20 meters (66 feet) into the terminal groin south of 93rd Street.	
Borrow Source Location	L1, L3, C1	
Dune Grass	Surface area =282,000 square meters (3,035,000 sq ft)	12”x12” spacing
Sand fence	11,000 meters (36,000 ft)	Single row
Outfall Extensions	Two @ 46 meters (150 ft) each	
Dune Cross-overs	113	

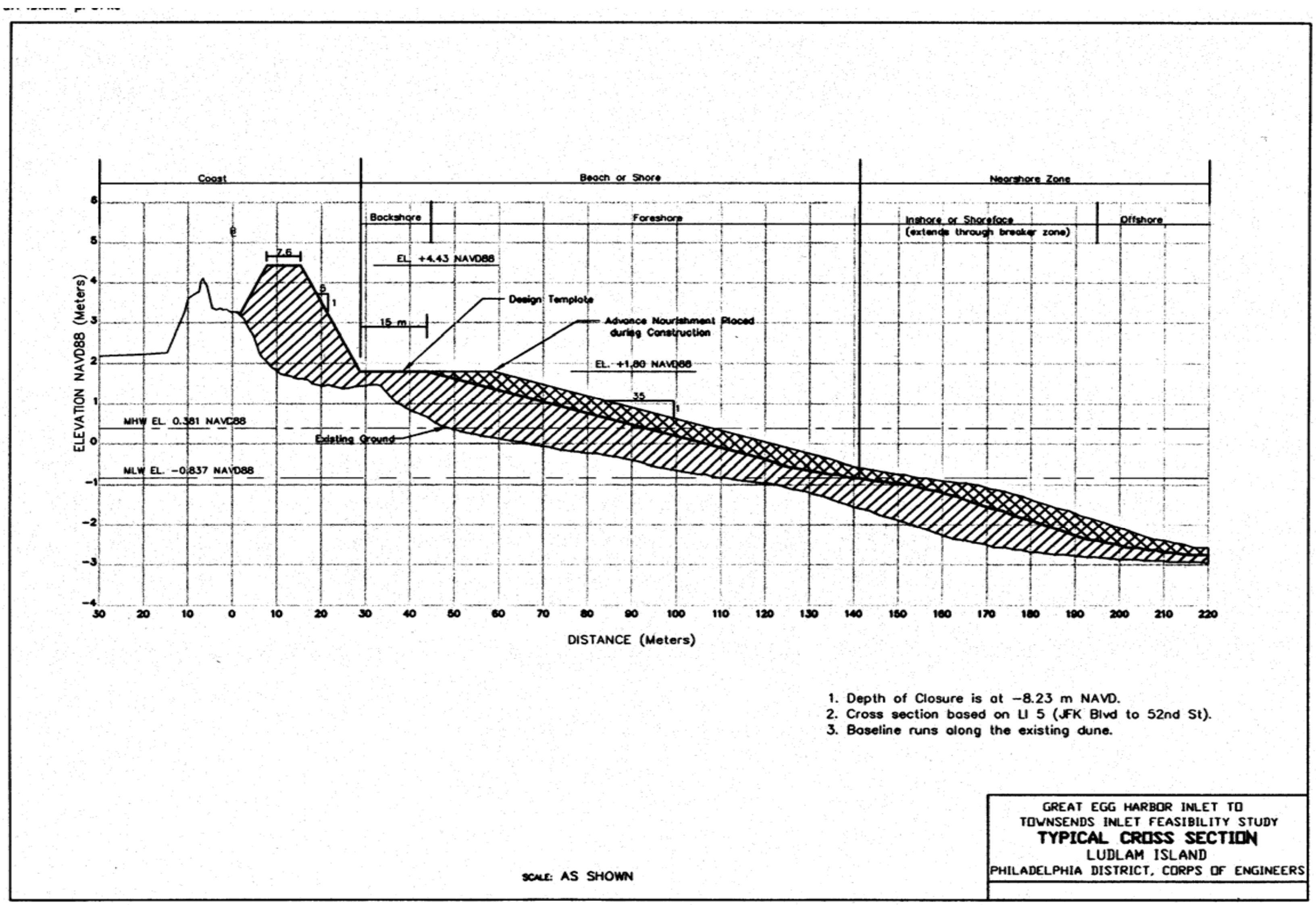


Figure 6.1-8 **Selected Plan for Ludlam Island, NJ - Typical Design Cross Section**

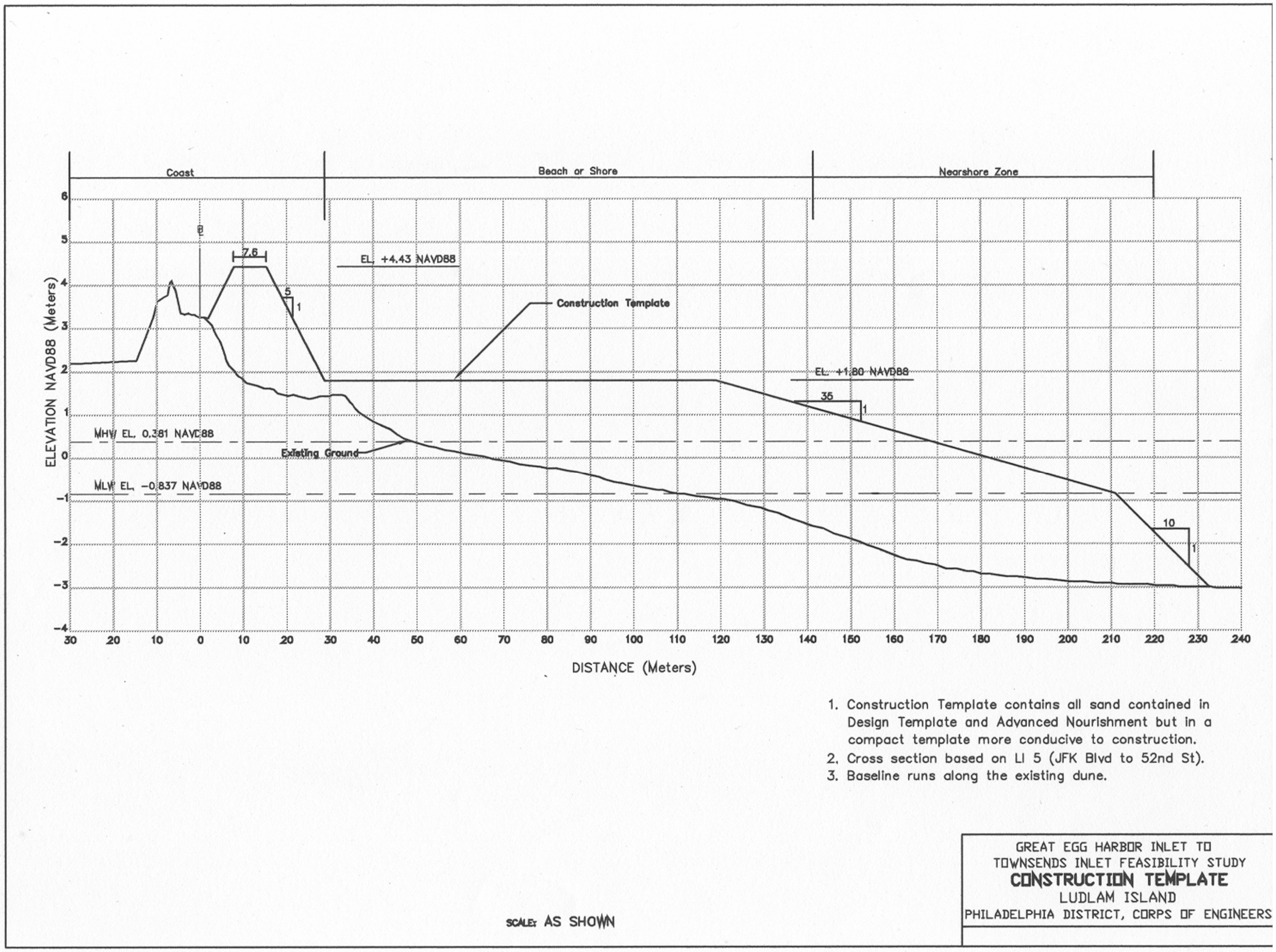


Figure 6.1-9 Selected Plan for Ludlam Island, NJ - Typical Construction Cross Section

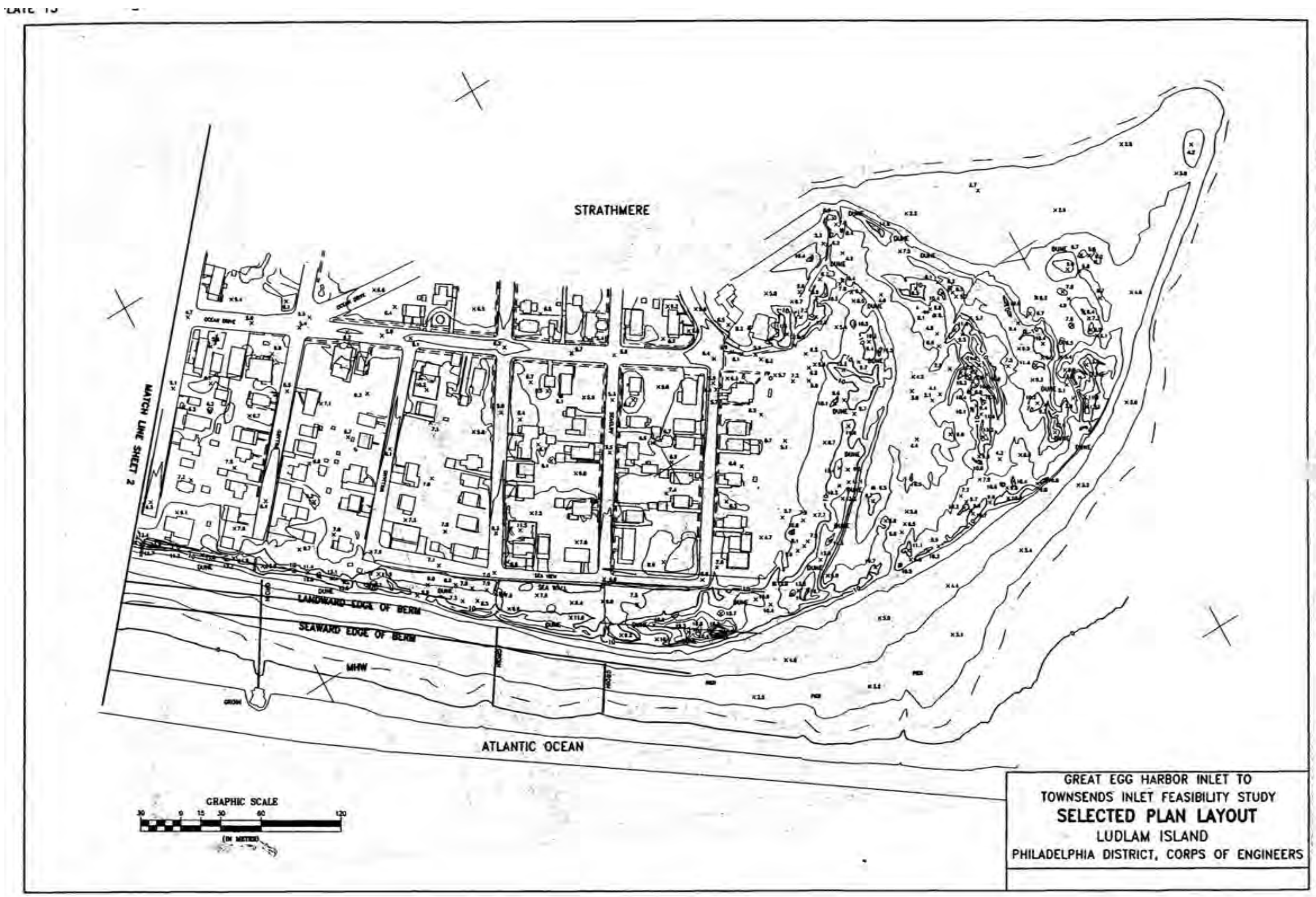


Figure 6.1-10 Selected Plan Layout for Ludlam Island, NJ – Corson's Inlet to Whittier Ave, Strathmere

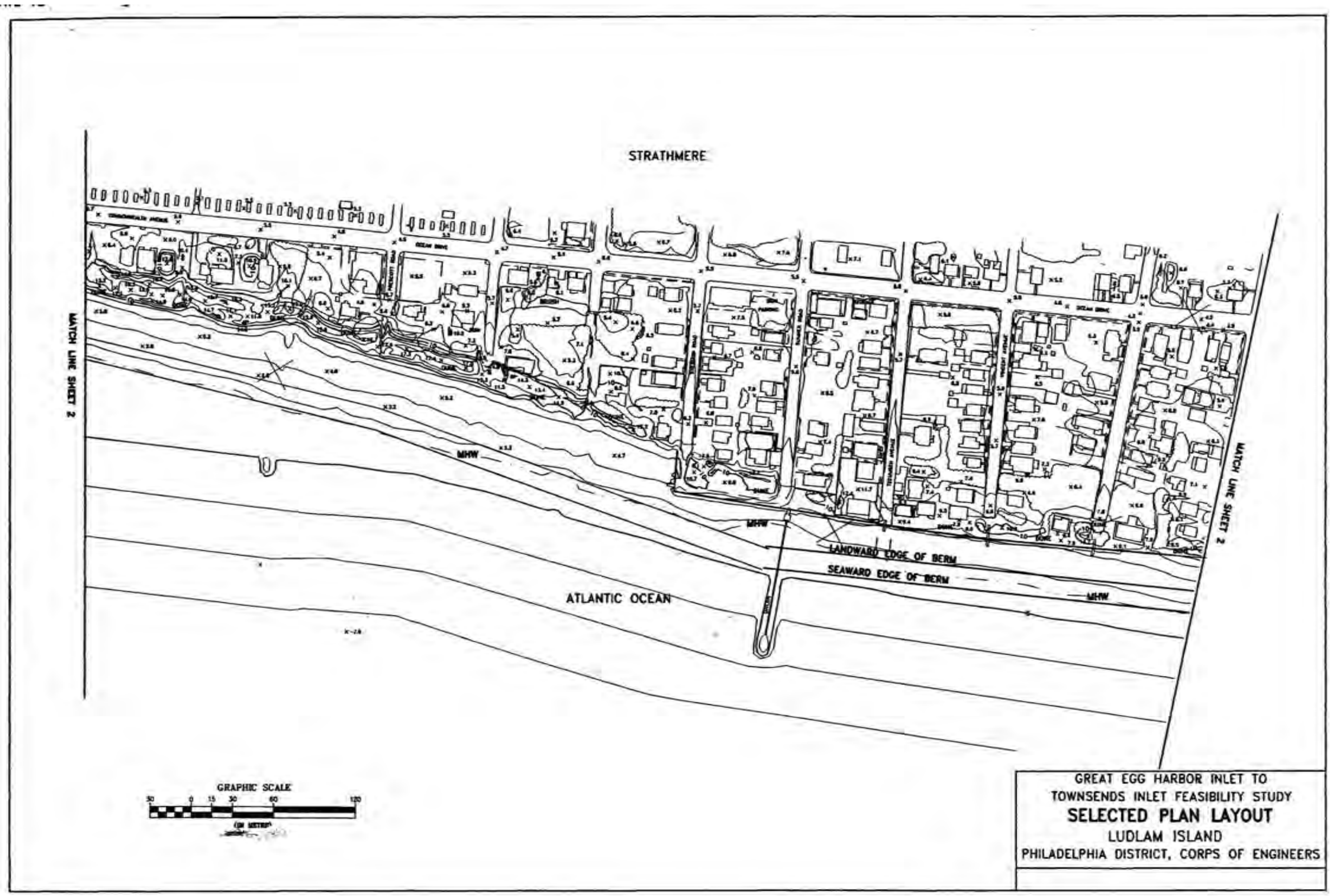


Figure 6.1-11 Selected Plan Layout for Ludlam Island, NJ – Whittier Ave to south of Prescott Ave, Strathmere

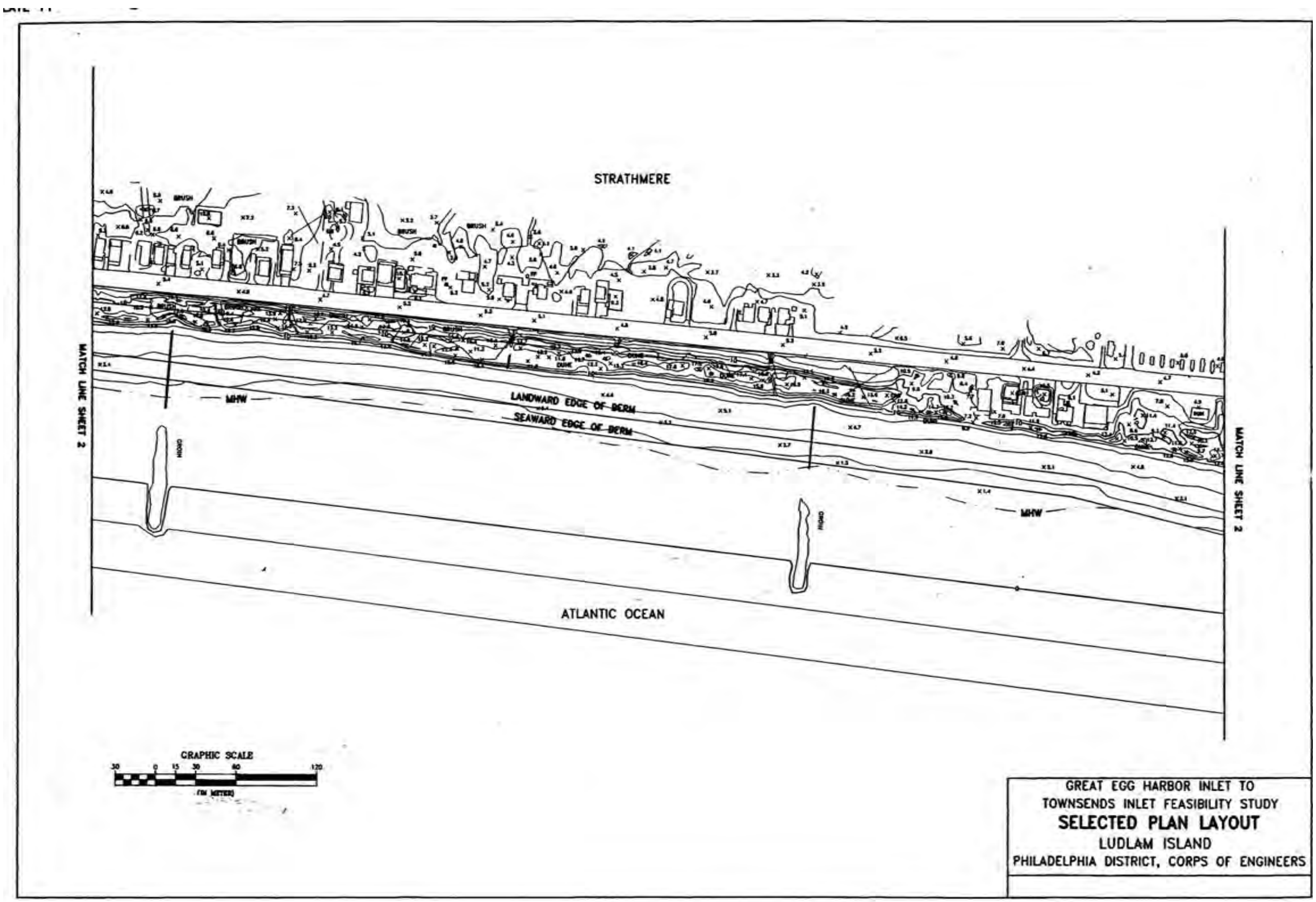


Figure 6.1-12 Selected Plan Layout for Ludlam Island, NJ –South of Prescott Ave to Grant Ave, Strathmere

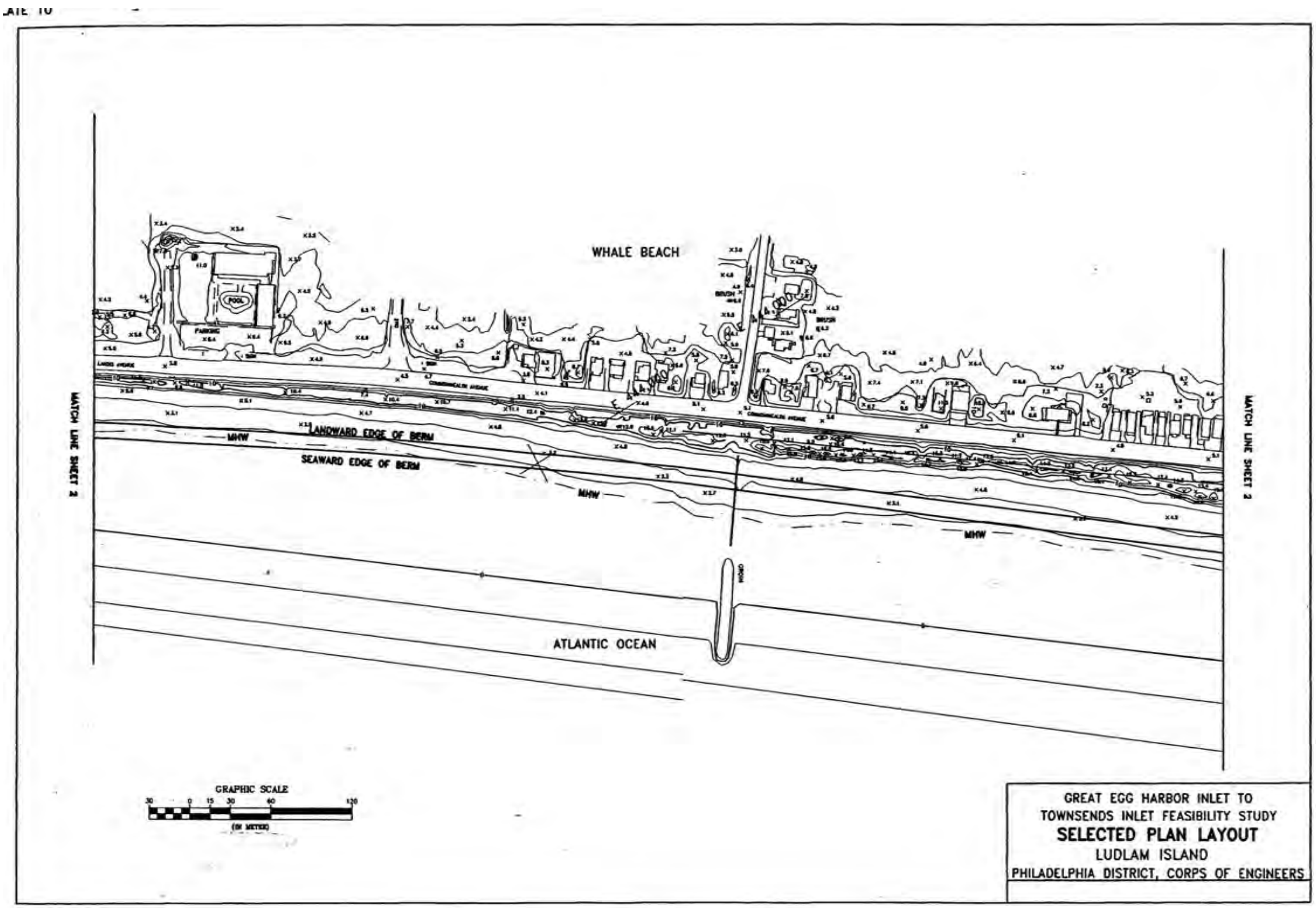


Figure 6.1-13 Selected Plan Layout for Ludlam Island, NJ – Grant Ave, Strathmere to 3rd Street, Sea Isle City

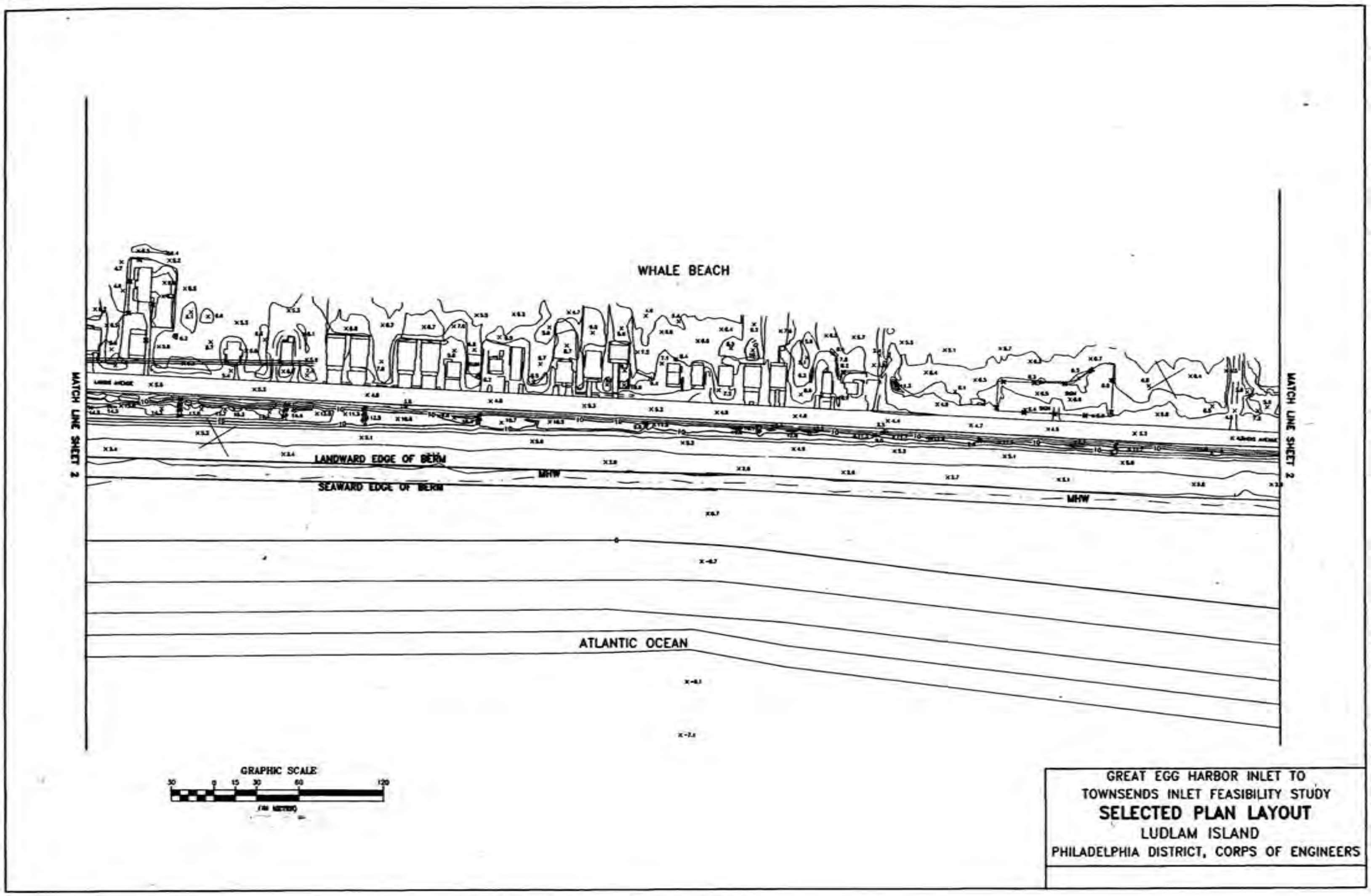


Figure 6.1-14 Selected Plan Layout for Ludlam Island, NJ –3rd Street to 14th Street, Sea Isle City

