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HEREFORD INLET TO CAPE MAY INLET NEW JERSEY SHORE PROTECTION STUDY

COMMUNICATION

FROM

THE ASSISTANT SECRETARY OF THE ARMY, CIVIL WORKS, DEPARTMENT OF DEFENSE

TRANSMITTING

THE DEPARTMENT'S HEREFORD INLET TO CAPE MAY INLET FINAL FEASIBILITY REPORT AND INTEGRATED ENVIRONMENTAL ASSESSMENT DATED APRIL 28, 2014

FEBRUARY 25, 2016.—Referred to the Committee on Transportation and Infrastructure and ordered to be printed

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DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

DEC - 1 2016

Honorable Paul Ryan
Speaker of the House of Representatives
U.S. Capitol Building, Room H-232
Washington, DC 20515-0001

Dear Mr. Speaker:

In response to a resolution by the Committee on Transportation and Infrastructure of the United States House of Representatives, adopted December 1987 and by the Committee on Environment and Public Works of the United States Senate dated December 1987, and in response to the Disaster Relief Appropriations Act of 2013 Public Law (P.L.) 113-2, the Secretary of the Army recommends a coastal storm damage reduction project for Hereford Inlet to Cape May Inlet, New Jersey. Initial construction will be undertaken under the authority of, and using funds provided in, PL 113-2. The proposal described in the Report of the Chief of Engineers, dated January 23, 2015, recommends authorization of periodic nourishment and any initial construction that will not be completed using PL 113-2 funding. The Secretary of the Army plans to implement periodic nourishment at the appropriate time, considering National priorities and the availability of funds.

The project study was conducted to analyze and formulate plans for reducing coastal storm damages in the coastal communities located between Hereford Inlet and Cape May Inlet, Cape May County, New Jersey, resulting from Super Storm Sandy. The recommended plan is the National Economic Development plan.

The plan consists of dune and berm construction using sand obtained from an on-shore beach borrow source located at the southern end of Five Mile Island (the Wildwoods). It extends approximately 4.5 miles from Hereford Inlet to Cape May Inlet and will encompass the towns of North Wildwood, Wildwood, Wildwood Crest and Lower Township. The plan includes the planting of approximately 64 acres of dune grass, 28,000 linear feet of sand fence, 44 extended crossovers, seven new pedestrian crossovers, seven extended handicap crossovers, six new handicap crossovers, eight existing vehicle crossover extensions and five new vehicular crossovers. The sand will be pumped from the southern borrow area using mobile back-passing technology to hydraulically pump sand from the Wildwood and Wildwood Crest borrow source to the placement area. Initial construction for the project will remove approximately 1,527,000 cubic yards (cy) of sand from the approved borrow zone, which includes a design quantity of 1,136,000 cy and advanced nourishment of 391,000 cy. Periodic nourishment is included in project design to maintain the integrity of the design beach template over the project period of analysis. Nourishment requirements were determined by considering losses resulting from diffusion of the design beach fill

planform and natural background erosion. Following the initial construction, approximately 391,000 cy of material will be back-passed every four years throughout the 50-year period of analysis for the periodic nourishment of the selected plan. The material will be placed in the same borrow area as used in the initial construction. Since the project would not have any significant adverse effects, no mitigation measures (beyond management practices and avoidance) or compensation measures would be required.

Based on October 2015, (FY 2016) price levels, the total nourishment cost is estimated at $107,505,000 composed of the first cost of initial construction estimated $22,321,000 and a total of 12 periodic nourishments estimated at $85,184,000. The cost of lands, easements, rights-of-way, relocations, and dredged or excavated material disposal (LERRD) is estimated at $1,350,000. The total estimated project cost includes monitoring costs estimated to average about $143,000 over the 50-year period for a total of $7,150,000. The operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) costs of the project after construction are estimated at about $155,000 per year.

The New Jersey Department of Environmental Protection (NJDEP) is the non-Federal cost sharing sponsor for all features. Cost sharing is applied in accordance with the provisions of section 103 of the Water Resources Development Act (WRDA) of 1986, as amended by section 215 of WRDA 1999, and is apportioned as follows: 1) Initial construction of the shore protection features are cost-shared at a rate of 65 percent Federal (or $14,509,000) and 35 percent non-Federal (or $7,812,000), which includes LERRD costs; 2). Periodic nourishment is cost shared 50 percent Federal and 50 percent non-Federal. Periodic nourishment costs are expected to be $6,204,000 for year 4 and 8, and $6,454,000 every four years thereafter, except in year 24, which assumes major nourishment is required at a cost of $8,257,000. In addition, nourishment activities include monitoring costs estimated to average about $143,000 over the 50-year period for a total of $7,150,000; 3) The NJDEP would be responsible for all OMRR&R of the project after construction, with an average annual cost currently estimated at $155,000 over the 50-year period of analysis. The non-Federal sponsor will receive credit for the costs of LERRD toward the non-Federal share.

Based on FY 2016 price levels, a 3.125 percent discount rate, and a 50-year period of analysis, the total equivalent average annual costs of the project are estimated to be $2,758,000, including monitoring and OMRR&R. The equivalent average annual benefits are estimated to be $6,461,000 with net average annual benefits of $3,703,000. The benefit-to-cost ratio is approximately 2.3 to 1. The project would reduce overall average annual coastal storm damages by about 41% and average annual damages attributed to wave attack and rapid erosion, by about 69%.

An Environmental Assessment (EA) was prepared in accordance with the National Environmental Policy Act. The recommended plan has been identified as the environmentally preferred plan. Adverse environmental impacts have been avoided and minimized where practicable. The EA resulted in a Finding of No Significant Impact to

the environment, therefore, preparation of an Environmental Impact Statement is not required. No compensatory mitigation is required.

The Independent External Peer Review was completed by Battelle Memorial Institute. The review comments resulted in expanded narratives throughout the report to support the decision-making process and justify the recommended plan. All comments from the above referenced reviews have been addressed and incorporated into the final documents.

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress, but that the project would need to compete with other proposed investments for funding in future budgets. A copy of OMB's letter dated January 21, 2016, is enclosed. I am providing a copy of this transmittal and the OMB letter to the Subcommittee on Water Resources and Environment of the House Committee on Transportation and Infrastructure, and the Subcommittee on Energy and Water Development of the House Committee on Appropriations. I am also providing an identical letter to the President of the Senate.

Very truly yours,

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

Enclosures

8 Enclosures

1. OMB Clearance letter, dated January 21, 2016
2. Finding of No Significant Impact, signed January 25, 2016
3. Chief's Report, January 23, 2015
4. Letter from Department of the Interior, Nov 17, 2014
5. Letter from the Environmental Protection Agency, Nov 13, 2014
6. Sponsor Letter of Intent, April 9, 2014
7. Project Slides
8. Hereford Inlet to Cape May Inlet Final Feasibility Report and Integrated Environmental Assessment, April 2014 (CD)

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

January 21, 2016

The Honorable Jo-Ellen Darcy
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon
Washington, DC 20310-0108

Dear Ms. Darcy:

As required by Executive Order 12322, the Office of Management and Budget has reviewed an April 2014 Army Corps of Engineers (Corps) feasibility study of the Hereford Inlet to Cape May Inlet, New Jersey, with a first cost of $21,794,000 (October 2014 price level) and a total cost of $104,966,000 (October 2014 price level). According to the Corps' report, the recommended project addresses wave and inundation damage, as well as erosion and municipal drainage issues, which are not part of the Corps' primary mission areas.

Based on an analysis of costs and benefits, the Corps estimated that the benefit-cost ratio for the project is 2.30 to 1 at a discount rate of 3.375 percent, which is the discount rate that the Corps is required to use for FY 2014 under section 80 of the Water Resources Development Act of 1974 to evaluate and formulate its proposed water resources projects. According to the Corps, the equivalent benefit-cost ratio is 1.90 to 1 at a seven percent discount rate. The coastal storm damage reduction portion of the project has a BCR of 1.58 to 1 at the seven percent discount rate. This is the discount rate that the Administration uses in the Budget to measure the performance of Corps construction projects whose primary purpose is to provide an economic return to the Nation.

The Office of Management and Budget does not object to you sending this report to the Congress. When you do so, please advise the Congress that this project, like all civil works projects, will need to compete with other proposed investments for funding in future budgets.

Sincerely,

John Pasquantino
Deputy Associate Director
Energy, Science, and Water

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

The United States Army Corps of Engineers, Philadelphia District, (Corps) has conducted an environmental analysis of the construction of the Hereford Inlet to Cape May Inlet Storm Damage Reduction Project in accordance with the National Environmental Policy Act of 1969, as amended. The Corps assessed the effects of the recommended plan in the Final Feasibility Report and Integrated Environmental Assessment, dated 28 April 2014, which is incorporated herein by reference:

- Construct a dune and berm extending approximately 4.5 miles from Hereford Inlet to Cape May Inlet using sand obtained from an onshore beach borrow source located at the southern end of Five Mile Island (the Wildwoods). The dune and berm will encompass the towns of North Wildwood, Wildwood, Wildwood Crest and Lower Township;
- Plant approximately 64 acres of dune grass;
- Construct 28,000 linear feet of sand fence, 44 extended crossovers, seven new pedestrian crossovers, seven extended handicap crossovers, six new handicap crossovers, eight existing vehicle crossover extensions and five new vehicular crossovers;
- Pump sand from the southern borrow area using mobile back-passing technology to hydraulically pump sand from the Wildwood and Wildwood Crest borrow source to the placement area;
- Remove approximately 1,527,250 cubic yards (cy) of sand from the approved borrow zone as part of initial construction, which includes a design quantity of 1,136,000 cy and advanced nourishment of 391,000 cy;
- Periodically nourish the beach to maintain the integrity of the design beach template over the project period of analysis. Nourishment requirements were determined by considering losses resulting from diffusion of the design beach fill planform and natural background erosion;
- Back-pass approximately 391,000 cy of material every four years after initial construction throughout the 50-year period of analysis for the periodic nourishment of the selected plan. The material will be taken from the same borrow area and placed in the same location as the initial construction;

The recommended plan was identified as the National Economic Development (NED) plan and is the environmentally-preferred alternative. All practicable means to avoid and minimize adverse environmental effects have been incorporated into the recommended plan. No compensatory mitigation is required.

Consistent with the programmatic Biological Opinion issued by the U.S. Fish and Wildlife Service (USFWS) in December 2005, the hydraulic back-passing of sand from Wildwood and Wildwood Crest for beach nourishment and restoration activities in North Wildwood, Wildwood, Wildwood Crest and Lower Township would not likely jeopardize the continued existence of any species or the critical habitat of any fish, wildlife, or plant, which is designated as endangered or threatened pursuant to the Endangered Species Act of 1973, as amended by P.L. 96-159. As required by the Biological Opinion, the Corps will undergo individual (Tier 2) consultation with USFWS prior to initial construction and each periodic nourishment cycle.

Pursuant to Section 401 of the Clean Water Act, a 401 Water Quality Certificate was obtained from the New Jersey Department of Environmental Protection (NJDEP). Based on the information developed during preparation of the EA, it was determined in accordance with Section 307 (C) of the Coastal Zone Management Act of 1972 that the plan complies with and can be conducted in a manner that is consistent with the approved Coastal Zone Management Program of New Jersey. A Federal Consistency Determination and Water Quality Certificate were received from NJDEP on 7 March 2014.

There are no known properties listed on, or eligible for listing on, the National Register of Historic Places that would be affected by the proposed activity. The plan has been designed to avoid archaeologically sensitive areas, and is therefore not expected to impact any cultural resources. The New Jersey State Historic Preservation Office concurred with this determination in a letter dated 26 December 2013.

General Conformity under the Clean Air Act, Section 176 has been evaluated for the project according to the requirements of 40 CFR 93, Subpart B. The requirements of this rule are not applicable to this project because the total emissions from the project are below the conformity threshold values established at 40 CFR 93.153(b) for ozone (NOx and VOCs) in a marginal nonattainment area (100 tons of NOx and 50 tons of VOCs per year).

Technical and economic criteria used in the formulation of alternative plans were those specified in the Water Resource Council's 1983 Economic and Environmental Principles for Water and Related Land Resources Implementation Studies. All applicable laws, executive orders, regulations, and local government plans were considered in the evaluation of the alternatives. It is my determination that the recommended plan does not constitute a major federal action that would significantly affect the human environment; therefore, preparation of an Environmental Impact Statement is not required.

1/25/16
Date

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

DEPARTMENT OF THE ARMY
CHIEF OF ENGINEERS
2600 ARMY PENTAGON
WASHINGTON, DC 20310-2600

DAEN (1105-2-10a) JAN 2 3 2015

SUBJECT: New Jersey Shore Protection, Hereford Inlet to Cape May Inlet, New Jersey

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on the study of hurricane and storm damage reduction for coastal communities located between Hereford Inlet and Cape May Inlet, Cape May County, New Jersey. It is accompanied by the report of the district and division engineers. This report is an interim response to a resolution by the Committee on Transportation and Infrastructure of the United States House of Representatives, adopted December 1987 and by the Committee on Environment and Public Works of the United States Senate dated December 1987 and an interim response to PL 113-2, the Disaster Relief Appropriations Act. The resolutions requested the Secretary of the Army 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. Preconstruction engineering and design activities for the Hereford Inlet to Cape May Inlet, New Jersey, project will continue under the study authority cited above. The Corps of Engineers intends to undertake initial construction of the project under the authority of, and using funds provided in, PL 113-2. I am recommending that the Congress authorize periodic nourishment and any initial construction of the project that will not be completed using PL 113-2 funds.

2. The reporting officers recommend authorization of the National Economic Development Plan that consists of a dune and berm construction using sand obtained from an onshore beach borrow source located at the southern end of Five Mile Island (the Wildwoods). The recommended plan extends approximately 4.5 miles from Hereford Inlet to Cape May Inlet and will encompass the towns of North Wildwood, Wildwood, Wildwood Crest and Lower Township. Dimensions of the project are a +16-foot North American Vertical Datum 1988 (NAVD88) dune, with a 25-foot wide dune crest on a 75- foot wide berm that is +6.5-foot NAVD88 in elevation within North Wildwood, Wildwood, Wildwood Crest and Lower Township. Side slopes for the dune will be 1V:5H and slopes for the berm will be 1V:30H. The plan includes approximately 64 acres of dune grass, 28,000 linear feet of sand fence, 44 extended crossovers, seven new pedestrian crossovers, seven extended handicap crossovers, six new handicap crossovers, eight existing vehicle crossover extensions and five new vehicular crossovers. The sand will be pumped from the southern borrow area using mobile back-passing technology to hydraulically pump sand from the Wildwood and Wildwood Crest borrow source to the placement area. Initial construction for the project will remove approximately 1,527,250 cubic yards (cy) of sand from the approved borrow zone, which includes a design quantity of 1,136,000 cy and advanced nourishment of 391,000 cy. Periodic nourishment is included in project design to maintain the integrity of the design beach template over the project period of analysis. Nourishment requirements were

determined by considering losses resulting from diffusion of the design beach fill planform and natural background erosion. Following the initial construction, approximately 391,000 cy of material will be back-passed every four years throughout the 50-year period of analysis for the periodic nourishment of the selected plan. Since the recommended plan would not have any significant adverse effects, no mitigation measures (beyond management practices and avoidance) or compensation measures would be required.

3. The New Jersey Department of Environmental Protection (NJDEP) is the non-federal cost sharing sponsor for all features. Based on a March 2014 price level, the estimated total nourishment cost is $104,030,000, which includes the project first cost of initial construction of $21,600,000 and a total of 12 periodic nourishments at a total cost of $82,430,000. Cost sharing is applied in accordance with the provisions of Section 103 of the Water Resources Development Act (WRDA) of 1986, as amended by Section 215 of WRDA 1999, as follows:

a. Shore protection features are cost-shared at a rate of 65 percent federal and 35 percent non-federal for the initial construction. Thus the federal share of the project first cost is $14,040,000 and the non-federal share is estimated at $7,560,000 which includes the costs of land, easements, rights-of-way, relocations, and dredged or excavated material disposal areas (LERRD). LERRD costs are estimated at about $1,270,000. The non-federal sponsor will receive credit for the costs of LERRD toward the non-federal share.

b. Periodic nourishment will be cost shared 50 percent federal and 50 percent non-federal. It is expected to have costs of $5,950,000 for year 4 and 8, and $6,190,000 every four years thereafter, except in year 24, which assumes major nourishment is required at a cost of $7,920,000. In addition, nourishment activities include monitoring costs estimated to average about $138,000 over the 50-year period for a total of $6,900,000.

c. The NJDEP would be responsible for the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project after construction, an average annual cost currently estimated at $150,000 over the 50-year period of analysis.

4. Based on a 3.375-percent discount rate and a 50-year period of analysis, the total equivalent average annual costs of the project are estimated to be $2,669,000, including monitoring and OMRR&R. All project costs are allocated to the authorized purpose of shoreline protection. The recommended plan has average annual benefits of $6,252,000. The net national economic development (NED) benefits of the project are $3,583,000 and the benefit to cost ratio (BCR) is 2.3. In addition to providing protection from coastal storms, the dunes and berm create habitat for bird nesting and coastal plant species. The 64 acres of Cape American Beach Grass has the potential to develop into a more diverse plant community in a stable dune system. This project should benefit the piping plover habitat in the North Wildwood by stabilizing the beaches through regular periodic nourishment and improve the overall quality of the beach habitat.

5. Risk and uncertainty has been explicitly factored into the economic analysis of this project. Chapter 6 of ER 1105-2-100, entitled "Risk Based Analysis for Evaluation of Hydrology/Hydraulics and Economics in Shore Protection Studies" specifies the analysis requirements for shore protection projects, the fundamental requirement being that all shore protection analyses adopt a life cycle approach. A risk and uncertainty analysis that incorporated key economic, hydraulic and sea level change parameters was preformed for the feasibility study. This risk and uncertainty plan was peer reviewed by the Jacksonville District of the Army Corps of Engineers and approved by North Atlantic Division. The project is not intended to, nor will it, reduce risk to loss of life during major storm events. Loss of life can only be prevented by residents and visitors following the local evacuation plans that are already in place. These residual risks have been communicated to the NJDEP.

6. In accordance with the Corps of Engineering Circular (EC 1165-2-212) on sea level change, the study performed a sensitivity analysis to look at the effects that different rates of accelerated sea level rise could have on the recommended plan. The plan was formulated using a historical or low rate of sea level rise of 0.013 feet/year. The sensitivity analysis used additional accelerated rates, which includes what the EC defines as intermediate and high rates of 0.023 feet/year and 0.056 feet/year, respectively. The analysis found that the influence of current sea level rise on the project is relatively low as compared to other factors causing erosion (waves, currents, winds and storms). The magnitude of the short-term storm induced erosion during hurricane events have a much greater effect along the New Jersey coastline than those indicated by the natural long term shoreline trends. Adaptive management will be used including monitoring and adding additional volume of sand during periodic nourishments to compensate for significant accelerated sea level rise beyond the current observed rate should it become necessary.

7. In accordance with the Corps of Engineers Circular (EC 1165-2-214) on the review of decision documents, all technical, engineering and scientific work underwent an open, dynamic and rigorous review process to ensure technical quality. This includes a District Quality Control review, an Agency Technical Review (ATR), an Independent External Peer Review (IEPR) (Type 1), and a Corps Headquarters policy and legal review. The IEPR was completed by Battelle Memorial Institute. All comments from the above referenced reviews have been addressed and incorporated into the final documents. Overall, the reviews resulted in improvements to the technical quality of the report.

8. Washington level review indicates that the project recommended by the reporting officers is technically sound, environmentally and socially acceptable, and economically justified. The plan complies with all essential elements of the U.S. Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Land related resources implementation studies and complies with other administrative and legislative policies and guidelines. Also, the views of interested parties, including federal, state and local agencies have been considered. During the State and Agency (S&A) review, comments were received from the U.S. Environmental Protection Agency (EPA) and the Department of the Interior (DOI). Other

agencies indicated they either had no comments or provided none. The EPA reiterated a comment on the draft report concerning the potential for erosion at dune cross over locations due to their alignment. The Corps responded that the final report had addressed the concern, and the seaward side of all of the vehicular and pedestrian crossovers would be constructed at an angle to the dune, not perpendicular, in order to enhance dune resiliency. The DOI commented on the consideration given to borrow from the inlet area and the potential listing of the Red Knot as a threatened species under the Endangered Species Act. The Corps responded that the recommended plan has no borrow from the Hereford Inlet. The Corps has been engaged in Endangered Species Act consultation with the U.S. Fish and Wildlife Service (FWS) regarding the red knot, which was listed as a threatened species following receipt of the DOI S&A comments. The district will coordinate any potential impacts related to this coastal project with the FWS and incorporate protection measures into the project plan as the design phase continues.

9. I generally concur in the findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend that the periodic nourishment associated with the project to reduce hurricane and storm damages for Hereford Inlet to Cape May Inlet, New Jersey and any initial construction of the project that will not be completed with PL 113-2 funds be authorized in accordance with the reporting officers' recommended plan, with such modifications as in the discretion of the Chief of Engineers may be advisable. The estimated cost of the project is $104,030,000, which includes an estimated total cost for periodic nourishment of $82,430,000 for 12 cycles of periodic nourishment and an estimated total cost of $21,600,000 for initial construction that would be reduced by any initial construction undertaken using PL 113-2 funds. My recommendation is subject to cost sharing, financing, and other applicable requirements of federal laws and policies, including Section 103 of the Water Resources Development Act (WRDA) of 1986, as amended by Section 215 of WRDA 1999. This recommendation is subject to the non-federal sponsor agreeing to comply with all applicable federal laws and policies, including that it will:

a. Provide a minimum of 35 percent of initial project costs assigned to coastal 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 coastal storm damage reduction, plus 100 percent of periodic nourishment costs assigned to protecting undeveloped private lands and other private shores which do provide public benefits, and as further defined below:

1) Provide all lands, easements, and rights-of-way, including suitable borrow areas, and perform or ensure performance of all relocations determined by the federal government to be necessary for the initial construction, periodic nourishment, operation, and maintenance of the project;

2) Provide during construction any additional amounts 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;

b. Operate, maintain, repair, replace, and rehabilitate 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 inspection, and, if necessary, after failure, to perform by the non-federal sponsor, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating 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, except for damages due to the fault or negligence of the United States or its contractors;

e. 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;

f. Assume complete financial responsibility, as between the federal government and the non-federal sponsor 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;

g. 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, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA

h. Participate in and comply with applicable federal floodplain management and flood insurance programs.

i. 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 use of such funds for the project is authorized;

j. Prevent obstructions of or encroachment on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) which might reduce the level of protection it affords, hinder operation and maintenance or future periodic nourishment, or interfere with its proper function, such as any new developments on project lands or the addition of facilities which would degrade the benefits of the project;

k. Not less than once each year, inform affected interests of the extent of protection afforded by the project;

l. 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;

m. For so long as the project remains authorized, ensure continued conditions of public ownership and use of the shore upon which the amount of federal participation is based;

n. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms; and

o. 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.