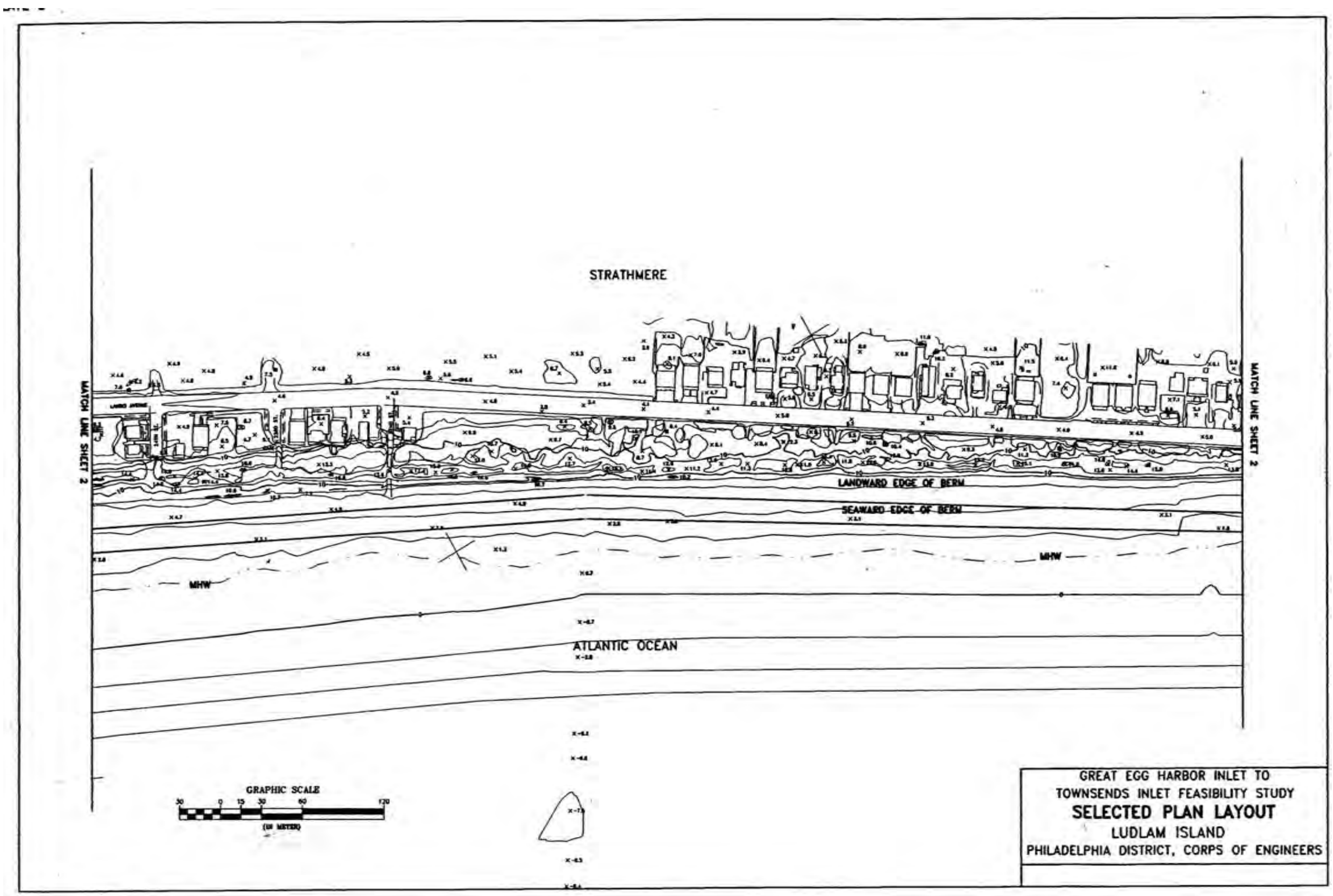


Figure 6.1-15 **Selected Plan Layout for Ludlam Island, NJ – 14th Street to 25th Street, Sea Isle City**

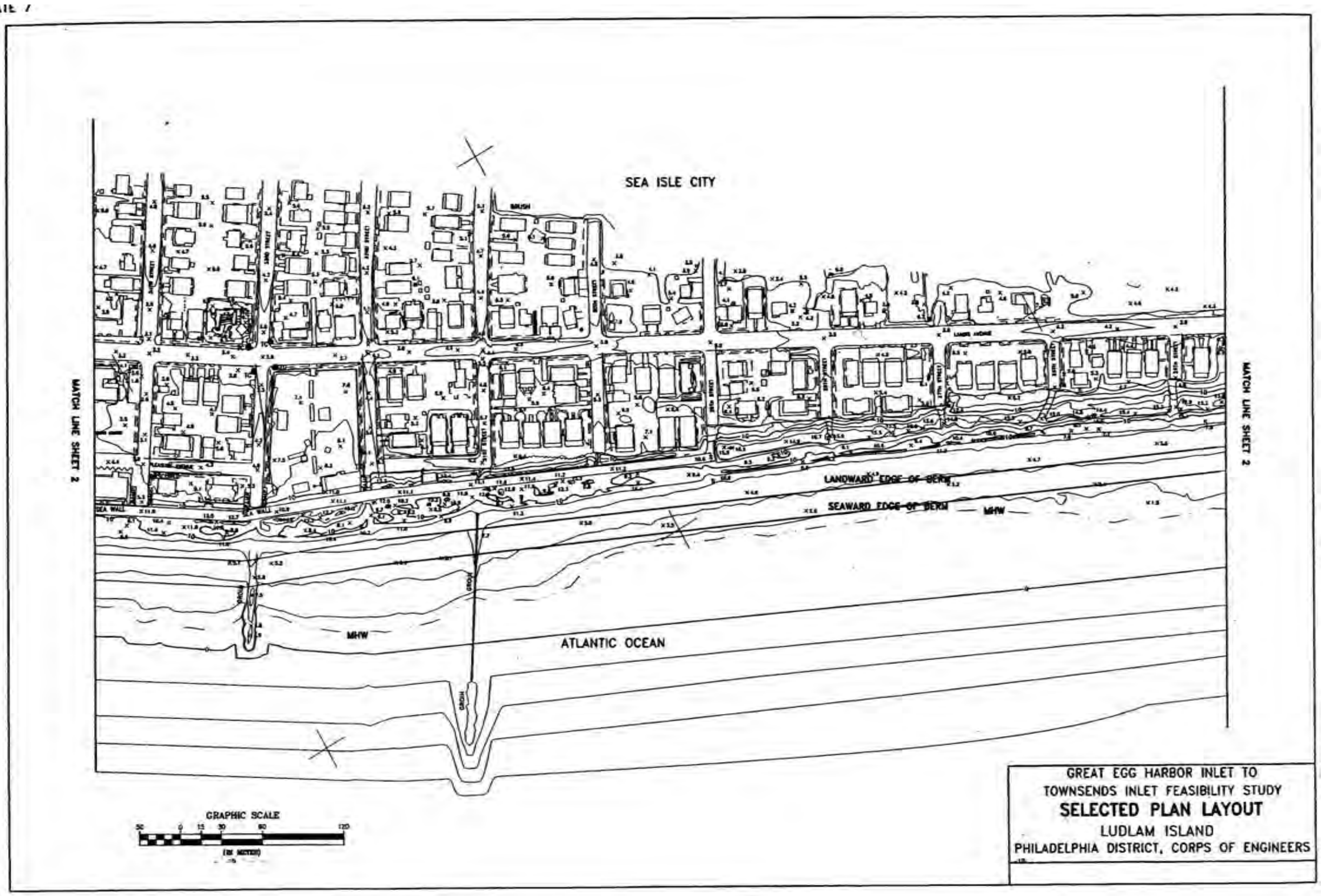


Figure 6.1-16 Selected Plan Layout for Ludlam Island, NJ – 25th Street to 34th Street, Sea Isle City

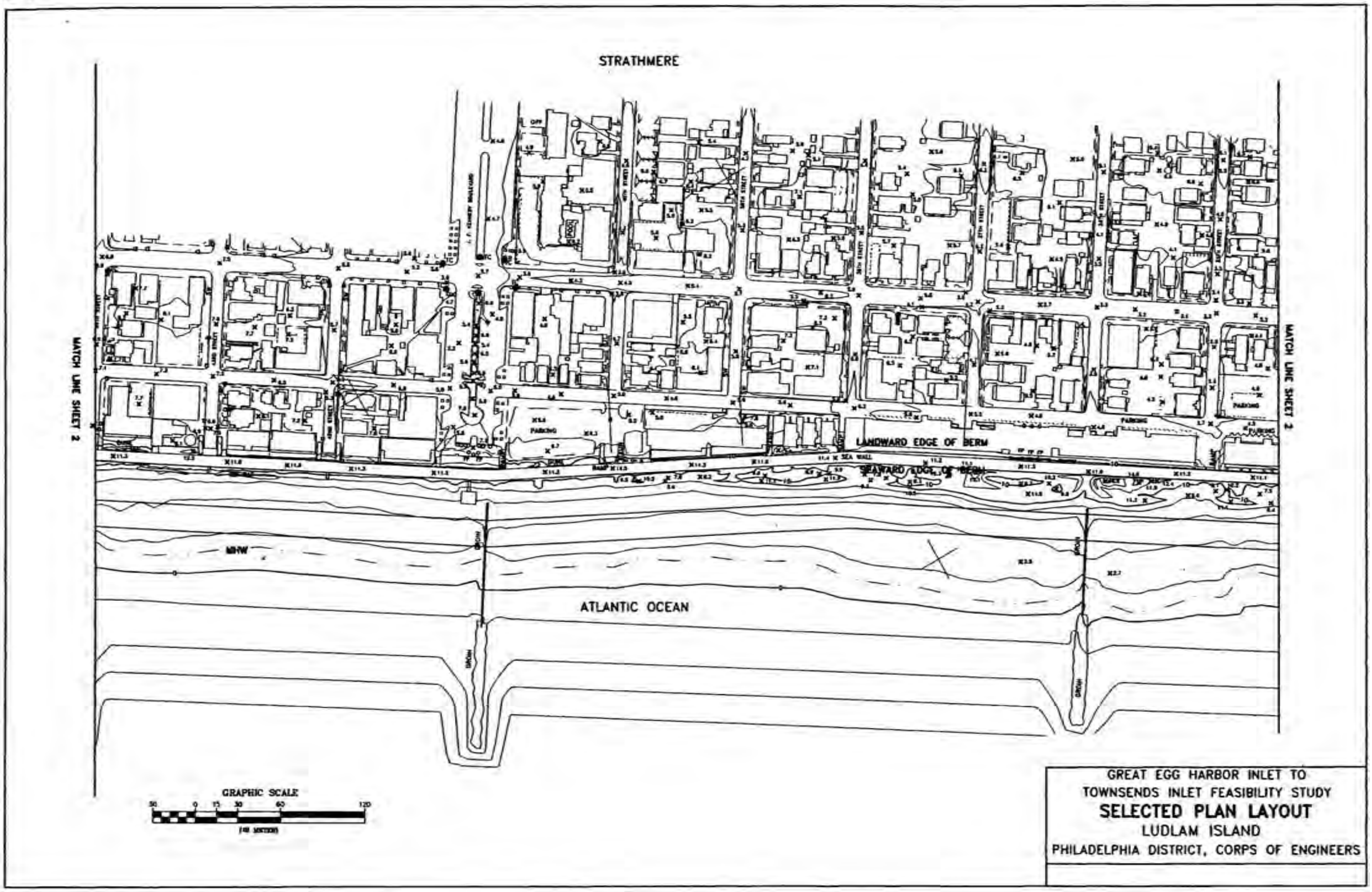


Figure 6.1-17 **Selected Plan Layout for Ludlam Island, NJ – 34th Street to 44th Street, Sea Isle City**

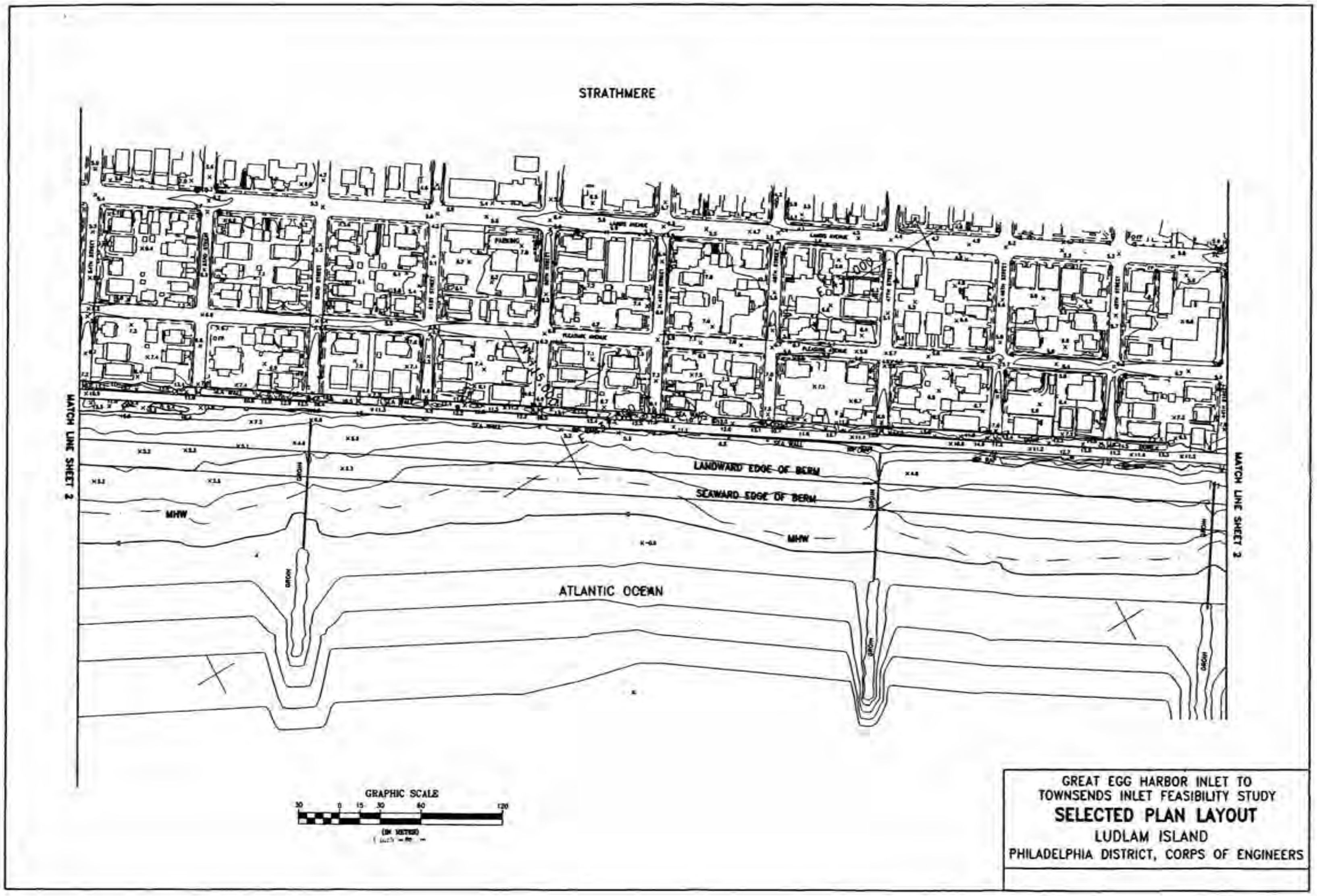


Figure 6.1-18 Selected Plan Layout for Ludlam Island, NJ – 44th Street to 54th Street, Sea Isle City

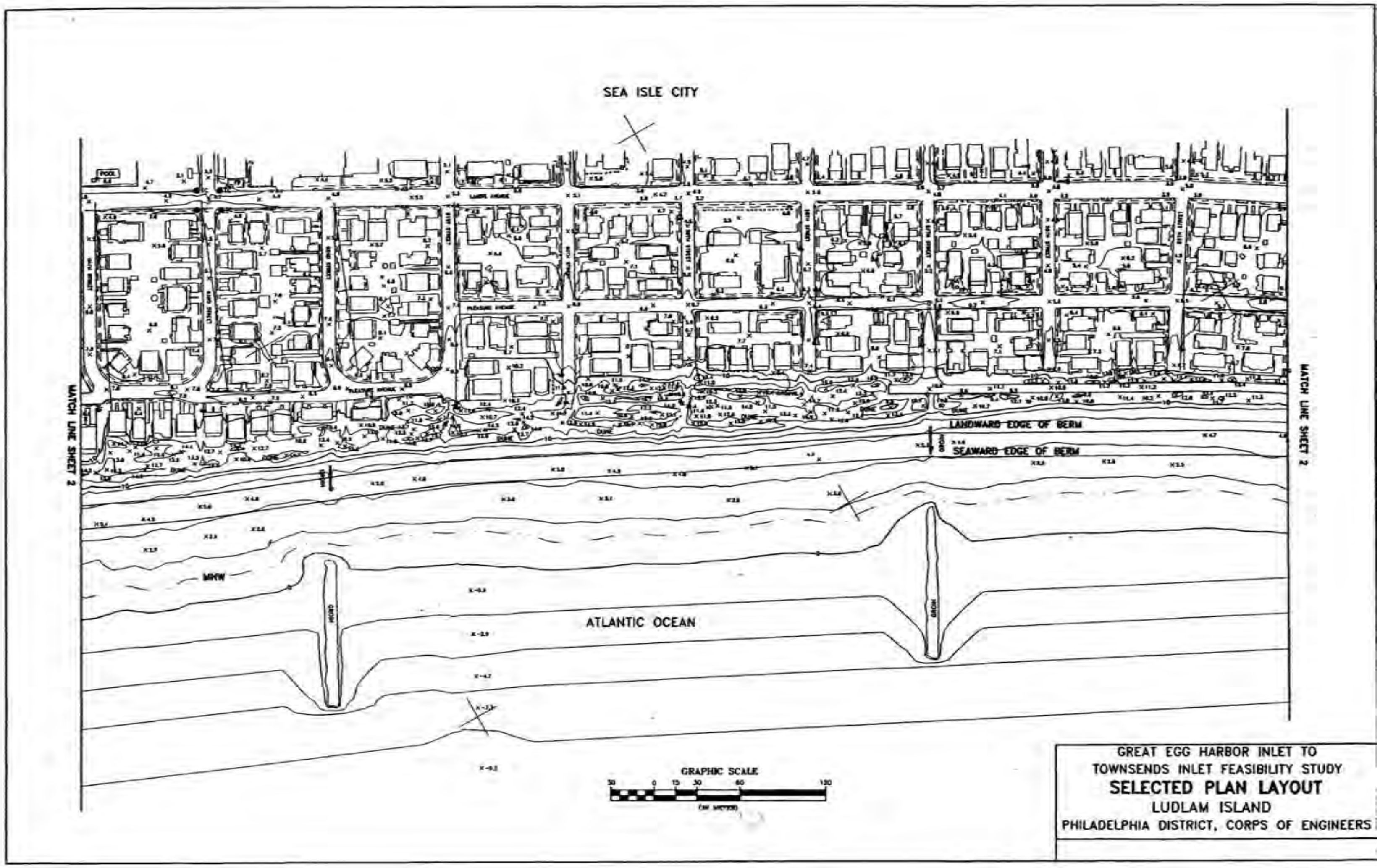


Figure 6.1-19 Selected Plan Layout for Ludlam Island, NJ – 55th Street to 64th Street, Sea Isle City

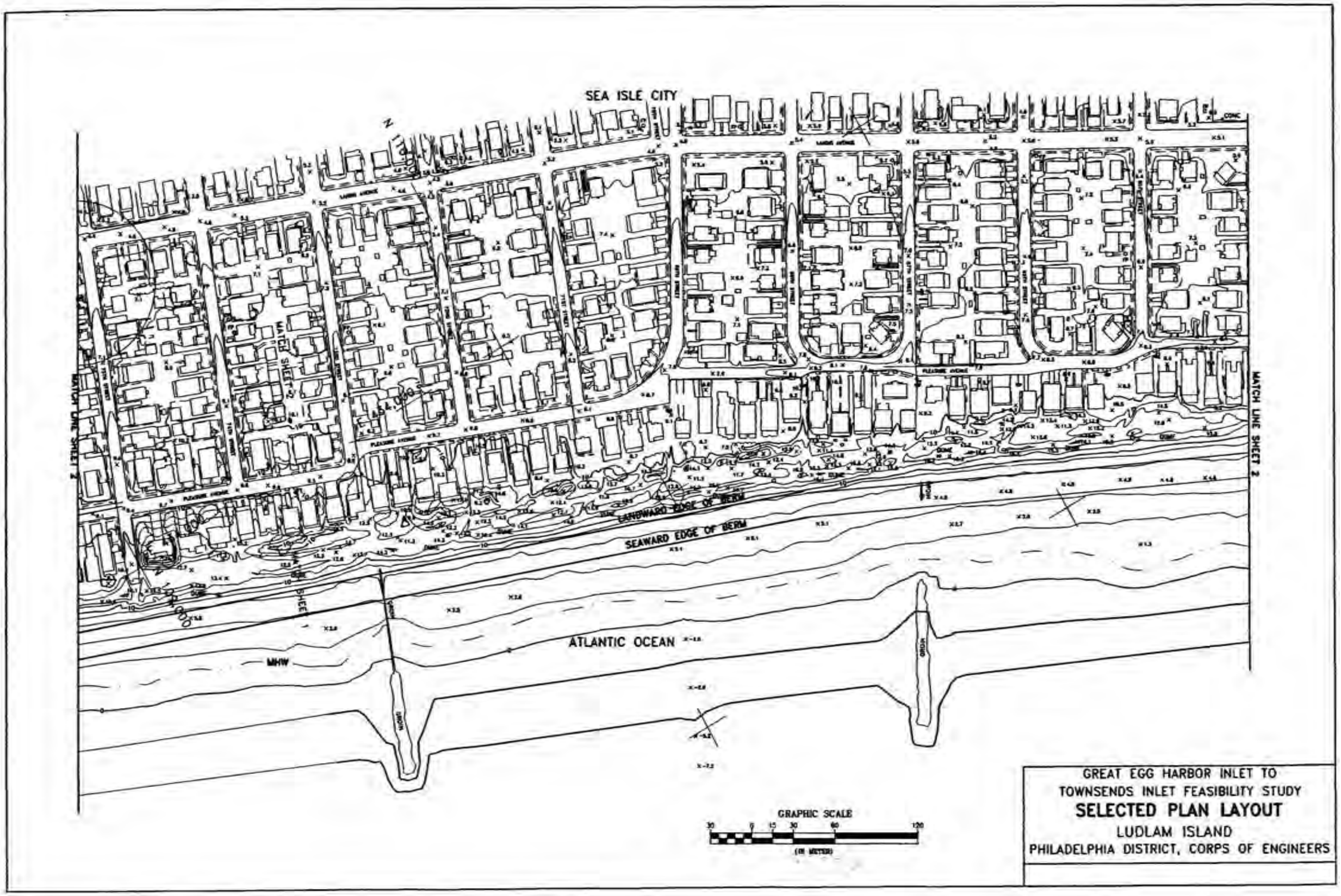


Figure 6.1-20 Selected Plan Layout for Ludlam Island, NJ – 65th Street to 75th Street, Sea Isle City

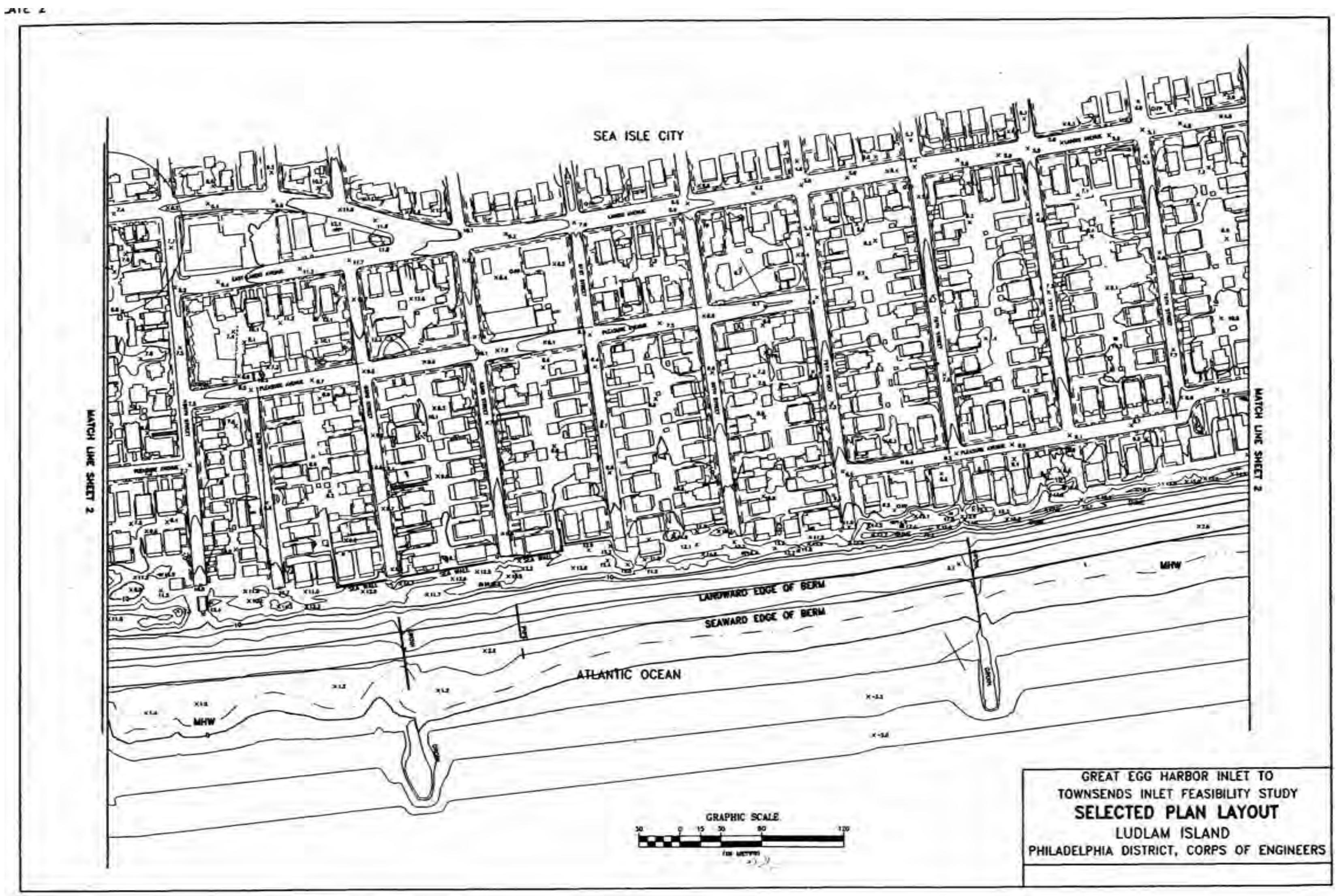
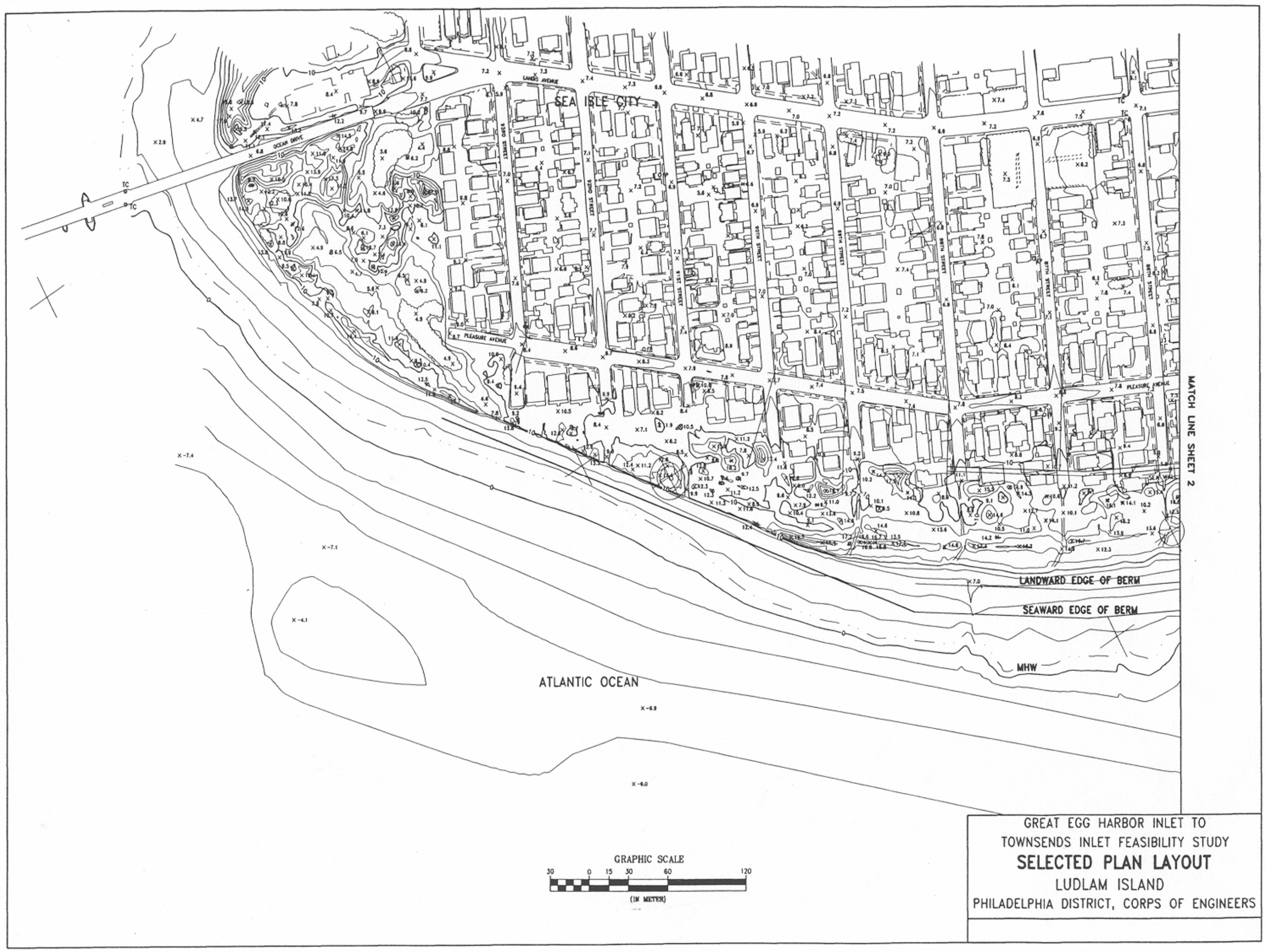


Figure 6.1-21 Selected Plan Layout for Ludlam Island, NJ – 76th Street to 85th Street, Sea Isle City



*93rd and 88th Street groins not shown.

Figure 6.1-22 Selected Plan Layout for Ludlam Island, NJ – 85th Street to Townsends Inlet, Sea Isle City.

6.1.2.1 Periodic Nourishment Requirements

In order to maintain the integrity of the design beachfill alternatives, periodic sand nourishment must be included in the project design. If periodic nourishment were not performed throughout the life of the project, longshore and cross-shore sediment transport mechanisms, separate from storm induced erosion, would act to erode the design beach. This erosion would reduce the protection from storm damage afforded by the project design. The nourishment quantities are considered sacrificial material which acts to ensure the integrity of the project design. Various coastal processes were analyzed to develop an estimate of the required annual nourishment fill volumes.

The nourishment parameters were developed by; considering background erosion losses using shoreline recession rates developed in the historic shoreline change analysis, losses due to the predicted rate of sea level rise, losses due to storm induced erosion, and "spreading out" losses due to diffusion of the beachfill through longshore transport gradients. The periodic nourishment requirement for the selected plan was computed to be 1,383,000 m^3 (1,820,000 $yd.^3$) every five years for Ludlam Island. This quantity includes overfill.

6.1.2.2 Major Replacement Requirements.

The periodic nourishment rate described previously includes losses due to storms that have occurred within the analysis period. This includes storms of approximately 50 year return period and more frequent (and therefore lower intensity). However, consideration was also given to project impacts due to less frequent (but greater intensity) storm events. Therefore, major replacement quantities were developed in accordance with Engineering Regulation 1110-2-1407 to identify additional erosional losses from the project due to higher intensity (low frequency) storm events. This methodology has also been used in other recent, approved studies conducted by the Philadelphia District along the coast.

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 economic project life 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 storm frequency event were obtained by interpolating between the 50 and 100-yr frequency events. Water levels and waves were hindcasted 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 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. As a conservative estimate of the necessary major rehabilitation quantity, a volume equal to 60% of the estimated storm eroded volume will require mechanical placement 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 217,000 m^3 (286,000 yd^3) along Ludlam Island 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 25 for costing purposes. Therefore, for Ludlam Island, the major replacement sand quantity is 1,383,000+217,000=1,600,000 cubic meters (2,105,000 cu yds). Since a high intensity storm would also likely impact the dune grass and sand fence, cost allocations were also made for their possible replacement as these components are important for dune stabilization.

6.1.2.3 Overfill Factor

The overfill factor has been included in the periodic nourishment quantities. These factors are shown in the following table:

Borrow Area	Overfill factor
L3A	1.006
L3B	1.049
L1A	1.028
L1B	1.044
C1	1.0

A detailed explanation of this and related concepts are as follows:

The winnowing out of the finer portion of the beachfill material as a result of wave action is a continually ongoing process that can best be described as “erosional losses.” Similar, yet separate from “erosional losses” are “pumping losses.” “Pumping losses” occur as a result of placement of the material during construction. Sand is pumped as a slurry and the finer portion of this material is washed away as the water from the slurry drains into the ocean. A “pumping losses” factor is included in the estimation of the initial fill quantity. “Erosional losses” are offset by the inclusion of an overfill factor which is used to estimate the number of volumetric units of borrow material required to produce the equivalent of one volumetric unit of native beach material after natural processes have adjusted the constructed beach to the equilibrium profile. It should be noted that the overfill factor should be used with caution when borrow materials are well sorted, as is the case with the designated borrow site. James (1975) indicates that when the borrow area is better sorted than the beach, there is insufficient material in the grain size distribution, hence, consideration of sorting losses is not required.

It is not necessary to include the overfill factor in addition to the "pumping loss" factor when calculating the initial construction quantity for the proposed project. Due to the inclusion of advance nourishment, the material contained within the “design template,” as distinct from the larger “construction template,” is effectively isolated from the long term erosion impacts which sort and transport sediment on the exposed face of the active profile. Hence, only the “pumping loss” factor, and not the overfill factor need be applied to the “design template.” The

Philadelphia District however, maintains the more conservative approach of applying both the overfill factor and the “pumping losses” factor to the periodic nourishment quantity because it is this material that will be subjected to long term erosion losses since it lies in the active wave zone.

The initial construction quantity is based on the cross-section required to construct the "design" profile plus a comparable or larger quantity required to advance the entire active profile out to the "depth of closure." The native beach composite grain size distribution, such as was computed for the study area, includes samples from the sub-aerial beach as well as the submerged portion of the active profile out to closure depth. The initial construction volume, because it is based on the quantity required to advance the entire active profile out to depth of closure, in effect already includes the fraction which is calculated with the overfill factor procedures. In addition, the performance characteristics of the proposed beachfill design takes into account the differences in grain size between the material in the borrow area and the material on the native beach.

6.1.2.4 Project Transition and Tapers.

The project includes a taper of 224 meters (734 feet) into Corson’s Inlet State Park and a taper of 20 meters (66 feet) into the terminal groin south of 93rd Street

6.1.2.5 Outfall Extensions

Two outfall extensions of 46 meters (150 ft) each would be required in Sea Isle City at 82nd and 86th Street.

6.2 Project Impacts

6.2.1 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 4.0 of this report. Two plans were formulated separately for Ocean City and Ludlam Island. General impacts will be discussed for both of these plans, however, specific impacts will be discussed when appropriate.

6.2.2 Groundwater

For the berm and dune restoration alternative and all of its construction options, the effects on the production well water in the project area due to dredging and beachfill placement during all phases of construction will be negligible. The primary source of water supply for the barrier islands, which is within the project area, is the Atlantic City 800-foot sand of the Kirkwood Formation (Clark, 1989). There exists a hydrogeologic disconnect between the areas where construction is to take place and the water supply aquifer. Based on this disconnect, it is believed that the dredging and beachfill placement will have no impacts on the water supply aquifer in the area.

6.2.3 Soils

6.2.3.1 Direct Impacts

Existing soils within the affected area are composed of unconsolidated sands deposited on the beach from wave action and previous beachfill activities. Sand grain size compatibility matches closely to existing sands on the beach, therefore, no expected adverse impacts to soils are anticipated.

6.2.3.2 Indirect Impacts

None anticipated.

6.2.4 Mineral Resources

Approximately 22,766,639 cubic meters (29,824,297 cubic yards) of sand material would be removed from the offshore borrow sites over the 50-year life of the project. Although sand resources will be removed from the borrow sites, the sand will be redistributed to the shoreline and littoral system. Therefore, this does not result in a permanent consumptive loss of this resource.

Two offshore borrow areas (M8- 852 acres) and a 258-acre portion of Borrow Area L3 lie outside of New Jersey State Waters and fall under Federal jurisdiction pursuant to the 1953 Outer Continental Shelf (OCS) Lands Act (43 U.S.C. 1331 et seq.; 43 U.S.C. 1801 et seq.). Under this Act, the Secretary of the Interior has direct responsibility for administration of oil, gas and mineral exploration; for development of the OCS; and for formulation of regulations to meet provisions of the Act. These functions are centralized under the Minerals Management Service (MMS). The Office of International Activities and Marine Minerals (INTERMAR), which is within MMS, is the liaison for agency involvement in international activities and provides policy direction for management and regulation of marine mineral resource activities on the OCS for minerals other than oil, gas, and sulfur (Louis Berger Associates, 1999). Because these two sites would make use of Federal OCS sand resources, coordination has been initiated with INTERMAR in regards to site locations and pertinent site data. Prior to initial construction, a project-specific Memorandum of Agreement between the USACE and MMS will be negotiated and executed concerning the use of these two sites.

6.2.5 Topography and Bathymetry

6.2.5.1 Affected Beaches and Nearshore Area

6.2.5.1.1 Direct Impacts

Based on the design template (typical cross section) for the berm and dune restoration alternative for the southern end of Ocean City, significant topographical changes will occur after initial placement (including design template and advance nourishment). Thickness in the beach width and foreshore slope will vary between nourishment cycles as the sacrificial portion of the beach will be 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 39 meters (128 feet). A range of 0 – 1.4 meters (0 – 4.7 feet) of vertical fill may initially cover the existing beach to produce a berm (flat portion of beach extending from the seaward edge of the dune to the foreshore slope) to a design elevation of +2.1 meters (7.0 feet) North American Vertical Datum (NAVD). The berm will initially extend seaward from the seaward base of the dune for a length of 46.5 meters (152.5 feet). This includes the sacrificial advanced nourishment. The base design template (w/o advanced nourishment) will have a berm that extends 30.4 meters (100 feet) from the seaward base of the dune. The base design template will have a beach that extends 66 meters (218 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, up to 1.5 meters (5 feet) of vertical fill may be placed over the existing beach to reach a standard project dune crest height of +3.9 meters (+12.8 feet) NAVD. The dune base will be approximately 22.5 meters (74 feet) with a 7.6 meter (25 foot) wide dune crest. The dune side slopes will be 1Vertical to 5 Horizontal. The foreshore zone (portion of the beach that slopes to the water) will be sloped 1 Vertical to 25 Horizontal, which is similar to current conditions.

Significant bathymetric changes are expected in the intertidal and subtidal portions of the beach and nearshore. An approximate range of 1.4 – 3.0 meters (4.6 feet – 9.8 feet) of vertical sand fill would initially be placed within the intertidal zone, which would displace the intertidal zone seaward approximately 39 meters (128 feet) from the current intertidal zone. Below the MLW line, vertical fill thickness will diminish with the slope to the depth of closure offshore. However, these changes based on fill placement would result in similar slopes as the existing slopes except they would be displaced seaward. It is expected that the thickness and widths would vary after initial construction and between periodic nourishment cycles as the sandy material becomes sorted and redeposited by wave action.

The selected plan for Ludlam Island contains dimensions that are different from the plan for Southern Ocean City. However, significant topographical changes will similarly occur after initial placement (including design template and advanced nourishment). Because Ludlam Island is a much larger segment of beach, the widths and thickness of beachfill placed to achieve the design template and advance nourishment will vary considerably within this segment. Based on a cross-section representing the beach from JFK Blvd to 52^{nd} St. (including design template and advanced nourishment), the upland portion of the beach (above Mean High Water (MHW)) will be extended seaward approximately 60 meters (197 feet). A range of 0.3 – 1.7 meters (0.98 – 5.6 feet) of vertical fill may initially cover the existing beach to produce a berm (flat portion of beach extending from the seaward edge of the dune to the foreshore slope) to a design elevation of +1.8 meters (6.0 feet) North American Vertical Datum (NAVD). The berm will initially extend seaward from the seaward base of the dune for a length of 30 meters (98.4 feet). This includes the sacrificial advanced nourishment. The base design template (w/o advanced nourishment) will have a berm that extends 15 meters (50 feet) from the seaward base of the dune. The base design template will have a beach that extends approximately 81 meters (265 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, 0 – 3.6 meters (0 – 11.8 feet) of vertical fill may be placed over the existing beach or an existing dune to reach a standard project dune crest height of +4.5 meters (+14.8 feet) NAVD. The dune base will vary depending on the existing dune base width and height, but will generally be 30 meters (98 feet) with a 7.6-meter (25 foot) wide dune crest. The dune side slopes will be 1Vertical to 5 Horizontal. The foreshore zone (portion of the beach that slopes to the water) will be sloped 1 Vertical to 35 Horizontal, which is similar to current conditions.

Significant bathymetric changes are also expected in the intertidal and subtidal portions of the beach and nearshore along Ludlam Island. An approximate range of 1.2 – 2.0 meters (3.9 feet – 6.5 feet) of vertical sand fill would initially be placed within the intertidal zone, which would displace the intertidal zone seaward approximately 39 meters (128 feet) from the current intertidal zone. Below the MLW line, vertical fill thickness will diminish with the slope to the depth of closure offshore. However, these changes, based on fill placement, would result in similar slopes as the existing slopes with the exception that they would be displaced seaward. It is expected that the thickness and widths would vary after initial construction and between periodic nourishment cycles as the sandy material becomes sorted and redeposited by wave action. The extension of two stormwater outfall extensions associated with this activity is not expected to have any adverse impacts on bathymetry.

6.2.5.1.2 Indirect Impacts

Beaches with over-designed berm elevations may result in the formation of significant escarpments in the foreshore zone as waves redistribute sand materials within the nearshore. This redistribution results in “sloughing” of the beach, which forms the escarpments. However, based on the design template for Southern Ocean City and Ludlam Island**,** the formation of escarpments within the foreshore zone is not expected to increase beyond existing natural escarpments caused by storms. It is expected that the proposed berm elevations are low enough to minimize this effect.

6.2.5.2 Offshore

6.2.5.2.1 Direct Impacts

Bathymetric changes will occur within the sand borrow sites where the bottom will be deepened 1.5 – 3.0 m (5 – 10 feet) as a result of dredging for beachfill material. According to the NOAA Navigation Chart #12318, depth soundings within the borrow sites vary. Area L1 (east and west) depths vary from 10.4 – 14.9 m (34 – 49 ft.). Area L3 depths vary from 9.75 – 15.2 m (32 – 50 ft.). Area M8 depths vary from 10.4 – 12.8 m (34 – 42 ft.). Corson Inlet depths are very shallow ranging from 0.3 – 4.2 m (1 – 14 ft.). Based on the sand deposit thickness and the desire to avoid creating deep pits, dredge cuts will not exceed 3.0 m (10 feet) in depth, therefore, the deepest areas will be no deeper than 18.3 m (60 feet). Therefore, post dredge depths could vary between 12.8 – 18.3 m (42 – 60 feet) within the borrow sites. No prominent offshore shoals with depths of 30 feet (9.1 m) 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.

6.2.5.2.2 Indirect Impacts

Deepening may produce minor localized changes in hydrodynamics within the borrow site. Some infilling and slumping may occur within the borrow site. The borrow site will be monitored after dredging for bathymetry, and water quality parameters to determine if the dredging practices should be modified for subsequent periodic nourishment cycles.

6.2.6 Hydrodynamics

6.2.6.1 Affected Beaches and Nearshore Area

Since the dominant direction of longshore transport along both Ocean City and Ludlam Island is to the south, sand placement on the beach will result in increased quantities of material moving in this direction. For the Ocean City portion of the project, this potentially means an increased shoaling rate in Corson Inlet.

Dredging of the borrow zone within Corson Inlet, however, will have potential impacts on the sediment transport and wave conditions in the vicinity of the inlet and adjacent shorelines. Wave, current and sediment transport modeling to provide an improved understanding of the inlet processes and potential impacts of the dredging will be conducted in the next phase of this study. Following completion of these studies, a more detailed delineation of the borrow area will be conducted. Dredging locations will be optimized to minimize impacts to the adjacent shorelines of Corson Inlet State Park and Ludlam Island.

6.2.6.2 Offshore

Dredging within the offshore borrow areas for Ocean City and Ludlam Island is expected to have negligible effects on nearshore sedimentation patterns and wave conditions. The locations of the borrow areas are approximately 2 to 3 miles offshore in water depths greater than 30 ft. The borrow area (M8) for the Ocean City portion of the fill is seaward of the three nautical mile line. At these offshore distances, dredging is not anticipated to impact any substantial features that will affect nearshore wave conditions or sediment transport patterns. Since dredging impacts are anticipated to be negligible on the hydrodynamics and processes, it will not cause or exacerbate nearshore erosion.

6.2.7 Air Quality

6.2.7.1 Affected Beaches, Nearshore, and Offshore Areas

6.2.7.1.1 Direct Impacts

Internal combustion engines in heavy equipment such as cutter-suction 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 (dredging operations could be continuous without stoppage for 24-hours a day over a period of several days) 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). Cape May County is in non-attainment status for ozone. However, no threshold levels for NO_x are established for Cape May 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 could 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 cutter-suction dredge (Louis Berger Group, 1999). Based on this estimate, the volumes required for initial construction and periodic nourishment appear to exceed the projected maximum dredging volumes to meet the PSD of 100 tons/year. However, this estimate was not developed specifically for this action. As part of the contract specifications, the construction contractor would be required to be in compliance with New Jersey air quality statutes and regulations. Based on preliminary review of this project, the proposed project is expected to conform to the SIP. A statement of conformity with the State Implementation Plan is provided as section 10.0 of this document.

6.2.7.1.2 Indirect Impacts

None anticipated.

6.2.8 Water Quality

6.2.8.1 Affected Beaches and Nearshore Area

6.2.8.1.1 Direct Impacts

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 beachfill 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 larger the grain-size, the smaller the area of impact. The period of turbidity is also less with larger grain-sized materials. Most of the sediments are greater than 90% sands and gravels; therefore, suspended particles should settle-out quickly after discharge. However, as the beachfill 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 beachfill. 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 beachfill material coupled with the deposition in a turbulent, well-oxygenated surf zone and nearshore environment.

There are several areas within the study area that impose 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 beachfill operations, as bacteria are fairly ubiquitous in the ocean environment. Therefore, periodic monitoring will be implemented during the dredging/placement of sand. 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 vibrocore 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 beachfill 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). However, water quality monitoring will be conducted periodically during beachfill operations to measure for any elevated chemical constituents or contaminants. The extension of two stormwater outfalls by 46 meters (150 feet) at 82nd and 86th Street in Sea Isle City is not expected to significantly alter water quality from existing conditions. Temporary, minor and localized impacts to water quality associated with outfall extensions are expected due to construction-generated turbidity.

6.2.8.1.2 Indirect Impacts

Indirect impacts of beachfill 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, midwater 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 beachfill material, these indirect effects on organisms are expected to be minor and temporary also.

6.2.8.2 Offshore

6.2.8.2.1 Direct Impacts

Dredging in the proposed borrow areas will also generate turbidity resulting in 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 hopper of a hopper dredge is allowed to overflow. Since the material is beachfill 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.

6.2.8.2.2 Indirect Impacts

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 depostited 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 10 feet (3.0 m) 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.

6.2.9 Terrestrial Habitat

6.2.9.1 Direct Impacts

Construction of the berm and dune restoration alternative would result in the initial placement of approximately 4.9 million cubic meters (6.5 million cubic yards) of sand on the dunes, beach and nearshore with subsequent periodic nourishments of approximately 305,900 cubic meters (400,279 cubic yards) every 3 years for the southern end of Ocean City and 2.0 million cubic meters (2.6 million cubic yards) every 5 years for Ludlam Island over a 50-year period. This construction will greatly disturb the impacted beach and dune area during the construction and periodic nourishment phases; however, impacts to terrestrial upland vegetation are expected to be minor and temporary. Since there is little vegetation on the beach area, the direct impact 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 on the constructed dunes is less diverse than the secondary dunes in Corson Inlet State Park and Strathmere Natural Area, which would not be affected. The affected dunes in the town areas are mainly composed of planted American beachgrass and lesser amounts of planted Japanese pines mixed in with a few volunteer species like sea rocket, seaside panicum, and slender-leaved goldenrod. The vegetation would initially be disturbed; however, the newly constructed dune would be replanted with American beachgrass and seaside panicum. It is assumed that the newly constructed dune would be recolonized by some of the aforementioned species over time. 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.

6.2.9.2 Indirect Impacts

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.

6.2.10 Wetlands

6.2.10.1 Direct Impacts

There are no vegetated wetlands within the affected areas along the shoreline, therefore, no direct impacts on vegetated wetlands are anticipated. The nearest vegetated wetlands occur landward within the interdunal swales inside of the dune line of Corson Inlet State Park. These wetlands are listed as palustrine scrub-shrub (PSS) and palustrine emergent (PEM), which are unique to the area, however, they are outside of the impacted area and would not incur any impacts from the proposed action. The affected area is primarily upland beach, marine-intertidal-unconsolidated-shore-sand-irregularly flooded (M2US2P) and regularly flooded (M2US2N), and marine-subtidal-unconsolidated-bottom-subtidal-habitat (M1UBL) (Cowardin et. al, 1979). Based on the selected plans, a total of approximately 75 hectares (184 acres) of intertidal marine habitat would be impacted in the southern end of Ocean City and Ludlam Island, however, there would be no losses of this habitat since it would be created seaward of the existing intertidal zone. Approximately 487 hectares (1,204 acres) of subtidal shallow marine habitat in both the southern end of Ocean City and Ludlam Island would also be impacted, but this habitat would likewise be shifted seaward of the existing shallow subtidal zone. The total aquatic habitat (below MHW) affected by beachfill placement is approximately 562 hectares (1,388 acres) in the entire project impact area.

6.2.10.2 Indirect Impacts

No indirect impacts on vegetated wetland habitats are anticipated.

6.2.11 Benthos

6.2.11.1 Affected Beaches, Intertidal Zone and Nearshore Area

6.2.11.1.1 Direct Impacts

The majority of the impacts of beachfill 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. Initial significant mortalities of non-motile benthic fauna can be expected, however, Maurer, et al. (1978) observed in a laboratory experiment that some benthic animals are able to migrate vertically through more than 30 centimeters 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. The nearshore and intertidal zone is highly dynamic, harsh, and is characterized by great variations in various abiotic factors. Table 6.2.11-1 provides estimates of aquatic habitat impacted by beachfill placement along the shorelines of Southern Ocean City and Ludlam Island (Strathmere, Whale Beach, and Sea Isle City) during initial construction.

Table 6.2.11-1 Estimated Areas of Intertidal/Nearshore Benthic Habitat Impacted By Beachfill Placement for Initial Construction

	Intertidal Zone (Mean High Water to Mean Low Water)		Subtidal Nearshore (Mean Low Water to Depth of Closure)		Total Shoreline Benthic Habitat (Mean High Water to Depth of Closure)	
	Volume of Sand Placed	Area Impacted	Volume of Sand Placed	Area Impacted	Volume of Sand Placed	Area Impacted
Southern Ocean City Area	94,570 m^3 (124,434 $yd^{3)}$	29.4 ha (72.6 ac)	624,684 m^3 (821,952 yd^3)	198.8 ha (491.2 acres)	719,253 m^3 (946,386 yd^3)	228.2 ha (563.8 acres)
Strathmere Area	41,940 m^3 (55,184 yd^3)	15.1 ha (37.2 ac)	227,158 m^3 (298,898 yd^3)	79.8 ha (197.1 acres)	269,102 m^3 (354,082 yd^3)	94.8 ha (234.3 acres)
Whale Beach Area	107,353 m^3 (141,254 yd^3)	8.3 ha (20.6 ac)	435,146 m^3 (572,560 yd^3)	33.8 ha (83.5 acres)	542,499 m^3 (713,814 yd^3)	42.1 ha (104.1 acres)
Sea Isle City	146,648 m^3 (192,958 yd^3.)	21.8 ha (53.8 ac)	1,311,669 m^3 (1,725,880 yd^3.)	175.0 ha (432.4 acres)	1,458,317 m^3 (1,918,838 yd^3)	196.8 ha (486.2 acres)
Total	390,511 m^3 (513,830 yd^3)	75 ha (184.2 ac)	2,598,656 m^3 (3,419,290 yd^3)	487 ha (1,204.2 acres)	2,989,171 m^3 (3,933,129 yd^3)	562 ha (1,388.2 acres)

Fauna of the intertidal zone are highly mobile and respond to stress by displaying large diurnal, tidal, and seasonal fluctuations in population density (Reilly and Bellis, 1983). Scott and Bruce (1999) found that the most dominant taxa found in the intertidal and nearshore portions of the study area include the small common surf-zone clam (*Donax variabilis*), the highly mobile haustorid amphipod (*Amphiporeia virginiana*), the mole crab (*Emerita talpoida*), and the mobile polychaete (*Scolelepis squamata*). Despite the resiliency of intertidal benthic fauna, the initial effect of beachfill deposition will be the smothering and mortality of some of the existing non-motile benthic organisms within the shallow nearshore (littoral) zone. 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 to begin with. Reilly and Bellis (1983) conclude that sand fill deposition initially destroys existing macrofauna, however, recovery is usually rapid after the sand deposition ceases. Recovery of the macrofaunal component may occur within one or two seasons if grain sizes are compatible with the natural beach sediments. However, the benthic community may be somewhat different from the original community. According to Hurme and Pullen (1988), "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." The frequency and periods between nourishment cycles may be of concern regarding life cycles of benthic organisms disturbed within the intertidal and subtidal zones. However, since most of these organisms (like the mole crab) complete their life cycle within a year after larval recruitment, two (or more) generations may exist within the time period before they are impacted by the next nourishment cycle. In this case, periodic nourishment of the beaches will occur every 3 years for the southern end of Ocean City and every 5 years for the beaches on Ludlam Island. Therefore, it is conceivable that the benthic community may attain a recovered state for a period of 2-4 years before being disturbed again by a re-nourishment cycle. This is based on a complete loss of the existing community at the time of renourishment. However, renourishment may not cover all of the beaches because only areas requiring sand to maintain the design template will be affected. 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 beachfill would be likewise created seaward. Therefore, no significant loss of intertidal or shallow nearshore benthic habitat is expected.