10. The recommendation contained herein reflects the information available at this time and current departmental policies governing the formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program or the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to Congress as a

DAEN
SUBJECT: New Jersey Shore Protection, Hereford Inlet to Cape May Inlet, New Jersey

proposal for authorization and implementation funding. However, prior to transmittal to Congress, the sponsor, the state, interested federal agencies, and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

THOMAS P. BOSTICK
Lieutenant General, USA
Chief of Engineers

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, DC 20240

NOV 17 2014

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PEP/NRM

ER 14/683

Mr. Theodore A. Brown, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works
U.S. Army Corps of Engineers
CECW-P (SA)
7701 Telegraph Road
Alexandria, VA 22315-3860

RE: Proposed Chief of Engineers and the Report of the District Engineer on the New Jersey Shore Protection Project

Dear Mr. Brown:

The U.S. Department of the Interior (Department) has reviewed the U.S. Army Corps of Engineers (Corps), Chief of Engineers Report and District Engineers Report to include the Final Feasibility Report and Environmental Assessment for the New Jersey Shore Protection Project, Hereford Inlet to Cape May Inlet.

General Comments

The Corps is authorized under the Water Resources Development Act 1986 (PL 99-662) and other Federal authorities to provide storm damage reduction, beach restoration, and water quality improvements from Hereford Inlet to Cape May Inlet, Cape May County, New Jersey (study area). Although the study area extends from Hereford Inlet to Cape May Inlet, no activities will be conducted on Hereford Inlet beaches north of the terminal jetty, at the Cape May Inlet, on the Cape May National Wildlife Refuge Two-Mile Beach, or at the U.S. Coast Guard's LORAN facility.

The project area exhibits several different coastal issues. The North Wildwood portion of the project area is prone to moderate to severe erosion, leaving the surrounding community vulnerable to storm damages. The beaches of Wildwood and Wildwood Crest have been accreting large quantities of sand, resulting in human health and water quality concerns due to clogged outfall pipes on the beach. The selected plan being proposed for the project includes "back-passing" sand, using mobile hydraulic dredges located in the surf zones from Wildwood to

"back-passing" sand, using mobile hydraulic dredges located in the surf zones from Wildwood to North Wildwood and changing the beach configuration in Wildwood by increasing berm height and adding a dune.

Specific Comments

The Hereford Inlet is listed as a potential borrow area (sub-areas H-1, H-2, H-3, and H-4) for the initial cycle of beach re-nourishment within the study area. Using Federal funds, the inlet sand was also used by the Corps to re-nourish nearby beaches in Stone Harbor as recently as 2013 and was extensively studied by the Corps with vibracore technology from 1994 to 2007. The Coastal Barrier Resource Act (CBRA) (16 U.S.C. § 3594(a)) specifically prohibits federal expenditures and financial assistance for the following activities within units of the Coastal Barrier Resource System (CBRS): "the construction or purchase of any structure, appurtenance, facility, or related infrastructure", "the construction or purchase of any road, airport, boat-landing facility, or other facility on, or bridge or causeway to, any System unit", and "the carrying out of any project to prevent the erosion of, or to otherwise stabilize, any inlet, shoreline, or inshore area with limited exceptions."

According to the official CBRS map for the area (Stone Harbor Unit NJ-09/NJ-09P dated July 12, 1996), the proposed sand borrow sub-areas of Hereford Inlet are located within System Unit NJ-09 of the CBRS. Therefore, it is necessary to clarify the issue of federally funded vibracore studies and beach nourishment activities and in relation to CBRA, specifically the assessment and removal of sand resources from within a unit of the CBRS for placement outside of the CBRS for beach re-nourishment. According to a previous clarification (enclosed) from the Department's Office of the Solicitor and by then U.S. Fish and Wildlife Service (FWS) Deputy Director Richard N. Smith, federal expenditures are prohibited in such cases (*i.e.*, when the shoreline stabilization project falls outside the CBRS unit).

Additional information is provided in the enclosed memorandum signed by the Federal Emergency Management Agency and the Corps in January 2013 outlining the Federal Interagency Floodplain Management Task Force's (FIFM Task Force) Consensus Recommendations and Actions from a Federal Floodplain Management Policy Analysis. Please note that the FIFM Task Force identified enhancing CBRA compliance across all Federal agencies as a recommended action on page 2 of the memorandum. We recommend that the Corps request a determination pursuant to the CBRA for any proposed activity involving the use of federal funds within Unit NJ-09 of the CBRS (Hereford Inlet).

The FWS developed an online mapper that depicts the approximate boundaries of the CBRS to assist Federal agencies in complying with the provisions of CBRA. The CBRS mapper and additional information on the CBRA consistency consultations process for proposed projects can be found on the FWS's CBRA website at: http://www.fws.gov/cbra.

In the subject report (page 308, Volume 1), the Corps refers to the red knot (*Calidris canutus rufa*) as a "Federally listed Candidate" that "will be present during construction activities . . . and will easily be able to move away from the construction activities to another portion of the beach where they will not be disturbed." We note that a proposed rule to list the *rufa* subspecies as threatened under the Endangered Species Act of 1973 (ESA) (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) was published on September 30, 2013. The FWS will make a final decision on the 2013 proposal to list the *rufa* subspecies as threatened under the ESA by November 28, 2014. Therefore, the proposed activities by the Corps will occur within documented foraging and roosting habitat of the red knot and may result in harassment of a federally listed species.

Federal regulation pursuant to Section 4(d) of the ESA, prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. Harm is further defined by the FWS to include significant habitat modification or degradation that results in the death or injury to listed species by significantly impairing essential behavioral patterns such as breeding, feeding, or sheltering. Harass is defined by the FWS as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns, which include, but are not limited to, breeding, feeding, or sheltering.

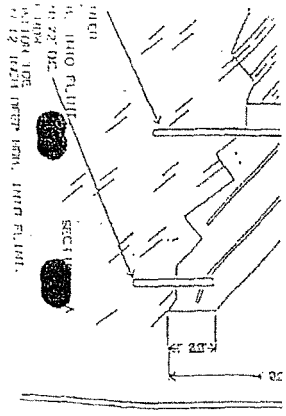
Pursuant to Section 7(a)(1) of the ESA, all Federal agencies shall, in consultation with and with the assistance of the Secretary of the Interior, utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species.

For any questions regarding these comments, and for further coordination related to the CBRA, fish and wildlife resources, or federally-listed threatened or endangered species, please contact Mr. Carlo Popolizio, FWS, New Jersey Field Office, (609) 383-3938, ext. 32; or email carlo_popolizio@fws.gov.

Sincerely,

Willie R. Taylor
Director, Office of Environmental Policy
and Compliance

Enclosures



In Reply Refer To:
FWS/DHC/BCWR

Memorandum

To: Regional Director, Regions 2, 3, 4, and 5

From: Director

Subject: Interpretation of Section 6 of the Coastal Barrier Improvement Act of 1990

A recent consultation submitted to the Service from the U.S. Army Corps of Engineers pursuant to Section 6 of the Coastal Barrier Resources Act (Act) has required clarification from the Department of the Interior's Office of the Solicitor regarding Federally funded beach nourishment activities (Attachment). More specifically, the issue involves removing sand materials from within a unit of the Coastal Barrier Resources System (System) for placement outside of the unit for erosion control measures.

Section 6 of the Act sets forth several exceptions to the general prohibition in section 5 against Federal expenditures affecting the System. The exception in section 6(a)(6)(G) is for "Nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore, natural stabilization systems" and that are also consistent with the purposes of the Act. The Department's Office of the Solicitor has carefully reviewed this issue and has advised us that section 6(a)(6)(G) applies only to projects for stabilizing the shoreline of a unit of the System; it does not apply to projects to stabilize shoreline outside the System regardless of whether the project might be consistent with the purposes of the Act. Therefore, any proposed Federal action designed to nourish beaches located outside the System using beach material taken from within the System does not meet the criteria for a section 6(a)(6)(G) exception.

If you have any questions regarding this matter please contact Linda Kelsey of my staff at (703) 358-2201.

RICHARD N. SMITH

Attachment
cc: 3012-MIB-FWS/Directorate Reading File
3012-MIB-FWS/CCU
3012-MIB-FWS/AEA Files
3024-MIB-FWS/AES Files
400-ARLSQ-FWS/DHC Files
412-ARLSQ-FWS/DHC/BCWR Files
FWS/DHC/BCWR/LKelsey:bg:06/20/94:(703)358-2201
Q:\DHC\KELSEY\SECT6.MEM

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington, D.C. 20240

ADDRESS ONLY THE DIRECTOR,
FISH AND WILDLIFE SERVICE

In Reply Refer To:
FWS/DHC/BCWR

JUN 0 2 1994

Major General Stanley G. Genega
Directorate of Civil Works
U.S. Army Corps of Engineers
20 Massachusetts Avenue, N.W.
Washington, D.C. 20314-1000

Dear General Genega:

It has come to my attention that some clarification is necessary on the issue of Federally funded beach nourishment activities in relation to the requirements of the Coastal Barrier Resources Act (Act). More specifically, the issue involves removing sand materials from within a unit of the Coastal Barrier Resources System (System) for placement outside of the unit for erosion control measures.

Section 6 of the Act sets forth several exceptions to the general prohibition in section 5 against Federal expenditures affecting the System. The exception in section 6(a)(6)(G) is for "Nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore, natural stabilization systems" and that are also consistent with the purposes of the Act. The Department of the Interior's Office of the Solicitor has carefully reviewed this issue and has advised us that section 6(a)(6)(G) applies only to projects for stabilizing the shoreline of a unit of the System; it does not apply to projects to stabilize shoreline outside the System regardless of whether the project might be consistent with the purposes of the Act. Therefore, any Corps' proposed action designed to nourish beaches located outside the System using beach material taken from within the System does not meet the criteria for a section 6(a)(6)(G) exception. The Department's Office of the Solicitor has reviewed this issue and this specific correspondence and fully concurs with our position on this matter.

A specific example of where this issue has arisen is relative to the Corps of Engineers proposed action for the use of a sand borrow area (Borrow Area #3) within Unit N01, Little Tybee Island, of the Coastal Barrier Resources System for a beach nourishment project outside of Unit N01. The U.S. Fish and Wildlife Service's Atlanta Regional Director wrote to your agency on April 5, 1994, expressing support for the formal opinion provided to the Corps of Engineers on August 2, 1993, by our Brunswick Field Office regarding your consultation request under the Act. The Atlanta Regional Director also supports the comments provided to your agency on the Joint Public Notice, dated February 14, 1994, and the Draft Environmental Assessment for the Tybee Island, Georgia Beach Erosion Control Project

Section 934 Revaluation Report. This proposed action does not meet the criteria for a section 6(a)(6)(G) exception.

Moreover, the Service believes the proposed project would not be consistent with the purposes of the Act. These purposes are to minimize the loss of human life, wasteful expenditure of Federal revenues, and damage to fish, wildlife, and other natural resources associated with units of the Coastal Barrier Resources System. Use of this site would cause damage to the fish, wildlife, and other natural resources associated with Unit N01, Little Tybee Island.

Taking sand from Borrow Area #3 is likely to cause erosion to the beaches of Little Tybee Island. This area has been identified as important habitat for migratory birds and the federally protected loggerhead sea turtle and piping plover. In addition, the nearshore tidal portions of this site are important spawning, nursery and habitat areas for estuarine larvae, shellfish, and juvenile fish, including Georgia's number one sportfish, the spotted seatrout. Negative impacts to these species include increased turbidity, physical changes in tidal currents or channel locations that could affect migration of these organisms. Furthermore, Little Tybee Island has been designated as a Natural Heritage Preserve to protect the natural, historical, and cultural values for the benefit of the public.

Relative to the Little Tybee Island proposed project, I support the position of our Field and Regional Offices. I strongly recommend that the Corps find an alternative borrow site. The Service has previously stated that Borrow Areas #1 and #2, which are located outside the System and which the Corps identified as possible alternative sites, would be acceptable to the Service, provided adequate testing is done to ensure that these areas contain suitable beach material.

With respect to this issue in general, please clarify this issue for your Divisions and Districts. Thank you for your cooperation on this matter.

Sincerely,

Richard N. Smith

Deputy DIRECTOR

IDENTICAL LETTER SENT TO:
Colonel Wayne W. Boy, Savannah District

Federal Emergency Management Agency

Assistant Secretary of the Army (Civil Works)

TO: Federal Interagency Floodplain Management Task Force Member Agencies

SUBJECT: FIFM Task Force Consensus Recommendations and Actions from a Federal Floodplain Management Policy Analysis

The Federal Interagency Floodplain Management (FIFM) Task Force was formed to promote, support, and encourage Federal agencies to formulate and implement programs and policies that: 1) reduce the loss of life and property caused by floods; and 2) protect and restore natural resources and functions of floodplains. It does this primarily through improving coordination, collaboration, and transparency among the federal agencies in floodplain management efforts; conducting studies of floodplain management activities; and improving alignment of federal programs.

The Task Force has already made progress in carrying out this mission. Specifically, it has:

- Convened a listening session with key stakeholders to identify and refine floodplain management issues and priorities.
- Developed guidance for Federal agencies on unwise use of floodplains.
- Conducted research on policies and programs that promote or interfere with good floodplain management practices.
- Made numerous presentations at floodplain and flood risk management events to exchange information relevant to the work of the Task Force.

The Task Force has also provided a forum for enhanced coordination and action on the part of individual member agencies. For example:

- U.S. Army Corps of Engineers (Corps) and Federal Emergency Management Agency (FEMA) have jointly resolved several policy conflicts, including accounting for the National Flood Insurance Program requirements of 44 CFR 65.12 during Corps evaluation of flood risk management projects in the floodplain. Guidance has been distributed to the field offices of both agencies through jointly signed memorandums.
- The Corps has coordinated its Flood Risk Management and Silver Jackets Programs with FEMA's Community Rating System Program to encourage and assist communities in taking responsible steps to better manage their flood risk.
- FEMA and the U.S. Fish and Wildlife Service (FWS) have updated an existing Interagency Agreement to place Coastal Barrier Resources System (CBRS) boundaries on Flood Insurance Rate Maps (FIRMs) and established a new Interagency Agreement to facilitate a digital conversion of the official CBRS maps and make changes that are necessary as a result of erosion and accretion.

At its meeting on July 27, 2012, the FIFM Task Force identified several opportunities and activities to enhance floodplain management efforts at various levels of government and to help agencies become better stewards of public resources. These activities were developed collaboratively by the Working Group of the Task Force, an interagency group with 19 representatives from the following agencies:

- U.S. Army Corps of Engineers
- Federal Emergency Management Agency
- National Oceanic and Atmospheric Administration
- U.S. Environmental Protection Agency
- U.S. Department of Transportation
- Tennessee Valley Authority
- U.S. Department of the Interior
- U.S. Department of Agriculture
- U.S. Department of Defense
- U.S. Department of Housing and Urban Development
- General Services Administration
- White House Council on Environmental Quality (Advisor)

Some of these activities are recommendations to one or more federal agencies. Others describe actions that the Task Force will take and incorporate into its overall work plan to be carried out over the next 3-4 years. Some activities will involve further action by numerous federal agencies, while others are informational in nature. These opportunities and activities are categorized into four areas and are described below.

Compliance

- **Enhance Coastal Barrier Resources Act (CBRA) Compliance.** Federal agencies operating under CBRA (16 U.S.C. 3501 et seq.), are required to comply with its provisions, which are designed to restrict federal expenditures and financial assistance in the development of coastal barriers designated as part of the CBRS. Section 3506(b) of CBRA also requires that each federal agency affected by CBRA report and certify annually to the Department of the Interior (DOI) that the agency is in compliance with the law. Federal agencies have not issued such certifications in recent years. DOI will issue a memorandum to federal agencies to remind them of their obligations under CBRA and request that they provide DOI with an annual letter certifying their compliance with the law, as appropriate. The Task Force recommends that federal agencies respond to DOI's request to help raise awareness about CBRA requirements and ensure that sufficient policies and protocols are in place to prevent the inappropriate provision of federal financial assistance within the CBRS.

- **Assess and Enhance Executive Order (EO) 11988 Compliance.** A recent study conducted by the Task Force indicated that implementation of *Executive Order 11988: Floodplain Management* may not be consistent across the federal government. Effective and consistent implementation of the EO will save lives and property, reduce the economic and environmental impacts of flooding in communities, and reduce costs to taxpayers across the country. Given the impacts of more extreme precipitation events anticipated as a result of climate change, flood losses will likely increase, thus further highlighting the importance of EO 11988. To address this issue, the Task Force will draft a memorandum for CEQ's consideration and issuance, requesting federal agencies that have adopted regulations and implementing guidance to assess their EO compliance and effectiveness of compliance and to take appropriate action where necessary. The Task Force will work with CEQ to assess responses.

Tools/Technology/Data

- **Modernize Coastal Barrier Resource System (CBRS) Maps.** Many of the maps that delineate CBRS boundaries require updates in light of natural changes to the system that occur over time and to be consistent with current technology. Digitizing and modernizing these maps will help all federal agencies responsible for CBRA compliance as well as developers, surveyors, planners, floodplain managers, realtors and other stakeholders who need to know the exact location of the CBRS unit boundaries. Homeowners, in particular, will have a clearer understanding of whether their property is located within the CBRS, so they can more accurately determine whether they are eligible for federal financial assistance, including flood insurance – avoiding the discovery and cancellation of invalid flood insurance policies after claims are made. The Task Force recognizes the value of the modernization efforts already underway and recommends that they be continued and expanded.

- **Enhance Technical Assistance to Communities in Coastal Areas.** Coastal areas are home to over 160 million people, support 66 million jobs and contribute $8.3 trillion to the U.S. economy. These areas are also prone to a number of natural hazards. As a result, it is critical that we provide coastal communities with the resources they need to make better decisions that reduce flood hazards. The Task Force will be exploring broader use of the Community Rating System as an incentive mechanism for coastal communities to make better floodplain management decisions. In addition, the Task Force plans to assess floodplain management-related technical assistance available to coastal communities and identify gaps that may need to be filled.

- **Enhance Collaboration and Research on Mapping to Support Floodplain Management.** Maps are powerful tools in floodplain management. The Task Force will be working to assess and enhance data collection, distribution, collaboration and research related to mapping to support floodplain management. It will place special emphasis on identifying, quantifying or mapping the natural areas of floodplains and their beneficial uses and values.

- **Improve the Link Between Agencies and Available Floodplain-related Research Capabilities.** There are potential disconnects between agencies responsible for establishing and implementing policies that impact flood risk or floodplains and those agencies involved in scientific research and data collection. The Task Force will evaluate disconnects and establish a more formal mechanism for coordination so the available research becomes more broadly available and research needs are aligned with future research plans.

- **Assess Federal Use of Flood Loss Data and Identify Potential Improvements in Collection, Dissemination and Use.** Federal agencies are often asked to report on flood-related losses. This information is important for understanding the impacts of policies and programs in and around floodplains. Federal agencies collect and use flood loss data differently based on their missions and the needs of their stakeholders. The Task Force will convene key federal agencies to discuss what flood loss data they have, how they calculate flood losses, and how they use these data (e.g., policy questions they try to answer). The Task Force will compile this feedback to create a more comprehensive view of how flood loss data is collected, calculated and used within federal agencies and key, high-level similarities and differences. Based on this feedback, the Task Force will identify approaches for improving the collection, dissemination and/or use of flood loss data to enhance future policy decisions.

- **Study the Benefits of Protecting Natural and Beneficial Functions.** Floodplains provide more value, or services, per acre than any other land type. However, floodplains continue to be degraded by development and other activities that often cause hidden losses, both economic and environmental, for communities and the nation. The Task Force will conduct a review of existing information to assess our current state of knowledge about valuing the natural resources and functions of floodplains. Based on this assessment, the Task Force will identify opportunities to quantify and/or qualitatively describe the benefits that floodplains provide.

Partnerships

- **Improve Silver Jackets Awareness and Participation.** Silver Jackets interagency teams promote valuable collaboration among federal and state agencies with respect to flood risk management. They focus on a common set of priorities and are capable of more easily leveraging resources to solve problems. Involvement by federal agencies other than FEMA and the Corps, however, has been inconsistent. Having stronger support for Silver Jackets teams from all agencies involved in flood risk and floodplain management will provide more resources and opportunities for collaboration to the Silver Jackets teams and promote more innovative and effective approaches to flood risk management. The Task Force will prepare a memorandum to its member agencies and other

interested agencies recommending that they designate a point of contact to coordinate their involvement in the Silver Jackets program.

- **Coordinate Under Presidential Policy Directive 8 (PPD#8) Initiatives.** PPD #8 provides an opportunity to improve floodplain management by providing a partnership venue to ensure assistance is available to integrate mitigation and floodplain management into recovery, mitigation and response policies, plans, programs, and decision making. The FIFM Task Force is developing processes to ensure that it is coordinating closely with the leadership structure of the National Disaster Recovery, Mitigation, and Response Frameworks as developed under PPD #8, specifically as it relates to floodplain management.