There are 23 groins within the study area (2 in Ocean City and 21 on Ludlam Island) that are composed of timber and stone, stone only, or concrete. Approximately 0.7 to 1.0 acres of hard bottom substrate below the mean high water line would be impacted by 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. 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 extension of two stormwater outfalls at 82nd and 86th Street in Sea Isle City is not expected to result in an increase or decrease in hard-bottom habitat.

6.2.11.1.2 Indirect Impacts

Beach replenishment may also inhibit the return of adult intertidal benthic organisms from their nearshore-offshore over-wintering refuges, cause reductions in organism densities on adjacent unnourished beaches, and inhibit pelagic larval recruitment efforts. Parr *et al*. (1978) notes 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 beachfill. 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). Since the grain sizes within the borrow site closely matches existing beach grain sizes, the impact is expected to be temporary and minor.

6.2.11.2 Offshore

6.2.11.2.1 Direct Impacts

The primary ecological impact of dredging within the sand borrow sites will be the complete removal of the existing benthic community within the affected area through entrainment into the dredge. Estimates of offshore benthic habitat impacted by dredging an average of 1.52 meters (5.0 feet) within the sand borrow sites are provided in Table 6.2.11-2. A total of approximately 337 hectares (833 acres) (80 ha or 198 acres for Ocean City plan and 257 ha or 635 acres for Ludlam Island plan) of sandy marine benthic habitat would be impacted from dredging associated with initial construction and a total of approximately 111 hectares (274 acres) (20 ha or 50 acres for Ocean City plan and 91 ha or 224 acres for Ludlam Island plan) would be impacted at a time with each periodic nourishment. Based on the projected estimates for sand required over a cumulative 50-year project, approximately 1,433 hectares (3,546 acres) (406 ha or 1,005 acres for the Ocean City plan and 1,027 ha or 2,541 acres for the Ludlam Island plan) of benthic habitat would be impacted within the sand borrow sites.

Table 6.2.11-2 Estimated Areas of Benthic Habitat Impacted By Dredging Within the Sand Borrow Sites To An Average Depth of 1.52 m (5.0 ft.).

Borrow Site (Mean Depth	Designation (Beach)	Initial Construction	Each Periodic Nourishment Cycle	Major Replacement	Total Cumulative (50-year period)

Dredged)		Qty. of Material Required (includes overfill factors)	Estimated Area Impacted	Qty. of Material Required (includes overfill factors)	Estimated Area Impacted	Qty. of Material Required (includes overfill factors)	Estimated Area Impacted	Qty. of Material Required (includes overfill factors)	Estimated Area Impacted
M8 (1.83 m) (6.0 ft.)	South End Ocean City Area	1,217,900 m^3 (1,595,449 yd^3)	79.9 ha (197.8 ac)	305,900 m^3 (400,729 yd^3)	20.1 ha (49.7 ac)	381,900 m^3 (500,289 yd^3)	25.1 ha (62.0 ac)	6,188,300 m^3 (8,106,673 yd^3)	406.1 ha (1,005.0 ac)
L3 (1.83 m) (6.0 ft.)	Strathmere Area	665,515 m^3 (871,825yd^3)	43.7 ha (108.1ac)	–	–	–	–	665,515 m^3 (871,825yd^3)	43.7 ha (108.1ac)
	Whale Beach Area	1,437,580m^3 (1,883,230 yd^3)	94.3 ha (233.5 ac)	440,580 m^3 (577,160 yd^3)	28.9 ha (71.5 ac)	499,580 m^3 (654,450 yd^3)	32.8 ha (81.1ac)	5,461,800 m^3 (7,154,958 yd^3)	358.4 ha (887.0 ac)
L1 (1.83 m) (6.0 ft.)	Sea Isle City	1,808,040 m^3 (2,368,532 yd^3)	118.6 ha (293.6ac)	707,776 m^3 (927,187 yd^3)	46.4 ha (114.9 ac)	836,776 m^3 (1,096,177 yd^3)	54.9 ha (135.9 ac)	8,307,024 m^3 (10,882,201 yd^3)	545.1 ha (1,349 ac)
Corson Inlet (1.4 m) (4.5 ft.)	Strathmere Area	0	0	235,000 m^3 (307,850 yd^3)	15.4 ha (38.2 ac)	264,000 m^3 (345,840 yd^3)	17.3 ha (42.9 ac)	2,144,000 m^3 (2,808,640 yd^3)	79.7 ha (197 ac)
Total		5,129,035 m^3 (6,719,036 yd^3)	336.5 ha (832.9 ac)	1,689,256 m^3 (2,212,925 yd^3)	110.9 ha (274.3 ac)	1,982,256 m^3 (2,596,755 yd^3)	130.1 ha (321.9 ac)	22,766,639 m^3 (29,824,297 yd^3)	1,433 ha (3,546 ac)

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 on the beach or nearshore. Despite the initial effects of dredging on the benthic community, recolonization is anticipated to occur within one year. However, depending on the post-dredging conditions, recovery of the benthic community through abundance, diversity, and biomass can be variable by taking a few months to several years (National Research Council, 1995). 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. Bowen and Marsh (1988) compared a recently dredged borrow pit with a 5-year old borrow pit, and determined that relative to the old pit, the new pit showed complete recovery within a year based on several aspects of community structure, but differences in species composition were evident. USACE (2001) conducted benthic investigations of borrow areas off of the northern New Jersey coast and concluded that after initial impacts on the infaunal assemblage, including decreases in abundance, biomass, taxa richness and the average size of the biomass dominant; the abundance, biomass, and taxa richness recovered quickly after the first dredging operation with no detectable difference between the dredged and undisturbed areas by the following spring. In another site dredged a year later, they noted that abundnace recovered quickly within the year, but both biomass and taxa richness were still reduced. However, the changes in biomass composition returned to undredged condition in 1.5 to 2.5 years. In contrast Salomon (1974) investigated benthic life in borrow pits dredged off Treasure Island, Florida where the macrobenthic fauna in 3-year old borrow pits were very small in size and low in abudndance and diversity compared to adjacent control areas. He attributed that recovery was slow due to the accumulation of fine-grained materials in the pits. 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 or increased hydrogen sulfide levels (Murawski, 1969; Saloman, 1974; National Research Council, 1995). 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 to a similar benthic community, the bottom sediments should be composed of the same grain sizes as the pre-dredge bottom. Cutler and Mahadevan (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. Hurme and Pullen (1988) recommend that borrow materials be obtained from broad, shallow pits in nearshore waters with actively shifting bottoms, which would allow for sufficient surficial layer of similar sediments for recolonization. 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.

In order to minimize adverse effects on the benthic community within the borrow area, several mitigative measures are being 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.

Benthic investigations in and around the borrow sites indicate the presence of a benthic community that has abundance and diversity typical for sandy bottoms in offshore waters of the middle Atlantic Coast (Scott and Bruce, 1999; Scott and Wirth, 2000). Scott and Wirth (2000) did not find any rare or unique benthic assemblages within the vicinity of the sand borrow areas. However, shifts in benthic community composition can be expected if the physical habitat is significantly different than the pre-dredging habitat. Since the majority of offshore borrow areas are in a less dynamic area (as opposed to the high-energy ebb shoal and inlet area witnessed at the Corson Inlet Site), 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. Vibrocore data confirm that surficial sand deposits of variable thickness exist within the area. These deposits should be correlated with vibrocore data to expose similar sand strata during dredging. These areas would be deepened by 1.52 – 3.04 meters (5-10 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. However, Corson's Inlet is an exception because it is expected to shoal frequently, and supply sand for periodic nourishment of Strathmere. Periodic disturbance on benthos in Corson's Inlet is expected to have minimal effects due to the highly dynamic nature of this area, and the presence of fauna suited for periodic disturbance. A study conducted at a similar borrow site (at Great Egg Harbor Inlet) indicated that the benthic community rapidly recolonized the area following dredging, and within two years established a population similar to pre-dredging conditions (Scott and Kelly

1998). Therefore, this could reasonably be expected for the Corson Inlet Site to be used for periodic nourishment for Strathmere.

6.2.11.2.2 Indirect Impacts

Many of the benthic organisms represent a food source for resident and migratory fish. Initial elimination of the benthic community through dredging would reduce the amount of forage habitat for some fish species within the immediate affected area. This effect is expected to be short-term as bottom-feeding fish would shift to other similar nearby unaffected or recolonized areas and then return to the area to feed after benthic recolonization occurs.

6.2.12 Plankton and Marine Macroalgae

6.2.12.1 Affected Beaches and Nearshore Area

6.2.12.1.1 Direct Impacts

Direct impacts on phytoplankton and zooplankton involve mortality based on physical disruption through the dredging and deposition process. A number of planktonic organisms may become stranded on the beach after dewatering is completed; however, this impact is expected to be minor based on the ubiquitous distribution of plankton in nearshore waters. There are no known major macroalgae beds within the nearshore zone, therefore, adverse impacts are expected to be non-existent or minimal. However, the placement of sand would likely impact some of the macroalgae that may be attached to the groins.

6.2.12.1.2 Indirect Impacts

Minor and temporary indirect impacts on phytoplankton may result from elevated turbidity levels that may impede light penetration, which could inhibit photosynthesis. This impact is expected to be minor and temporary because it is expected that turbidity levels would drop quickly upon cessation of discharges associated with beachfill placement. In areas with high organic content in sediments, dredging may suspend nutrients that could be associated with algae blooms, however, since organic concentrations in beachfill sediments are low, abnormal algae blooms are not anticipated. Therefore, no changes or adverse long-term effects concerning primary or secondary productivity are expected.

6.2.12.2 Offshore

6.2.12.2.1 Direct Impacts

Certain forms of zooplankton such as some copepod species may be more susceptible to being entrained during dredging based on their diurnal vertical migration patterns. This impact is dependent on the time of day that dredging is conducted. This impact is expected to be minor based on the fairly ubiquitous distribution of zooplankton within the offshore marine waters.

6.2.12.2.2 Indirect Impacts

Turbidity generated in the offshore waters during dredging is expected to be temporary and minor, therefore, no changes in primary and secondary production are anticipated.

6.2.13 Fisheries

6.2.13.1 Finfish

6.2.13.1.1 Nearshore and Offshore

6.2.13.1.1.1 Direct Impacts

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 impacts to fish eggs and larvae are expected because these life stages are widespread throughout the Middle Atlantic Bight, and are not particularly concentrated in the borrow site or surf zone of the project area (Grosslein and Azarovitz, 1982), however, dredging and beachfill 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 of the potential borrow areas were either eliminated or modified to avoid adversely impacting prominent shoal habitat. The placement of beachfill 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.

6.2.13.1.1.2 Indirect Impacts

The primary indirect impact to fisheries will be felt from the immediate loss of a food source by disturbing benthic macroinvertebrate 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 271 hectares (669 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 beachfill placement, periodic beach nourishments could disrupt benthic forage habitat at approximately 96 hectares (238 acres) at a time. However, each portion of the borrow areas utilized for periodic nourishment would also be left to be recolonized after it is used, and not be disturbed again.

6.2.13.2 Shellfish

6.2.13.2.1 Nearshore and Offshore

6.2.13.2.1.1 Direct Impacts

Surfclams are the most prominent shellfish resource that would be impacted by project activities. The direct effect of dredging operations on the commercial shellfish of the region is of great concern to natural resource managers. The Atlantic surfclam (*Spisula solidissima*) harvest along New Jersey's coast accounts for more than 80% of the total mid-Atlantic catch (NJDEP 1997b). Annual commercial surfclam surveys conducted by the New Jersey Department of Environmental Protection, Division of Fish and Wildlife indicates that the vast majority of commercial surfclam beds in New Jersey waters are located between Atlantic City and Shrewsbury Rocks. There are no surfclam conservation zones (as established in N.J.A.C. 7:25-12) within the affected areas. The nearest surfclam conservation zone is approximately 13.5 km northeast of Great Egg Harbor Inlet, which begins in the Absecon Inlet area, and extends north to Little Egg Inlet. Although the project impact areas are to the south of this region, dredging sand for beach replenishment has potential to impact these resources. An immediate effect is the removal of existing shellfish communities and alteration of the substrate composition, which may affect important nursery habitats and hinder surfclam recruitment success (Scott and Wirth, 2000).

Small and large surfclams were present at all four borrow areas in or near Corson Inlet. Juvenile clams, as collected with the Young grab, were present in low numbers ($< 41/m^2$) and the abundances were not significantly different from the reference areas. The Corson Inlet area had the highest average density of adult clams of 13 clams/100 sq. ft. collected during the dredge survey. Average densities in the offshore areas were low, between 1 and 2 clams /100 sq. ft. Surfclam data collected from the current offshore borrow areas were similar to the data collected from the previously sampled borrow areas (Scott and Bruce 1999; Scott and Wirth 2000).

The current survey suggest that marketable sized surfclams exist in the area although in low numbers in the offshore borrow areas. The shallow waters near the Corson Inlet borrow area would most likely preclude commercial dredging of surfclams. Both the current survey and NJDEP surveys indicate that populations of mature adults exist near the four borrow areas in or near Corson Inlet. These clams should provide a good recruitment base for population recovery. Based on the existing surfclam populations within the four borrow areas, each area is expected to recover from dredging operations provided suitable environmental conditions are present following dredging. These conditions include a thick (at least 3 feet) surficial sandy substrate and sufficient dissolved oxygen concentrations. Evidence from a dredged area at Great Egg Harbor Inlet near Ocean City, New Jersey, indicates that surfclam populations are resilient and will be able to successfully recruit even after multiple dredging operations (Scott and Kelley 1998). Data from that study indicated that good clam recruitment is occurring and the clams in the area are reaching mature and harvestable sizes. Since NJDEP surveys indicate that populations of mature adults exist in the Corson Inlet vicinity, it can be assumed that these clams will provide a recruitment base after dredging (Scott and Wirth, 2000).

The temporary loss of the surfclam resources within the borrow areas are unavoidable. To minimize the impacts of the proposed project on the surfclam population, dredging would be conducted in the area only one time (with the exception of Corson Inlet Area) to allow for recruitment after the area is impacted. In addition, dredging depths could be restricted to allow for similar and sufficient depth of suitable substrate and physical/chemical conditions favorable for surfclam recruitment. Monitoring would be required to determine physical substrate and dissolved oxygen content along with determining rate of recruitment. Adaptive measures such as modifying dredging depths may be required if recruitment is poor within impacted areas. Other possible measures may include harvesting the clams prior to dredging.

6.2.13.2.1.2 Indirect Impacts

Dredging and subsequent removal of surfclams would reduce reproductive stock, however, this impact would be minor as gametes and larvae from surrounding areas are fairly ubiquitous and well-dispersed in Atlantic coastal waters.

6.2.13.3 Essential Fish Habitat

As discussed in the Existing Conditions section, 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 beachfill 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 the 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 these 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 eliminating such sites with prominent shoal habitat such as the eastern portion of L1 and L2 because they would have impacted an area known as the "Sea Isle Lump", which is considered an important sport and commercial fishing ground (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 surfclam recruitment or spawning of some finfish species. This could be avoided by correlating vibrocore strata data with sand thickness to restrict dredging depths to avoid exposing a different substrate. Based on the vibrocore 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 6.2.13-1 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 52, 53, 63, and 64) that encompasses the entire project impact area.

Table 6.2.13-1 Direct And Indirect Impacts On Federally Managed Species And Essential Fish Habitat (Efh) In The 10 Min. X 10 Min. Squares Of 52, 53, 63 And 64 (NOAA, 1999)

Direct And Indirect Impacts On Federally Managed Species And Essential Fish Habitat (EFH) In The 10 Min. X 10 Min. Squares Of 52, 53, 63 And 64 (NOAA, 1999)				
MANAGED SPECIES	**EGGS**	**LARVAE**	**JUVENILES**	**ADULTS**
1. Atlantic cod *(Gadus morhua)*				**Direct:** Physical habitat in borrow site should remain basically similar to pre-

Direct And Indirect Impacts On Federally Managed Species And Essential Fish Habitat (EFH) In The 10 Min. X 10 Min. Squares Of 52, 53, 63 And 64 (NOAA, 1999)				
MANAGED SPECIES	**EGGS**	**LARVAE**	**JUVENILES**	**ADULTS**
				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.	
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. Winter flounder (Pseudop*leuronectes americanus*)	Eggs are demersal in very shallow waters of coves and inlets in Spring. Dredging in Corson Inlet may have some effect on eggs, however, borrow site is primarily in a high-energy area of the inlet where eggs are not likely to be highly concentrated.	Larvae are initially planktonic, but become more bottom-oriented as they develop. Potential for some to become entrained during dredging in Corson Inlet area.	**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.
5. 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.
6. Atlantic sea herring *(Clupea harengus)*			**Direct:** Occur in pelagic and near bottom. Physical habitat in borrow site	**Direct:** Occur in pelagic and near bottom. Physical habitat in borrow site

Direct And Indirect Impacts On Federally Managed Species And Essential Fish Habitat (EFH) In The 10 Min. X 10 Min. Squares Of 52, 53, 63 And 64 (NOAA, 1999)				
MANAGED SPECIES	**EGGS**	**LARVAE**	**JUVENILES**	**ADULTS**
			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	should remain basically similar to pre-dredge conditions. **Indirect:** None, prey items are primarily planktonic
7. Monkfish *(Lophius americanus)*	Eggs occur in surface waters with depths greater than 25 m; therefore, no direct or indirect effects are expected.	Larvae occur in pelagic waters with depths greater than 25 m; therefore, no direct or indirect effects are expected.		
8. 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.
9. 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.
10. Short finned squid *(Illex ilecebrosus)*	n/a	n/a		
11. Atlantic butterfish *(Peprilus tricanthus)*			**Direct:** Juvenile butterfish are pelagic species. No significant direct effects anticipated. **Indirect:** Temporary disruption of benthic food prey organisms.	
12. 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.
13. 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	**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

Direct And Indirect Impacts On Federally Managed Species And Essential Fish Habitat (EFH) In The 10 Min. X 10 Min. Squares Of 52, 53, 63 And 64 (NOAA, 1999)				
MANAGED SPECIES	**EGGS**	**LARVAE**	**JUVENILES**	**ADULTS**
			dredge. **Indirect:** Temporary disruption of benthic food prey organisms.	prey organisms.
14. 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. Approximately 0.7 to 1.0 acres of intertidal and subtidal rocky habitat may be impacted due to sand partially covering groins 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. Approximately 0.7 to 1.0 acres of intertidal and subtidal rocky habitat may be impacted due to sand partially covering groins along the shoreline. **Indirect:** Temporary disruption of benthic food prey organisms.
15. Surfclam *(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. **Indirect:** Temporary reduction in reproductive potential. *See shellfish section for more discussion.
16. Ocean quahog *(Artica islandica)*	n/a	n/a		
17. Spiny dogfish *(Squalus acanthias)*	n/a	n/a		
18. 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.
19. 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	**Direct Impacts:** Adults are pelagic and highly migratory, therefore no adverse impacts are anticipated. **Indirect Impacts:** Minor indirect adverse effects on food chain through

Direct And Indirect Impacts On Federally Managed Species And Essential Fish Habitat (EFH) In The 10 Min. X 10 Min. Squares Of 52, 53, 63 And 64 (NOAA, 1999)				
MANAGED SPECIES	**EGGS**	**LARVAE**	**JUVENILES**	**ADULTS**
			community, however, mackerel are highly migratory.	disruption of benthic community, however, mackerel are highly migratory.
20. 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.
21. Sand tiger shark *(Odontaspis taurus)*		**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. However, some mortality of young could be expected from entrainment into the dredge because they may be oriented with the bottom. **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.
22. Atlantic angel shark *(Squatina dumerili)*		**Direct:** Physical habitat in borrow site should remain basically similar to pre-dredge conditions. However, some mortality of larvae could be expected from entrainment into the dredge because they may be oriented with the bottom. **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. However, some mortality of juveniles could be expected from entrainment into the dredge. **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 mobile and are capable of avoiding impact areas. **Indirect:** Temporary disruption of benthic food prey organisms and food chain within borrow and placement sites.
23. 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 sites.		
24. Sandbar shark *(Charcharinus plumbeus)*		**Direct:** Physical habitat in borrow site should remain	**Direct:** Physical habitat in borrow site should	**Direct:** Physical habitat in borrow site should remain

Direct And Indirect Impacts On Federally Managed Species And Essential Fish Habitat (EFH) In The 10 Min. X 10 Min. Squares Of 52, 53, 63 And 64 (NOAA, 1999)				
MANAGED SPECIES	**EGGS**	**LARVAE**	**JUVENILES**	**ADULTS**
		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.	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.	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.
25. 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.		
26. Atl. sharpnose shark *(Rhizopriondon terraenovae)*				**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.

Of the 26 species identified with Fishery Management Plans, the proposed project could have immediate direct impacts on habitat for surfclams, black sea bass, scup, summer flounder, 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 effect on surfclams 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 1 to 2.5 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 surfclam surveys, and bottom trawls (if necessary) within affected areas. This monitoring would serve to provide valuable information early on in the project concerning the effects on EFH to base future adaptive management measures to minimize any adverse effects in subsequent periodic nourishment cycles.

6.2.14 Birds

6.2.14.1 Affected Beaches and Nearshore Area

6.2.14.1.1 Direct Impacts

The project impact area of Peck Beach Island and Ludlam Island is host to a variety of migratory shorebirds, colonial nesting waterbirds, migratory waterfowl, raptors, and other passerine bird species (USFWS, 1999b). 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). According to Andrews (1990) and USFWS (1999b), there were two barrier beach nesting colonies within the project area located at Corson Inlet State Park (403 064) on Peck Beach Island and at Whale Beach (403 067) on Ludlam Island. These sites consisted of nesting least terns and black skimmers. A large colony of least terns and black skimmers were present at the Strathmere Natural Area in 1999. Timing restrictions and/or buffer zones should be established to avoid adversely impacting any nest sites.

6.2.14.1.2 Indirect Impacts

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.

6.2.14.2 Offshore

6.2.14.2.1 Direct Impacts

Some pelagic birds may be disturbed by equipment noise within the immediate vicinity of the dredging operation. This impact is temporary and minor, and will only last during the operation of the dredge. Pelagic birds are expected to move to nearby waters away from the equipment during the dredging activity.

6.2.14.2.2 Indirect Impacts

None anticipated.

6.2.15 Mammals

6.2.15.1 Affected Beaches and Dunes

6.2.15.1.1 Direct Impacts

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 are expected to return after construction is completed.

6.2.15.1.2 Indirect Impacts

Habitat value for terrestrial mammalian wildlife may improve slightly with a more stable vegetated dune and wider beach.

6.2.15.2 Nearshore and Offshore Areas

Impacts to whales are addressed in the Rare, Threatened and Endangered Species Section.

6.2.15.2.1 Direct Impacts

Marine mammals such as bottlenose dolphins may be present in the dredging impact area. These animals are capable of moving away from the equipment during dredging activities, therefore, this would result in a temporary and minor or negligible impact on marine mammals.

6.2.15.2.2 Indirect Impacts

The initial impact of the loss of the benthic community may have an effect on the food chain by reducing the amount of available food for prey species that marine mammals may depend on. Also, marine mammals that are sight feeders may experience a reduction in visibility within the immediate impact area due to turbidity generated from dredging and beachfill placement. These impacts are expected to be minor and temporary, as most marine mammals are highly mobile and transient, and capable of relocating to another area until construction ceases.

6.2.16 Reptiles and Amphibians

Sea turtle impacts are addressed under the Rare, Threatened, and Endangered Species section.

6.2.16.1 Affected Beaches and Dunes

6.2.16.1.1 Direct Impacts

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 interdunal swales were identified within the affected areas; therefore, there would be no adverse impacts associated with breeding habitat for amphibians and some reptiles. Project construction is not expected to result in adverse impacts on diamondback terrapin breeding habitat.

6.2.16.1.2 Indirect Impacts

Habitat value for terrestrial reptiles and amphibians may improve slightly with a more stable dune and wider beach.

6.2.17 Rare, Threatened and Endangered Species

6.2.17.1 Affected Beaches and Nearshore Area

6.2.17.1.1 Direct Impacts

The piping plover, which is Federally listed as threatened and State listed as endangered, is a frequent inhabitant of New Jersey's coastal barrier beaches, and is known to be present within the project impact areas of both Peck Beach Island (northern and middle portions) and Ludlam Island (almost the entire length) (USFWS, 1999b). The least tern and black skimmer (both State endangered species) are colonial nesters within the project impact area. Beach replenishment can potentially have significant direct adverse impacts on these species. Sand placement can bury nests, and machinery on the beach can crush eggs, nestlings, and adults. Human disturbance related to noise and lights can disrupt successful nesting of these birds (Louis Berger Group, 1999). Also, pipelines used during construction may become barriers to young chicks trying to reach intertidal areas to feed. USFWS (1999b) attributes human disturbance and loss of nests as the most critical contributors to the population decline of the piping plover.

The proposed project may also create habitat for the seabeach amaranth, which is a Federally listed threatened plant that inhabits overwash flats, accreting ends of coastal barrier beaches and lower foredunes of non-eroding beaches. No extant populations are known to currently exist within the study area. However, this species has recently recolonized or has been observed in coastal sites within northern New Jersey, New York, Delaware, and Maryland (USFWS, 1999b and D. Adamo, personal communication). Based on this, the seabeach amaranth could become naturally reestablished within the project area during the project life (USFWS 1999b). Impacts to this species are 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 submitted 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 currently developing 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 or in areas where recent nesting activites have occured, construction of temporary protective fencing, and avoidance during the construction. Other issues to be addressed include dune fence orientation, local practices such as beach raking, off-road vehicles, permanent easements for monitoring and management activities, 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.

The project area is located beyond the normal breeding range of threatened and endangered sea turtles, therefore, impacts on sea turtle nesting habitat within the project area are not likely.

6.2.17.1.2 Indirect Impacts

The quality of forage habitat for piping plover and other shorebirds within the intertidal zone may become temporarily diminished 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 skimmer. Although this may appear to be beneficial, it is possible that this could have adverse impacts on these species. This is because a replenished wider beach may attract these birds away from natural areas where human disturbance effects are less (USFWS, 1999; personal communication with D. Jenkins – NJDEP Endangered and Non-Game Program). As discussed above, replenished beaches may become suitable habitat for the seabeach amaranth.

6.2.17.2 Offshore

6.2.17.2.1 Direct Impacts

From June through November, New Jersey's coastal waters may be inhabited by transient sea turtles, especially the loggerhead (Federally listed threatened) or the Kemp's ridley (Federally listed endangered). Sea turtles have been known to be adversely impacted during dredging operations that have utilized a hopper dredge. Dredging encounters with sea turtles have been more prevalent among waters of the southern Atlantic and Gulf coasts; however, incidences of "taking" sea turtles have been increasing in waters of the Middle Atlantic Coast in hopper dredges, which utilize high-suction heads. Endangered whales such as the highly endangered Right whale may also transit 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.

Formal consultation 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 utilizing a hopper dredge that may have impacts to Federally threatened or endangered species (including shortnose sturgeon, sea turtles, and marine mammals). A Biological Assessment (USACE, 1995) that discusses Philadelphia District hopper dredging activities and potential effects on Federally threatened or endangered species of sea turtles, marine mammals and shortnose sturgeon has been prepared, and was formally submitted to NMFS in accordance with Section 7 of the Endangered Species Act. A Biological Opinion (NMFS, 1996) from NMFS was completed and submitted to the Corps on November 26, 1996. The Biological Opinion provides several measures to avoid or minimize the potential for adverse effects on threatened and endangered species. Measures relevant to this project suggest that dredging (w/ a hopper dredge) be avoided between June 1 and November 30. However, if dredging (w/ a hopper dredge) must be conducted during this period, a NMFS-approved, trained sea turtle/marine mammal observer is required to be present on the dredge. The Biological Opinion provides for incidental take limits for sea turtles, and states that Section 7 Consultation must be reinitiated if the take level for any one species is exceeded (NMFS, 1996). Adherence to the findings and conditions of the Biological Opinion will insure compliance with Section 7 of the Endangered Species Act.