Communication

- **Promote the Task Force Role in Resolving Interagency Conflicts.** One reason the Task Force was formed was to identify and address policy or programmatic conflicts among federal agencies that may be resulting in poor floodplain management decisions. The Task Force will more actively promote its role in addressing these issues and opportunities so other members of the floodplain management community are aware of the potential resource the Task Force can offer.

As noted previously, many of the above recommendations will be merged into the Task Force's work plan. Participation by all federal agencies in support of Task Force efforts is encouraged. Please contact any member of the Task Force for further information on the work of the Task Force or its current activities.

David L. Miller
Associate Administrator, Federal Insurance and Mitigation Administration
Co-Chair, FIFM-TF

Date: 1/24/13

Jo-Ellen Darcy
Assistant Secretary of the Army (Civil Works)
Co-Chair, FIFM-TF

Date: Jan. 28, 2013

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

NOV 13 2014

Peter R. Blum, P.E.
Chief, Planning Division
Philadelphia District, Corps of Engineers
Wanamaker Building, 100 Penn Square East
Philadelphia, Pennsylvania 19107-3391

Dear Mr. Blum:

This letter is in response to the New Jersey Shore Protection Study, Hereford Inlet to Cape May Inlet, Final Feasibility Report and Integrated Environmental Assessment (EA). The document addressed hurricane and storm damage reduction alternatives for the coastal communities located between Hereford Inlet and Cape May Inlet, in Cape May County, New Jersey.

The selected storm damage reduction plan will entail backpassing sand obtained from the beaches of Wildwood, Wildwood Crest and Lower Township to create a dune and berm. These locations are experiencing beach accumulation that is impacting municipal outfall systems that drain storm water to the ocean. The excess sand will be used to form a continuous dune and berm within North Wildwood, which is experiencing beach erosion, as well as Wildwood, Wildwood Crest and Lower Township. The sand for the dune and berm will be transported using a mobile back-passing technology to hydraulically pump the sand from within the intertidal zone. The plan includes periodic nourishment every four years. The sand for nourishment efforts will be sourced from the approved borrow zone.

In our review, we did not notice whether our comment regarding the orientation of entry points/access paths along the dune was addressed so we are reiterating our recommendation. Access paths are often created perpendicular to the shore, resulting in significant dune erosion during intense storms and greater inland impacts. High force waves gain power as they push through the narrow passages causing increased erosion and flooding. Reduced flooding was seen after Super Storm Sandy behind dunes that had paths at a 45 degree angle rather than perpendicular to the shoreline. EPA continues to maintain that this modification could enhance the resiliency of the beaches and we recommend the inclusion of this information in the decision document for the project.

Thank you for the opportunity to comment. Should you have any questions concerning this letter please feel free to contact Stephanie Lamster of my staff at 212-637-3465.

Sincerely,

SLamster for GM

Grace Musumeci, Chief
Environmental Review Section

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

Planning and Policy Division

DEC 22 2014

Ms. Grace Musumeci
Chief, Environmental Review Section
United States Environmental Protection Agency
Region 2
290 Broadway
New York, NY 10007-1866

Dear Ms. Musumeci:

This letter is in response to your comments on the Hereford Inlet to Cape May Inlet Shore Protection Project provided in a letter dated November 13, 2014. We value and appreciate your commentary on the proposed project.

In regards to the orientation of the proposed entry points/access paths along the dune, we apologize if the response contained in our report was unclear. The plans contained in the report show the seaward side of all of the vehicular and pedestrian crossovers would be constructed at an angle to the dune, not perpendicular in order to enhance dune resiliency during storm events. The information is specifically contained in Volume 3, Appendix G-2, page 16 of the report.

Again, we thank you for the commentary that you have provided. If you would like to discuss these issues further, please contact the review manager, Lee Ware, at (202) 761-0523.

Sincerely,

Theodore A. Brown

Theodore A. Brown, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works

Printed on Recycled Paper

XXX

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NATURAL & HISTORIC RESOURCES
Office of Engineering and Constructions
501 East State Street
Mail Code 501-01A
P. O. Box 420
Trenton, NJ 08625-0420
Tel. 609-292-9236 FAX 609-984-1908

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

April 9, 2014

John C. Becking, P.E.
Lieutenant Colonel, US Army Corps of Engineers
Philadelphia District
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107

Reference: Hereford Inlet to Cape May Inlet Feasibility Study

Dear Colonel Becking:

The purpose of this letter is to confirm the New Jersey Department of Environmental Protection's (Department) support of the US Army Corps of Engineers (USACE) recommended plan contained in the Hereford Inlet to Cape May Inlet Feasibility Study. The Department is committed to partnering with the USACE Philadelphia District and will continue to provide the staffing and support needed to complete the project.

Sincerely,

Dave Rosenblatt
Administrator

Hereford Inlet to Cape May Inlet, New Jersey

Coastal Storm Risk Management Feasibility Study

Feasibility Report and Integrated EA

U.S.ARMY

US Army Corps of Engineers

BUILDING STRONG®

Initial Study Authority

This report is an interim response to the Senate Resolution adopted on December 17th 1987 by the Committee on Environmental and Public Works states:

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

Additional Study Authority

- Disaster Relief Appropriations Act (Public Law 113-2)
  - Hereford Inlet to Cape May Inlet Included in the Second Interim Report to Congress
  - Authorizes initial project construction
  - Does not authorize periodic nourishment cycle – additional project authorization required for nourishment cycle

BUILDING STRONG®

Project Purpose

To determine a hurricane and storm damage reduction plan for coastal communities located between Hereford Inlet and Cape May Inlet, Cape May County, New Jersey

BUILDING STRONG®

Key Study Sponsor & Partners

- Non-Federal Sponsor - State of New Jersey, Department of Environmental Protection
  - ► NJDEP Commissioner -Bob Martin
  - ► NJDEP- BCE Administrator- Dave Rosenblatt
- Key Stakeholders
  1. North Wildwood
  2. Wildwood
  3. Wildwood Crest
  4. Lower Township

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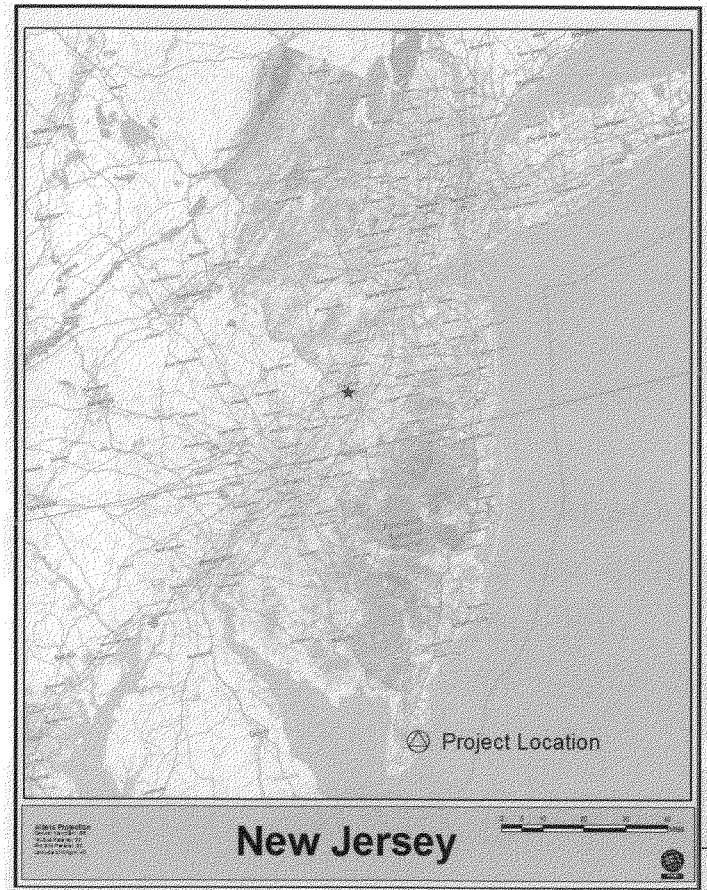
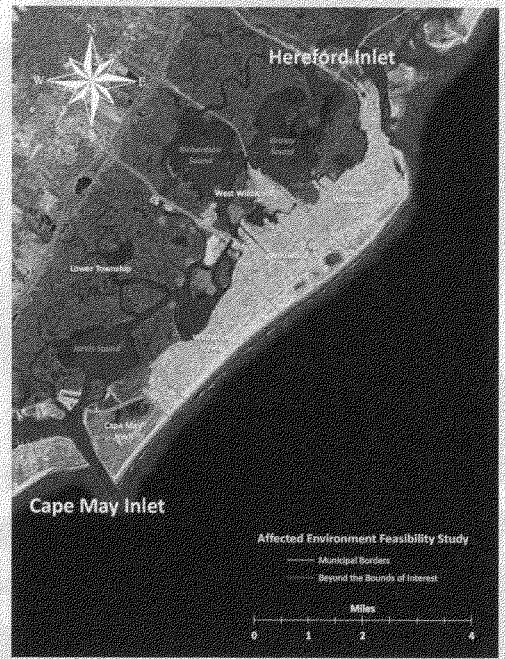
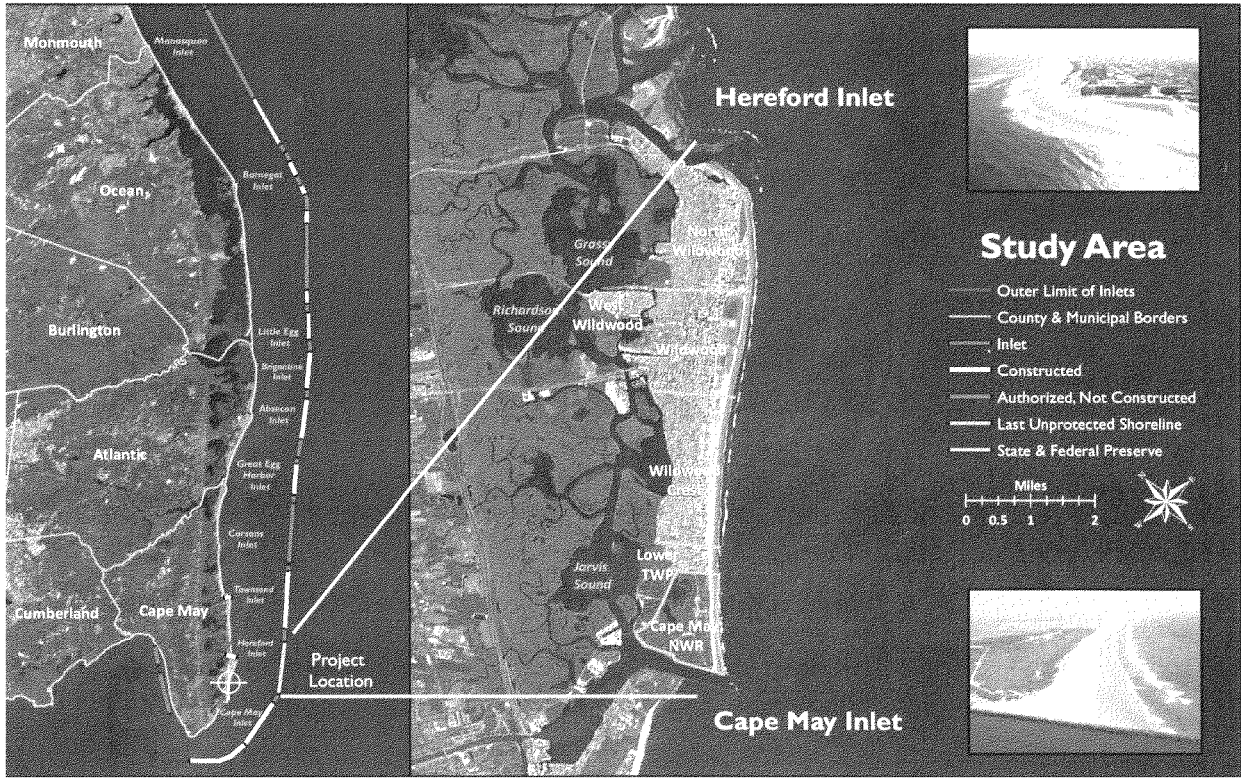




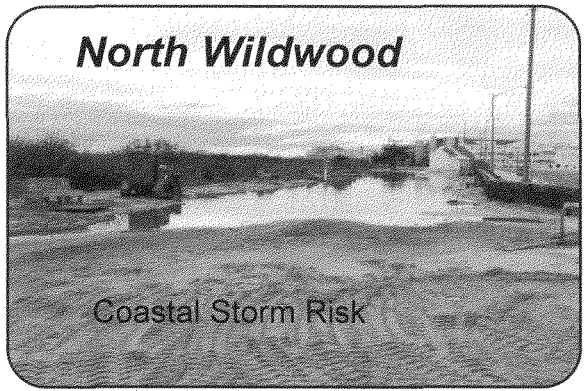
BUILDING STRONG®

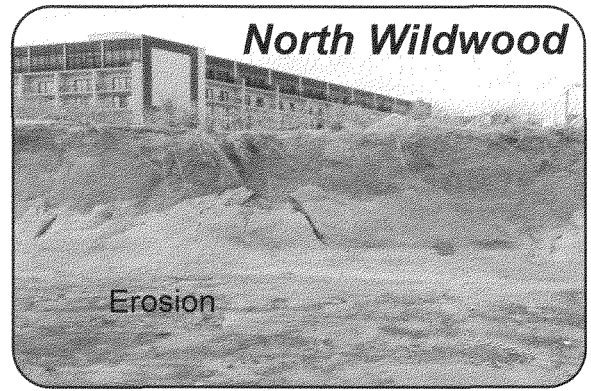
Hereford Inlet to Cape May Inlet Study Area

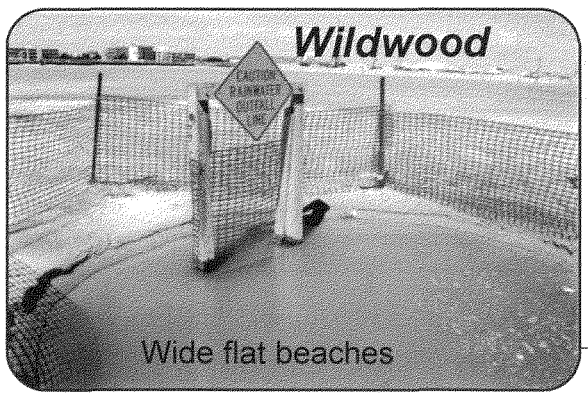
Last ocean front component of the NJ shore protection system

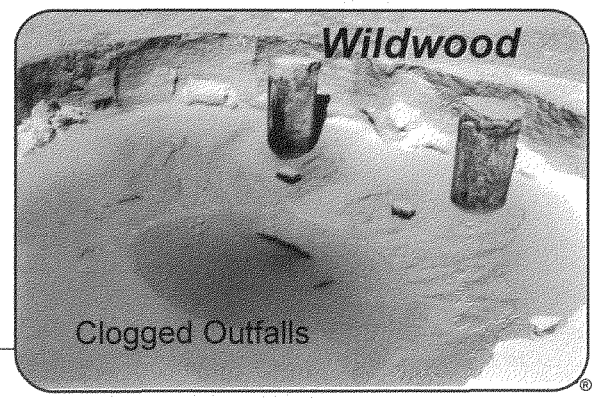


Problems


North Wildwood
Coastal Storm Risk


North Wildwood
Erosion


Wildwood
Wide flat beaches


Wildwood
Clogged Outfalls

Problems /Opportunities /Objectives

Problems

- Erosion, flood, and wave damage.
- Storm water drainage issues.
- Drainage maintenance costs.
- Impacts to recreation.
- Health and safety.

Opportunities

- Protect homes and infrastructure.
- Reduce health and safety issues.
- Mitigate damages caused by beach growth.
- Restore natural storm water flow.

Objectives

- Restore beaches.
- Regional Sediment Management.
- Reduce environmental and cultural impacts.
- Utilize excess sand to reduce maintenance.
- Satisfy non-Federal and Local Sponsors.

~ Constraints ~

- Comply with USACE Regulations
- Ensure the Economic Feasibility of the selected plan
- Use of natural dune elevations, berm elevations, side slopes
- Balancing the sediment distribution
- Ensure Environmental Protection
- Maintain storm damage reduction and recreation
- Consideration of public health, safety and social well-being

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Plan Formulation

Initial Screening

Non-structural Alternatives	Structural Alternatives
No Action	Berm & Dune Restoration using Backpass Technology
Regulation of future development	Berm & Dune Restoration from an Inlet Source
Permanent evacuation	Groins
	Excavate Sand from in Front of Outfalls
	Extend Outfalls
	Combine Outfalls
	Bulkhead around Piers
	Seawall
	Elevate Amusements
	Remove Amusements
	Hereford Inlet Channel Maintenance
	Geotextile tubes

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Recommended Plan

- Construction of beach berm and dune from Hereford Inlet to Cape May Inlet, via Hydraulic Back-Passing System
  - Berm Description
    - Elevation - +6.5 NAVD 88
    - Width – 75 feet
  - Dune Descripton
    - Elevation - +16 NAVD 88
    - Width at Crest – 25 feet

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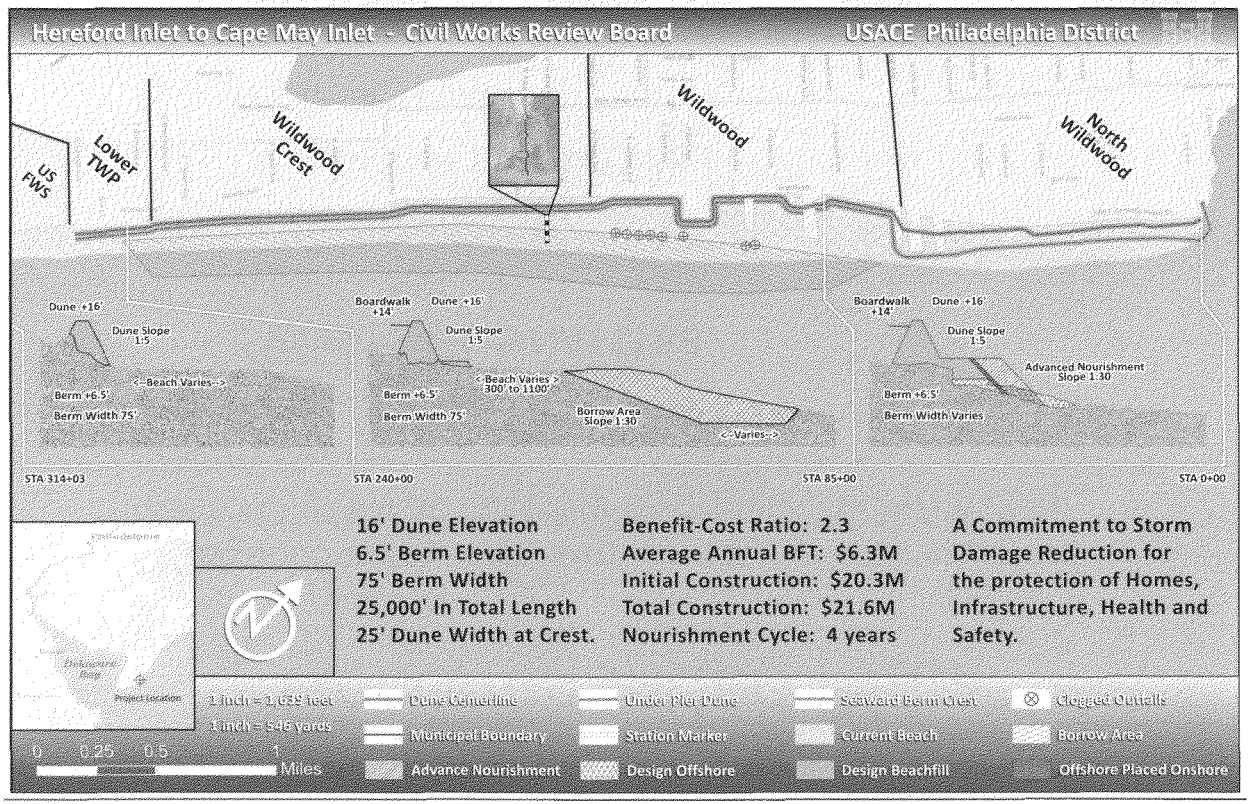
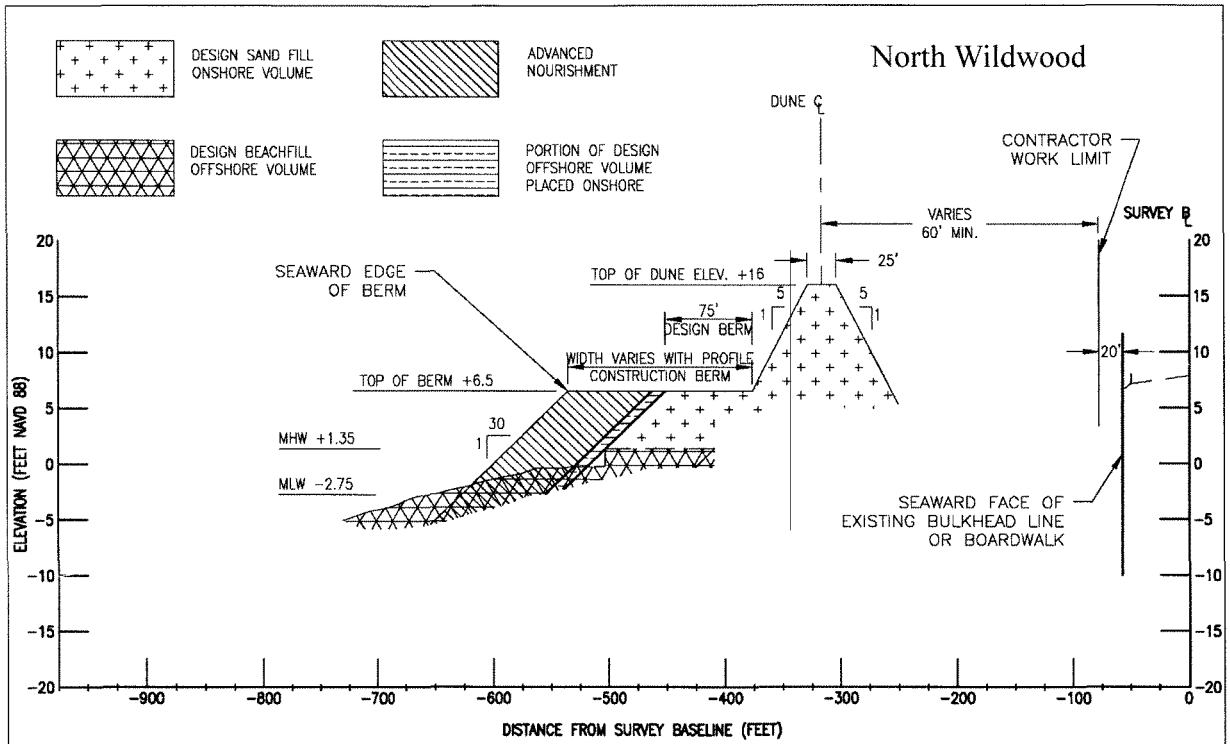
Recommended Plan

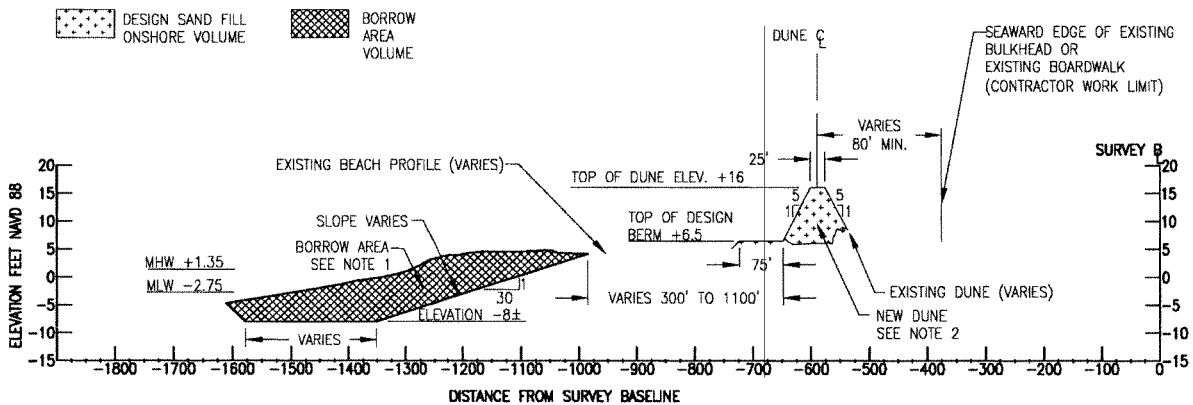




HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY

TYPICAL BEACHFILL DESIGN AND CONSTRUCTION CROSS SECTION
STATION 0+00 TO 85+00
ELEVATION +6.5 BERM +16' DUNE ELEVATION
SCALE AS SHOWN IN FEET

Wildwood/Wildwood Crest



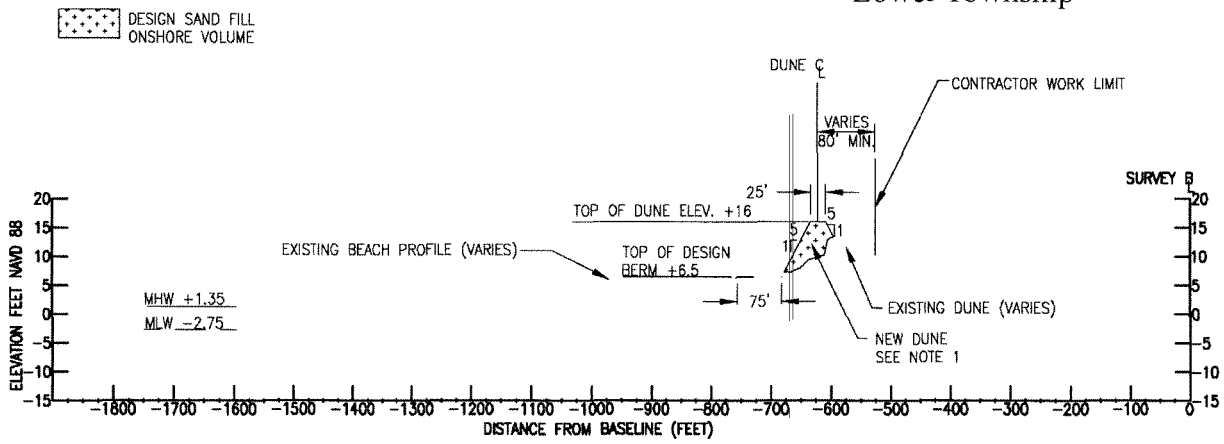
NOTES:
1. EXACT LIMITS OF BORROW AREA MAY VARY FROM THAT SHOWN HERE, BASED ON EXISTING BEACH CONDITIONS AND DREDGING EQUIPMENT SELECTED AT TIME OF CONSTRUCTION.
2. CENTERLINE OF NEW DUNE IS LOCATED ALONG THE SEAWARD EDGE OF THE EXISTING DUNES IN ORDER TO MINIMIZE SAND VOLUME REQUIRED
3. NEW DUNE VEGETATION IS NOT SHOWN.

HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY

TYPICAL DESIGN CROSS SECTION STATION 85+00 TO 240+00
BEACH BORROW AREA WITH ELEVATION +16 DUNE

SCALE AS SHOWN IN FEET

Lower Township



NOTES:
1. CENTERLINE OF NEW DUNE IS LOCATED ALONG THE SEAWARD EDGE OF THE EXISTING DUNES IN ORDER TO MINIMIZE SAND VOLUME REQUIRED.
2. NEW DUNE VEGETATION IS NOT SHOWN.

HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY
TYPICAL DESIGN CROSS SECTION
STATION 240+00 TO 314+03
ELEVATION +16 DUNE
SCALE AS SHOWN IN FEET

Economic Summary

▪ Discount Rate (FY15)	3.375%
▪ Period of Analysis	50 years
▪ Price Level	October 2014
▪ Base Year	2016
▪ Estimated Total Cost	$104,966,000
▪ Initial Construction Cost	$21,794,000
▪ Total Renourishment Cost	$83,172,000
▪ Periodic Nourishment (cycles 1,2)	$6,004,000
▪ Periodic Nourishment (other cycles)	$6,246,000
▪ Major Rehabilitation (year 24)	$7,991,000
▪ Interest During Construction	$349,000

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Economic Summary Cont'd.

- Total Avg Annual NED Benefits $6,309,000
- Total Avg Annual Costs $2,693,000
- Net Benefits $3,616,000
- Benefit-Cost Ratio at 3.375% 2.3
- Benefit to Cost Ratio at 7% 1.9

Benefit Breakdown

- Storm Damage Reduction $4,132,000
- Local Costs Forgone $1,375,000
- Recreation $699,000
- Benefits During Construction $103,000

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Cost Apportionment Table

Item	Federal Cost	Non-Federal Cost	Total Cost
PED	$1.4M	$0.5M	$1.9M
LERR&D		$1.3M	$1.3M
Flood Damage Reduction	$14.0M	$7.6M	$21.6M
Renourishment	$41.2M	$41.2M	$82.4M
Total	**$56.6M**	**$50.6M**	**$107.2M**

Environmental Considerations

- Environmental Assessment (EA)
  - FONSI was prepared
  - Red Knot is close to the study area
    - Listed as threatened in November 2014
    - NAP is consulting with FWS

Public Review

- Date of Public Notice – 20 Dec 2013
- Public Meeting Dates – 4 Public Meetings/ Workshops/Hearings in Feb 2014
- ~ 100 to 150 comments from concerned citizens, engineering firms working for the municipalities, the mayor and council
  - Support of the plan
  - Concerns with dune height
  - Concerns with impact of dune on tourism, real estate and recreation

Project Implementation

- PPA Execution Date – 4 December 2015
- Contract Award Date – 29 July 2016
- Construction Completion Date – 15 Jun 2017

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CWRB Summary
21 August 2014

- CWRB Decision: The project was approved for State and Agency review at the 21 August 2014 CWRB.
- OMB Attendees: The OMB Examiner was in attendance.

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NEW JERSEY
SHORE PROTECTION STUDY

US Army Corps of Engineers
Philadelphia District

New Jersey Department of Environmental Protection

Hereford Inlet to Cape May Inlet

Final Feasibility Report and Integrated Environmental Assessment

Volume 1 Final Feasibility Report and Integrated Environmental Assessment

4/28/2014

New Jersey Shore Protection Study
Hereford Inlet to Cape May Inlet

Final Feasibility Report
And Integrated Environmental Assessment

New Jersey Shore Protection Study
Hereford Inlet to Cape May Inlet

Final Feasibility Report and Integrated Environmental Assessment

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

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

New Jersey Shore Protection Study
Hereford Inlet to Cape May Inlet

Final Feasibility Report and Integrated Environmental Assessment

New Jersey Shore Protection Stndy

Final Feasibility Report and Integrated Environmental Assessment (EA)

EXECUTIVE SUMMARY

Proposed Action:	Dune and berm construction through the backpassing of sand from a beach borrow source in Wildwood, Wildwood Crest and Lower Township for all of the oceanfront communities between Hereford Inlet and Cape May, New Jersey.
Location of Action:	Municipalities of North Wildwood, Wildwood, Wildwood Crest and Lower Township.
Type of Statement:	Final Feasibility Report and Integrated Environmental Assessment (EA).
Lead Agency:	U.S. Army Corps of Engineers, Philadelphia District.
More Information:	For further information please contact: Pete Blum, Chief, Planning Division Attn: Beth Brandreth, Environmental Resources Branch U.S. Army Engineer District, Philadelphia Wanamaker Building, 100 Penn Square East Philadelphia, PA 19107-3390 Telephone: (215) 656-6555

Executive Summary

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

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

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

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

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

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

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

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

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

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

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

Figure ES-2 North Wildwood

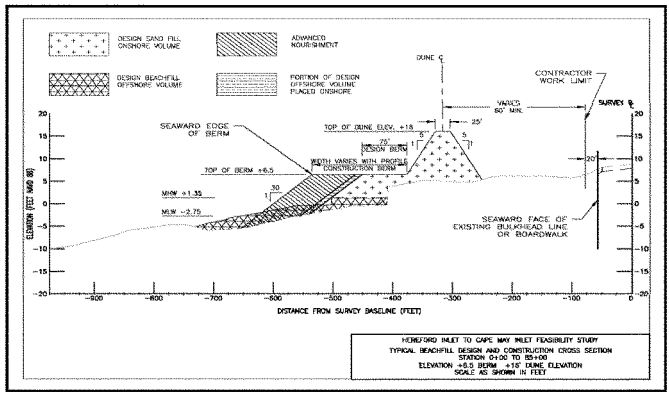


Figure ES-3 Wildwood aud Wildwood Crest

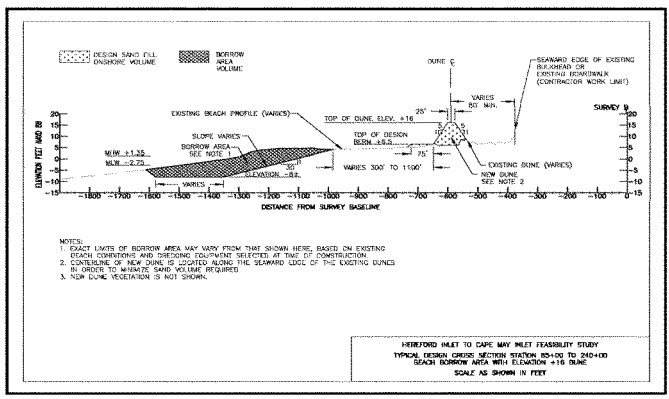
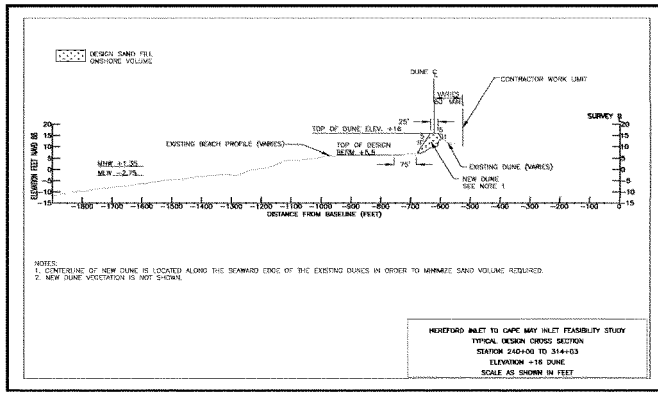


Figure ES-4 Lower Township.



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

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

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

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

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

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

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

Because the EA concludes that the proposed project does not constitute a major Federal action significantly affecting the human environment, I have determined that an Environmental Impact Statement is not required.

_____
Date

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

Environmental Operating Principles

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

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

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

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

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

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

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

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

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

Contributions to the USACE Campaign Plan

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

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

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

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

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

New Jersey Shore Protection Study
Hereford Inlet to Cape May Inlet
Feasibility report and Integrated Environmental Assessment
Table of Contents
Volume I

1.0 Introduction....25
1.1 Study Background....25
1.2 Study Authorization....26
1.3 Study Purpose and Scope....27
1.4 Study Area....27
1.5 The non –Federal Sponsor....39
1.6 Prior Studies, Reports, Projects -Federal....40
1.7 Prior Studies, Reports and Projects -State....44
1.8 Prior Studies, Reports, Projects- Municipal....45
1.9 Project Area Photos....47
2.0 Existing Conditions....51
2.1.1 Socioeconomic Resources....51
2.1.2 Population and Land Use....51
2.1.3 Employment and Income....53
2.1.4 Regional Economy and Development....55
2.1.5 Cape May County Toll Volumes....58
2.2 Environmental Resources....59
2.2.1 Environmental Setting....59
2.2.2 Air Quality....60
2.2.3 Natural Forces....61
2.2.4 Temperature and Salinity....62
2.2.5 Water Quality Parameters....63
2.2.6 Wetland Habitats....65
2.2.7 Dune Habitat....66
2.2.8 Upper Beach Habitat....67
2.2.9 Intertidal Zone Habitat....67
2.2.10 Benthos of Intertidal and Subtidal Zone....67
2.2.11 Nearshore and Offshore Zones....68
2.2.12 Benthos of Nearshore and Offshore Zones....69
2.2.13 Plankton and Marine Macroalgae....69
2.2.14 Finfish....70
2.2.15 Shellfish....71
2.2.16 Essential Fish Habitat....72
2.2.17 Birds....75
2.2.18 Mammals, Amphibians, Reptiles....75
2.2.19 Threatened and Endangered Species....76
2.2.20 Recreation....78
2.2.21 Visual and Aesthetic Values....78
2.2.22 Noise....78
2.3 Cultural Resources....79
2.3.1 Historic Background....79

2.3.2 Cultural Environment 85
2.3.3 The Battle of Turtle Gut Inlet 86
2.3.4 "Doo Wop" Architecture 88
2.4 Geotechnical Analysis 89
2.4.1 Geomorphology 89
2.4.2 Physiography 91
2.4.3 Drainage of the Coastal Plain. 91
2.4.4 Geologic Conditions 91
2.4.5 Surface Deposits 92
2.4.6 Subsurface Geology (Principal Stratigraphy and Aquifers) 93
2.4.8 Native Beach and Borrow Source Data Collection 98
2.4.9 Acoustic Sub-bottom Profiles 99
2.4.10 Investigation of Potential Borrow Areas 99
2.4.11 Native Beach Characteristics 100
2.4.12 Borrow Area Suitability Analysis 103
2.4.13 Potential Borrow Areas 105
2.4.15 Approximate Perimeter Coordinates of Potential Borrow Areas 110
2.4.16 Details of Borrow Area Design Analyses 111
2.4.17 Hereford Inlet Borrow Area – Subareas H-1, H-2, H-3, H-4 and Total Area "H" 111
2.4.18 Wildwood – Wildwood Crest – Area "WW/WC" (Formerly Area "D") 113
2.4.19 Offshore Borrow Areas 114
2.4.20 Supplemental Investigations 116
2.5 Structure Inventory 116
2.5.1 Shore Protection Structure Inventory 117
2.5.2 Municipal Outfall Inventory 118
2.5.3 Pier Inventory 119
2.6 Coastal Processes 119
2.6.1 Waves 119
2.6.2 Winds 127
2.6.3 Tides. 129
2.6.4 Sea Level Rise 129
2.6.5 Storms 131
2.6.6 Ocean Stage Frequency 139
2.6.7 Longshore Sediment Transport 140
2.6.8 Beach Profile Characteristics 142
2.6.9 Bathymetry 149
2.6.10 Inlet Sediment Bypassing 156
2.6.12 Section 111—Shore Damage Attributable to Federal Navigation Projects 158
2.7 Summary of Historic Shoreline Conditions 161
2.7.1 Prior Shoreline Change Studies 161
2.7.2 Historic Aerial Photography 1933-2012 162
2.7.3 Analysis of Beach Profile Data, 1955-2003, 2012 171
2.8.1 Sediment Budget 183
2.8.2 Analysis Procedures 184
2.8.3 Sediment Budget Uncertainty 185
2.8.4 Sediment Budget Balancing 186

2.8.5 Sediment Budget Results 186
3.0 Without Project Analysis 190
3.1 Hydraulic Analysis 190
3.1.1 Storm Erosion, Inundation and Wave Attack Analyses 190
3.1.2 Factors Influencing Storm Effects 190
3.1.3 Modeling Storm-induced Erosion 191
3.1.4 Overview of SBEACH Methodology 191
3.1.5 SBEACH Calibration 192
3.1.6 Development of Input Data for Storm Erosion Modeling 195
3.1.7 Profile Data 195
3.1.8 Model Parameters 201
3.1.9 Water Elevation 201
3.1.10 Wave Height, Period, and Angle 201
3.1.11 Storm Parameters 201
3.1.12 Storm Erosion Simulations 202
3.1.13 Analysis of Erosion Model Results 213
3.1.14 Storm Inundation and Wave Attack Evaluation 214
3.1.15 Inundation/Wave Attack Methodology 214
3.1.16 Back Bay Flooding 215
3.1.17 Other Parameters 215
3.1.18 Without Project Inundation and Wave Attack Results 215
3.2 Economic Analysis 215
3.2.1 Recent Storms 216
3.2.2 Structure Inventory 218
3.2.3 Storm Damage Methodology 220
3.2.4 Erosion Damages 221
3.2.5 Wave-Inundation Damages 222
3.2.6 Emergency Clean-Up Information 223
3.2.7 Damage Zone Structures 223
3.2.8 Structure Damages 225
3.2.9 Infrastructure and Improved Property Damages 225
3.2.10 Summary of Damages 226
3.2.11 Emergency/Clean-Up Costs 226
3.2.12 Back Bay Flooding 227
3.2.13 Wildwood, Wildwood Crest and Lower Township 227
3.2.14 Accreted Area Damage Summary 227
3.2.15 Amusement Piers Damages 228
3.2.16 Estimated Total Damages 228
3.2.17 Beach Maintenance 229
3.3 Future Without Project Conditions 231
3.3.1 Future Without Project Hydraulic Conditions 232
3.3.2 Future Without Project Economic Conditions 233
3.3.2.1 Additional Study Efforts as a Result of Hurricane Sandy 233
3.3.2.2 FEMA, the Community Rating System, and the Hazard Mitigation Program 234
3.3.2.3 Community Rating System (CRS) 234
3.3.2.4 The Hazard Mitigation Program (HMP) 235

3.3.2.5 Increased Cost of Compliance Grant 235
3.3.2.6 Impacts of FEMA grants and Floodplain Maps on Structure Database 235
4.0 With Project Analysis 238
4.1 General 238
4.2 Planning Objectives 238
4.3 Constraints 239
4.3.1 Planning Constraints 239
4.3.2 Technical Constraints 239
4.3.3 Economic Constraints 239
4.3.4 Environmental Constraints 240
4.3.5 Institutional Constraints 240
4.3.6 Regional and Social Constraints 241
4.4 Problems Within the Study Area 241
4.5 Cycle 1 - Initial Screening of Solutions 242
4.6 Cycle-2 251
4.7 Cycle-3 262
4.7.1 Beachfill Design Parameters 262
4.7.2 Berm and Dune Heights for Previously Authorized Federal Projects 264
4.7.3 Pier Protection Measures 269
4.7.4 Storm Damage Reduction Benefits 272
4.7.5 Optimization 273
4.8 Summary of Optimized Plan 278
4.9 Resiliency, Risk Reduction and Sustainability 278
4.9.1 Resiliency 278
4.9.2 Risk Analysis 280
4.9.3 Risk Reduction 280
4.9.4 Sustainability 281
5.0 Selected Plan 283
5.1 Identification of the Selected Plan 283
5.1.1 Description of the Selected Plan 283
5.1.2 Periodic Nourishment Requirements 284
5.1.3 Borrow Area Infilling Analysis 288
5.1.4 Project Construction Template 289
5.1.5 Backpass Methodology 298
5.1.6 Existing Backpass Systems 298
5.1.7 Sediment Backpassing Technology 298
5.1.8 Pumps 300
5.1.9 Major Replacement Requirements 303
5.1.10 Project Transitions and Tapers 303
5.2 Environmental Impacts 304
5.2.1 Physical Environment 304
5.2.2 Water Quality 304
5.2.3 Biological Environment 305
5.2.3.1 Terrestrial 305
5.2.4 Aquatic 305
5.2.4.1 Effects on Benthos 305