6.2.17.2.2 Indirect Impacts

Forage habitat for sea turtles may be slightly reduced from initial loss of benthic community within the borrow areas following dredging. This impact is expected to be short-term and minor, as sea turtles are highly mobile and capable of moving to better forage areas until the affected area becomes recolonized by benthic organisms.

6.2.18 Reserves, Preserves and Parks

6.2.18.1 Direct and Indirect Impacts

On the southern part of Peck Beach Island, the proposed plan terminates at the northern end of Corson Inlet State Park. However, on the northern part of Ludlam Island, the proposed plan includes a 224 meter (734 foot) taper into the southern portion of the Strathmere State Natural Area). Although this taper is intended to provide storm damage reduction for the town of Strathmere, the State Natural Area may indirectly benefit from additional sand and a wider beach at the taper area. This is expected to provide additional recreational beach as well as additional protection and habitat for colonial nesting shorebirds, which nest frequently in the Strathmere Area.

There is one unit identified within the project impact area that is a part of the Coastal Barrier Resources System under the Coastal Barrier Resources Act (CBRA). The purpose of the CBRA is to protect undeveloped barrier islands and to restrict future Federal expenditures and financial assistance, which encourage development of coastal barriers. This unit (NJ-08P) is located in the Corson's Inlet area encompassing the Corson Inlet State Park and Strathmere Natural Area. The proposed action is exempt for this location because this unit has been designated as an "Otherwise Protected Unit" (P). Congress determined that these areas (P) should not be included as part of the System, but would be ineligible for Federal flood insurance after November 16, 1991.

6.2.19 Recreation

6.2.19.1 Affected Beaches and Nearshore Area

6.2.19.1.1 Direct Impacts

Direct adverse impacts on recreation are 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 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.

6.2.19.1.2 Indirect Impacts

The proposed project as a secondary benefit, may improve opportunities for recreational beach use by providing and maintaining a wider beach.

6.2.19.2 Offshore Area

6.2.19.2.1 Direct Impacts

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.

6.2.19.2.2 Indirect Impacts

Recreational fishing may be temporarily reduced in portions of the borrow area after dredging due to the temporary loss of benthic prey organisms.

6.2.20 Cultural and Historical Impacts

Proposed project construction has the potential to impact cultural resources in three areas. These are the existing beach shoreline and near-shore sand placement areas and the offshore borrow areas. In the beach shoreline and near-shore sand placement 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 properties.

The Philadelphia District has conducted several cultural resources investigations in the project area in order to identify and evaluate historic properties that may be impacted by proposed construction (Dolan Research, Inc., 1999, 2000; Hunter Research, Inc., 1999). These investigations resulted in the identification of twenty one historic properties and sites located in, or adjacent to, the project area. These properties include two prehistoric sites, numerous historic buildings and foundations, one bridge, several historic structural features such as groins and fishing piers, and seven remote sensing targets. Four of these properties have been determined eligible for, or are listed on, the National Register of Historic Places and include 1) the 10th Street Station, 2) 34th Street Station, 3) Ocean City - Longport Bridge, and 4) Sindia Shipwreck.

On the basis of the current project plan, the Philadelphia District is of the opinion that sand placement in the shoreline project areas will have no effect on significant cultural resources. However, proposed sand placement in the underwater near-shore area and sand dredging from offshore underwater borrow areas could impact four remote sensing targets exhibiting shipwreck characteristics. An underwater investigation of these four target locations began in November 2000, and results will be incorporated in the final version of this report. The results of this investigation and previous cultural resources studies will be closely coordinated with the New Jersey State Historic Preservation Office and Section 106 consultation will be concluded prior to any project construction activity.

6.2.21 Hazardous, Toxic and Radioactive Wastes (HTRW)

A review of the literature search and comparison of the risk of encountering HTRW versus the study have lead to the following conclusions:

i. The project area has been primarily a residential area and most contamination could be attributed to non-point sources (parking lots, roadways, etc) and commercial activities (leaking underground storage tanks, waste generation/discharge). The storm water outfalls listed in Table 2.5-2 are a source of possible contamination, however since the area drained is residential, the severity of the contamination is low and will not pose a concern to the project.

ii. The proposed project will not worsen HTRW conditions in the project area. "With" Project and "Without" Project HTRW conditions are essentially the same.

iii. All sites listed in Table 2.5-1 are outside the project area. These sites all have either soil or groundwater HTRW issues and since they are outside of the project area only groundwater is of concern. The current plan does not include any type of onshore excavation where groundwater could be encountered. However, if the plan is changed there may need to be a reevaluation of the HTRW sites of concern for impacts.

iv. The potential offshore borrow areas identified for this study where analyzed for possible HTRW impacts. All of the HTRW sites listed can be eliminated as possible sources of contamination for the potential borrow areas because of their distance offshore.

v. The Philadelphia District performed a search using the Project Information Retrieval System (PIRS) for Formerly Used Defense Sites (FUDS) within the project boundaries. There were no sites identified in the project area or the potential borrow area locations.

6.2.22 Community Settings

6.2.22.1 Land Use

6.2.22.1.1 Affected Beaches and Nearshore Area

6.2.22.1.1.1 Direct Impacts

The proposed beach replenishment plan will only affect the beach, dunes, intertidal area and nearshore area, therefore, there will be no changes in land use within the affected areas.

6.2.22.1.1.2 Indirect Impacts

The proposed beach replenishment plan is intended to provide storm damage reduction for the communities on Peck Beach Island and Ludlam Island. Because these areas are already highly developed and are bordered by protected beaches and marshland, the proposed action is not likely to increase development or other changes in land use in addition to existing development pressure in the area.

6.2.22.2 Visual And Aesthetic Values

6.2.22.2.1 Affected Beaches and Nearshore Area

6.2.22.2.1.1 Direct Impacts

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 berm width considered during formulation was determined based upon the average existing beach profile. Dune height and berm width for the selected plan were chosen based upon 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 compatible with the native material. Initial fill placement may exhibit some scarping, however, since the native beach material and the borrow material are relatively close in composition, 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 beachfill 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 +3.9 meters (+12.8 feet) NAVD in Southern Ocean City and +4.5 meters (14.8 feet) on Ludlam Island would likely have an obstructed ocean view.

6.2.22.2.1.2 Indirect Impacts

There are no significant adverse indirect impacts on visual and aesthetic values expected with implementation of the proposed plan.

6.2.22.3 Noise Impacts

6.2.22.3.1 Affected Beaches, Nearshore Area and Offshore Area

6.2.22.3.1.1 Direct Impacts

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 and air quality impacts would be restricted to site construction preparation (generally beginning two weeks prior to dredging) and the actual dredging and placement operation. Noise is limited to the utilization of heavy equipment such as bulldozers to manipulate the material during placement. 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. The municipalities within the project impact area impose restrictive noise ordinances, however, construction activities such as this project would comply or be exempt from noise ordinances. All noise impacts would end upon cessation of construction activities.

6.2.22.3.1.2 Indirect Impacts

Excessive noise in the vicinity of nesting piping plovers or other 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.

6.2.23 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 (ie. 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.

6.2.24 Socioeconomic Impacts and Environmental Justice

6.2.24.1 Socioeconmic Impacts

Implementation of the selected plan for berm and dune restoration will not significantly impact key, macroeconomic elements of the local or regional economy. The project's scope is such that it will not affect the long-term population, employment, or income trends in the study area.

Population trends are not expected to be impacted by project implementation. Physical changes are localized and not likely to effect current population trends. No relocations of existing households are required. No existing population centers will be affected. It is not expected that residents will be inclined to relocate because of the project.

The impact of the proposed project on local or regional employment distribution is not expected to be significant. The project will not, in and of itself, spur growth in the major industries in the study area, nor will it stimulate significant growth in other, less dominant industries. Tourism and agriculture will continue to thrive with or without the project.

The impact of the proposed project on income in the study area will not be significant. The project will not change the median household income.

The initial construction and periodic nourishments may produce a minor and temporary increase in employment during construction and perhaps a slight increase in use of temporary lodging. The proposed dredging and placement will be accomplished by a small construction crew operating dredges, bulldozers and trucks. These workers, if they do not live locally, will likely spend money in the area for food and lodging.

6.2.24.2 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.

6.2.25 Cumulative Impacts

Cumulative Impacts, as defined in CEQ regulations, are the "impacts 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 beachfill 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 replenishment 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 beachfill projects, if planned properly, have short-term and minor adverse ecological effects, however, we are not aware of any studies that consider regional or national cumulative impacts of these projects on resources of concern.

6.2.25.1 Offshore Habitats

There are several beach replenishment projects currently in the planning phase for the NJ coastline. There are also several beach replenishment projects that have already been built, and may entail long-term commitments to periodic nourishment. The cumulative loss of offshore sandy shoals may pose impacts on fisheries and essential fish habitat. The shoals on the inner continental shelf have been increasingly relied upon to provide sand for beach replenishment projects, which could lead to a significant decrease in the amount of shoal habitat (USFWS, 1999). Table 6.2.25-1 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. The scope of this table focuses on recent or proposed actions and locations within the Philadelphia District along the New Jersey Atlantic Coast (from Manasquan Inlet to Cape May Point) where offshore or inlet sand sources were or are being proposed for use.

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 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. The Federal, state and local replenishment projects have all used either inlet borrow sites or offshore sites, which have impacted a total area of 431.7 ha (1,067 acres) since 1995. Approximately 71% of the existing affected areas are inlet ebb shoal habitat (304.6 ha/753 ac) and 29% (127.1 ha/314 ac) of the affected areas are considered prominent offshore shoal or "lump" habitats.

There are six Federal projects (including Great Egg Harbor to Townsends Inlet) proposed along various segments of the NJ Atlantic Coast within the Philadelphia District that involve beachfill placement from offshore or inlet sand sources and one other ongoing feasibility study that may propose the use of two offshore sand sources. These combined with the recent past and currently active projects constitute a significantly higher amount of offshore or inlet areas over the existing impacted areas that will be utilized as sand sources. It is estimated that a total of 3,769 hectares (9,314 acres) of marine benthic habitat would be impacted. This includes 763 hectares (1,866 acres) of inlet ebb shoals, 2,675 hectares (6,610 acres) of offshore shoals of lower relief and 204 hectares (818 acres) of prominent offshore shoal or "lump" habitats. The proposed Federal projects result in an 873 % increase in 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 being used over current or recently impacted areas. No offshore shoal areas with lower relief were previously impacted, therefore, the 2,675 hectares of this type of habitat will only be affected with the proposed Federal projects.

The four sand borrow sites proposed for the Great Egg Harbor Inlet to Townsends Inlet project represents nearly 50% of the marine benthic habitat impacted by all of the previously impacted and the proposed (Federal) impacted sites. This is due to the fact of the large study area and the beachfill requirements of Southern Ocean City and Ludlam Island projected over a 50-year period with nourishment. Also, in an effort to avoid prominent shoal areas, which are considered valuable fish and shellfish habitat, areas of lower relief were selected. 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 (no deeper than ten feet from existing or surrounding bathymetry) 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 project with each periodic nourishment cycle. Based on the projected nourishment quantities per cycle, it is estimated that approximately 111 hectares (274 acres) of marine bottom would be impacted with an average deepening of 1.52 m (5 feet) (See Table 6.2.11-2.). 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. An exception to this is the use of Corson Inlet for Strathmere periodic nourishment. Corson Inlet is expected to contain renewable sources of sand available for each nourishment cycle, which requires the same locations within the borrow area to be dredged. However, because this area is highly dynamic, the benthic community is more resilient to periodic disturbance and should recover more rapidly than the offshore sites.

Table 6.2.25-1 Summary Of Recent Past, Active And Proposed Future Projects Within The Philadelphia District Geographic Boundaries In New Jersey (Manasquan Inlet to Cape May Point) that Utilize Offshore or Inlet Sand Sources For Beach Replenishment

Summary Of Recent Past, Active And Proposed Future Projects Within The Philadelphia District Geographic Boundaries In New Jersey (Manasquan Inlet To Cape May Point) That Utilize Sand Sources For Beach Replenishment

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 Specific Commercial and Sportfish Area**	**Area of Wreck Zones, Reefs, and Other Habitat Features**
Recent Past and Active Projects												
Cape May Inlet to Lower Township	USACE/ NJDEP	Federal project with 50-years of periodic nourishment	Ongoing	M-1 (depleted-currently seeking new source)	2.2 – 2.6 km offshore Cape May City	Cape May City and Lower Township	77.7 ha (192.0 ac)			77.7 ha (192.0 ac)		
Avalon/Sea Isle City Beachfill	Avalon and Sea Isle City	State and city project where replenishment is conducted on an "as-needed" basis.	Periodic	Townsends Inlet	Townsends Inlet Ebb Shoal	Avalon and Sea Isle City	29.1* ha (72.0*ac)	29.1* ha (72.0*ac)				
Strathmere and Southern Ocean City	NJDEP	State and city project where replenishment is conducted on an "as-needed" basis.	Periodic	Corson Inlet	Corson Inlet Ebb Shoal	Strathmere/ So. Ocean City	21* ha (52*ac)	21* ha (52*ac)				
Southern Ocean City	NJDEP	State and city project conducted in 1995	One-time activity	OC-3	3.3 – 4.2 km offshore So. Ocean City	Southern Ocean City	49.4 ha (122 ac)			49.4 ha (122 ac)		
Great Egg Harbor Inlet and Peck Beach	USACE/ NJDEP	Federal project with 50-years of periodic nourishment	Ongoing	Great Egg Harbor Inlet	Great Egg Harbor Inlet Ebb Shoal	Northern Ocean City (34th St. to Surf Road)	234.3 ha (579 ac)	234.3 ha (579 ac)				
Brigantine Beachfill	City of Brigantine	Intermittent	Completed 1997/ proposed 2000	Brigantine Inlet	Brigantine Inlet Ebb Shoal	Brigantine	20.2* ha (50* ac)	20.2* ha (50*ac)				

Summary Of Recent Past, Active And Proposed Future Projects Within The Philadelphia District Geographic Boundaries In New Jersey (Manasquan Inlet To Cape May Point) That Utilize Sand Sources For Beach Replenishment												
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 Specific Commercial and Sportfish Area**	**Area of Wreck Zones, Reefs, and Other Habitat Features**
Total Area of Habitat Affected by Recent Past and Active Projects							**431.7 ha (1,067 ac)**	**304.6 ha (753 ac)**		**127.1 ha (314 ac)**		
Proposed Federal Projects												
Lower Cape May Meadows	USACE/ NJDEP	Federal project with 50-years of periodic nourishment	Proposed (PED Phase)	M4	1.3 – 1.6 km offshore Cape May City	Cape May Meadows/ Cape May Point State Park/Cape May Point	65.9 ha (163 ac)		65.9 ha (163 ac) – trough area between finger shoals			
				M5	1.75- 3.2 km offshore Cape May City	Cape May Meadows/ Cape May Point State Park/Cape May Point	71.6 ha (177 ac)			71.6 ha (177 ac) finger shoal and trough		
				P1	1.8 – 2.4 km	Cape May Meadows/ Cape May Point State Park/Cape May Point	81.3 ha (201 ac)			81.3 ha (201 ac) of finger shoal and trough		
Townsends Inlet to Cape May Inlet	USACE/ NJDEP	Federal project with 50-years of periodic nourishment	Proposed (PED Phase)	G	Hereford Inlet Ebb Shoal	Stone Harbor Point/Stone Harbor	67.6 ha (167 ac)	67.6 ha (167 ac)				
				E	Townsends Inlet Ebb Shoal	Avalon/Seven Mile Beach	59.1 ha (146 ac)	59.1 ha (146 ac)				

Summary Of Recent Past, Active And Proposed Future Projects Within The Philadelphia District Geographic Boundaries In New Jersey (Manasquan Inlet To Cape May Point) That Utilize Sand Sources For Beach Replenishment													
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 Specific Commercial and Sportfish Area**	**Area of Wreck Zones, Reefs, and Other Habitat Features**
Great Egg Harbor Inlet to Townsends Inlet	USACE/ NJDEP	Potential for Federal project with 50-years of periodic nourishment pending findings of the study	Proposed (Feasibility Phase)	C1	Corson Inlet Ebb Shoal	Strathmere Periodic Nourishment	79.7 ha (197 ac)	79.7 ha (197 ac)				
				L1	3.2 – 5.1 km offshore Sea Isle City	Sea Isle City	613.9 ha (1,517 ac)		613.9 ha (1,517 ac)			
				L3	3.25 – 6.4 km offshore Whale Beach/Strathmere	Whale Beach/ Strathmere	842.6 ha (2,082 ac)		842.6 ha (2,082 ac)			
				M8	5.5 – 6.9 km offshore So. Ocean City	Southern Ocean City (Peck Beach)	344.8 ha (852 ac)		344.8 ha (852 ac)			
Absecon Island	USACE/ NJDEP	Federal project with 50-years of periodic nourishment	Proposed (PED Phase)	A	Absecon Inlet Ebb Shoal	Longport/ Ventnor/ Margate/ Atlantic City	137 ha (339 ac)	137 ha (339 ac)				
Brigantine Island	USACE/ NJDEP	Federal project with 50-years of periodic nourishment	Proposed (PED Phase)	D	Brigantine Inlet Ebb Shoal	City of Brigantine	151.8 ha (375 ac)	151.8 ha (375 ac)				
Barnegat Inlet to Little Egg Inlet (Long Beach Island)	USACE/ NJDEP	Federal project with 50-years of periodic nourishment	Proposed (PED Phase)	D1	3.6 – 5.5 km offshore Harvey Cedars/ Surf City	Long Beach Island (LBI)	229.5 ha 567 ac		229.5 ha 567 ac			43.9 ha (108.6 ac) portion of 1 wreck zone

Summary Of Recent Past, Active And Proposed Future Projects Within The Philadelphia District Geographic Boundaries In New Jersey (Manasquan Inlet To Cape May Point) That Utilize Sand Sources For Beach Replenishment												
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 Specific Commercial and Sportfish Area**	**Area of Wreck Zones, Reefs, and Other Habitat Features**
				D2	5.5 – 6.9 km offshore Harvey Cedars	LBI	231.5 ha (572 ac)		231.5 ha (572 ac)			
				A	Barnegat Inlet Ebb Shoal	LBI	33.6 ha (83 ac)	33.6 ha (83 ac)				
Manasquan Inlet to Barnegat Inlet	USACE/ NJDEP	Potential for Federal project with 50-years of periodic nourishment pending findings of the study	Proposed (Feasibility Phase)	1	2.7 – 4.4 km offshore Island Beach S.P.	Not determined	346.8 ha (857 ac)		346.8 ha (857 ac)			
				2	2.1 – 3.3 km offshore Mantoloking	Not determined	50.9 ha (126 ac)			50.9 ha (126 ac)		
Total Estimated Area of Offshore Habitat Affected by Proposed Federal Projects							**3,407.6 ha (8,421 ac)**	**529 ha (1,307 ac)**	**2,675 ha (6,610 ac)**	**204 ha (504 ac)**		
Total Estimated Area of Offshore Habitat Affected by Recent Past, Currently Active and Proposed Federal Projects							**3,769 ha (9,314 ac)**	**763 ha (1,886 ac)**	**2,675 ha (6,610 ac)**	**331 ha (818 ac)**		
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	6.7 – 9.9 km offshore Sea Isle City	Not determined	1,486.8 ha (3,674 ac)			Sea Isle Shoal (269 ha) (665 ac) Sea Isle Lump (44.1ha) (109 ac)	Sea Isle Shoal (269 ha) (665 ac) Sea Isle Lump (44.1 ha) (109 ac)	Fish Haven Area (110 ha) (272 ac)

Summary Of Recent Past, Active And Proposed Future Projects Within The Philadelphia District Geographic Boundaries In New Jersey (Manasquan Inlet To Cape May Point) That Utilize Sand Sources For Beach Replenishment

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 Specific Commercial and Sportfish Area**	**Area of Wreck Zones, Reefs, and Other Habitat Features**
				A2	11.7 – 15.2 km offshore Sea Isle City	Not determined	1,885 ha (4,659 ac)		1,431 ha (3,536 ac)	Avalon Shoal (454.5 ha) (1,123 ac)	Inshore Stone Bed (284 ha) (702 ac) Avalon Shoal (454.5 ha) (1,123 ac)	2 wreck zones (267.4 ha) (661 ac)
				G1	5.5 – 8.4 km offshore Brigantine	Not determined	1,045 ha (2,584 ac)		869.7 ha 2,149 ac	Brigantine Shoal (176 ha) (435 ac)	Brigantine Shoal (176 ha) (435 ac)	1 wreck zone (167.5 ha) (414 ac)
				G2	5.5 – 8.9 km offshore Brigantine	Not determined	1,311.2 ha (3,240 ac)		1,159.4 ha (2,865 ac)	Brigantine Shoal (151.7 ha) (375 ac)	Brigantine Shoal (151.7 ha) (375 ac)	
				G3	5.7 – 9.7 km offshore Brigantine Inlet	Not determined	(978.9 ha) (2,419 ac)		(978.9 ha) (2,419 ac)			2 wreck zones (35.6 ha) (88 ac)
				C1	5.5 – 8.4 km offshore Harvey Cedars)	Not determined	1,749.5 ha (4,323 ac)		1,749.5 ha (4,323 ac)			1 wreck zone (93.5 ha) (231 ac)
				F1	10.2 km – 12.8 km offshore Chadwick Beach	Not determined	270.3 ha (668 ac)		270.3 ha (668 ac)			

Summary Of Recent Past, Active And Proposed Future Projects Within The Philadelphia District Geographic Boundaries In New Jersey (Manasquan Inlet To Cape May Point) That Utilize Sand Sources For Beach Replenishment

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 Specific Commercial and Sportfish Area**	**Area of Wreck Zones, Reefs, and Other Habitat Features**
				F2	8.8 km – 11.3 km offshore Manto-loking	Not determined	738.5 ha (1,825 ac)		174.4 ha (431 ac)	Manasquan Ridge (564.1 ha) (1,394 ac)	Manasquan Ridge (564.1 ha) (1,394 ac)	
Total Estimated Area of Offshore Habitat Affected by Proposed Federal Outer Continental Shelf Sand Resources							**9,466.6 ha (23,392 ac)**		**6,633.2 ha (16,391 ac)**	**1,659.4 ha (4,101 ac)**	**1.375.4 ha (3,399 ac)**	**674 ha (1,666 ac)**

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 Specific Commercial and Sportfish Area – 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 is little regional information (within the Philadelphia District) concerning monitoring and impacts of beach replenishment concerning offshore borrow areas. Most of the aforementioned projects have not been constructed and most of the constructed ones were individual permits issued to the State of New Jersey or a local municipality where no benthic or fisheries monitoring was required. Of the Federal beach replenishment projects that have been constructed in the Philadelphia District, only the Great Egg Harbor Inlet and Peck Beach (northern Ocean City) has biological monitoring associated with it. Scott and Kelley (1998) investigated the impacts of dredging to the benthic community within Great Egg Harbor Inlet associated for the northern Ocean City Federal beach replenishment project. Results of the monitoring indicated minor shifts in benthic community composition from a dominance of polychaetes to a dominance of amphipods. However, they found that diversity measures were not significantly lower after dredging, and diversity measures were similar to unimpacted reference stations. In addition, total mean abundance and abundances of major faunal groups were not statistically different from the pre-dredge data. Scott and Kelley (1998) indicated that good juvenile surfclam recruitment occurred in the impacted area, however, size levels were less than other nearby undisturbed sites. The New York District Corps of Engineers has recently completed a comprehensive biological monitoring program (USACE, 2001) for the beach replenishment projects conducted from Manasquan Inlet to Sandy Hook. This monitoring included substantial pre and post-construction data collection for benthic resources, fish populations, and suspended solids. Based on the data collection efforts, it was concluded that borrow area dredging did not result in any significant long-term adverse impacts on the affected benthic and finfish communities, which is consistent with findings of similar projects in other regions. These investigations indicate that these projects do not have significant adverse cumulative impacts on resources of concern. However, since few of the aforementioned projects proposed in the Philadelphia District area have been constructed, the cumulative impacts on benthic resources and fisheries can only be described based on the limited monitoring within the region and/or the effects-based studies from other coastal regions. It should be noted that all of the unconstructed Federal beach replenishment projects in the Philadelphia District listed in Table 6.2.25-1 include monitoring of the benthic community and commercial surfclam densities. Therefore, cumulative effects could be monitored over the whole District program of shore protection projects.

The cumulative impacts on Essential Fish Habitat (EFH) are not considered to be 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 in the Great Egg Harbor Inlet to Townsends Inlet 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 habitats (considered to be valuable fish and shellfish habitat) were avoided through iterative 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 111 hectares 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 surfclams can be avoided by not dredging deep holes, and leaving similar sandy substrate (w/ 3 feet of sand or more) for recruitment.

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 5.5 – 12.8 km (offshore and cover large portions of bottom with a total coverage of 9,467 hectares (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 Specific Commercial and Sportfish Areas. 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).

6.2.25.2 Affected Beaches and Nearshore Habitats

Table 6.2.25-2 provides brief summaries of recent past, currently active, and proposed future Federal beach replenishment projects on impacted beaches and shorelines within the Philadelphia District Corps of Engineers' geographic boundaries along the New Jersey Atlantic Coast (from Manasquan Inlet to Cape May Point). Since 1995, a total of approximately 23.2 kilometers (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 six 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 109 kilometers (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 Southern Ocean City and Ludlam Island represents nearly 14% of the affected beaches and 9.5% of all of the beaches along this entire stretch of coast.

Although nearly 71% of the beaches along the N.J. Coast south of Manasquan Inlet could potentially be impacted by beachfill 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.

Table 6.2.25-2 Shoreline Area Impacts from Recent Past, Currently Active, and Proposed Federal Beach Replenishment Projects Along the New Jersey Atlantic Coastline from Manasquan Inlet to Cape May Point

Recent Past, Currently Active, and Proposed Federal Beach Replenishment Projects Along the New Jersey Atlantic Coastline from Manasquan Inlet to Cape May Point*.

Projects	Action Agency	Quantity Of Sand Filled Or Proposed For Initial Construction	Quantity Of Sand Estimated For Periodic Nourish-Ment (If Applicable)	Periodic Nourishment Cycle (Years)	Date Of Most Recent Fill Place-Ment	Length Of Affected Atlantic Coast Shoreline	% Atlantic Coast Shoreline Affected W/In Philadelphia District Boundaries*
Recent Past and Currently Active Projects							
Cape May Inlet to Lower Township	USACE/NJDEP	1,071,155 m^3 1,400,000 yd^3	275,440 m^3 360,000 yd^3	2	1999	5.21 km 3.24 mi	3.4%
Cape May Section 227 Demonstration Project**	USACE	22,953 m^3 30,000 yd^3			2000	0.35 km 0.22 mi	
Avalon**	Avalon	unknown			1998	0.84 km 0.52 mi	0.5%
Sea Isle City**	Sea Isle City	185,922 m^3 243,000 yd^3			1999	0.52 km 0.32 mi	0.3%
Southern Ocean City**	NJDEP	765,110 m^3 1,000,000 yd^3			1995	4.18 km 2.6 mi	2.7%
Great Egg Harbor Inlet and Peck Beach	USACE/NJDEP	4,743,688 m^3 6,200,000 yd^3	841,622 m^3 1,100,000 yd^3	3	1997	6.89 km 4.28 mi	4.5%
Brigantine**	Brigantine	918,133 m^3 1,200,000 yd^3			1997	1.38 km 0.86 mi	0.9%
Brant Beach**	NJDEP	38,255 m^3 50,000 yd^3			1997	0.98 km 0.61 mi	0.6%
Harvey Cedars**	NJDEP	401,683 m^3 525,000 yd^3			1995	2.86 km 1.78 mi	1.9%
Subtotal of Previous and Currently Active Projects						**23.2 km** **14.4 mi**	**15.1%**
Proposed Federal Projects							
Lower Cape May Meadows	USACE/NJDEP	1,814,843 m^3 2,372,000 yd^3	497,322 m^3 650,000 yd^3	4	NA	3.2 km 1.99 mi	2.1%
Stone Harbor Point	USACE/NJDEP	1,045,141 m^3 1,366,000 yd^3		NA	NA	0.42 km 0.26 mi	0.3%
Avalon/Stone Harbor	USACE/NJDEP	2,380,260 m^3 3,111,000 yd^3	570,773 m^3 746,000 yd^3	3	NA	13.93 km 8.66 mi	9.1%
Ludlam Island	USACE/NJDEP	3,920,112 m^3	1,150,991 m^3	5	NA	10.78 km	7.0%

Recent Past, Currently Active, and Proposed Federal Beach Replenishment Projects Along the New Jersey Atlantic Coastline from Manasquan Inlet to Cape May Point*.							
Projects	**Action Agency**	**Quantity Of Sand Filled Or Proposed For Initial Construction**	**Quantity Of Sand Estimated For Periodic Nourish-Ment (If Applicable)**	**Periodic Nourishment Cycle (Years)**	**Date Of Most Recent Fill Place-Ment**	**Length Of Affected Atlantic Coast Shoreline**	**% Atlantic Coast Shoreline Affected W/In Philadelphia District Boundaries***
		5,123,587 yd^3	1,504,346 yd^3			6.7 mi	
Southern Ocean City	USACE/NJDEP	1,178,271 m^3 1,540,000 yd^3	266,258 m^3 348,000 yd^3	3	NA	4.18 km 2.6 mi	2.7%
Absecon Island	USACE/NJDEP	4,743,688 m^3 6,200,000 yd^3	1,274,675 m^3 1,666,000	3	NA	11.26 km 7 mi	7.3%
Brigantine	USACE/NJDEP	495,792 m^3 648,000 yd^3	238,714 m^3 312,000 yd^3	6	NA	2.83 km 1.76 mi	1.8%
Long Beach Island	USACE/NJDEP	5,661,821 m^3 7,400,000 yd^3	1,453,711 m^3 1,900,000 yd^3	7	NA	27.36 km 17 mi	17.8%
Manasquan Inlet to Barnegat Inlet	USACE/NJDEP	Undetermined	Undetermined	Undeter-mined	NA	22.53 km 14 mi	
Subtotal of Proposed Federal Projects						**96.5 km** **60.0** mi	**62.8%**
Total of All Projects						**108.6 km** **67.5 mi**	**70.7%**

*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.

As is the case with the offshore borrow areas, there are few regional studies addressing long-term biological impacts of replenishing area beaches. A study by 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. Comprehensive biological monitoring of intertidal and nearshore benthos, near shore and surf zone icthyoplankton and surf zone finfish were studied by USACE (2001) for a large beach replenishment project along the northern New Jersey coast. Despite initial short-term declines in abundance, biomass, and taxa richness of the intertidal and nearshore benthic communities, they found that recovery of intertidal benthic assemblage was complete within 2 –6.5 months of the conclusion of filling. USACE (2001) did not find any obvious differences between reference and nourished beaches based on an analysis of surf zone ichthyoplankton abundance, size and species composition. No long-term impacts to surfzone finfish distribution and abundance patterns were evident either.

The initial impacts of project construction in conjunction with the other planned an ongoing beach replenishment activites will be large scale (approximately 71% of the shoreline from Manasquan Inlet to Cape May Point). However, the impacts of these activites on the benthic community are expected to be short-lived (Parr *et al*. 1978; Naqvi and Pullen, 1982; Reilly and Bellis, 1983) and intermittent because not all projects would likely be nourished at the same time. Another consideration is that renourishment may not be directed over entire project areas if portions are found to have stable beach profiles that do not require additional sand. Nevertheless, benthic invertebrates inhabiting nearshore and intertidal zones are directly impacted during beachfill activities, but given the rapid recovery of beach and nearshore fauna, the cumulative adverse effects are not expected to be significantly adverse. Based on work performed by USACE (2001), no significant adverse cumulative effects on surfzone and nearshore finfish distribution and abundance are expected. The sandy intertidal and nearshore habtitats would likely be similar to preconstruction conditions provided that similar grain sizes are utilized. The covering of artificial hard bottoms including groins and outfall pipes may represent a cumulative loss of this habitat for specialized hard-bottom species, however, this loss would not be significant as these areas would become intermittently exposed during erosion/nourishment cycles.

6.2.26 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.

6.2.27 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 7.3 km (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.

6.2.28 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 were adopted for the proposed action for storm damage reduction within the project impact area. The careful selection of flatter areas (away from known prime fish habitats or prominent relict shoals) to obtain sand 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.

6.2.28.1 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 area 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.

6.2.28.2 Fisheries and Essential Fish Habitat

Adverse impacts to the surfclam resource 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 surfclams, and to locate areas within the proposed borrow site where surfclam 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 if and/or where surfclam 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 "Sea Isle Lump") 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 surfclam recruitment. Therefore, the borrow sites, after sand is removed, would be no deeper than ten feet below the existing bathymetry. 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 surfclam recruitment and other benthic species. 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.

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.

6.2.28.3 Rare, Threatened and Endangered Species

The selected plan has the potential to adversely affect state and Federal listed threatened and endangered birds along the beach. In addition, the U.S. Fish and Wildlife Service (USFWS) has identified potential future impacts on the endangered plant, seabeach amaranth. Formal consultation with the U.S. Fish and Wildlife Service is being undertaken to address these issues. A biological assessment is currently being prepared and will be submitted to the USFWS for review and a subsequent biological opinion document. In these documents, measures to mitigate these impacts will be addressed. These measures include identification and monitoring of nests/populations, timing restrictions, protective buffer zones, protective construction practices, and agreements with the State and local municipalities to further protect these resources.

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 (with suction head) is used between June and November, NMFS approved turtle/marine mammal monitors would be present on the dredge and would follow procedures as required in the NMFS Biological Opinion (NMFS, 1996).

6.2.28.4 Recreation

Beachfill operations typically occur within isolated segments, subsequently moving as the work progresses. As each work segment is completed, it can be opened for recreational use. This would allow access for recreation in all areas outside of the segment under construction. Schedules and timing of construction would be coordinated with local municipalities to minimize impacting beach-related recreation.

6.2.28.5 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.

6.2.29 Environmental Monitoring

Environmental monitoring has been designated as 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 surfclam investigations of the sand borrow area (2) monitoring pursuant to Section 7 of the Endangered Species Act for sea turtles during dredging activities, and (3) water quality monitoring.

6.2.29.1 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 unimpacted 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 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 (> 10 ft.), and would document the locations 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 surfclam 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 for 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 surfclam surveys.

6.2.29.2 Surfclam Monitoring

A surfclam survey will be performed during PED (prior to construction) to provide an update on the condition of commercial surfclam stocks prior to construction. This is necessary due to the potential variability of surfclam 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 to allow for a commercial harvest within the borrow site prior to construction.

Benthic macroinvertebrate and commercial surfclam 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 surfclams. Benthic sampling shall be conducted using the same methodology utilized by Scott and Wirth (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 surfclam sampling shall also be conducted using the methodology utilized by Scott and Wirth (2000). Commercial surfclam 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 surfclam survey will be provided to the NJDEP Bureau of Shellfisheries.

6.2.29.3 Finfish Monitoring

Baseline data on finfish populations will be collected during PED on a seasonal basis within the proposed sand borrow sites and nearshore placement sites. This will be done to establish baseline finfish data prior to construction in order to assess if there are any adverse or beneficial impacts on finfish populations within the impacted areas. Finfish collection methods will include trawl surveys and gill nets within the proposed borrow sites and reference sites, and seining along the shoreline areas.

Seasonal data on finfish populations will correspond with periodic nourishment cycles. Sampling will be conducted within the previously impacted areas of the borrow sites and nearshore placement sites. Outside reference areas will also be sampled for comparison. This will be done to establish if there are any short-term or long-term trends concerning finfish populations within the impacted areas.

6.2.29.4 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. The monitoring specifications were provided by NMFS in the Biological Opinion, and are presented in Appendix B. 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 do 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 construction. 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. As part of the survey, previous nesting locations will be identified and located. This would provide the basis for the establishment and identification (e.g., fencing and signing) of protective zones around identified piping plover nests. This survey will also include the identification and location of State listed (endangered) species such as the least tern (*Sterna antillarum*) and black skimmer (*Rynchops niger*).

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

A Biological Assessment was submitted to address formal Section 7 consultation for Federal beach replenishment actions along the New Jersey coast. A Biological Opinion from the USFWS is pending at this time, and will be available prior to project implementation. 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 and Wildlife.

6.2.29.5 Sediment and Water Quality Monitoring

Baseline sediment and water quality chemical testing will be performed using procedures as outlined in NJDEP. 1997c. "The Management and Regulation of Dredging Activities and Dredged Material in New Jersey's Tidal Waters". Sediments for chemical testing will be sampled concurrently with the collection of the geotechnical vibrocores within the proposed sand borrow sites. Bulk sediment analysis and elutriate analysis will be performed on sediments. Representative background water samples in the sand borrow sites and surf zones will also be analyzed.

Water quality monitoring will include monitoring of dissolved oxygen (DO) in the borrow site before, during and after dredging to determine if local hydrodynamics are adversely affected in the borrow site causing anoxic conditions near the bottom. DO levels will be monitored to determine if corrective measures in dredging technique are necessary. Also, beach water quality would be periodically monitored during beachfill operations to monitor for bacteria levels and other pollutants. This monitoring would be consistent with State of New Jersey methods for monitoring beach water quality.

6.2.30 Environmental Statutes and Requirements

Preparation of the Environmental Impact Statement (EIS) 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, and Section 401 Water Quality Certification has been received from NJDEP provided that several conditions are met. A Section 404(b)(1) evaluation has been prepared, and is included in Section 11.0 of this report. 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 report and supplemental planning aid letter was obtained and is provided in Appendix A. A Section 2(b) FWCA report was received from the U.S. Fish and Wildlife Service, and is presented with District responses in Appendix A – Comments and Responses. A Statement of Conformity is presented in Section 10.0 concluding that the proposed project would be in compliance with Section 176(c)(1) of the Clean Air Act Amendments of 1990. There is one unit identified within the project impact area that is a part of the Coastal Barrier Resources System under the Coastal Barrier Resources Act (CBRA). The purpose of the CBRA is to protect undeveloped barrier islands and to restrict future Federal expenditures and financial assistance, which encourage development of coastal barriers. This unit (NJ-08P) is located in the Corson's Inlet area encompassing the Corson Inlet State Park and Strathmere Natural Area. The proposed action is exempt for this location because this unit has been designated as an "Otherwise Protected Unit" (P). Congress determined that these areas (P) should not be included as part of the System, but would be ineligible for Federal flood insurance after November 16, 1991.

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 permit approvals. Table 6.2.30-1 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 6.2.30-1 Compliance With Environmental Quality Protection Statutes and Other Environmental Review Requirements

Federal Statutes	Compliance W/Proposed Plan
Archeological - Resources Protection Act of 1979, as amended	Full
Clean Air Act, as amended	Full
Clean Water Act of 1977	Full
Coastal Barrier Resources Act	Full
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	Full
National Environmental Policy Act, as amended	Full
Rivers and Harbors Act	Full
Watershed Protection and Flood Prevention Act	N/A
Wild and Scenic River Act	N/A
Executive Orders, Memorandums, etc.	
EO 11988, Floodplain Management	Full
EO 11990, Protection of Wetlands	Full
EO12114, Environmental Effects of Major Federal Actions	Full
EO 12989, Environmental Justice in Minority Populations and Low-Income Populations	Full
County Land Use Plan	Full

Full Compliance - Requirements of the statute, EO, or other environmental requirements are met for the current stage of review.
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.

6.3 Project Cost Estimate

6.3.1 Initial Construction Costs

<u>South End Ocean City</u>

The estimated initial construction cost for the selected plan for South End Ocean City is $12,742,000 (Oct 2000 price level) which includes real estate acquisition costs (including administrative costs), planning, engineering, and design (P,E,&D), construction management (S&A), and associated contingencies.

Table 6.3.1-1 Initial Construction Costs Summary-South End Ocean City, NJ (Oct 2000 price level)

Description of Item	Quantity	Unit	Unit Price	Estimated Amount	Contingency	Total Cost
Lands and Damages						
Required Easements	1	Job	LS	$93,550	$14,033	$107,583
Total Lands and Damages				**$93,550**	**$14,033**	**$107,583**
Beach Construction						
Mobilization, Demobilization, and Preparatory Work	1	Job	LS	$582,518	$69,902	$652,420
Beachfill	1,217,900	m^3	$6.57	$8,001,603	$1,200,240	$9,201,843
Sand Fence Parallel to Dune	4,092	m	$14.04	$57,452	$11,490	$68,942
Sand Fence for Dune Crossovers	2,350	m	$14.04	$32,994	$6,559	$39,593
Dune Crossovers	22	Ea.	$3,788	$83,336	$16,667	$100,003
Dune Grass	79,624	m^2	$6.56	$522,333	$104,467	$626,800
Total Beach Construction				**$9,280,236**	**$1,409,366**	**$10,689,602**
Planning, Engineering and Design (P,E,&D) and Construction Management (S&A)						
Planning, Engineering and Design (P,E&D)	1	Job	LS	$941,500	$141,225	$1,082,725
Construction Management (S&A)	1	Job	LS	$749,978	$112,497	$862,475
Total P,E,&D and S&A				$1,691,478	$253,722	$1,945,200
Total Initial Construction Cost				**$11,065,264**	**$1,677,120**	**$12,742,384**
Rounded				**$11,065,000**	**$1,677,000**	**$12,742,000**

Ludlam Island

The estimated initial construction cost for the selected plan for Ludlam Island is $30,419,000 (Oct 2000 price level) which includes real estate acquisition costs (including administrative costs), planning, engineering, and design (P,E,&D), construction management (S&A), and associated contingencies.

Table 6.3.1-2 Initial Construction Costs Summary-Ludlam Island, NJ
(Oct 2000 price level)

Description of Item	Quantity	Unit	Unit Price	Estimated Amount	Contingency	Total Cost
Lands and Damages						
Required Easements	1	Job	LS	$159,150	$23,873	$183,023
Surveys Appraisal & Admin	1	Job	LS	$38,751	$5,813	$44,564
Total Lands and Damages				$197,901	$29,685	$227,586
Relocations						
Mobilization, Demobilization, and Preparatory Work	1	Job	LS	$7,971	$957	$8,928
Timber Pile Supports	22	Ea.	$2,186	$48,092	$7,214	$55,306
300mm Dia. Ductile Iron Pipe	92	M	$228.36	$21,009	$3,151	$24,160
Total Relocations				$77,072	$11,322	$88,394
Beach Construction						
Mobilization, Demobilization, and Preparatory Work	1	Job	LS	$1,165,777	$139,893	$1,305,670
Beachfill (Cells LI1-LI2A)	665,500	m^3	$3.65	$2,429,075	$364,361	$2,793,436
Beachfill (Cell LI3)	1,437,600	m^3	$3.91	$5,621,016	$843,152	$6,464,168
Beachfill (Cells LI4-LI6B)	1,808,000	m^3	$6.16	$11,137,280	$1,670,592	$12,807,872
Beach Construction Subtotal	3,911,100	m^3		$19,187,371	$2,878,106	$22,065,477
Sand Fence Parallel to Dune	10,797	m	$14.04	$151,590	$30,318	$181,908
Sand Fence for Dune Crossovers	12,069	m	$14.04	$169,449	$33,890	$203,339
Dune Crossovers	113	Ea.	$3,779	$427,027	$85,405	$512,342
Dune Grass	282,131	m^2	$6.56	$1,850,779	$370,156	$2,220,935
Total Beach Construction				$22,951,993	$3,537,768	$26,489,761
Planning, Engineering and Design (P,E,&D) and Construction Management (S&A)						
Planning, Engineering and Design (P,E&D)	1	Job	LS	$1,397,000	$209,550	$1,606,550
Construction Management (S&A)	1	Job	LS	$1,745,181	$261, 807	$2,007,188
Subtotal P, E,&D and S&A				$3,142,181	$471,357	$3,613,508
Total Initial Construction Cost				$26,369,347	$4,050,132	$30,419,479
Rounded				$26,369,000	$4,050,000	$30,419,000

6.3.1.1 Real Estate

The project will be constructed on existing beachfront owned by private and commercial owners, and public properties owned by the towns of City of Ocean City, Township of Upper (Strathmere), City of Sea Isle City, New Jersey Department of Environmental Protection, and

United States Coast Guard Finance Center Water & Sewer. Construction areas would exclude any existing structures.

In Ocean City a total of approximately 18 privately owned parcels with 17 ownerships, no commercial parcels, and 123 parcels owned by Ocean City are indicated to be impacted by the proposed project. The required temporary staging/access areas are publicly owned, as are perpetual access areas.

For Ludlam Island a total of approximately 783 publicly owned parcels with 4 ownerships, 105 privately owned parcels with 88 ownerships, and 12 commercial parcels with 3 ownerships are impacted by the project. The required temporary staging/access areas, with one exception, are publicly owned, as are perpetual access areas. The exception impacts one privately owned parcel, which is also part of the perpetual restrictive dune/beach nourishment easement.

Submerged lands below the Mean High Water level of the Atlantic Ocean are owned by the State of New Jersey and managed by the New Jersey Department of Environmental Protection (NJDEP) Bureau of Tidelands Management.

For both Ocean City and Ludlam Island, no Temporary Work Area Easement (TWAE), except for staging, will be required during construction, since the work will be confined to the seaward side of the dune and equipment will be such as to work over the dune.

There are two (2) outfall pipes located in Sea Isle City, one at 82nd Street, the other at 86th Street. As a result of this project, these pipes will need to be extended approximately 46 meters (150 feet) to 61 meters (200 feet). According to the records of the Tax Assessor's Office of Sea Isle City, all lands East of the Easterly Street ends of 82nd and 86th Streets belong to Sea Isle City. In addition, the City of Sea Isle City has owned and maintained these outfall piles for over fifty (50) years. Though no land records are available to confirm this, Sea Isle City has stated it will provide letters to certify their ownership. If upon review these letters prove satisfactory to certify ownership, a Preliminary Attorney's Opinion of Compensability will be prepared to determine the compensable interest in the relocation of these outfall pipes. These relocations are included in the cost of this project and in the real estate cost estimate. A final Attorney's Opinion will be completed prior to Project Cooperation Agreement execution.

Real Estate related costs were estimated to be $108,000 for Ocean City and $316,000 for Ludlam Island. More detailed information can be found in Appendix F of this report.

6.3.1.1.1 Public Access

Public access and adequate parking must be assured by the non-Federal sponsor as a prerequisite to the project. There are no private-use shores in the project area and adeqauate beach access and parking exist for the proposed project.

In Ocean City the entire oceanfront is open to the public, resident and non-resident alike. Beach access is provided at all street ends, which is approximately every 550 feet. Daily and weekly beach tags are available all season on the beach. Weekly tags are also available at City Hall, as well as seasonal passes, all year. On street parking is available within the first two shorefront blocks with no time limits or with long-term meters. There are municipal lots at 34th and 59th Streets.

For Ludlam Island, the entire oceanfront of Sea Isle City and Upper Township is open to the public, resident and non-resident alike. Beach access is provided at all street ends. In Sea Isle City, the length between access points is approximately 350 feet; Strathemere approximately 325 feet; and the Whale Beach area about every 300 feet.

In Sea Isle City, daily, weekly, and seasonal beach tags are available at the Beach Tag Office and on the beach. Beach tags are not required at any time in Upper Township. Two municipal parking lots are available in Sea Isle City, one at Townsends Inlet Waterfront Park accommodating approximately 20 cars, and another at 42nd Place accommodating approximately 1,000 cars. Parking is also available on both sides of Landis Avenue, which parallels the ocean.

While there are no public parking lots in Upper Township, parking to accommodate approximately 15 cars on each side of all the side streets in Strathmere leading to the beach is available. Parking is also available on both sides of Commonwealth Avenue (named "Landis Avenue" in Sea Isle City), which parallels the ocean and runs through the entire island, notably the Whale Beach area.

6.3.2 Periodic Nourishment Costs.

South End Ocean City

Periodic nourishment is expected to occur at 3 year intervals subsequent to the completion of initial construction (year 0) of the project.

Table 6.3.2-1 Period Nourishment Costs Summary-South End Ocean City, NJ
(Oct 2000 price level)

Years 3,6,9,12,15,18,21,27,30,33,36,39,42,45,48

Description of 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	$320,321	$38,439	$358,760
Beachfill	305,900	m^3	$7.04	$2,153,536	$323,030	$2,476,566
Total Beach Construction				$2,473,857	$361,469	$2,835,326
Planning, Engineering and Design (P,E,&D) and Construction Management (S&A)						
Planning, Engineering and Design (P,E&D)	1	Job	LS	$530,500	$79,575	$610,075
Construction Management (S&A)	1	Job	LS	$236,017	$35,403	$271,420
Total P,E,&D and S&A				**$766,517**	**$114,978**	**$881,495**
Total Initial Construction Cost				**$3,240,374**	**$476,446**	**$3,716,820**
Rounded				**$3,240,000**	**$476,000**	**$3,716,000**

Year 24 – Major Replacement

Description of 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	$320,321	$38,439	$358,760
Beachfill	381,900	m^3	$6.97	$2,661,843	$399,276	$3,061,119
Sand Fence Parallel to Dune	4,092	m	$14.04	$57,452	$11,490	$68,942
Sand Fence for Dune Crossovers	2,350	m	$14.04	$32,994	$6,599	$39,593
Dune Crossovers	22	Ea.	$3,788	$83,336	$16,667	$100,003
Dune Grass	79,624	m^2	$6.56	$522,333	$104,467	$626,800
Total Beach Construction				**$3,678,279**	**$576,938**	**$4,,255,217**
Planning, Engineering and Design (P,E,&D) and Construction Management (S&A)						
Planning, Engineering and Design (P,E&D)	1	Job	LS	$660,500	$99,075	$759,575
Construction Management (S&A)	1	Job	LS	$334,677	$50,202	$384,879
Total P,E,&D and S&A				$995,177	$149,277	$1,144,454
Total Initial Construction Cost				**$4,673,456**	**$726,215**	**$5,339,671**
Rounded				**$4,673,000**	**$726,000**	**$5,339,000**

Ludlam Island

Periodic nourishment is expected to occur at 5 year intervals subsequent to the completion of initial construction (year 0) of the project.

Table 6.3.2-2 Period Nourishment Costs Summary-Ludlam Island, NJ
(Oct 2000 price level)

Years 5,10,15,20,30,35,40,45,50

Description of 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	$611,765	$73,412	$685,177
Beachfill (Cells LI1-LI2A)	235,000	m^3	$3.90	$916,500	$137,475	$1,053,975
Beachfill (Cell LI3)	440,600	m^3	$4.05	$1,784,430	$267,665	$2,052,095
Beachfill (Cell LI4)	137,800	m^3	$5.15	$709,670	$106,451	$816,121
Beachfill (Cells LI4N-LI6B)	570,000	m^3	$4.11	$2,342,700	$351,405	$2,694,105
Total Beach Construction	1,383,400	m^3		$6,365,065	$936,407	$7,301,472
Planning, Engineering and Design (P,E,&D) and Construction Management (S&A)						
Planning, Engineering and Design (P,E&D)	1	Job	LS	$802,000	$120,300	$922,300
Construction Management (S&A)	1	Job	LS	$514,726	$77,209	$591,935
Total P,E,&D and S&A				**$1,316,726**	**$197,509**	**$1,514,235**
Total Initial Construction Cost				$7,681,791	$1,133,916	$8,815,707
Rounded				$7,682,000	$1,134,000	$8,816,000

Year 25 – Major Replacement
(Oct 2000 price level)

Description of 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	$611,765	$73,412	$685,177
Beachfill (Cells LI1-LI2A)	264,000	m^3	$3.87	$1,021,680	$153,252	$1,174,932
Beachfill (Cell LI3)	499,600	m^3	$4.04	$2,018,384	$302,758	$2,321.142
Beachfill (Cell LI4)	164,800	m^3	$5.05	$832,240	$124,836	$957,076
Beachfill (Cells LI4N-LI6B)	672,000	m^3	$4.08	$2,741,760	$411,264	$3,153,024
Beach Construction Subtotal	1,600,400			$6,614,064	$992,110	$7,606,174
Sand Fence Parallel to Dune	10,797	m	$14.04	$151,590	$30,318	$181,908
Sand Fence for Dune Crossovers	12,069	m	$14.04	$169,449	$33,890	$203,339
Dune Crossovers	113	Ea.	$3,789	$428,157	$85,631	$513,788
Dune Grass	282,131	m^2	$6.56	$1,850,779	$370,156	$2,220,935
Total Beach Construction				$9,825,804	$1,58516	$11,411,320
Planning, Engineering and Design (P,E,&D) and Construction Management (S&A)						
Planning, Engineering and Design (P,E&D)	1	Job	LS	$937,000	$140,550	$1,077,550
Construction Management (S&A)	1	Job	LS	$794,003	$119,101	$913,103
Total P,E,&D and S&A				**$1,731,003**	**$259,651**	**$1,990,653**
Total Initial Construction Cost				**$11,556,807**	**$1,845,167**	**$13,401,974**
Rounded				**$11,557,000**	**$1,845,000**	**$13,402,000**

6.3.3 Construction Management (S&A)

Costs for construction management include supervision and administration activities in overseeing project construction efforts.

6.3.4 Planning, Engineering, and Design (P,E,&D)

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

6.3.4.1 Project Monitoring (as part of Engineering and Design).

A beach fill project has a specific longevity and must undergo periodic inspection, maintenance and periodic renourishment in order to preserve project functionality over the designed lifetime. 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 monitoring programs for Ocean City and Ludlam Island were developed in accordance with EM 1110-2-1004, ER 1110-2-1407, CETN-II-26 and CETN II-35. The following items are included in the proposed monitoring program: beach profile surveys, inlet hydrographic and borrow area surveys, sediment sampling and aerial photography. Laboratory and data analysis will be conducted regularly using the field data collected in the program. The proposed monitoring program will begin at the initiation of pre-construction efforts and continue throughout the project life. A more detailed description of the monitoring program is provided in the Engineering Technical Appendix, Section 2

Specifics of monitoring include:

6.3.4.1.1 Project Performance Monitoring

Beach Profiles

This will be used to quantify loss rates from project cells in order to define required periodic nourishment quantities, determine the accuracy of predicted loss rates, and document cross-shore and longshore transport patterns of the beachfill. Quarterly onshore/offshore sled (or similar accuracy) surveys will be conducted for the first year following construction with semi-annual onshore/offshore sled surveys will be performed thereafter. A total of 17 profile lines from 36th Street to and including Corson Inlet for South End Ocean City and a total of 35 profile lines for Ludlam Island will be monitored.

Inlet Hydrographic Surveys

This monitoring will be used document changes in Corson Inlet channel and shoal complex. Comprehensive hydrographic survey of Corson Inlet channel and ebb shoal complex will be performed every 2 years. Corson Inlet will be monitor in more detail following initial dredging to the first nourishment (semi-annual for first 2 years, annually thereafter).

Aerial Photography

This task will document changes along the project area shoreline as a supplement to beach profile data with quarterly flights being conducted.

Tidal Data

Since Atlantic City NOS gage is available; no additional gage will be placed.

Sediment Sampling

This will be used to identify sediment resorting and fill behavior; identify cross-shore and longshore grain size distribution changes; evaluate fill factor method. Samples will be collected post-fill and then semi-annually (winter and summer, coordinated with beach profiles) and will be taken at dune, berm, high tide, mid tide, low tide lines, then 6 ft intervals to 30 ft depth (total of 10 samples per profile line). For South End Ocean City, this will occur every 3 years along 8 additional survey lines only (4 lines already included in the monitoring plan for existing Federal project at Ocean City). For Ludlam Island, sampling will occur every 5 years along 12 profile lines.