5.2.5. Impacts on Fisheries 306
5.2.5.1 Finfish 306
5.2.5.2 Essential Fish Habitat 306
5.2.7 Cultural Resources 309
5.2.8 Impacts on Air and Noise Quality 310
5.2.9 Environmental Justice 311
5.2.10 Cumulative Impacts 311
5.2.11 Coordination 314
5.2.12 Compliance with Environmental Statutes 315
5.3 Project Cost Estimate 316
5.3.1 Cost Contingencies 316
5.3.2 Initial Construction Costs 317
5.3.2.1 Real Estate 317
5.3.2.2 Public Access 318
5.3.3 Periodic Nourishment and Major Replacement Costs 318
5.3.4 Construction Management (S&A) 320
5.3.5 Planning Engineering and Design 320
5.3.6 Project Monitoring 320
5.3.6.1 Project Performance Monitoring 321
5.3.6.2 Environmental Monitoring 322
5.3.6.3 Total Monitoring Costs 323
5.3.7 Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R) 323
5.3.8 Construction and Funding Schedule 323
5.3.9 Interest During Construction 323
5.4 Project Benefits 324
5.4.1 National Economic Development Benefits 324
5.4.2 Local Costs Forgone 324
5.4.3 Incidental Benefits 325
5.4.3.1 Recreation Benefits 325
5.4.3.2 Benefits During Construction 327
5.4.4 Benefit-Cost Summary 328
5.5 Risk and Uncertainty Associated with Coastal Projects 329
5.5.1 Risk and Uncertainty Coordination 329
5.5.2 Risk Analysis 329
5.5.3 Risk and Uncertainty Methodology 330
5.5.4 H&H Risk and Uncertainty methodology 330
5.5.5 Economic Risk and Uncertainty Methodology 333
5.5.6 Risk and Uncertainty Results 335
5.6 Cost Sharing and Local Cooperation 338
5.6.1 Sponsor Cooperation and Financial Capability 339
5.6.2 Project Partnership Agreement 341
6.0 Conclusions and Recommendations 345
6.1 Conclusions 345
6.1.1 Study Continuation: Needs and Requirements 345
6.1.2 Additional Tasks 345
6.2 Recommendations 347

7.0 List of Preparers....349
8.0 Public Involvement....350
9.0 Clean Air Act Statement of Conformity....353
10.0 District Legal Certification....354
11.0 Evaluation of 404 (B) (1) Guidelines....355
12.0 References....364
13.0 Index....372
14.0 Glossary of Terms....373

List of Figures

Figure 1 Study Area....28
Figure 2 Hereford Inlet....29
Figure 3 North Wildwood....30
Figure 4 North Wildwood....31
Figure 5 North Wildwood and Wildwood....32
Figure 6 Wildwood and Wildwood Crest....33
Figure 7 Wildwood and Wildwood Crest (Fishing Pier)....34
Figure 8 Wildwood Crest....35
Figure 9 Wildwood Crest Diamond Beach....36
Figure 10 Lower Township. *This area contains the US Fish and Wildlife Property*....37
Figure 11 Cape May Inlet *This area contains the USFW Property.*....38
Figure 12 North Wildwood, Hereford Inlet and Stone Harbor Point....47
Figure 13 North Wildwood (date unknown)....47
Figure 14 North Wildwood 1991....48
Figure 15 North Wildwood 2004....48
Figure 16 Clogged Outfall in Wildwood....49
Figure 17 Clogged Outfall in Wildwood, looking seaward....49
Figure 18 Wildwood Crest Fishing Pier, 1990s....50
Figure 19 Wildwood Crest Fishing Pier, 2003....50
Figure 20 Winter and Summer Population....52
Figure 21 Historic Population....53
Figure 22 Value of Owner Occupied Housing Units....57
Figure 23 Beach Intertidal and Nearshore Zones....69
Figure 24 Turtle Gut Inlet....86
Figure 25 Turtle Gut Inlet Locality Sketch from the War Department....87
Figure 26 Physiographic Provinces....89
Figure 27 Coastal Plain Aquifers....94
Figure 28 Stratigraphic Cross Section....97
Figure 29 Soil Classification System....102
Figure 30 Wildwood Borrow Areas Evaluated for Feasibility....106
Figure 31 Hereford Inlet Borrow Area....107
Figure 32 Wildwood and Wildwood Crest Borrow Area....108
Figure 33 Offshore Borrow Area....109
Figure 34 Wave Hindcast Stations....122
Figure 35 Percent Occurrence Histogram....125
Figure 36 Wave Rose of Station 147....125
Figure 37 Wave Rose of Station 147....126
Figure 38 Wave Rose of Station 147....126
Figure 39 Sea Level Trends Atlantic City....130
Figure 40 Hurricane Sandy Track....133
Figure 41 North Wildwood 2nd Avenue pre and post Sandy Surveys....134
Figure 42 10th Avenue in Wildwood pre and post Sandy Surveys....134
Figure 43 26th Avenue in North Wildwood/Wildwood pre and post Sandy Profiles....135
Figure 44 Baker Avenue in Wildwood pre and post Sandy Surveys....135

Figure 45 Wildwood Crest Fern Road pre and post Sandy Surveys....136
Figure 46 Wildwood Crest Trenton Ave pre and post Sandy Surveys....136
Figure 47 Bulkhead Overtopping at 2nd Avenue in North Wildwood During Sandy....137
Figure 48 Bulkhead Overtopping During Hurricane Sandy North Wildwood....137
Figure 49 Wildwood Post Storm....138
Figure 50 Wildwood Crest Post Storm....138
Figure 51 Beach Profile Locations....147
Figure 52 Wildwoods Bathymetry 1937-1940....150
Figure 53 Wildwoods Bathymetry 1970-1977....151
Figure 54 Wildwoods Bathymetry 1999-2004....152
Figure 55 Hereford Inlet Bathymetry 1994....153
Figure 56 Hereford Inlet Bathymetry 1999....154
Figure 57 Hereford Inlet Bathymetry2002....155
Figure 58 Inlet Sediment Bypassing....157
Figure 59 Historic Shoreline Yearly Accretion Rates in Segments 1,2,3,4....159
Figure 60 1920 Aerial Photograph....160
Figure 61 1933 Aerial Photograph....160
Figure 62 Aerials 1920....163
Figure 63 Aerials 1933....164
Figure 64 Aerial 1944....165
Figure 65 Aerials 1962....166
Figure 66 Aerials1970....167
Figure 67 Aerials 2003....168
Figure 68 Aerials 2006....169
Figure 69 Aerials 2012....170
Figure 70 1955, 2003 and 2012 Profile comparison in Wildwood....172
Figure 71 North Wildwood Shoreline Positions 1899-2003....174
Figure 72 North Wildwood and Wildwood Shoreline Positions 1899-2003....175
Figure 73 Wildwood and Wildwood Crest Shoreline Positions 1899-2003....176
Figure 74 Wildwood Crest Shoreline Positions 1899-2003....177
Figure 75 Wildwood Crest and Lower Township Shoreline Positions 1899-2003....178
Figure 76 Lower Township Shoreline Position 1899-2003....179
Figure 77 Sediment Budget....188
Figure 78 Sediment Budget....188
Figure 79 Ocean City NJ 1992 SBEACH calibration Plots-138....194
Figure 80 Ocean City, NJ 1992 SBEACH Calibration Plot-223....194
Figure 81 Cell 1 Without Project Profile....196
Figure 82 Cell 2 Without Project Profile....196
Figure 83 Cell 3 Without Project Profile....197
Figure 84 Cell 4 Without Project Profile....197
Figure 85 Cell 5 Without Project Profile....198
Figure 86 Cell 6 Without Project Profile....198
Figure 87 Cell 7 Without Project Profile....199
Figure 88 Cells 1-7 Layout....200
Figure 89 Storm Conditions 5 year Event....202
Figure 90 Storm Conditions 10 Year Event....203
Figure 91 Storm Conditions 20 Year Event....203
Figure 92 Storm Conditions 50 Year Event....204
Figure 93 Storm Conditions 100 Year Event....204
Figure 94 Storm Conditions 200 Year Event....205
Figure 95 Storm Conditions 500 Year Event....205
Figure 96 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 1....206
Figure 97 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 2....207
Figure 98 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 3....208
Figure 99 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 4....209
Figure 100 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 5....210

Figure 101 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 6 211
Figure 102 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 7 212
Figure 103 Map and Photo of Structure Inventory 220
Figure 104 Pile and Slab Foundation Erosion 221
Figure 105 Without Project Structures and Total Damage in North Wildwood 225
Figure 106 Cell 1 in North Wildwood 267
Figure 107 Cell 2 in North Wildwood 267
Figure 108 Pier Protection Plan View 271
Figure 109 Pier Protection Cross Section 271
Figure 110 North Wildwood Structure Damage 273
Figure 111 Benefits Optimization for North Wildwood 275
Figure 112 The Three Pillars of Sustainability, World Summit on Social Development 282
Figure 113 North Wildwood Cross Section 290
Figure 114 Wildwood and Wildwood Crest Cross Section 290
Figure 115 Lower Township Cross Section 291
Figure 116 North Wildwood Plan View 292
Figure 117 North Wildwood/Wildwood Plan View 293
Figure 118 Wildwood Plan View 294
Figure 119 Wildwood Crest Plan View (2) 295
Figure 120 Wildwood Crest Plan View 296
Figure 121 Wildwood Crest and Lower Township Plan View 297
Figure 122 Schematic of Hydraulic Backpassing System courtesy of ERDC 299
Figure 123 Side View of Crawler Crane and Crater 299
Figure 124 Sandy Recovery Projects, NJ and DE 313
Figure 125 Empirical Simulation Technique (EST) 90% confidence curve for water level 332

List of Tables

Table 1 Year Round Population in the Study Area (2010) 52
Table 2 Employment Comparison (2012) 54
Table 3 Study Area Employment Comparison (2012) 54
Table 4 Income Comparison (2010) 55
Table 5 Proposed Residential Site Plans 56
Table 6 Housing Units by Usage Category (2010) 56
Table 7 Development Projects in the Wildwoods 58
Table 8 Major non-residential Space 58
Table 9 Cape May County Toll Volumes 59
Table 10 Essential Fish Habitat 73
Table 11 Habitat Utilization of EFH Species 74
Table 12 Beach and Survey Sampling Locations 98
Table 13 North Wildwood Composite Values 104
Table 14 Borrow Area Coordinates 110
Table 15 Overfill and Renourishment Factors for Hereford Inlet Borrow Areas 112
Table 16 Overfill and Renourishment Factors for WW/WWC 114
Table 17 Overfill and Renourishment Factors for Borrow Area OS-1 115
Table 18 Overfill and Renourishment Factors for Borrow Area OS-2 115
Table 19 Overfill and Renourishment Factors for Borrow Area OS-3 116
Table 20 Shore Protection Structure Inventory 117
Table 21 Local Beachfills 118
Table 22 Municipal Outfalls 118
Table 23 Piers in the Project Area 119
Table 24 Percent Occurrence of Wave Height by Month WIS-147 123
Table 25 Percent Occurrence of Peak Period by Month WIS -147 123
Table 26 Percent Occurrence of Mean Direction by Month WIS – 147 124
Table 27 Summary of Mean Wave Height by Year 1980-1999 124
Table 28 Percent Occurrence of Wind Speed by Month 128

Table 29 Percent Occurrence of Winds Speed by Direction....128
Table 30 Wildwood Crest Station Datum Elevations Summary for 8535835....129
Table 31 The 10 Highest Observed Stages at Atlantic City, NJ 1912-2012....132
Table 32 SBEACH Volume Losses Compared to Sandy profiles....139
Table 33 Ocean Stage Frequency Data....140
Table 34 Potential Longshore Sediment Transport Rates....141
Table 35 Study Area Profiles....144
Table 36 Elevation Parameters....145
Table 37 Contour Locations....146
Table 38 1955, 2003, 2012 Volume Comparisons....172
Table 39 Historic Shoreline Analysis Segments....173
Table 40 Shoreline Change Rates, Segment 1....180
Table 41 Shoreline Change Rates for Wildwood Segment 2....181
Table 42 Shoreline Change Rates for Wildwood Crest, Segment 3....182
Table 43 Shoreline Change Rates for Lower Township, Segment 4....183
Table 44 Sediment Budget Uncertainty....185
Table 45 Sediment Budget Results....189
Table 46 Hurricane Sandy vs. SBEACH Volume Loss Table....193
Table 47 Profiles Used in Hydraulic Analysis....195
Table 48 Post Storm Erosion Distances....213
Table 49 North Wildwood Storm Damages....217
Table 50 Summary of Depreciated Replacement Cost Values....219
Table 51 Beginning Damage Event....223
Table 52 Without Project Damages by Frequency (In $000, June 2007 p.l.)....224
Table 53 North Wildwood Average Annual Structural (Dollars in thousands)....225
Table 54 North Wildwood Without Project Conditions Infrastructure Damages....226
Table 55 North Wildwood Without Project Average Annual Infrastructure and Improved Property Damages (Dollars in thousands)....226
Table 56 Average Annual Damages (Dollars in thousands)....226
Table 57 North Wildwood Without Project Damages, Emergency Cleanup Costs....227
Table 58 Wildwood, Wildwood Crest Lower Township Without Project Average Aumual Damages (Dollars in thousands)....228
Table 59 North Wildwood & Wildwood Pier Damages (Dollars in thousands)....228
Table 60 Without Project Average Annual Damages, Total (Dollars in thousands)....229
Table 61 Drainage Issue Options....230
Table 62 Wildwood Crest Outfall Extensions....230
Table 63 NFIP and SBA claims after Hurricane Sandy....236
Table 64 Problems, Opportunities and Objectives Within the Study Area....242
Table 65 Study Measures Measured Against the Four Planning Criteria....247
Table 66 Study Measures Measured Against the Objectives....248
Table 67 Combined Five Part Evaluation with the 4 Planning Criteria and Objectives Scoring....249
Table 68 System of Accounts....252
Table 69 Cost Estimates for a Groin field....260
Table 70 Previously Authorized Project Dimensions....265
Table 71 Dune and Berm Configurations....266
Table 72 Initial Formulation Quantities....269
Table 73 North Wildwood Storm Damage Reduction Benefits by Measure....272
Table 74 AAB/AAC/Net Benefits for Backpass Alternative....274
Table 75 Wildwood and Wildwood Crest and Lower Township AAB, AAC, Net Benefits....276
Table 76 North Wildwood and Wildwood Piers AAB, AAC, Net Benefits & BCR by Plan....277
Table 77 Risk Reduction for Without Project and With Project by Cell....281
Table 78 Planform Evolution Model Inputs....285
Table 79 Description of the Selected Plan....287
Table 80 Potential Longshore Transport Rates....288
Table 81 Sediment Backpassing Production, 300 cyh....301
Table 82 Sediment Backpassing Production, 450 cyh....302

Table 83 Major Replacement Volumes 303
Table 84 Compliance with Environmental Statutes....316
Table 85 Initial Construction Cost Summary 317
Table 86 Public Access by Municipality 318
Table 87 Periodic Nourishment Costs Years 4 and 8 319
Table 88 Periodic Nourishment Costs remaining 8-50 319
Table 89 Major Rehabilitation Costs 320
Table 90 Total Estimated Costs 324
Table 91 Risk and Uncertainty Results....336
Table 92 Cost Sharing for the Selected Plan 339
Table 93 Estimated Schedule of Federal and non Federal Expenditures....340

Volume 2

Appendix A. Engineering and Technical Appendix

Volume 3

Appendix B. Economic Analysis
Appendix C. Environmental Analysis
Appendix D. US Fish and Wildlife Coordination
Appendix E. Cultural Resources
Appendix F. Real Estate Plan
Appendix G. Pertinent Correspondence
Appendix G-2. Comments and Responses
Appendix H. Public Access Plan

1.0 Introduction

1.1 Study Background

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

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

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

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

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

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

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

1.2 Study Authorization

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

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

Supplemental Authority

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

1.3 Study Purpose and Scope

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

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

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

1.4 Study Area

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

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

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

The Wildwood Boardwalk is located within the study area and receives hundreds of thousands of visitors per year. The first of the 70,000 planks that make up the Boardwalk were laid in 1900 along a 150 yard span between Oak and Maple Avenue in Wildwood City. Expansion of the

boardwalk was soon to follow and by the first decade of the 20th century the boardwalk stretched from Cresse Avenue in Wildwood to 2nd Avenue in North Wildwood. The current boardwalk stretches from 15th street in North Wildwood to the border of Wildwood Crest and Wildwood at Cresse Avenue, a distance of approximately 1 $^{3/4}$ miles.

Figure 1 Study Area

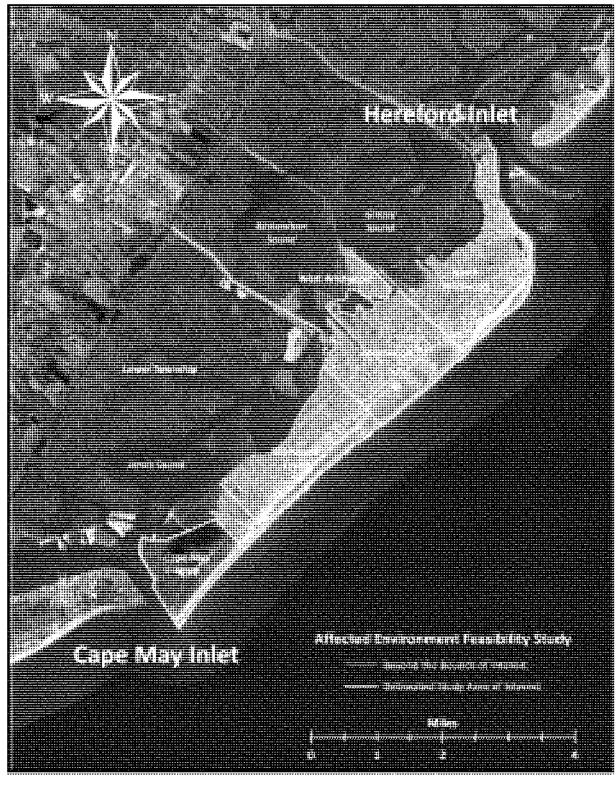


Figure 2 Hereford Inlet

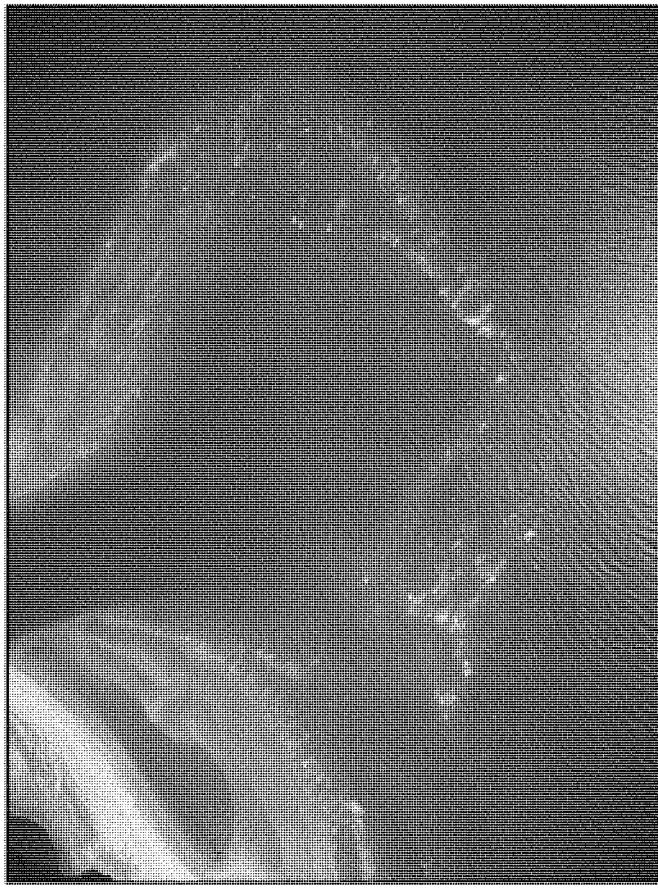


Figure 3 North Wildwood

Figure 4 North Wildwood

Figure 5 North Wildwood and Wildwood

Figure 6 Wildwood and Wildwood Crest

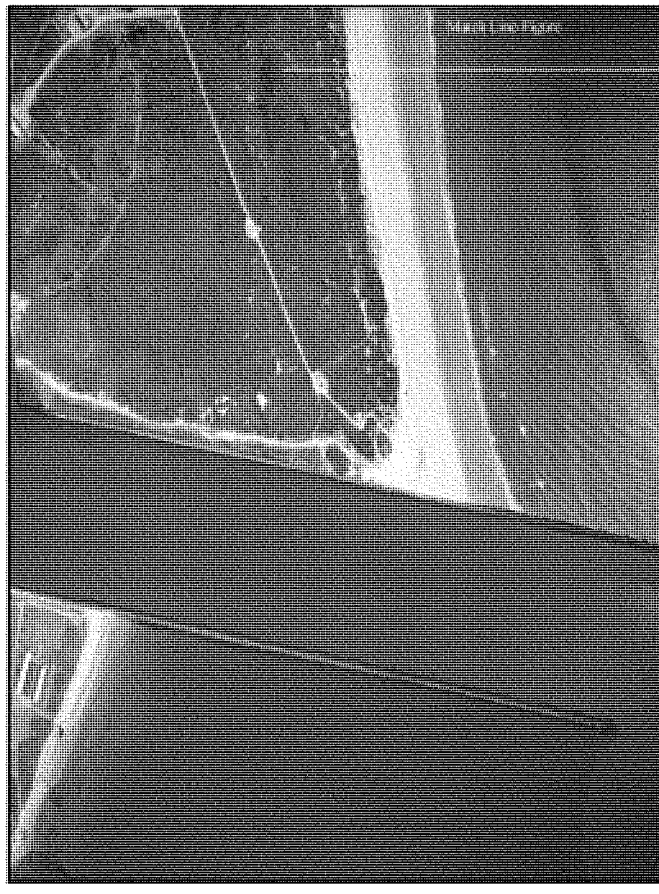
Figure 7 Wildwood and Wildwood Crest (Fishing Pier)

Figure 8 Wildwood Crest

Figure 9 Wildwood Crest Diamond Beach

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

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



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

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

1.5 The non –Federal Sponsor

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

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

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

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

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

and emergency repairs from coastal storms impacting New Jersey.

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

1.6 Prior Studies, Reports, Projects -Federal

Studies

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Projects

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

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

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

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

gradually worsened and required Federal and State attention.

1.7 Prior Studies, Reports and Projects -State

Studies

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

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

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

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

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

After the Halloween Storm of 1991 devastated New Jersey's shoreline, $15 million was appropriated as an amendment to the States Economic Recovery Fund for Shore Protection. Soon

thereafter, the January 1992 storm struck, overwhelming the States fiscal resources and prompting a Presidential Disaster declaration.

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

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

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

1.8 Prior Studies, Reports, Projects- Municipal

Studies

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

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

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

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

Projects

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

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

1.9 Project Area Photos

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

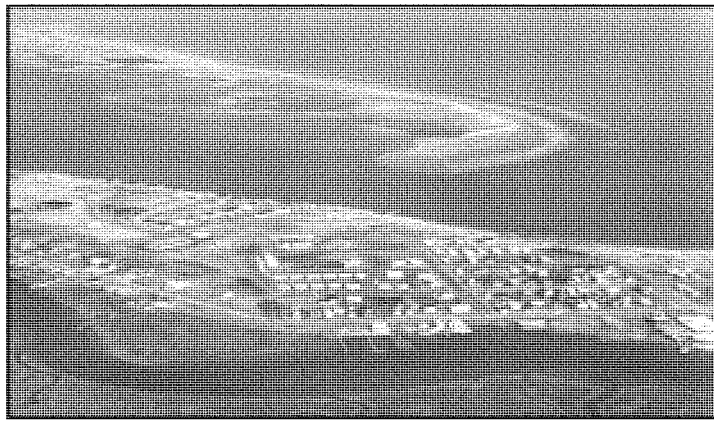


Figure 13 North Wildwood (date unknown)

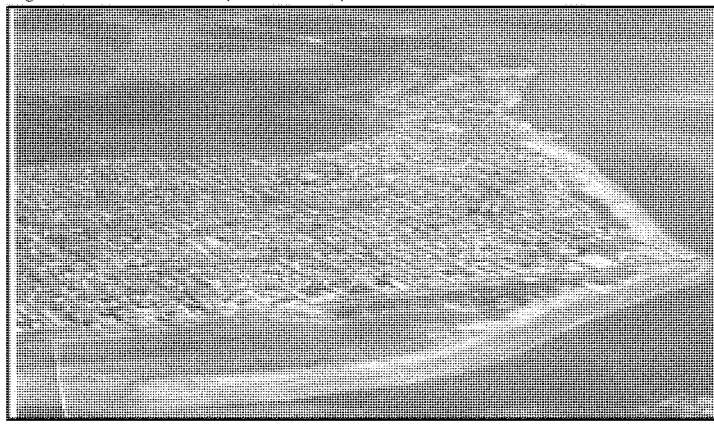


Figure 14 North Wildwood 1991
Figure 14 and 15 show the erosion of the wide beaches in North Wildwood from 1991 to 2004.

Figure 15 North Wildwood 2004

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

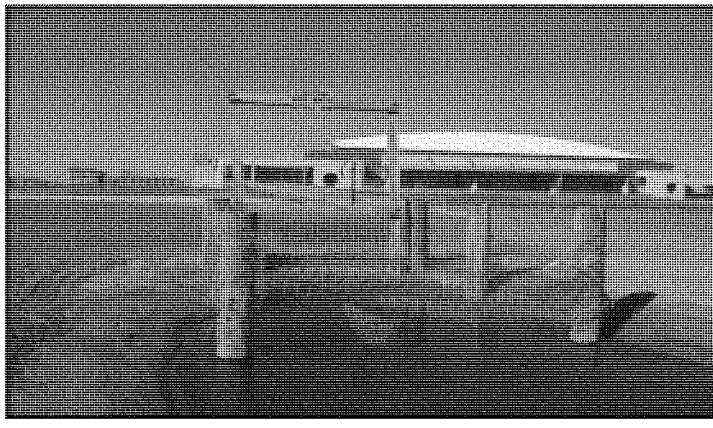


Figure 17 Clogged Outfall in Wildwood, looking seaward

Figure 18 Wildwood Crest Fishing Pier, 1990s
Figures 18 and 19 show the accumulation of sand over time at the Wildwood Crest fishing pier.

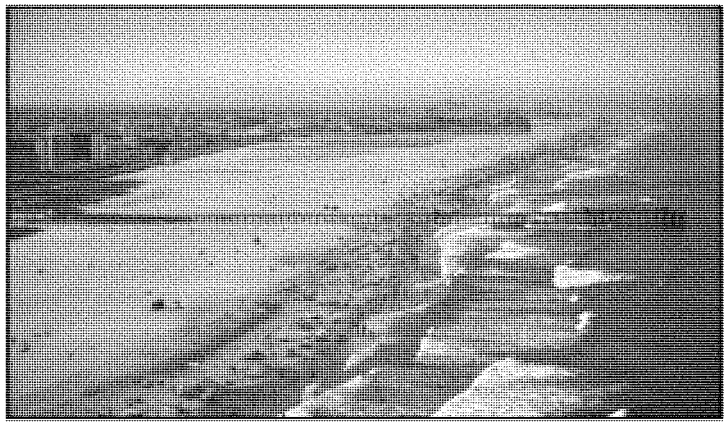
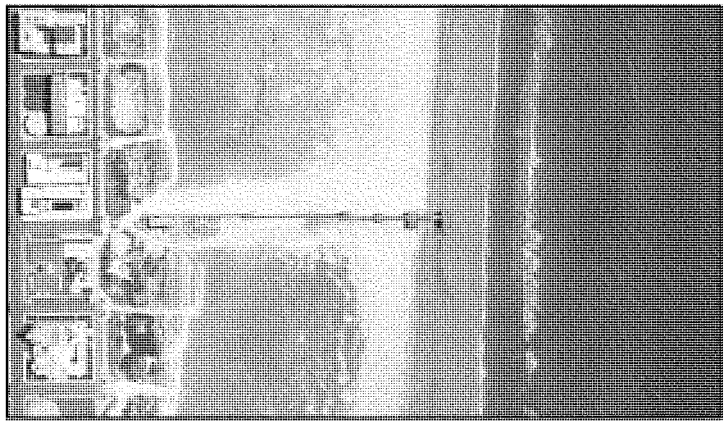


Figure 19 Wildwood Crest Fishing Pier, 2003



2.0 Existing Conditions

2.1.1 Socioeconomic Resources

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

2.1.2 Population and Land Use

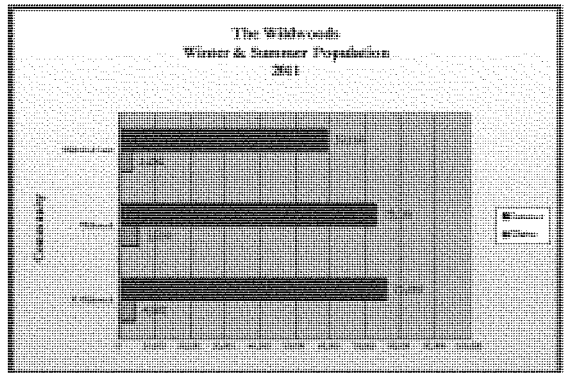
The study area is located on a barrier island community in Cape May County, New Jersey along the Atlantic Ocean. Within USACE- Philadelphia District boundaries, Cape May County is one of the four counties including Atlantic, Ocean, and Monmouth counties, located along the New Jersey coast. Cape May County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

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

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

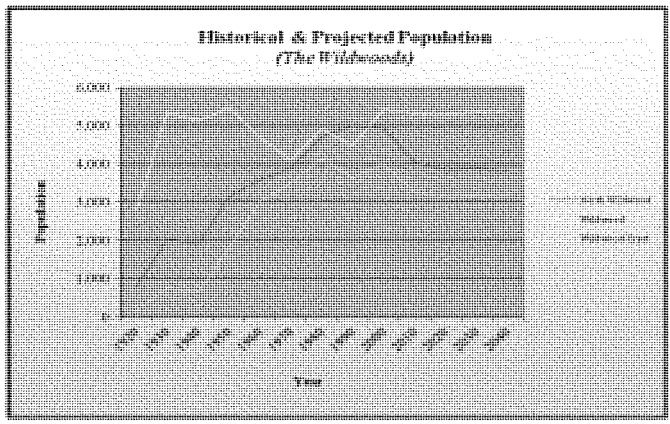
Municipality	Square Miles	Population	Persons Per Square Mile
North Wildwood	1.7	4,041	2,377
Wildwood	1.3	5,325	4,096
Wildwood Crest	1.1	3,270	2,973
The Wildwoods	*4.1*	*12,636*	*9,446*

Figure 20 Winter and Summer Population



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

Figure 21 Historic Population



2.1.3 Employment and Income

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

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

Table 2 Employment Comparison (2012)

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

Table 3 Study Area Employment Comparison (2012)

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

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

Table 4 Income Comparison (2010)

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

2.1.4 Regional Economy and Development

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

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

Table 5 Proposed Residential Site Plans

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

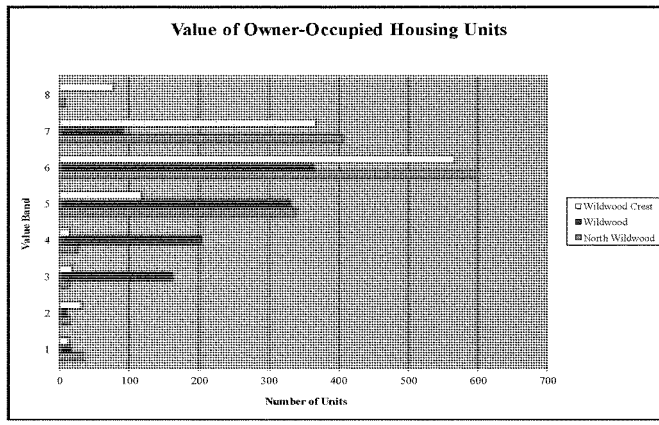
The number of housing units by usage category for the three coastal cities of *the Wildwoods* is displayed in **Table 6**. In 2010, seasonal and/or rental housing units represent a large percentage of housing units in the coastal counties of New Jersey. Almost half of the seasonal and/or rental properties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

Table 6 Housing Units by Usage Category (2010)

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

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

Figure 22 Value of Owner Occupied Housing Units



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

Table 7 Development Projects in the Wildwoods

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

Table 8 Major non-residential Space

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

2.1.5 Cape May County Toll Volumes

Each summer tourists flock to Cape May County's beaches, boardwalks, promenades, and amusement piers for day trips and extended vacations. The county is also a popular birding destination for tourists seeking to catch a glimpse of the migratory birds that stop along the

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

Table 9 Cape May County Toll Volumes

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

2.2 Environmental Resources

2.2.1 Environmental Setting

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

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

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

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

2.2.2 Air Quality

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

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

Cape May County, NJ is classified as a non-attainment area for ozone for 2012. This means that the national primary health standard is not being met for ozone. There are varying degrees of non-attainment in New Jersey, which range from marginal (0.121 – 0.137 ppm) to severe #2 (0.191 – 0.279 ppm). Cape May County was also classified as a "marginal" non-attainment for

ozone based on the May 2008 mandated 8-hour standard (USEPA, 2011). Ozone is caused by various photochemical reactions of volatile organic substances (hydrocarbons) with oxides of nitrogen on days with bright sunshine and warm temperatures. Thus ozone is only a potential problem in the late spring, summer, and early fall months (NJDEP, 2005). For ozone specifically, measurements at the Brigantine station exceeded the New Jersey and National Standards for the revised maximum daily 8-hour average primary standard on two occasions with hours above 0.075 ppm (USEPA, 2011).

2.2.3 Natural Forces

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

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

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

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

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

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

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

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

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

2.2.4 Temperature and Salinity

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

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

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

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

2.2.5 Water Quality Parameters

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

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

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

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

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

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

Water quality within the project area is also evaluated under the Cooperative Coastal Water Quality Monitoring Program. This program is designed to provide basic measures of the ecological health of New Jersey's coastal waters. The program measures parameters such as Dissolved Oxygen (DO), salinity, nitrogen, phosphorous, temperature and suspended solids at approximately 270 locations within the state on a quarterly basis. None of the assessment units sampled in 2007 met the criteria for general aquatic life use. This was generally due to a region containing low dissolved oxygen (DO) that forms off the coast between Sandy Hook and the Wildwoods during the summer months. During sampling, almost 50% of assessed coastal units exceeded the applicable DO criteria. It should be noted however, that surface water DO levels

have historically met applicable criteria. While the cause of the low DO cell is not known, summer algal bloom die-offs have been implicated as a potential source.

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

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

2.2.6 Wetland Habitats

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

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

cordgrass (*Spartina patens*) and salt grass (*Distichlis spicata*). This zone is typically flooded by spring high-tide.

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

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

2.2.7 Dune Habitat

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

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

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

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

2.2.8 Upper Beach Habitat

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

2.2.9 Intertidal Zone Habitat

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

2.2.10 Benthos of Intertidal and Subtidal Zone

Benthic macro-invertebrates refer to those organisms living along the bottom of aquatic environments. They can be classified as those organisms dwelling in the substrate (infauna) or

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

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

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

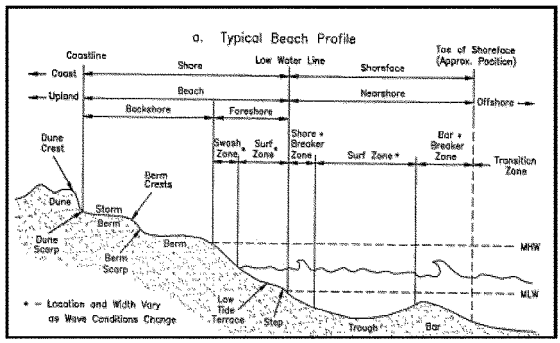
2.2.11 Nearshore and Offshore Zones

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

2.2.12 Benthos of Nearshore and Offshore Zones

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

Figure 23 Beach Intertidal and Nearshore Zones



2.2.13 Plankton and Marine Macroalgae

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

A number of species of marine macroalgae have been identified in the project region. The habitats include jetties, sand beaches, enclosed bays, and tidal creeks. The productivity is primarily seasonal with the densest population occurring in June through August. Distribution

and abundance of algae is closely related to seasonal temperature, salinity variations and nutrient levels coming from tributary streams. Rhodophyta (red algae) are the predominant benthic algae while Chlorophyta (green algae) comprise the largest number of intertidal algae species. Phaeophyta (brown algae) such as rockweed (*Fucus* spp.) may be found attached or floating free around rock jetties and pilings or washed onto the shore to make up part of the wrack line.

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

2.2.14 Finfish

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

The coastal waters within the project area support significant commercial and recreational fisheries. Commercially important species include: Atlantic croaker (*Micropogonias undulates*), Atlantic menhaden (*Brevoortia tyrannus*), summer flounder (*Paralichthys dentatus*), black sea bass (*Centropristis striata*), striped bass (*Morone saxatilis*), bluefish (*Pomatomus saltatrix*), winter flounder (*Pseudopleuronectes americanus*), tautog (*Tautoga onitis*), weakfish (*Cynoscion*

regalis), scup (*Stenotomus chrysops*), and white perch (*Morone americana*). Harvesting is generally accomplished by use of purse seines, otter trawls, pots, and gill nets. In 2011, the port of Cape May-Wildwood was the 6rd largest commercial fishing port on the East Coast in terms of volume, bringing in 40 million pounds of seafood at a value of $103 million. In 2010, the port harvested 43 million pounds of seafood product at a value of $81 million dollars, placing the port at a ranking of 7th in the National Commercial Fisheries Landing chart for dollar values (NMFS, 2011).

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

2.2.15 Shellfish

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

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

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

In addition to supporting some of the best hard clam resources in the State, the bays in the project area also support other species of shellfish. American oysters (*Crassostrea virginica*) are

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

2.2.16 Essential Fish Habitat

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

Table 10 Essential Fish Habitat

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

*Candidate species for listing under the endangered Species Act

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

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

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

Table 11 Habitat Utilization of EFH Species

HABITAT UTILIZATION OF IDENTIFIED EFH SPECIES AND THEIR SUMMARY OF SPECIES WITH EFH DESIGNATION IN THE 10 MIN. x 10 MIN. SQUARES WITHIN THE PROJECT AREA (NOAA, 2013)				
MANAGED SPECIES	EGGS	LARVAE	JUVENILES	ADULTS
Atlantic cod *(Gadus morhua)* (Fahay, 1998)				**Habitat:** Bottom (rocks, pebbles, or gravel) winter for Mid-Atlantic **Prey:** shellfish, crabs, and other crustaceans (amphipods) and polychaetes, squid and fish (capelin redfish, herring, plaice, haddock).
Whiting (*Merluccius bilinearis*)	**Habitat:** Surface waters, all year, peaking June – Oct.	**Habitat:** Surface waters, all year, peaks July – Sept.	**Habitat:** Bottom habitats of all substrate types, depths between 20 and 270 meters.	
Red hake *(Urophycis chuss)* (Steimle et al. 1998)	**Habitat:** Surface waters, May – Nov.	**Habitat:** Surface waters, May – Dec. Abundant in mud and outer continental shelf of Mid-Atl. Bight. **Prey:** copepods and other microcrustaceans under floating eelgrass or algae.	**Habitat:** Pelagic at 25-50 mm and bottom at 35-80 mm. Young-juvenile depressions on open seabed. Older juveniles include shelter provided by shells and shell fragments. **Prey:** small benthic and pelagic crustaceans (decapod shrimp, crabs, mysids, euphausids, and amphipods) and polychaetes).	
Redfish (*Sebastes fasciatus*)	n/a	n/a		
Witch flounder (*Glyptocephalus cynoglossus*) (Cargnelli et. al., 1998)	**Habitat:** Pelagic , generally over deep water in depths ranging from 10 – 1250 m			
Winter Flounder (*Pseudopleuronectes americanus*) (Pereira et. al., 1998)	**Habitat:** Demersal, near shore low energy (primarily inlets and coves) shallows with sand, muddy sand, mud and gravel bottoms.	**Habitat:** Demersal, near shore low (primarily inlets and coves) energy shallows with sand, muddy sand, mud and gravel bottoms. **Prey:** Nauplii, invertebrate eggs, Protozoans, Polychaetes	**Habitat:** Young of the year (YOY) are demersal, near shore low (primarily inlets and coves) energy shallows with sand, muddy sand, mud and gravel bottoms. **Prey:** YOY Amphipods and annelids JUV – Sand dollar, flexible siphons, Annelids, Amphipods	**Habitat:** Demersal offshore (in spring) except when spawning when they are in shallow inshore waters (fall). **Prey:** Amphipods, Polychaetes, bivalves or siphons, Capelin eggs, Crustaceans
Windowpane flounder (*Scophthalmus aquosus*) (Chang, 1998)	**Habitat:** Surface waters <70 m, Feb-July; Sept-Nov.	**Habitat:** Initially in pelagic waters, then bottom <70m, May-July and Oct-Nov. **Prey:** copepods and other zooplankton	**Habitat:** Bottom (fine sand) 5-125cm depth, in near shore bays and estuaries less than 75 m **Prey:** small crustaceans (mysids and decaped shrimp) polychaetes and various fish larvae	**Habitat:** Bottom (fine sands), peak spawning in May , in near shore bays and estuaries less than 75 m **Prey:** small crustaceans (mysids and decaped shrimp) polychaetes and various fish larvae
Atlantic sea herring (*Clupea harengus*) (Reid et al., 1998)			**Habitat:** Pelagic waters and bottom, < 10 C and 15-150 m depths **Prey:** zooplankton (copepods, decaped larvae, euphaus larvae, chaetognaths, and pelecypod larvae)	**Habitat:** Pelagic waters and bottom habitats; **Prey:** chaetognath, euphausids, pteropods and copepods
Monkfish (*Lophius americanus*) (Steimle et al., 1998)	**Habitat:** Surface waters, Mar – Sept, peak at time in upper water column of inner to mid continental shelf	**Habitat:** Pelagic waters in depths of 15 – 1000 m along mid shelf also found in surf zone **Prey:** zooplankton (copepods, crustacean larvae, chaetognaths)		
Bluefish (*Pomatomus saltatrix*)			**Habitat:** Pelagic waters of continental shelf and in Mid Atlantic estuaries from May-Oct. **Prey:** Squid, smaller fish	**Habitat:** Pelagic waters, found in Mid Atlantic estuaries April – Oct. **Prey:** Squid, smaller fish
Long finned squid (*Loligo pealei*)	n/a	n/a		
Short finned squid (*Illex illecebrosus*)	n/a	n/a		
Atlantic butterfish (*Peprilus triacanthus*)		**Habitat:** Pelagic waters greater than 30' deep	**Habitat:** Pelagic waters in 10 – 360 m	**Habitat:** Pelagic waters **Prey:** Jellyfish, crustaceans, worms, small fish
Summer flounder (*Paralichthys dentatus*)		**Habitat:** Pelagic waters, near shore at depths of 10 – 70 m from Nov. – May	**Habitat:** Demersal waters (mud and sandy substrates) **Prey:** Mysid shrimp	**Habitat:** Demersal waters (mud and sandy substrates). Shallow coastal areas in warm months, offshore in cold months **Prey:** Fish, squid, shrimp, worms
Scup (*Stenotomus chrysops*)	n/a	n/a	**Habitat:** Demersal waters	**Habitat:** Demersal waters offshore from Nov – April **Prey:** Small benthic invertebrates
Black sea bass (*Centropristis striata*)	n/a		**Habitat:** Demersal waters over rough bottom, shellfish and eelgrass beds, man made structures in sandy-shelly areas	**Habitat:** Demersal waters over structured habitats (natural and man made), and sand and shell areas **Prey:** Benthic and near bottom invertebrates, small fish, squid
Surf clam (*Spisula solidissima*)	n/a	n/a	**Habitat:** Throughout bottom sandy substrate to 5' in depth from beach zone to 60 m	
Ocean quahog (*Arctica islandica*)	n/a	n/a		
Spiny dogfish (*Squalus acanthias*)	n/a	n/a		
King mackerel (*Scomberomorus cavalla*)	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone **Prey:** Zooplankton, fish eggs	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone **Prey:** Zooplankton, shrimp, crab larvae, squid, herring	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone
Spanish mackerel (*Scomberomorus maculatus*)	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory **Prey:** Zooplankton, fish eggs	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory **Prey:** Zooplankton, shrimp, crab larvae, squid, herring	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory **Prey:** Squid, herring, silversides, anchovies
Cobia (*Rachycentron canadum*)	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone.	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory **Prey:** Crabs, shrimp, small fish	**Habitat:** Pelagic waters with sandy shoals of capes and offshore bars, high profile rocky bottom and barrier island ocean-side waters from the surf to the shelf break zone. Migratory **Prey:** Crabs, shrimp, small fish
Sand tiger shark (*Odontaspis taurus*)* *Candidate species for listing under Endangered Species Act		**Habitat:** Shallow coastal waters, bottom or demersal		**Habitat:** Shallow coastal waters, bottom or demersal **Prey:** Crabs, squid, small fish
Atlantic angel shark (*Squatina dumerili*)		**Habitat:** Shallow coastal waters	**Habitat:** Shallow coastal waters	**Habitat:** Shallow coastal waters, bottom (sand or mud near reefs)
Atl. sharpnose shark (*Rhizoprionodon terraenovae*)				**Habitat:** Shallow coastal waters
Dusky shark (*Carcharhinus obscurus*)		**Habitat:** Shallow coastal waters		
Sandbar shark (*Carcharhinus plumbeus*)		**Habitat:** Shallow coastal waters	**Habitat:** Shallow coastal waters	**Habitat:** Shallow coastal waters
Tiger shark (*Galeocerdo cuvieri*)		**Habitat:** Shallow coastal waters		
Scalloped hammerhead shark (*Sphyrna lewini*)			**Habitat:** Shallow coastal waters	
Cleanose skate (*Raja eglanteria*)			**Habitat:** Shallow coastal waters with soft bottom, rocky or gravelly substrates	**Habitat:** Shallow coastal waters with soft bottom, rocky or gravelly substrates
Little skate (*Raja erinacea*)			**Habitat:** Shallow coastal waters with sandy, gravelly, or mud substrates	**Habitat:** Shallow coastal waters with sandy, gravelly, or mud substrates
Winter skate (*Raja ocellata*)			**Habitat:** Shallow coastal waters with a substrate of sand and gravel or mud	