6.3.4.1.2 Environmental Monitoring

Environmental monitoring has been designated as an integral component of the Engineering and Design (E&D) for initial construction and for each nourishment cycle under the proposed plan. Environmental monitoring provides a basis to determine and document whether or not the project is having 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:

Sediment and Water Quality Testing

Baseline sediment and water quality chemical testing will be performed prior to project construction using procedures as outlined in NJDEP 1997, “The Management and Regulation of Dredging Activities and Dredged Material in New Jersey’s Tidal Waters”. Sediments for chemical testing will be sampled concurrently with the collection of the geotechnical vibrocores within the proposed sand borrow sites. Bulk sediment analysis and elutriate analysis will be performed on sediments. Representative background water samples in the sand borrow sites and surf zones will also be analyzed.

Water quality monitoring will be conducted periodically during construction to measure the degree and duration of water quality impacts of the discharges during construction. Water quality samples will be obtained from within the discharge plume. Samples will also be taken outside of the influence of the plume to establish background conditions at that time. Representative samples will be obtained approximately every two weeks during the duration of the dredging. Water quality samples will be tested for the concentrations of priority pollutants, turbidity, and total suspended solids. If construction occurs within the summer bathing season, samples will be tested for human pathogenic bacteria indicators in accordance with Cape May County Health Department testing procedures. Results of bacteria counts will be coordinated with the Cape May County Health Department.

Baseline Fish Monitoring

Baseline data on finfish populations will be collected prior to project construction on a seasonal basis within the proposed sand borrow sites and nearshore placement sites. Finfish collection methods will include trawl surveys and gill nets within the proposed borrow sites and reference sites, and seining along the shoreline areas.

Seasonal data on finfish populations will correspond with each periodic nourishment cycle. Sampling will be conducted within the previously impacted areas of the borrow sites and nearshore placement sites. Outside reference areas will also be sampled for comparison. This will be done to establish if there are any short-term or long-term trends of finfish populations within the impacted areas.

Benthic/Surfclam Monitoring

A surfclam survey will be performed prior to construction to provide an update on the condition of commercial surfclam stocks within designated borrow sources. This is necessary due to the potential variability of surfclam 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 to allow for a commercial harvest within the borrow site prior to construction.

Benthic macroinvertebrate and commercial surfclam 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. Benthic sampling shall be conducted using the same methodology utilized by Scott and Bruce (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 surfclam sampling shall also be conducted using the methodology utilized by Scott and Bruce (2000). Commercial surfclam 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 surfclam survey will be provided to the NJDEP Bureau of Shellfisheries

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 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. As part of the survey, previous nesting locations will be identified and located. This would provide the basis for the establishment and identification (e.g., fencing and signing) of protective zones around identified piping plover nests. This survey will also include the identification and location of State listed (endangered) species such as the least tern (*Sterna antillarum*) and black skimmer (*Rynchops niger*).

As recommended by the USFWS, a survey will be performed to identify and locate the Federally listed (threatened) plant, seabeach amaranth (*Amaranthus pumilus*) within the project impact area.

Currently, a Biological Assessment is being produced 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.

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 pursuant to the Biological Opinion (National Marine Fisheries Service, 1996) if a hopper dredge is used from June 15th to November 15th. This monitoring is required 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 and other State listed beach nesters such as the least tern and black skimmer, monitoring will be conducted 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 insure that adequate protection is provided. This monitoring will continue throughout the duration of the construction during the nesting season. 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 nourishment. If seabeach amaranth populations are located within the project area prior to construction, monitoring shall be conducted to insure 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 the offshore sand borrow areas.

<u>Total Monitoring Costs</u>

For South End Ocean City, monitoring costs related to initial construction total $508,000 (Oct 00 price level) with average annual cost over the 50-year period of analysis equal to$166,000. For Ludlam Island, monitoring costs related to initial construction total $985,000 (Oct 00 price level) with average annual cost over the 50-period of analysis equal to$270,000.

6.3.5 Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R).

The annual operation and maintenance of the project is the responsibility of the Non-Federal sponsor and includes maintaining of the dunes (including sand fence and dune grass), pedestrian accesses, and beach shaping. The beach will be maintained by shaping the sand with heavy equipment to help ensure the presence of the design template. Dune walkovers for beach access, dune grass, and sand fence will be the responsibility of the Non-Federal sponsor. Based on experience with similar projects and typical costs, average annual costs were estimated at $32,000 for South End Ocean City and $96,000 for Ludlam Island.

6.3.6 Construction and Funding Schedule.

The duration of initial construction for the project was estimated at 7 months for South End Ocean City and 19 months for Ludlam Island initial construction of the, including project mobilization and demobilization. The Project Management Plan (PMP), which is a separate volume of this report, will describe the activities leading to, through, and after construction of the selected plan.

6.3.7 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. The preconstruction engineering and design (PED) phase will begin approximately one year prior to the start of construction and was added included in the calculations. Annualized costs were calculated for to be $18,000 for South End Ocean City and $108,000 for Ludlam Island.

6.3.8 Summary of Total Estimated Costs

Table 6.3.8-1 Estimated Costs - South End Ocean City

Discount Rate	*6.375%*
Period of Economic Analysis	*50 years*
Price Level	*October 2000*
Base year	*2005*
Initial Construction Cost (includes $508,000 of monitoring costs)	$12,742,000
Interest During Construction	$271,000
Total Periodic Nourishment (50 years)	$63,824,000

(includes $7,216,000 of monitoring costs)	
Average Annual Costs (AAC)	
Initial Construction (includes of $33,000 of monitoring)	$849,000
Periodic Nourishment (includes $134,000 of monitoring)	$1,231,000
Subtotal Average Annual Cost (includes $166,000 of monitoring)	$2,080,000
Interest During Construction	$18,000
Operation and Maintenance	$32,000
Total Average Annual Cost	**$2,130,000**

Table 6.3.8-2 Estimated Costs – Ludlam Island

Discount Rate	*6.375%*
Period of Economic Analysis	*50 years*
Price Level	*October 2000*
Base year	*2005*
Initial Construction Cost (includes $985,000 of monitoring costs)	$30,419,000
Interest During Construction	$1,614,000
Total Periodic Nourishment (50 years) (includes $11,444,000 of monitoring costs)	$96,960,000
Average Annual Costs (AAC)	
Initial Construction (includes $64,000 of monitoring)	$2,028,000
Periodic Nourishment (includes $207,000 of monitoring)	$1,709,000
Subtotal Average Annual Cost (includes $270,000of monitoring)	$3,737,000
Interest During Construction	$108,000
Operation and Maintenance	$96,000
Total Average Annual Cost	**$3,941,000**

6.4 Project Benefits

6.4.1 National Economic Development (NED) Benefits

The selected plan provides storm damage reduction to South End Ocean City and Ludlam Island. Benefits were attributed to reduced damages to structures, infrastructure, and private land. Compared to without-project conditions detailed in the section 4 of this report, damages would be reduced by 53% in South End Ocean City and 55% along Ludlam Island. Average annual damage reduction total $2,821,000 for South End Ocean City and $3,082,000 Ludlam Island (not including local costs foregone).

6.4.2 Local Costs Foregone

As detailed in sections 1.5.3, 1.6, and 4.2.5 of this report, the State of New Jersey and local communities have been active in providing storm damage protection measures. Average annual local costs foregone for South End Ocean City were calculated to be $455,000 and $1,303,000 for Ludlam Island (updated to October 2000 price level and a discount rate of 6.375%.

6.4.3 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.

A contingent valuation method survey was completed by the Rutgers State University for the New Jersey Department of Environmental Protection and the U.S. Army Corps of Engineers to determine willingness to pay for the existing beach and an "enhanced" beach. This was accomplished by sampling in the beach communities of Atlantic City, Ventor, 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.

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 was the beach.

The survey also used a density measure developed in cooperation with the Corps to determine if crowding was a problem. It was found that over 60% of the time there was at least several yards of space between beach towels or blankets, and only 7% of the time it was very crowded (only 2 feet between towels). Further, it was determined that crowding was not considered a very important issue 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 then 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 is $4.22.

The beachgoers were asked how much more they were willing to pay if the beach were widened. While the majority 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 increase of $0.47 for all beachgoers. For the purpose of this study this value was indexed to an October 1999 price level, for a willingness to pay of $0.53.

Benefits were not computed to accrue 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. Recreation benefits are calculated assuming an average of 100 square feet (of the 2,014,000 square feet of beach space from the mean high water line) is utilized per beach user and that only 80% of space would be utilized for recreation, or 16,100 daily beach users. The daily beach user number was then multiplied by the estimated number of days in the season. It was estimated that the recreational season would consist of 97 days reflecting a 30% loss of days due to inclement weather (i.e., 1,562,000 annual person estimated use). Finally, this number was then multiplied by the difference between the average without project value and the average with project value of $0.53 (at October 1999 price level). No benefits are claimed for increased use of the beach. All of the benefits are based on the increased value of the beach to the current beach users. For South End Ocean City, average annual recreation benefits amount to $854,000. For Ludlam Island, average annual recreation benefits amount to $1,631,000.

6.4.4 Benefits during Construction.

Benefits during construction are calculated because portions of the project will be completed before the project is completed in its entirety. These completed portions will provide storm damage reduction benefits.

For South End Ocean City, the project will be constructed over seven months, which includes an additional month before and after construction for mobilization and demobilization. Portions of the beach will be nourished early in the construction phase and will provide storm damage reduction benefits. This equals $41,000 on an average annual basis.

For Ludlam Island, the project will be constructed over 18 months, which includes an additional month before and after construction for mobilization and demobilization. Portions of the beach will be nourished early in the construction phase and will provide storm damage reduction benefits. This equals $143,000 on an average annual basis.

6.4.5 Detour

The project at Ludlam Island would prevent the $38,000 in detour costs discussed in section 4.2.4.3 of this report.

6.4.6 Unquantified Benefits

Due to the current shallow draft conditions at Corson Inlet, it is estimated that between 12-24 accidents occur along the oceanside with at least another 25 or more accidents occurring closer to the bayside. In addition, the Coast Guard estimates approximately 5-10 risk of life calls per year while many groundings go unreported as boaters simply wait for the tide level to rise Since the project will be using Corson Inlet as a sand borrow source, a reduction of these incidents should occur.

6.4.7 Benefit-Cost Summary

Table 6.4.7-1 Benefit-Cost Summary for the Selected Plan – South End Ocean City

Discount Rate	*6.375%*
Period of Analysis	*50 years*
Price Level	*October 2000*
Base Year	*2005*
Average Annual Benefits	
Storm Damage Reduction	$2,821,000
Local Costs Foregone	$455,000
Recreation	$854,000
Benefits During Construction	$41,000
Total Average Annual Benefits	$4,171,000
Average Annual Costs	
Initial Construction (includes of $33,000 of monitoring)	$849,000
Periodic Nourishment (includes $134,000 of monitoring)	$1,231,000
Subtotal Average Annual Cost (includes $166,000 of monitoring)	$2,080,000
Interest During Construction	$18,000
Operation and Maintenance	$32,000
Total Average Annual Cost	**$2,130,000**
Net Benefits	**$2,041,000**
Benefit to Cost Ratio	**2.0**

Table 6.4.7-2 Benefit-Cost Summary for the Selected Plan – Ludlam Island

Discount Rate	*6.375%*
Period of Analysis	*50 years*
Price Level	*October 2000*
Base Year	*2005*
Average Annual Benefits	
Storm Damage Reduction	$3,082,000
Local Costs Foregone	$1,303,000
Recreation	$1,631,000
Benefits During Construction	$143,000
Detour	$38,000
Total Average Annual Benefits	**$6,197,000**
Average Annual Costs	
Initial Construction (includes $64,000 of monitoring)	$2,028,000
Periodic Nourishment (includes $207,000 of monitoring)	$1,709,000
Subtotal Average Annual Cost (includes $270,000of monitoring)	$3,737,000
Interest During Construction	$108,000
Operation and Maintenance	$96,000
Total Average Annual Cost	**$3,941,000**
Net Benefits	**$2,256,000**
Benefit to Cost Ratio	**1.6**

6.4.7.1 BCR Sensitivity Analysis

As the benefit category "local costs foregone" makes up 21% of the total benefits, a sensitivity analysis was performed to determine the effect of different assumptions on this benefit category. These scenarios are as follows:

Scenario A

This scenario, first documented in Section 4.2.6 of this report, is the one applied to the selected plan shown in Table 6.4.7-2 above. Once again, the table detailing the assumptions is as follows:

Cell	(1) Historical Storm Damage Fills[28] (all 1984$ unless noted)	(2) Plans[29] (current $)	(3) Estimate of beachfill needed due to long-term erosion[30]	(4) Estimate of major nourishment due to storm events[31]	Local Costs Determination Calculation
LI1 (Seaview to Whittier)	$436,809	Before base year (by NJDEP)			Based on column 1 at years 2006, 2026, and 2046.
LI2 (Whittier to Sherman)	$358, 221	Same as previous			Same as previous
LI2A (Sherman to Hamilton)	$716,909	Same as previous			Same as previous
LI3 (Hamilton to 13th Street)	$988,061	$1,984,590	$542,808		Based on column 2 at 2006, column 1 at years 2026 and 2046, and column 3 every 5 years starting at year 2010.
LI4 (13th to 29th)		$2,767,764		$1,400,000	Based on column 2 at 2005 and column 4 at years 2026 and 2046.
LI4N (29th to JFK (41st))		$324,000		$1,430,000	Based on column 2 at 2005 and column 4 at years 2026 and 2046.
LI5 (41st to 52nd)	$475,198	$1,270,500			Based on column 2 at 2005, then add column 1 at 2026 and 2046.
LI4S (52nd to 57th)	$499,476	$278,250			Same as previous
LI5B (57th to 75th)	$1,667,144				Based on column 1 at year 2006 then 2026, and 2046.
LI6 (75th to 88th)	$1,010,683				Same as previous
LI6B (88th to 93rd)	$33,397 (1985) $480,940 (1987)				Same as previous

Scenario B

[28] Based on information contained in Table 1.5.3.3-1 and 1.5.3.2-1 of feasibility report.

[29] Based on information provided by Sea Isle City.

[30] Based on sand volumes needed to offset the effects long-tern erosion rate of 3 feet per year

[31] Based on quantities calculated by CENAP.

This scenario assumes that the storm event shown in column 1 in the table occurs prior to the base year (say 2004), rather than in 2006. Therefore, this event would not be included in the local costs foregone. Local costs foreone for this scenario would total $895,000.

Cell	(1) Historical Storm Damage Fills[32] (all 1984$ unless noted)	(2) Plans[33] (current $)	(3) Estimate of beachfill needed due to long-term erosion[34]	(4) Estimate of major nourishment due to storm events[35]	Local Costs Determination Calculation
LI1 (Seaview to Whittier)	$436,809	Before base year (by NJDEP)			Based on column 1 at years, 2024 and 2044
LI2 (Whittier to Sherman)	$358, 221	Same as previous			Same as previous
LI2A (Sherman to Hamilton)	$716,909	Same as previous			Same as previous
LI3 (Hamilton to 13th Street)	$988,061	$1,984,590	$542,808		Based on column 2 at 2005, column 1 at years 2024and 2044 and column 3 every 5 years starting at year 2010 unless following storm response.
LI4 (13th to 29th)		$2,767,764		$1,400,000	Based on column 2 at 2005 and column 4 at years 2024 and 2044.
LI4N (29th to JFK (41st))		$324,000		$1,430,000	Based on column 2 at 2005 and column 4 at years 2024 and 2044.
LI5 (41st to 52nd)	$475,198	$1,270,500			Based on column 2 at 2005, then add column 1 at 2024 and 2044.
LI4S (52nd to 57th)	$499,476	$278,250			Same as previous
LI5B (57th to 75th)	$1,667,144				Based on column 1 at year 2024, and 2044.
LI6 (75th to 88th)	$1,010,683				Same as previous
LI6B (88th to 93rd)	$33,397 (1985) $480,940 (1987)				Same as previous

32 Based on information contained in Table 1.5.3.3-1 and 1.5.3.2-1 of feasibility report.

33 Based on information provided by Sea Isle City.

34 Based on sand volumes needed to offset the effects long-tern erosion rate of 3 feet per year

35 Based on quantities calculated by CENAP.

Scenario C

This scenario assumes that the proposed local plans shown in column 2 in the table occur either prior to the base year or not at all. Therefore, this event would not be included in the local costs foregone. In Cell LI3, a storm event is assumed to occur in year 2005 rather than the proposed plans. Local costs foreone for this scenario would total $1,293,000.

Cell	**(1) Historical Storm Damage Fills[36] (all 1984$ unless noted)**	**(2) Plans[37] (current $)**	**(3) Estimate of beachfill needed due to long-term erosion[38]**	**(4) Estimate of major nourishment due to storm events[39]**	**Local Costs Determination Calculation**
LI1 (Seaview to Whittier)	$436,809	Before base year (by NJDEP)			Based on column 1 at years 2005, 2025, and 2045.
LI2 (Whittier to Sherman)	$358, 221	Same as previous			Same as previous
LI2B (Sherman to Hamilton)	$716,909	Same as previous			Same as previous
LI3 (Hamilton to 13th Street)	$988,061	$1,984,590	$542,808		Based on column 1 at years 2005, 2025 and 2045, and column 3 every 5 years starting at year 2010, unless same year as column 1.
LI4 (13th to 29th)		$2,767,764		$1,400,000	Based on column 4 at years 2005, 2024 and 2044.
LI4N (29th to JFK (41st))		$324,000		$1,430,000	Based on column 4 at years 2024 and 2044.
LI5 (41st to 52nd)	$475,198	$1,270,500			Based on column 2 at 2005, then add column 1 at 2024 and 2044.
LI4S (52nd to 57th)	$499,476	$278,250			Same as previous
LI5B (57th to 75th)	$1,667,144				Based on column 1 at year 2005 then 2024, and 2044.
LI6 (75th to 88th)	$1,010,683				Same as previous
LI6B (88th to 93rd)	$33,397 (1985) $480,940 (1987)				Same as previous

36 Based on information contained in Table 1.5.3.3-1 and 1.5.3.2-1 of feasibility report.

37 Based on information provided by Sea Isle City.

38 Based on sand volumes needed to offset the effects long-tern erosion rate of 3 feet per year

39 Based on quantities calculated by CENAP.

Scenario D

This scenario is a combination of the previous two and assumes that the proposed local plans and storm event occur prior to the base year. Local costs foreone for this scenario would total $433,000.

Cell	(1) Historical Storm Damage Fills[40] (all 1984$ unless noted)	(2) Plans[41] (current $)	(3) Estimate of beachfill needed due to long-term erosion[42]	(4) Estimate of major nourishment due to storm events[43]	Local Costs Determination Calculation
LI1 (Seaview to Whittier)	$436,809	Before base year (by NJDEP)			Based on column 1 at years, 2024, and 2044.
LI2 (Whittier to Sherman)	$358, 221	Same as previous			Same as previous
LI2A (Sherman to Hamilton)	$716,909	Same as previous			Same as previous
LI3 (Hamilton to 13th Street)	$988,061	$1,984,590	$542,808		Based on column 1 at years 2024 and 2044, and column 3 every 5 years starting at year 2010.
LI4 (13th to 29th)		$2,767,764		$1,400,000	Based on column 4 at years 2024 and 2044.
LI4N (29th to JFK (41st))		$324,000		$1,430,000	Based on column 4 at years 2024 and 2044.
LI5 (41st to 52nd)	$475,198	$1,270,500			Based on column 1 at 2024 and 2044.
LI4S (52nd to 57th)	$499,476	$278,250			Same as previous
LI5B (57th to 75th)	$1,667,144				Based on column 1 at 2024, and 2044.
LI6 (75th to 88th)	$1,010,683				Same as previous
LI6B (88th to 93rd)	$33,397 (1985) $480,940 (1987)				Same as previous

40 Based on information contained in Table 1.5.3.3-1 and 1.5.3.2-1 of feasibility report.

41 Based on information provided by Sea Isle City.

42 Based on sand volumes needed to offset the effects long-tern erosion rate of 3 feet per year

43 Based on quantities calculated by CENAP.

Scenario E

This scenario assumes that no storms or local plans are ever constructed throughout the 50-year project life. Only on-going local activities are expected to continue. In this case, Sea Isle City has spent $135,000 the last two years to maintain sand over the geotextile tubes. This average annual local cost foregone would be $151,000.

Summary:

Below is a summary of how the different scenarios affect the benefits.

Table 6.4.7-3 Summary of Ludlam Island Plan BCR Sensitivity

Discount Rate = 6.375%					
Price level = October 2000					
ANNUALIZED BENEFITS					
Structure	$2,795,000				
Infrastructure	$64,000				
Improved Property (cost of fill)	$80,000				
Subtotal:	$2,939,000				
	SCENARIO A	B	C	D	E
Local Costs Foregone	**$1,278,000**	**$895,000**	**$1,293,000**	**$433,000**	**$151,000**
Recreation	$1,590,000				
Benefits During Contrsuction	$136,000				
Detour	$37,000				
Total Benefits	$5,980,000	$5,597,000	$5,995,000	$5,135,000	$4,853,000
ANNUALIZED COSTS					
Construction	3,722,000				
Interest During Construction	108,000				
OMRR&R Costs	52,000				
TOTAL ANNUALIZED COST	$3,882,000	3,882,000	$3,882,000	$3,882,000	$3,882,000
BENEFIT TO COST RATIO	1.5	1.4	1.5	1.3	1.3
NET BENEFITS	$2,098,000	$1,715,000	$2,113,000	$1,253,000	$971,000

6.5 Risk and Uncertainty Analysis Associated with Coastal Projects

A decrease in the discount rate results in an increase to the benefit to cost ratio. It is recognized that over time there is variation in economic conditions as well as hydrological and hydraulic parameters. As part of a feasibility analysis, detailed information has been collected to the extent defined by the scope of work. The analysis used statistical modeling techniques that took into account probability of occurrence of storm events, mechanism of storm damages, and sources that accounted for regional labor and construction rates.

The benefits were recalculated with a ten percent variation from the calculated expected mean as assessed in the benefit analysis for the selected plan (i.e., at the 6 3/8% discount rate and the October 2000 price level). The benefits were then again calculated with a ten percent variation with a half a percent increase in the discount rate to a 6 7/8% discount rate and a ten percent variation from the calculated expected mean.

6.5.1 South End Ocean City

Discount Rate	***6.375%***
Period of Analysis	*50 years*
Price Level	*October 2000*
Base Year	*2005*
-10% in Benefit Categories	
Average Annual Benefits	$3,755,000
Average Annual Costs	$2,130,000
Net Benefits	$1,625,000
Benefit to Cost Ratio	1.8
+10% in Benefit Categories	
Average Annual Benefits	$4,588,000
Average Annual Costs	$2,130,000
Net Benefits	$2,458,000
Benefit to Cost Ratio	2.2

Discount Rate	***6.875%***

Period Of Analysis	*50 years*
Price Level	*October 2000*
Base Year	*2005*
-10% in Benefit Categories	
Average Annual Benefits	$3,762,000
Average Annual Costs	$2,185,000
Net Benefits	$1,577,000
Benefit to Cost Ratio	1.7
+10% in Benefit Categories	
Average Annual Benefits	$4,596,000
Average Annual Costs	$2,185,000
Net Benefits	$2,411,000
Benefit to Cost Ratio	2.1

6.5.2 Ludlam Island

Discount Rate	***6.375%***
Period of Analysis	*50 years*
Price Level	*October 2000*
Base Year	*20053*
-10% in Benefit Categories	
Average Annual Benefits	$5,578,000
Average Annual Costs	$3,941,000
Net Benefits	$1,673,000
Benefit to Cost Ratio	1.4
+10% in Benefit Categories	
Average Annual Benefits	$6,816,000
Average Annual Costs	$3,941,000
Net Benefits	$2,875,000
Benefit to Cost Ratio	1.7

Discount Rate	***6.875%***

Period Of Analysis	*50 years*
Price Level	*October 2000*
Base Year	*2005*
-10% in Benefit Categories	
Average Annual Benefits	$5,657,000
Average Annual Costs	$3,875,000
Net Benefits	$1,782,000
Benefit to Cost Ratio	1.5
+10% in Benefit Categories	
Average Annual Benefits	$6,579,000
Average Annual Costs	$3,875,000
Net Benefits	$2,704,000
Benefit to Cost Ratio	1.7

6.6 Cost Sharing and Local Cooperation

6.6.1 Cost Apportionment

The selected plan is justified on benefits associated with hurricane and storm damage reduction. There are no separable recreation features included with this project. Recreation benefits resulting from 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 LREDD provided by the non-Federal Sponsor is included in the total project costs, and they shall receive credit for the value of these contributions against the non-Federal cost share. Operation, Maintenance, Repairs, Replacement, and Rehabilitation (OMRR&R) costs are 100% non-Federal responsibility.

Section 215 of the Water Resources Development Act of 1999 amended the cost sharing for the periodic nourishment of shore protection projects. Under Section 215 of WRDA 99, periodic nourishment for the selected plan would be 50% Federal and 50% non-Federal (as the periodic nourishment would be accomplished after year 2003). It should also be noted that the current Administration budgetary policy (shore protection projects not budgetable) on shore protection projects remains unchanged since WRDA 99.

Table 6.6.1-1 summarizes cost-sharing for the selected plan.

Table 6.6.1-1 Cost Sharing for the Selected Plan

Oct 2000 price level

Project Feature	Federal Cost	%	Non-Federal Cost	%	Total Cost
Initial Project Costs	**$28,054,000**	**65%**	**$15,107,000**	**35%**	**$43,161,000**
South End Ocean City	$8,282,000	65%	$4,460,000	35%	$12,742,000
Ludlam Island	$19,772,000	65%	$10,647,000	35%	$30,419,000
LERRD Credit	***$0***	***0%***	***$424,000***	***100%***	***$424,000***
South End Ocean City	*$0*	*0%*	*$108,000*	*100%*	*$108,000*
Ludlam Island	*$0*	*0%*	*$316,000*	*100%*	*$316,000*
Initial Project Cash Contribution	***$28,054,000***		***$14,683,000***		***$42,737,000***
South End Ocean City	*$8,282,000*		*$4,352,000*		*$12,634,000*
Ludlam Island	*$19,772,000*		*$10,331,000*		*$30,103,000*
Periodic Nourishment (50-Years)	**$80,392,000**	**50%**	**$80,392,000**	**50%**	**$160,784,000**
South End Ocean City (3 year cycle)	$31,912,000	50%	$31,912,000	50%	$63,824,000
Ludlam Island (5 year cycle)	$48,480,000	50%	$48,480,000	50%	$96,960,000
Ultimate Project Cost (50-Years)	**$108,446,000**	**53%**	**$95,499,000**	**47%**	**$203,945,000**
South End Ocean City	$40,194,000	52%	$36,372,000	48%	$76,566,000
Ludlam Island	$68,252,000	54%	$59,127,000	46%	$127,379,000
LERRD Credit	***$0***		***$424,000***		***$424,000***
South End Ocean City	*$0*		*$0*		*$108,000*
Ludlam Island	*$0*		*$0*		*$316,000*
Ultimate Cash Contribution (50-Years)	***$108,446,000***		***$95,499,000***		***$203,521,000***
South End Ocean City	*$40,194,000*		*$36,372,000*		*$76,458,000*
Ludlam Island	*$68,252,000*		*$59,127,000*		*$127,063,000*

*NOTE: Ultimate project cost does not include OMRR&R costs throughout the 50 year period of analysis which are estimated at $ annually and are the responsibility of the non-Federal sponsor. Interest during Construction (IDC) it also is not included in the above cost estimates.

6.6.2 Local Cooperation

6.6.2.1 Sponsor Financing and Financial Capability.

In accordance with Section 105 (a)(1) of WRDA 1986, the Great Egg Harbor Inlet to Townsends Inlet 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 (NJDEP) demonstrates their intent to support a project for the study area. The state has a $25,000,000 stable source of funding for shore protection projects and has further indicated its intent to enter into a PCA at the conclusion of this study by a letter dated 7 September 2000 (see Appendix A). The sponsor has also demonstrated their financial capability through their ongoing cost sharing of current Philadelphia District projects namely *Cape May Inlet to Lower Township, NJ* and *Great Egg Harbor Inlet to Peck Beach,* *Ocean City, NJ*. Coordination efforts with the sponsor will continue regarding project financing as the process continues.

A current estimated schedule of estimated Federal and non-Federal expenditures by Federal fiscal year is shown on Tables 6.6.2-1 and 6.6.2-1.

Table 6.6.2-1 Schedule of Estimated Federal and Non-Federal Expenditures – South End Ocean City

WRDA 99 Cost-Sharing
Oct 2000 price level

FY	Federal	Non-Federal			Total
		Cash	LERR&D	OMRR&R	
2003	$0	$0			$0
2004	$458,000	$153,000			$611,000
2005	$7,614,000	$4,086,000	$108,000	$0	$11,808,000
2006	$112,000	$61,000		$20,000	$193,000
2007	$98,000	$53,000		$20,000	$171,000
2008	$1,858,000	$1,858,000		$20,000	$3,736,000
2009	$55,000	$55,000		$20,000	$130,000
2010	$55,000	$55,000		$20,000	$130,000
2011	$1,858,000	$1,858,000		$20,000	$3,736,000
2012	$55,000	$55,000		$20,000	$130,000
2013	$55,000	$55,000		$20,000	$130,000
2014	$1,858,000	$1,858,000		$20,000	$3,736,000
2015	$55,000	$55,000		$20,000	$130,000
2016	$55,000	$55,000		$20,000	$130,000
2017	$1,858,000	$1,858,000		$20,000	$3,736,000
2018	$55,000	$55,000		$20,000	$130,000
2019	$55,000	$55,000		$20,000	$130,000
2020	$1,858,000	$1,858,000		$20,000	$3,736,000
2021	$55,000	$55,000		$20,000	$130,000
2022	$55,000	$55,000		$20,000	$130,000
2023	$1,858,000	$1,858,000		$20,000	$3,736,000
2024	$55,000	$55,000		$20,000	$130,000
2025	$55,000	$55,000		$20,000	$130,000
2026	$1,858,000	$1,858,000		$20,000	$3,736,000
2027	$55,000	$55,000		$20,000	$130,000
2028	$55,000	$55,000		$20,000	$130,000

2029	$2,282,000	$2,282,000		$835,000	$5,399,000
2030	$55,000	$55,000		$20,000	$130,000
2031	$55,000	$55,000		$20,000	$130,000
2032	$1,858,000	$1,858,000		$20,000	$3,736,000
2033	$55,000	$55,000		$20,000	$130,000
2034	$55,000	$55,000		$20,000	$130,000
2035	$1,858,000	$1,858,000		$20,000	$3,736,000
2036	$55,000	$55,000		$20,000	$130,000
2037	$55,000	$55,000		$20,000	$130,000
2038	$1,858,000	$1,858,000		$20,000	$3,736,000
2039	$55,000	$55,000		$20,000	$130,000
2040	$55,000	$55,000		$20,000	$130,000
2041	$1,858,000	$1,858,000		$20,000	$3,736,000
2042	$55,000	$55,000		$20,000	$130,000
2043	$55,000	$55,000		$20,000	$130,000
2044	$1,858,000	$1,858,000		$20,000	$3,736,000
2045	$55,000	$55,000		$20,000	$130,000
2046	$55,000	$55,000		$20,000	$130,000
2047	$1,858,000	$1,858,000		$20,000	$3,736,000
2048	$55,000	$55,000		$20,000	$130,000
2049	$55,000	$55,000		$20,000	$130,000
2050	$1,858,000	$1,858,000		$20,000	$3,736,000
2051	$55,000	$55,000		$20,000	$130,000
2052	$55,000	$55,000		$20,000	$130,000
2053	$1,858,000	$1,858,000		$20,000	$3,736,000
2054	$55,000	$55,000		$20,000	$130,000
2055	$55,000	$55,000		$20,000	$130,000
Total	**$40,194,000**	**$36,265,000**	**$108,000**	**$1,815,000**	**$78,382,000**

Table 6.6.2-2 Schedule of Estimated Federal and Non-Federal Expenditures – Ludlam Island

WRDA 99 Cost-Sharing
Oct 2000 price level

FY	Federal	Non-Federal			Total
		Cash	LERR&D	OMRR&R	
2001	$0	$0			$0
2002	$585,000	$195,000			$780,000
2003	$18,808,000	$9,931,000	$316,000	$0	$29,055,000
2004	$194,000	$104,000		$52,000	$350,000
2005	$186,000	$100,000		$52,000	$338,000
2006	$97,000	$0		$52,000	$149,000
2007	$97,000	$0		$52,000	$149,000
2008	$4,408,000	$4,408,000		$52,000	$8,868,000
2009	$97,000	$97,000		$52,000	$246,000
2010	$97,000	$97,000		$52,000	$246,000
2011	$97,000	$97,000		$52,000	$246,000
2012	$97,000	$97,000		$52,000	$246,000
2013	$4,408,000	$4,408,000		$52,000	$8,868,000
2014	$97,000	$97,000		$52,000	$246,000
2015	$97,000	$97,000		$52,000	$246,000
2016	$97,000	$97,000		$52,000	$246,000
2017	$97,000	$97,000		$52,000	$246,000
2018	$4,408,000	$4,408,000		$52,000	$8,868,000
2019	$97,000	$97,000		$52,000	$246,000
2020	$97,000	$97,000		$52,000	$246,000
2021	$97,000	$97,000		$52,000	$246,000
2022	$97,000	$97,000		$52,000	$246,000
2023	$4,408,000	$4,408,000		$52,000	$8,868,000
2024	$97,000	$97,000		$52,000	$246,000
2025	$97,000	$97,000		$52,000	$246,000
2026	$97,000	$97,000		$52,000	$246,000
2027	$97,000	$97,000		$52,000	$246,000
2028	$5,141,000	$5,141,000		$3,120,000	$13,402,000
2029	$97,000	$97,000		$52,000	$246,000
2030	$97,000	$97,000		$52,000	$246,000
2031	$97,000	$97,000		$52,000	$246,000
2032	$97,000	$97,000		$52,000	$246,000

2033	$4,408,000	$4,408,000		$52,000	$8,868,000
2034	$97,000	$97,000		$52,000	$246,000
2035	$97,000	$97,000		$52,000	$246,000
2036	$97,000	$97,000		$52,000	$246,000
2037	$97,000	$97,000		$52,000	$246,000
2038	$4,408,000	$4,408,000		$52,000	$8,868,000
2039	$97,000	$97,000		$52,000	$246,000
2040	$97,000	$97,000		$52,000	$246,000
2041	$97,000	$97,000		$52,000	$246,000
2042	$97,000	$97,000		$52,000	$246,000
2043	$4,408,000	$4,408,000		$52,000	$8,868,000
2044	$97,000	$97,000		$52,000	$246,000
2045	$97,000	$97,000		$52,000	$246,000
2046	$97,000	$97,000		$52,000	$246,000
2047	$97,000	$97,000		$52,000	$246,000
2048	$4,408,000	$4,408,000		$52,000	$8,868,000
2049	$97,000	$97,000		$52,000	$246,000
2050	$97,000	$97,000		$52,000	$246,000
2051	$97,000	$97,000		$52,000	$246,000
2052	$97,000	$97,000		$52,000	$246,000
2053	$4,408,000	$4,408,000		$52,000	$8,868,000
Total	**$68,272,000**	**$58,635,000**	**$316,000**	**$5,668,000**	**$132,891,000**

6.6.3 Project Cooperation Agreement

A fully coordinated Project Cooperation Agreement (PCA) package will be prepared subsequent to the approval of the feasibility phase and will reflect the recommendations of this feasibility study. The non-Federal sponsor, NJDEP, has indicated support of the recommendations presented in this feasibility report and the desire to execute a PCA for the recommended plan.

Should Congress appropriate funds for construction of the project, the non-Federal sponsor would have to assume non-Federal responsibilities subject 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 USC 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." Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33USC 701b-12), which requires a non-Federal interest to have prepared a flood plain management plan within one year after the date of signing a Project Cooperation Agreement. The plan shall be designed to reduce the impacts of future flood events in the project area, including but not limited to, addressing those measures to be undertaken by Non-Federal interest to preserve the level of flood protection provided by the project. As required by Section 402, as amended, implement the plan not later than one year after completion of construction of the project. Provide an information copy of the plan to the Government upon its preparation;

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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7 CONCLUSIONS AND RECOMMENDATIONS

7.1 Conclusions

A plan was developed to reduce potential ocean-related storm damages. This plan consists of the construction of a berm and dune along South End Ocean City and Ludlam Island. This plan includes periodic sand nourishment every 3 years for South End Ocean City and every 5 years for Ludlam Island. Specific project details can be found in section 6.1 of this report.

Initial construction costs total $43,161,000 (Oct 2000 price level) and would be cost-shared 65% Federal, 35% non-Federal while periodic nourishment would be cost-shared 50%. More detailed cost-sharing information can be found in section 6.6.1 of this report.

The plan identified reflects the information available at the time and current Corps policies governing formulation of individual projects. This plan may be modified before being transmitted to Congress as a proposal for authorization and implementation funding. However, prior to transmittal to Congress, the project sponsor, interested Federal and non-Federal agencies, and other parties will be advised of any modification and afforded an opportunity to comment further.

7.1.1 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 (P,E,&D) Phase would consist primarily of the preparation of Plans and Specifications (P&S). The District will ask that the project proceed to the Preconstruction Engineering and Design (PED) phase if the Administration's policy makes shore protection projects a higher budget priority.

7.1.2 Additional Tasks

Following execution of a cost sharing agreement for Preconstruction Engineering and Design (PED) phase, these activities will be cost shared on a 75% Federal, 25% non-Federal basis. In the event the PED efforts lead to construction, further reimbursement by the non-Federal sponsor would be made as a project cost shared item based on 65% Federal, 35% non-Federal cost share for initial construction.

7.2 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 the 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, is socially and environmentally acceptable, and has support from the non-Federal sponsor. Further federal participation in design and construction of this hurricane and storm protection project would be likely.

Project Benefits

The selected plan has primary outputs based on hurricane and storm damage reduction and provides average annual net benefits of approximately $2,041,000 and a benefit-to-cost ratio of 2.0 for South End Ocean City while also providing average annual net benefits of approximately $2,256,000 and a benefit-to-cost ratio of 1.6 for Ludlam Island.

Initial Project Cost

The total initial project cost of construction is estimated at $43,161,000 (Oct 2000 price level). The Federal share of this first cost is $28,054,000 and the non-Federal share is $15,107,000. Lands Easements, Rights-of-Ways, Relocations and Dredged Material Disposal Areas (LERRD) costs are $424,000 and will be credited towards the non-Federal sponsor's cash contribution.

Continuing Construction Cost

Periodic nourishment is expected to occur at 3-year intervals for the South End Ocean City portion of the project and at 5-year intervals for Ludlam Island subsequent to the completion of initial construction (year 0). Over the 50-year project life, the total periodic nourishment cost is estimated to be $160,784,000 (Oct 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 $203,945,000 (Oct 2000 price level), cost-shared 53% Federal, 47% non-Federal, based on WRDA 1999 cost-sharing. All costs also include planning, engineering, and design. Operation, Maintenance, Repair, Replacement, and Rehabilitation (OMRR&R) is a non-Federal responsibility.

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 the Congress as proposals for authorization and implementation funding. However, prior to transmittal to the Congress, the Sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded an opportunity to comment further.

Timothy Brown
Lieutenant Colonel, Corps of Engineers
District Engineer

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8 LIST OF PREPARERS

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The following individuals were primarily responsible for the preparation and technical support for the Feasibility Study and Integrated Environmental Impact Statement.

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8.2 Studies Conducted for or Reported in this Feasibility Study and Integrated Environmental Impact Statement

Dolan Research, Inc. & Hunter Research, Inc. 1996. Phase I Submerged and Shoreline Cultural

Resources Investigations, Peck Beach (34th Street to Corson Inlet), City of Ocean City, Cape May County, New Jersey.

Dolan Research, Inc. and Hunter Research, Inc. 1999. Phase 1A Cultural Resources Investigations, Great Egg Harbor Inlet to Townsends Inlet, Cape May County, New Jersey.

Hunter Research, Inc., Dolan Research, Inc. and Enviroscan, Inc. 1999. Phase I Submerged and Shoreline Cultural Resources Investigations, Great Egg Harbor Inlet to Townsends Inlet, Cape May County, New Jersey.

Dolan Research, Inc. 2000. Supplemental Phase I Submerged Cultural Resources Investigation, Great Egg Harbor Inlet to Townsends Inlet, Cape May County, New Jersey.

Duffield Associates, Inc. September 1999. Corson Inlet- Proposed Borrow Area Investigation. Prepared for U.S. Army Corps of Engineers, Philadelphia District under DACW61-98-D-0008 (Task Order #9).

Ocean Surveys, Inc. March 1997. Final Report, Ocean City, NJ, Beach Profile Survey and Sediment Sampling, Post-Winter Condition. Prepared for the US Army Corps of Engineers, Philadelphia District.

Ocean Surveys, Inc. September 1997. Final Report, Ocean City, NJ, Beach Profile Survey and Sediment Sampling, Post-Summer Condition. Prepared for the US Army Corps of Engineers, Philadelphia District.

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, New Jersey. Prepared by Versar, Inc. for U. S. Army Corps of Engineers, Philadelphia District under DACW61-95-D-0011 (0084).

U.S. Army Corps of Engineers, Philadelphia District. 1998. Great Egg Harbor Inlet to Townsends Inlet Sediment Budget. Prepared by Andrews Miller & Associates, Inc for the Philadelphia District, Philadelphia, PA.

Woodward-Clyde, April 1998. Results of Geophysical (Acoustic Imaging) Survey and Vibrocore Program: Offshore Corson Inlet, New Jersey. Prepared for U.S. Army Corps of Engineers, Philadelphia District under DACW61-95-D-0005 (Delivery Order #016).

9 PUBLIC INVOLVEMENT

A notice of intent to prepare a Environmental Impact Statement (DEIS) for the Great Egg Harbor Inlet to Townsends Inlet Interim Feasibility Study was published in the Federal Register on March 9, 1999. The public was invited to participate in the scoping process via a Public Notice dated March 27, 1998 which informed the public of the study purpose and to solicit public comment on identifying any potential issues or concerns to be addressed in the feasibility study and environmental impact statement. In addition, coordination with Federal, state, local agencies was undertaken via written letters, e-mails, telephone conversations, and meetings. Information in this document was generated based on comments and concerns of the interested public.

The DEIS was made available for public review and filed with the Environmental Protection Agency on May 11, 2001. Public notification of the availability of the DEIS was made through a public notice, District press release, the Distric internet website, and public workshop meetings held in Sea Isle City and Ocean City.

A Planning Aid Report prepared by the USFWS is provided in Appendix C. A Section 2(b) Fish and Wildlife Coordination Act Report was received from the USFWS. This report provides official USFWS comments on the project pursuant to the Fish and Wildlife Coordination Act, and is presented along with Philadelphia District responses in Appendix A.

A copy of the Draft Great Egg Harbor to Townsends Inlet Interim Feasibility Study and Integrated Environmental Impact Statement was provided to the following individuals/agencies for review in addition to the interested public that requested copies.

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10 CLEAN AIR ACT STATEMENT OF CONFORMITY

CLEAN AIR ACT
STATEMENT OF CONFORMITY
GREAT EGG HARBOR INLET TO TOWNSENDS INLET; FEASIBILITY STUDY
CAPE MAY COUNTY, NEW JERSEY

Based on the conformity analysis in the subject report, I have determined that the proposed action conforms to the applicable State Implementation Plan (SIP). The Environmental Protection Agency had no adverse comments under their Clean Air Act authority. All comments from the New Jersey Department of Environmental Protection were addressed in the feasibility study and the proposed action would comply with all air quality statutes and regulations. Based on this, the proposed project would comply with Section 176 (c)(1) of the Clean Air Act Amendments of 1990 prior to initiation of construction.

9 August 01

Date

Timothy Brown
Lieutenant Colonel, Corps of Engineers
District Engineer

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11 EVALUATION OF 404(B)(1) GUIDELINES

PROJECT DESCRIPTION

A. Location

The proposed project site is located along the Atlantic Coast shoreline of New Jersey from Great Egg Harbor Inlet to Townsends Inlet that includes the Southern End of Ocean City (Southern Peck Beach) and the entire Ludlam Island, which includes Strathmere, Whale Beach and Sea Isle City. The specific areas involved are the beaches and nearshore zones within this area. Three offshore sand borrow sites and one borrow site within Corson Inlet Ebb Shoal are proposed.

B. General Description

The proposed project involves reducing potential storm damages at Southern Ocean City, Strathmere, Whale Beach and Sea Isle City, New Jersey by the placement of dredged material (sand) obtained from the offshore sand borrow sites on the beachfront in the form of a berm and dune. Specifically, the proposed plan for Southern Ocean City is beachfill with a berm width of 30.5 meters (100 feet) at an elevation of +2.1 meters (+7.0 feet) North American Vertical Datum (NAVD) and a dune with a top elevation of +3.9 meters (+12.8 feet) NAVD and a crest width of 7.6 meters (25 feet). The berm will extend from the seaward toe of the dune for a distance of 30.5 meters (100 feet) before sloping down at 1V:25H to elevation –0.38 meters (-1.25 ft) NAVD. The remainder of the design template parallels the existing profile slope to the depth of closure. the total width of the berm from the seaward toe of the dune to Mean High Water (MHW) is 66 meters (218 feet). The plan extends from 34th Street south to 59th Street for a total length of 4,268 meters (14,000 feet or 2.6 miles). Initial sand quantity is approximately 1,217,900 cubic meters (1,595,449 cubic yards), which includes overfill factor and advanced nourishment. Periodic nourishment of 305,900 cubic meters (400,729 cubic yards) is scheduled to occur every 3 years synchronized with the existing Federal beachfill project at Ocean City (Great Egg Harbor Inlet to 34th Street). Material would be taken from borrow source M8 (see Figure 2.2.11-1). This borrow source is located immediately outside the 3 nautical mile boundary of New Jersey.

The selected plan for Ludlam Island (Strathmere, Whale Beach, and Sea Isle City) consists of berm and dune restoration utilizing sand obtained from offshore borrow sources. The dune crest will have a top elevation of +4.5 meters (+14.8) NAVD, a top width of 7.6 meters (25 feet) and side slopes of 1V:5H. The berm width will extend from the seaward toe for a distance of 15 meters (50 feet) at an elevation of +1.8 meters (+6.0 feet) NAVD before sloping down (varying from 1V:30H to 1V:50H) to an elevation of –0.38 meters (-1.25 feet) NAVD. The remainder of the design template parallels the existing profile slope to the depth of closure. The total width from the seaward toe of the dune to Mean High Water (MHW) varies depending upon location from 43 to 55 meters (140 to 235 feet). The plan extends from 38 meters (125 feet) north of Seaview Avenue in Strathmere to Pleasure Ave (just beyond 93rd Street) in Sea Isle City for a total length of 10,507 meters (6.5 miles). In addition, there is a taper of 224 meters

(734 feet) into Corson's Inlet State Park (Strathmere Natural Area) and a taper of 20 meters (66 feet) into the terminal groin south of 93rd Street. Total length of beachfill, including tapers, is 10,751 meters (6.7 miles). The plan also includes the extension of two stormwater outfalls by 150 feet at 82nd St. and 86th St. Initial sand quantity is approximately 3,911,135 cubic meters (5,123,587 cubic yards), which includes design fill quantity, overfill factor, and advanced nourishment. Periodic nourishment of approximately 1,383,356 cubic meters (1,812,196 cubic yards) is estimated to occur every 5 years. Material would be taken from borrow sources L3, L1, and C1 (see Figure 2.2.11-1). A portion of borrow source L3 is located just outside the 3 nautical mile boundary of New Jersey.

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 Section 6.1 of this report

C. Authority and Purpose

The Great Egg Harbor Inlet to Townsends Inlet Interim Feasibility Study is part of the overall New Jersey Shore Protection Study, which was authorized by resolutions adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environment and Public Works of the U.S. Senate in December 1987 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 hearby 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 hearby 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.

The purpose of the project is to reduce storm damages to the beaches and oceanfront structures of Southern Ocean City, Strathmere, Whale Beach, and Sea Isle City, Cape May County, New Jersey.

D. General Description of Dredged or Fill Material

1. General Characteristics of Material. The proposed material to be dredged is poorly graded, or well-sorted, fine to coarse sands with little to some fines and gravel. Clay, silt, and organic content are low with neutral pH and low fertility.

2. Quantity of Material. The quantity of beachfill material required for Southern Ocean City is estimated to be approximately 1,217,900 cubic meters (1,595,449 cubic yards), which includes overfill factor and advanced nourishment. Periodic nourishment of 305,900 cubic meters (400,729 cubic yards) is scheduled to occur every 3 years synchronized with the existing Federal beachfill project at Ocean City (Great Egg Harbor Inlet to 34th Street). Material would be taken from borrow source M8. The quantity of beachfill material required for Ludlam Island (Strathmere, Whale Beach and Sea Isle City) is estimated to be approximately 3,911,135 cubic meters (5,123,587 cubic yards), which includes design fill quantity, overfill factor, and advanced nourishment. Periodic nourishment of approximately 1,383,356 cubic meters (1,812,196 cubic yards) is estimated to occur every 5 years. Material would be taken from borrow sources L3, L1, and C1. The two stormwater outfall extensions include a total of 22 timber pile supports and 92 meters (300 feet) of 300 mm diameter ductile iron pipe to be placed in the intertidal and subtidal nearshore zones.

3. Source of Material. The proposed source of the beachfill material for Southern Ocean City is from a relatively flat area 5.5 – 6.9 km offshore Southern Ocean City. The size of the borrow area is approximately 344.8 ha (852 ac). The existing depths within the borrow area vary from -34 feet (-10.4 m) to -42 feet (-12.8 m) MLW. There are three proposed sources of beachfill material for Ludlam Island beaches. The first site is the Corson Inlet Ebb Shoal (79.7 ha/197 ac) where depths range from –1 feet (-0.3 m) to –15 feet (4.6 m). The second site is L1 (614 ha/1,517 ac), which is 3.2 – 5.1 km offshore Sea Isle City in depths ranging from –34 feet (-10.3 m) to –47 feet (-14.3 m). The third site is

L3 (842.6 ha/2,082 ac), which is 3.25 – 6.4 km offshore Whale Beach and Strathmere in water depths of –32 feet (-9.75 m) to –50 feet (-15.2 m).

E. Description of the Proposed Discharge Site

1. Location. The proposed discharge locations are depicted in Section 6.0 of this report.

2. Size. Initial construction beachfill placement quantities discharged into waters of the United States are presented in the table below:

Table 11-1. Estimated Areas of Intertidal/Nearshore Benthic Habitat Impacted By Beachfill Placement For Initial Construction

	Intertidal Zone (Mean High Water to Mean Low Water)		Subtidal Nearshore (Mean Low Water to Depth of Closure)		Total Shoreline Benthic Habitat (Mean High Water to Depth of Closure)	
	Volume of Sand Placed	Area Impacted	Volume of Sand Placed	Area Impacted	Volume of Sand Placed	Area Impacted
Southern Ocean City Area	94,570 m^3 (124,434 $yd^{3)}$	29.4 ha (72.6 ac)	624,684 m^3 (821,952 yd^3)	198.8 ha (491.2 acres)	719,253 m^3 (946,386 yd^3)	228.2 ha (563.8 acres)
Strathmere Area	41,940 m^3 (55,184 yd^3)	15.1 ha (37.2 ac)	227,158 m^3 (298,898 yd^3)	79.8 ha (197.1 acres)	269,102 m^3 (354,082 yd^3)	94.8 ha (234.3 acres)
Whale Beach Area	107,353 m^3 (141,254 yd^3)	8.3 ha (20.6 ac)	435,146 m^3 (572,560 yd^3)	33.8 ha (83.5 acres)	542,499 m^3 (713,814 yd^3)	42.1 ha (104.1 acres)
Sea Isle City	146,648 m^3 (192,958 yd^3.)	21.8 ha (53.8 ac)	1,311,669 m^3 (1,725,880 yd^3.)	175.0 ha (432.4 acres)	1,458,317 m^3 (1,918,838 yd^3)	196.8 ha (486.2 acres)
Total	390,511 m^3 (513,830 yd^3)	75 ha (184.2 ac)	2,598,656 m^3 (3,419,290 yd^3)	487 ha (1,204.2 acres)	2,989,171 m^3 (3,933,129 yd^3)	562 ha (1,388.2 acres)

3. Type of Site. The proposed discharge is comprised of eroding sandy beaches located in Southern Ocean City and the entire Ludlam Island. 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:

Southern Ocean City – 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 or colonial nesting birds are nesting within the impact area(s) during the nesting season (March – August). For initial construction, the discharge would be continuous for approximately **7 months**. Periodic nourishment would occur over a duration of approximately **3 months** every **3 years** during the 50-year project life.

Ludlam Island - 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 or colonial nesting birds are nesting within the impact area(s) during the nesting season (March – August). For initial construction, the discharge would be continuous for approximately **19 months**. Periodic nourishment would occur over a duration of approximately **8 months** every **5 years** during the 50-year project life.

Berm and Dune restoration will be accomplished by the placement of beachfill obtained through a hydraulic slurry pipeline from either a hydraulic dredge or a hopper dredge at the locations described previously. The discharges would continue through the manipulation of material with mechanized equipment.

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 Southern Ocean City, the final proposed elevation of the beach substrate after fill placement would be +2.1 meters (+7.0 feet) NAVD at the top of the berm. The proposed profile would have a foreshore slope of 25H:1V and an underwater slope that parallels the existing bottom to the depth of closure. The Ludlam Island beaches would have a final proposed elevation of +1.8 meters (+6.0 feet) NAVD at the top of the berm. The proposed foreshore profile would vary from 30H:1V to 50H:1V.

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 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 or winnowing 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 ten to twelve 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. <u>Water Circulation, Fluctuation, and Salinity Determinations</u>

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. 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 with a reported mean tide range for Great Egg Harbor Inlet of 1.16 m (3.81 ft) in the Tide Tables published annually by the National Oceanic and Atmospheric Administration (NOAA). The spring tide range is reported as 1.4 m (4.59 ft). 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. <u>Suspended Particulate/Turbidity Determinations</u>

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, utilizes 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 and periodic nourishment is required to insure that the nesting locations can be avoided during construction until the chicks fledge the nest. Additional issues such as beach-use management after construction and nourishment are being addressed through a programmatic biological assessment (currently under development) 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 areas 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 areas 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 (with suction head) is used, 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. <u>Proposed Disposal/Discharge (Beachfill Placement) Site Determinations</u>

1. **Mixing Zone Determination**

   a. **Depth of water** - 0 to-20 feet (-6.1 m) 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 (597 cubic meters) per hour
   g. **Dredged material characteristics** - medium-fine 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 Corson Inlet State Park and Strathmere Natural Area, would be affected. Coordination with State Park administrators has been undertaken and the needs and views of the State parks will be considered during the development of detailed plans and specifications.

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 5.0 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 biological assessment addressing impacts and mitigative measures for piping plovers and seabeach amaranth and the subsequent Biological Opinion. 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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