2.2.17 Birds

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

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

2.2.18 Mammals, Amphibians, Reptiles

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

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

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

2.2.19 Threatened and Endangered Species

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

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

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

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

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

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

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

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

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

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

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

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

2.2.20 Recreation

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

2.2.21 Visual and Aesthetic Values

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

2.2.22 Noise

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

2.3 Cultural Resources

2.3.1 Historic Background

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

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

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

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

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

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

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

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

to be extinguished by the explosion of the rest of the gunpowder below. Seven British Sailors were reported to have died in the blast. The explosion was said to be heard forty miles above Philadelphia. By 1794 Captain John Barry would be known as Commodore Barry, the father of the American Navy.

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

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

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

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

In 1883 Baker and his brother had walked north of Holly Beach and along an old Indian Path into a tangled forest of maple, oak, poplar, magnolia, holly, and cherry trees all covered with Spanish moss. The Baker brothers were impressed with the natural beauty of the area and imagined a summer destination and cottage colony set against the backdrop of this primitive but

beautiful forest. But first they had to deal with the problem of wild and aggressive cattle. Before the age of summer destination development, mainland farmers transported cattle in flat-bottomed boats to graze on Five Mile Island. Many were left on the island where they thrived on native grasses and grew in numbers. Early accounts report that these cattle were so wild and aggressive that a man walking across the island was advised to carry a rifle and a good supply of cartridges. As the town developed, the cattle became quite bold, wandering the streets, harassing the citizens, and raiding fruit and vegetable stands. Finally, the Baker brothers hired hunters to eliminate the wild cattle problem.

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

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

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

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

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

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

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

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

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

With such a wealth of attractions and entertainment, Wildwood's hotel and motel industry grew enormously during the 1960s. The summer destination 's hotel, motel, boarding-house and cottage owners were soon providing rooms for up to two hundred thousand people per week. By

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

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

2.3.2 Cultnral Environment

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

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

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

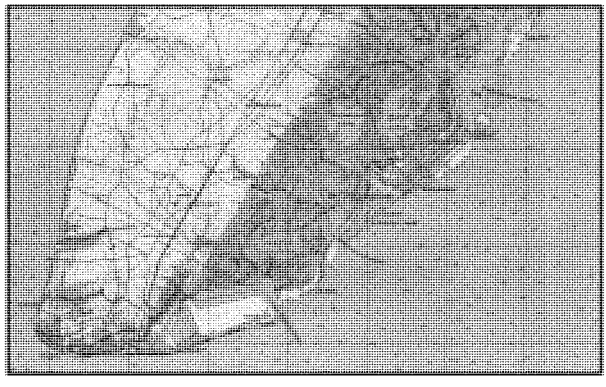
sloops and brigs native to Cape May. These pilots were adept at dodging in and out of the small harbors and inlets like Turtle Gut to escape capture by the British navy.

2.3.3 The Battle of Turtle Gut Inlet

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

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

Figure 24 Turtle Gut Inlet

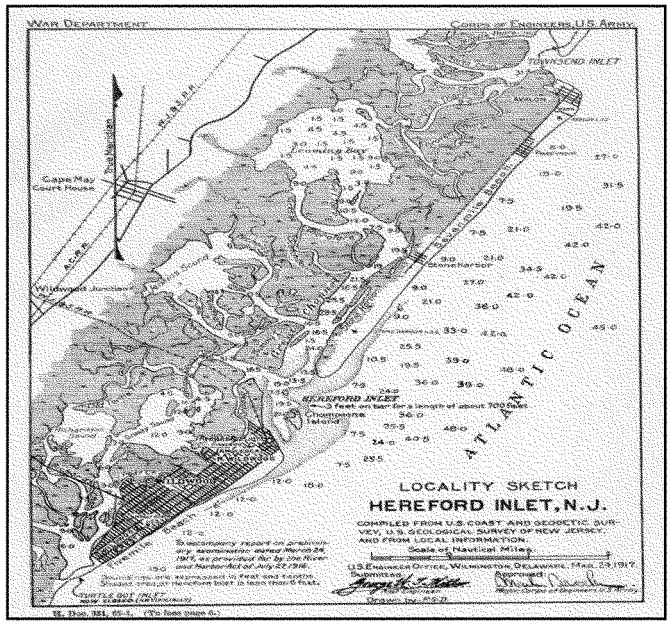


The Battle of Turtle Gut Inlet is historically significant for its strategic importance in getting munitions to the struggling Continental Army but also for its association with the young Captain

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

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

Figure 25 Turtle Gut Inlet Locality Sketch from the War Department



2.3.4 "Doo Wop" Architecture

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

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

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

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

Styles of "Doo-Wop" architecture include; Modern/Blast Off, a glass walled, angular roof style that brings to mind the jet-age airports of the 1950s and 1960s (Satellite and Admiral Motels), Vroom, an architectural movement expressed in angular, forward-thrusting and pointed building elements (Ebb Tide, Pan American and Bel Air Motels; Surfside Restaurant). Tiki/Polynesian,

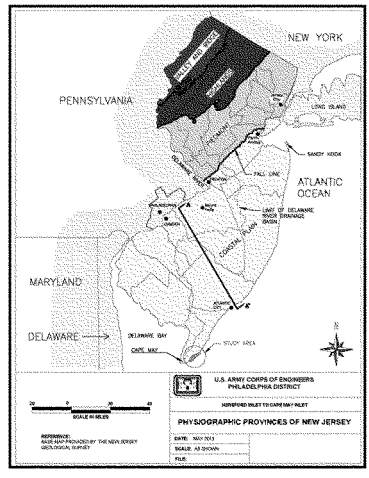
which reflects the fascination with the South Pacific, incorporating plastic palm trees and tiki heads in abundance (Ala Kai, Tahiti, Waikiki, Kona Kai and Casa Bahama Motels). Chinatown Revival reflects interest in exotic foreign travel, particularly the orient (Singapore Motel). and Phony Colonee, a patriotic style that reflects Colonial American brick and lamppost elements (Saratoga and Carriage Stop Motels). (Courtesy of the Wildwood Crest Historical Society)

2.4 Geotechnical Analysis

2.4.1 Geomorphology

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

Figure 26 Physiographic Provinces.



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

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

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

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

2.4.2 Physiography

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

2.4.3 Drainage of the Coastal Plain.

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

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

2.4.4 Geologic Conditions

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

over 40,000' (12,200 meters) in the area of the Baltimore Canyon Trough located around 50 miles (80.5 kilometers) offshore of Atlantic City.

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

2.4.5 Surface Deposits

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

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

Between Bay Head and Cape May City, the coastal lagoons, tidal marshes and barrier beaches that fringe the coast have contributed to the sands of the present beaches. During Quaternary

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

2.4.6 Subsurface Geology (Principal Stratigraphy and Aquifers)

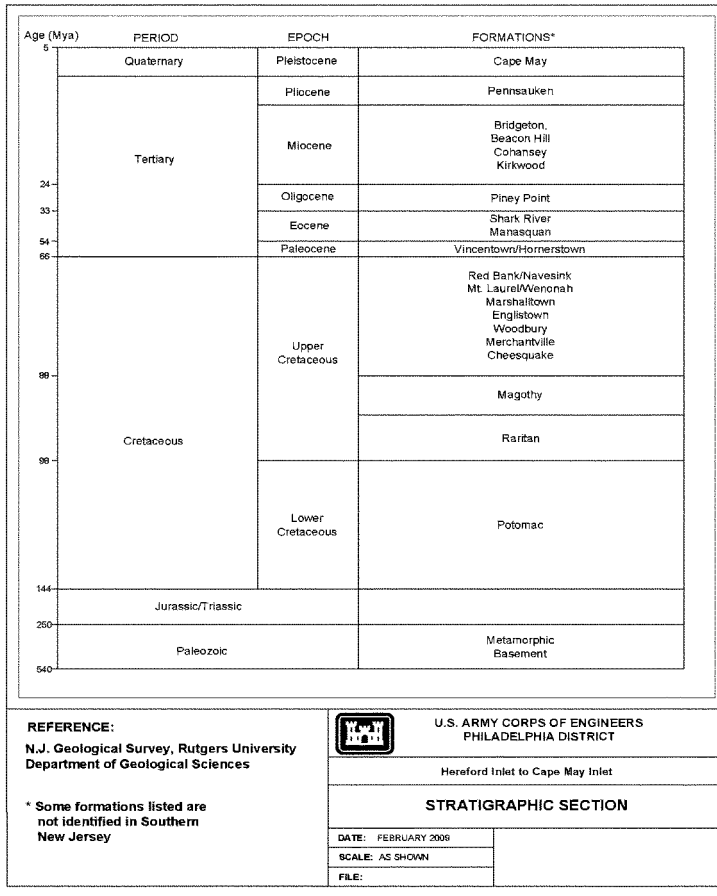
Based on information provided by the NJGS, the principal aquifers of New Jersey are subdivided into two main groups. These include the Coastal Plain aquifers south of the Fall Line and non-Coastal Plain aquifers north of the Fall Line. The Coastal Plain aquifers and their relative position in geologic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

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

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

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

Figure 27 Coastal Plain Aquifers



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

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

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

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

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

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

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

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

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

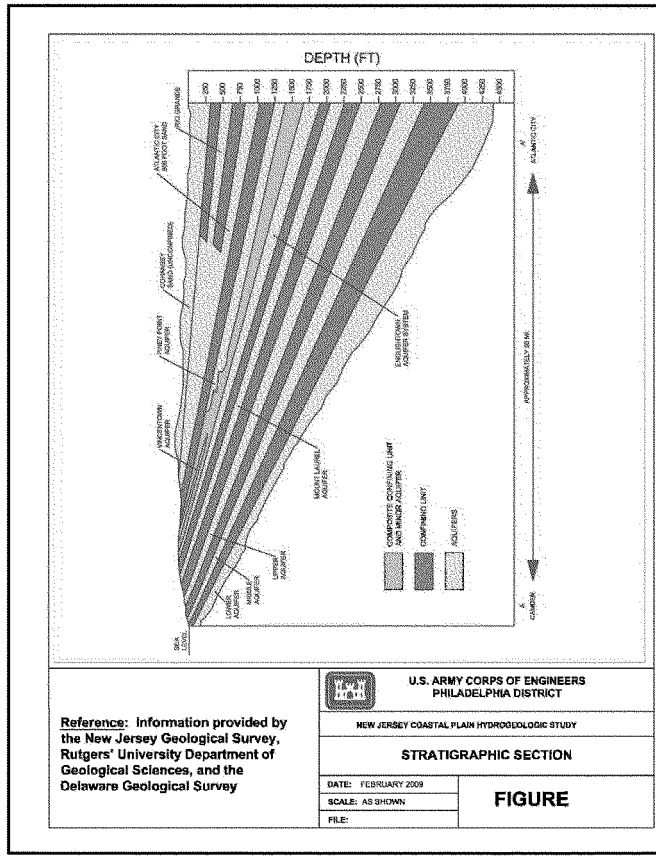
NJGS reports indicate that more than 75 percent of the freshwater supply in the New Jersey Coastal Plain is derived from ground water resources. In the Coastal Plain, high-capacity production wells used for public supply commonly yield from around 500 to 1,000 gallons per minute (gpm), and many exceed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

2.4.7 Local Geology

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

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

Figure 28 Stratigraphic Cross Section



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

U.S. ARMY CORPS OF ENGINEERS
PHILADELPHIA DISTRICT

NEW JERSEY COASTAL PLAIN HYDROGEOLOGIC STUDY

STRATIGRAPHIC SECTION

DATE: FEBRUARY 2009
SCALE: AS SHOWN
FILE:

FIGURE

2.4.8 Native Beach and Borrow Source Data Collection

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

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

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

Table 12 Beach and Survey Sampling Locations

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

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

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

** Depth is referenced to NAVD 88 datum*

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

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

2.4.9 Acoustic Sub-bottom Profiles

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

2.4.10 Investigation of Potential Borrow Areas

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

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

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

Between April 14 and 15, 2006 a series of 8 additional vibracores were obtained offshore from the Wildwood beach area between Hereford Inlet and Cape May Inlet. The vibracores were performed by Schnabel Engineering and their subcontractor Alpine Drilling. Three of the

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

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

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

2.4.11 Native Beach Characteristics

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

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

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

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

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

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

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

Figure 29 Soil Classification System

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

2.4.12 Borrow Area Suitability Analysis

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

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

Table 13 North Wildwood Composite Values

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

2.4.13 Potential Borrow Areas

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

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

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

Figure 30 Wildwood Borrow Areas Evaluated for Feasibility

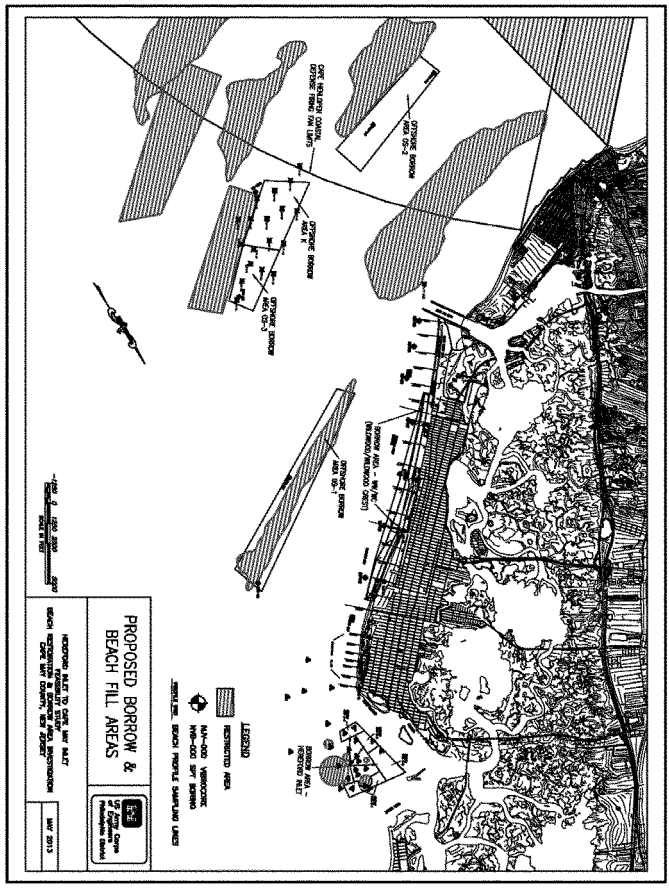


Figure 31 Hereford Inlet Borrow Area

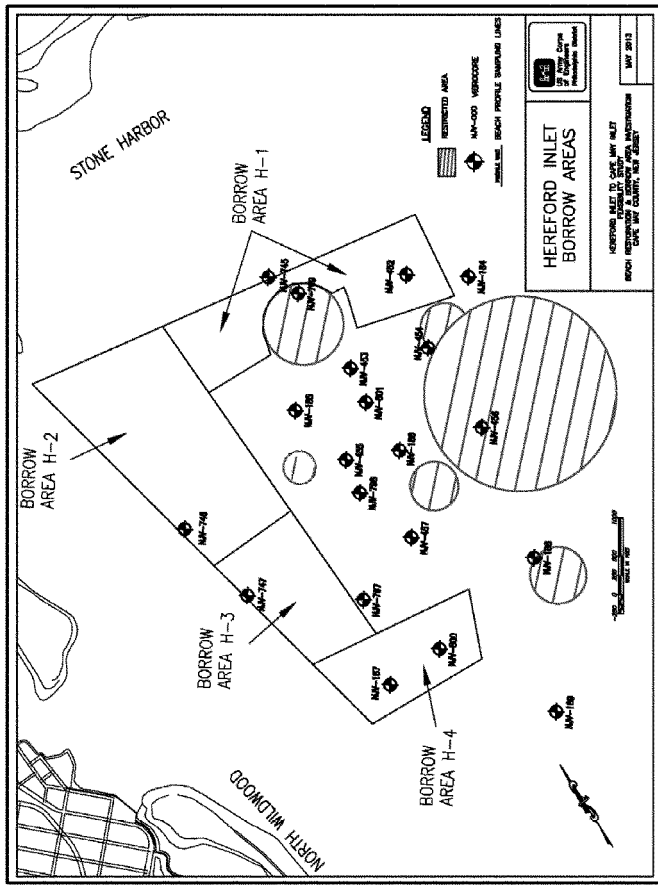


Figure 32 Wildwood and Wildwood Crest Borrow Area

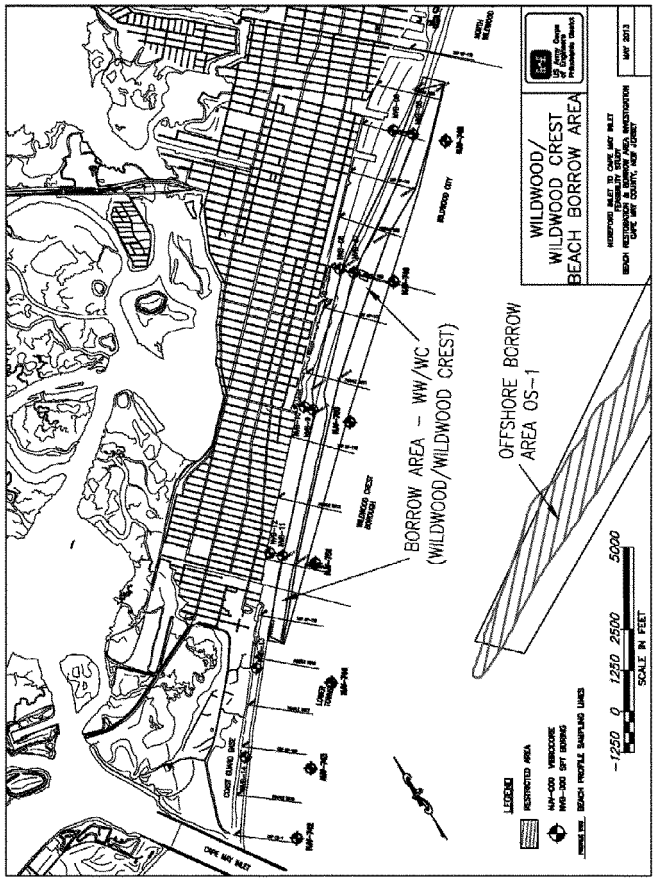
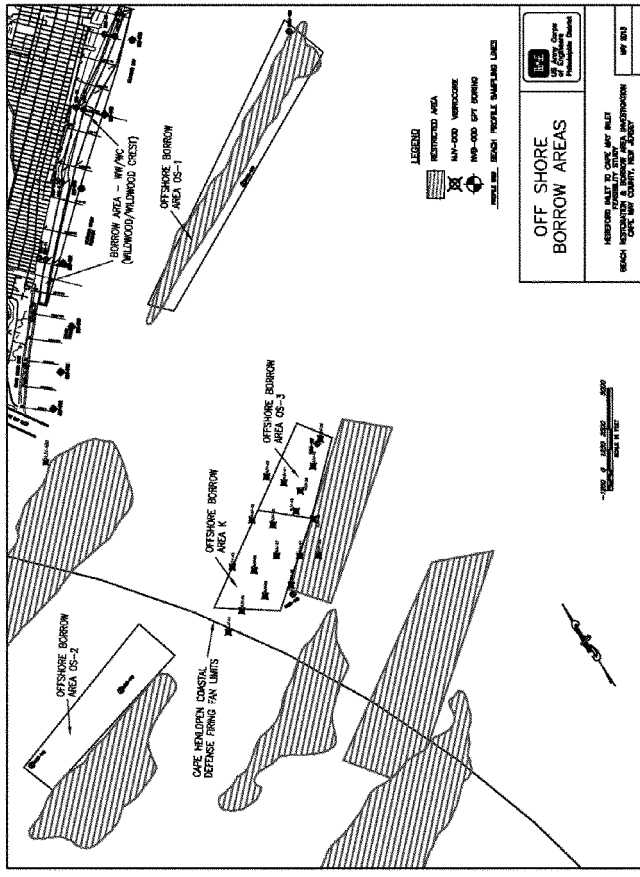


Figure 33 Offshore Borrow Area



2.4.15 Approximate Perimeter Coordinates of Potential Borrow Areas

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

Table 14 Borrow Area Coordinates

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

2.4.16 Details of Borrow Area Design Analyses

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

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

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

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

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

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

There is concern regarding the use of material from subareas H-3 and H-4 of the Hereford Inlet borrow area. The removal of this material is likely to change the character and ferocity of wave

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

Table 15 Overfill and Renourishment Factors for Hereford Inlet Borrow Areas

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

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

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

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

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

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

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

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

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

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

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

Table 16 Overfill and Renourishment Factors for WW/WWC

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

2.4.19 Offshore Borrow Areas

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

2.4.20 Supplemental Investigations

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

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

2.5 Structure Inventory

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

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

2.5.1 Shore Protection Structure Inventory

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

Table 20 Shore Protection Structure Inventory

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

Table 21 Local Beachfills

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

2.5.2 Municipal Outfall Inventory

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

Table 22 Municipal Outfalls

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

2.5.3 Pier Inventory

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

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

Table 23 Piers in the Project Area

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

2.6 Coastal Processes

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

2.6.1 Waves

Several hindcast data sources were available to generate wave statistics for the study area (**Figure 34**). One source was from a report entitled "Hindcast Wave Information for the U. S. Atlantic Coast" (Wave Information Study (WIS) Report 30) prepared by Hubertz, *et al.*, 1993. WIS Report 30 provided revised wave data for 108 locations along the U. S. Atlantic coast, and superseded WIS Report 2 (Corson, *et al.* 1981), WIS Report 6 (Corson, *et al.* 1982) and WIS Report 9 (Jensen 1983). The wave information for each location was derived from wind fields

developed in a previous hindcast covering the period 1956 through 1975, exclusive of hurricanes, and the WIS wave model, WISWAVE 2.0 (Hubertz 1992). Wave heights were universally higher for the revised hindcast than for the original hindcast since the values more closely corresponded to maximum measured (buoy) values. A separate report (WIS Report 19) documented hindcast wave information for Atlantic Coast hurricanes during the 1976-1995 time period. The WIS output results are a verified source of information for wind and wave climate along the U.S. Atlantic Coast and have been used to gain a basic understanding of the wind and wave climate for the study area.

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

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

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

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

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

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

Figure 34 Wave Hindcast Stations

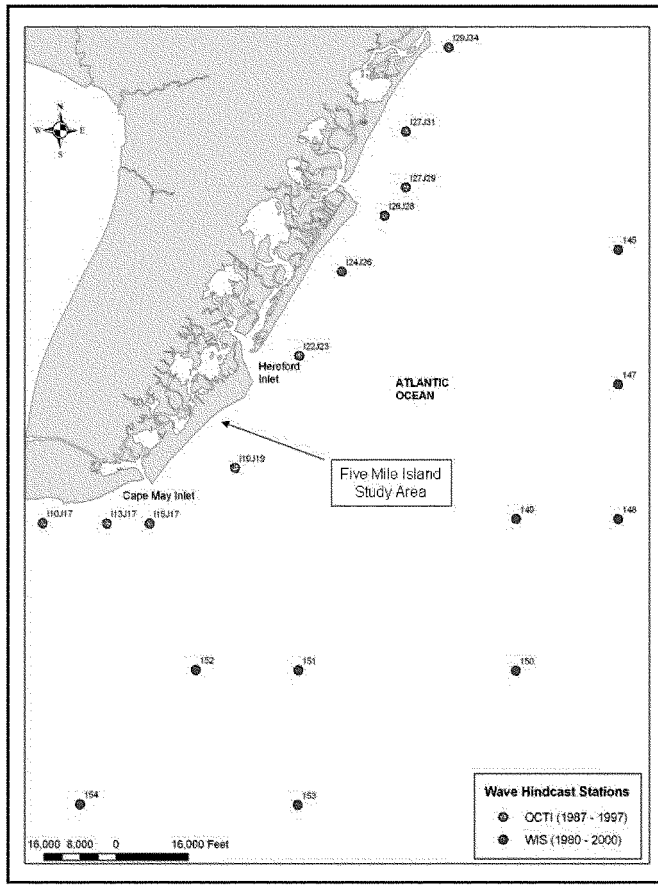


Table 24 Percent Occurrence of Wave Height by Month WIS-147

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

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

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

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

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

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

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

Figure 35 Percent Occurrence Histogram

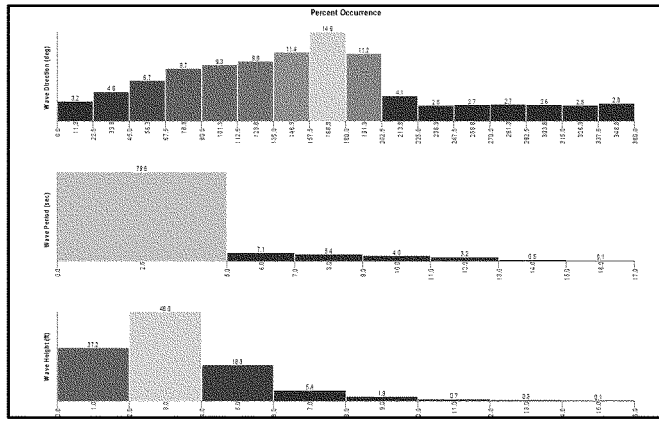


Figure 36 Wave Rose of Station 147

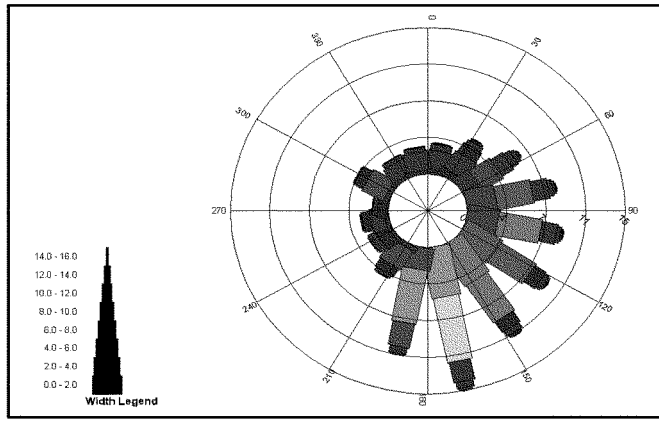


Figure 37 Wave Rose of Station 147

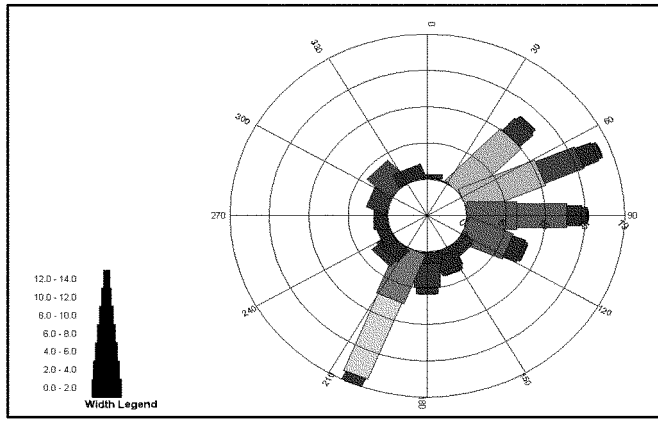
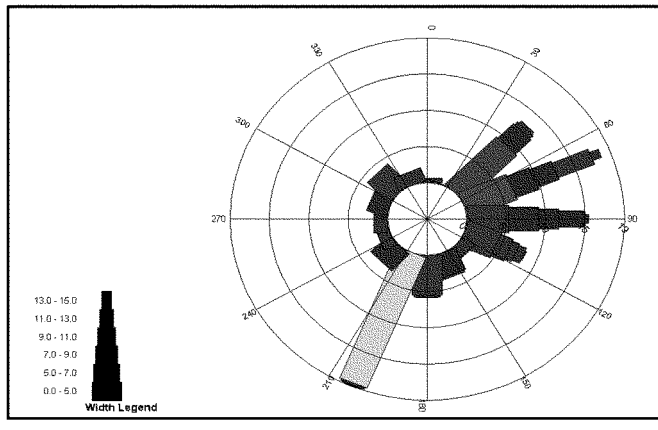


Figure 38 Wave Rose of Station 147



2.6.2 Winds

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

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

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

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

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

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

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

Table 28 Percent Occurrence of Wind Speed by Month

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

Table 29 Percent Occurrence of Winds Speed by Direction

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

2.6.3 Tides.

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

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

Table 30 Wildwood Crest Station Datum Elevations Summary for 8535835

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

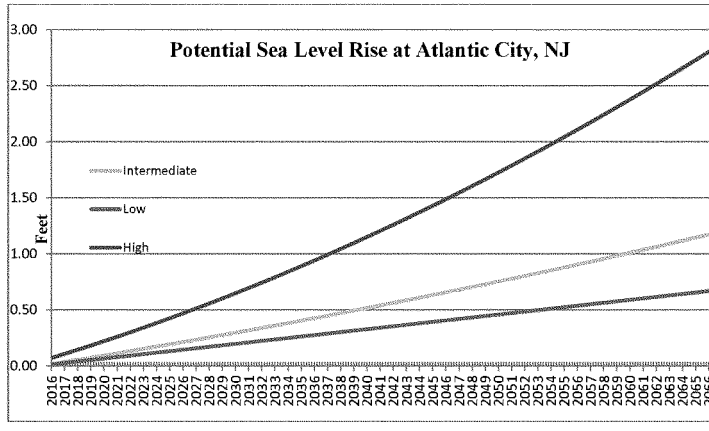
No official datum relationship has been established between NAVD 88 and the tidal elevations shown in the table above within the study area. Tidal elevations were referenced to NAVD 88 by interpolating values for the study area utilizing nearby stations. Mean High Water (MHW) was calculated to be 1.45'NAVD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

2.6.4 Sea Level Rise

Global Mean Sea Level (GMSL) is rising at the majority of tide gage locations around the world (National Research Council, 1987), although local mean sea level is falling in some areas where local tectonic effects cause the land to rise faster than GMSL. Major implications of sea level

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

Figure 39 Sea Level Trends Atlantic City



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

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

2.6.5 Storms

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

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

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

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

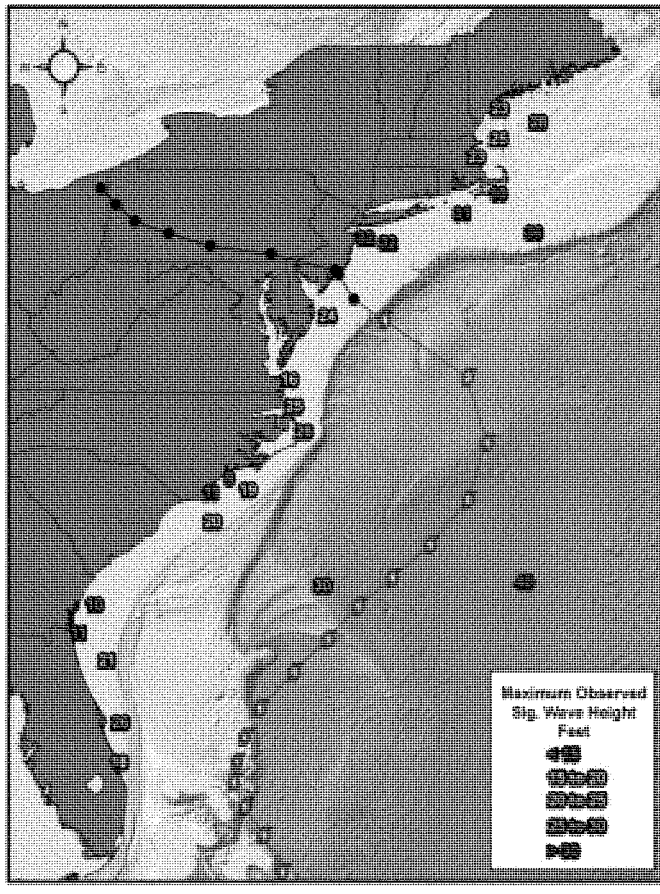
Table 31 shows the 10 highest observed water levels at the Atlantic City tidal station relative to the 1983-2001 tidal epoch. These observed stages have not been adjusted for sea-level rise and are considered as representative of the water levels experienced at the study area over the same period. Hurricane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

Table 31 Tbe 10 Higbest Observed Stages at Atlantic City, NJ 1912-2012

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

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

Figure 40 Hurricane Sandy Track



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

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

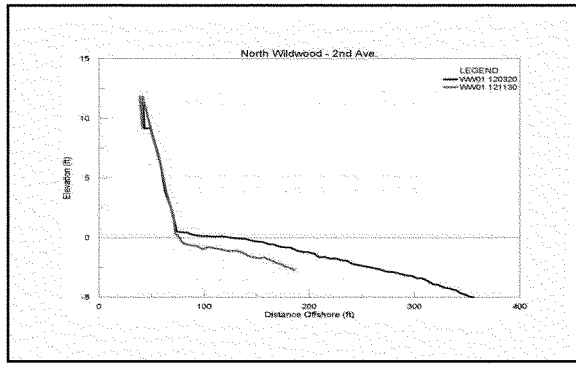


Figure 42 10th Avenue in Wildwood pre and post Sandy Surveys

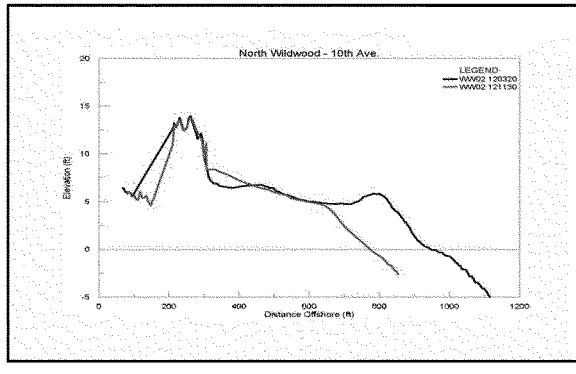


Figure 43 26th Avenue in North Wildwood/Wildwood pre and post Sandy Profiles

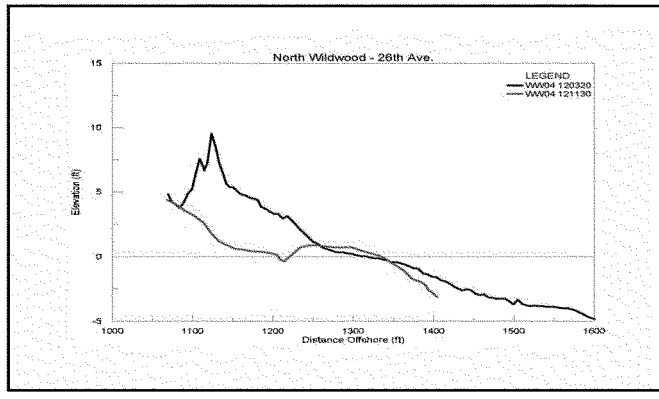


Figure 44 Baker Avenue iu Wildwood pre and post Sandy Surveys

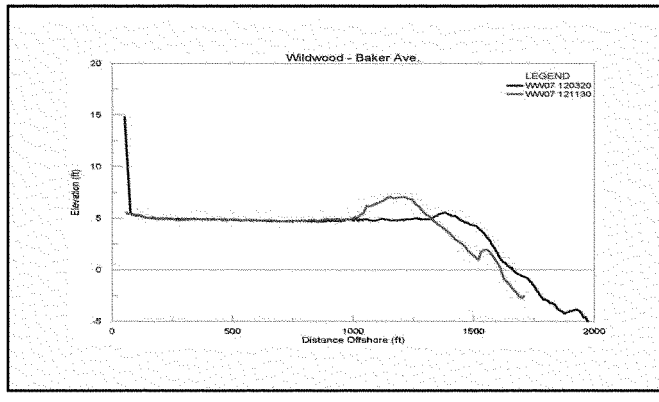


Figure 45 Wildwood Crest Fern Road pre and post Sandy Surveys

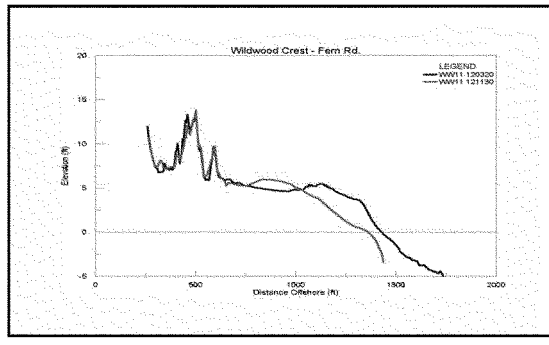


Figure 46 Wildwood Crest Trenton Ave pre and post Sandy Surveys

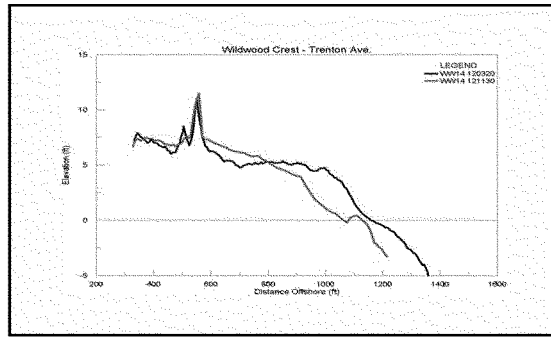


Figure 47 and **Figure 48** show storm surge in North Wildwood that penetrated a small dune and overtopped the existing bulkhead between 2nd and 6th Avenues. **Figure 49** and **Figure 50** show a berm in Wildwood that was overtopped by storm surge during the storm.

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

Figure 48 Bulkhead Overtopping During Hurricane Sandy North Wildwood

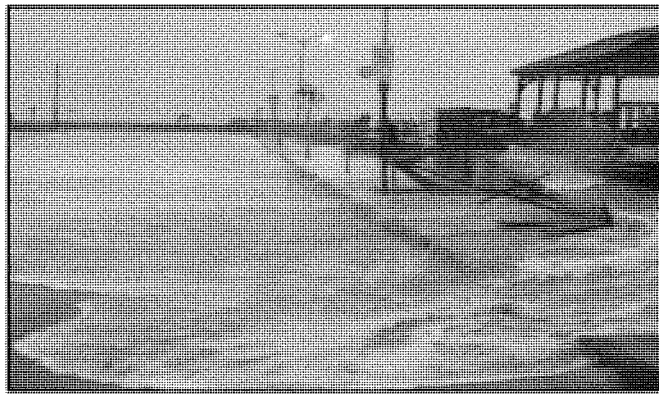


Figure 49 Wildwood Post Storm

Figure 50 Wildwood Crest Post Storm

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

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

Table 32 SBEACH Volume Losses Compared to Sandy profiles

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

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

2.6.6 Ocean Stage Freqnency

The ocean stage frequency curve recommended for the study area was developed from NOAA tide gage data obtained at Atlantic City and Ventnor, New Jersey. The current Atlantic City NOAA gage is approximately 30 miles north of the study area. Previous to its current location in Atlantic City, the gage was located just south of Atlantic City in the town of Ventnor, NJ. Table 30 has the highest observed stages at the gage when it was located first at Ventnor and later moved to Atlantic City. In order to adjust for sea-level rise, a base year was established and the annual peak stages were adjusted using the annual rate of rise multiplied by the years in between

the base year and the year the peak stage was observed. From the adjusted annual series a stage frequency curve was constructed using Weibul plotting positions for each of the gage values and drawing the best fit curve through the points. Values of stage at selected reference frequencies are shown in **Table 33**. For reference, Hurricane Sandy would fall somewhere between the 20-50 year event.

Table 33 Ocean Stage Frequency Data

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

2.6.7 Longshore Sediment Transport

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

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

A GENESIS shoreline change model was not employed to predict longshore transport rates for this study due to several factors. GENESIS was designed to describe long-term trends of a beach

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

Table 34 Potential Longshore Sediment Transport Rates

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

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

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

The values are also representative of potential average conditions over a span of 12 years. It can be expected, however, that changes in long shore sediment transport could happen in a seasonal manner and could contribute significantly to both the short- and long-term behavioral patterns of the shoreline especially in the vicinity of Hereford Inlet in North Wildwood. Depending on the duration of the antecedent incident wave directions and intensities, a specific pattern may exist

for an extended period time or change in a matter of a day or so. It is not unreasonable to expect that northern transport from North Wildwood into Hereford Inlet could be larger during some times than southern transport from Hereford Inlet depending on certain wave conditions and Hereford Inlet morphology. The southerly long shore sand transport from North Wildwood to Wildwood along with the lack of a consistent long shore sand transport from Hereford Inlet to replenish the beaches in North Wildwood is one reason for the eroding shoreline in North Wildwood.

2.6.8 Beach Profile Characteristics

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

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

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

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

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

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

Table 35 Study Area Profiles

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

Table 36 Elevation Parameters

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

Table 37 Contour Locations

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

Figure 51 Beach Profile Locations

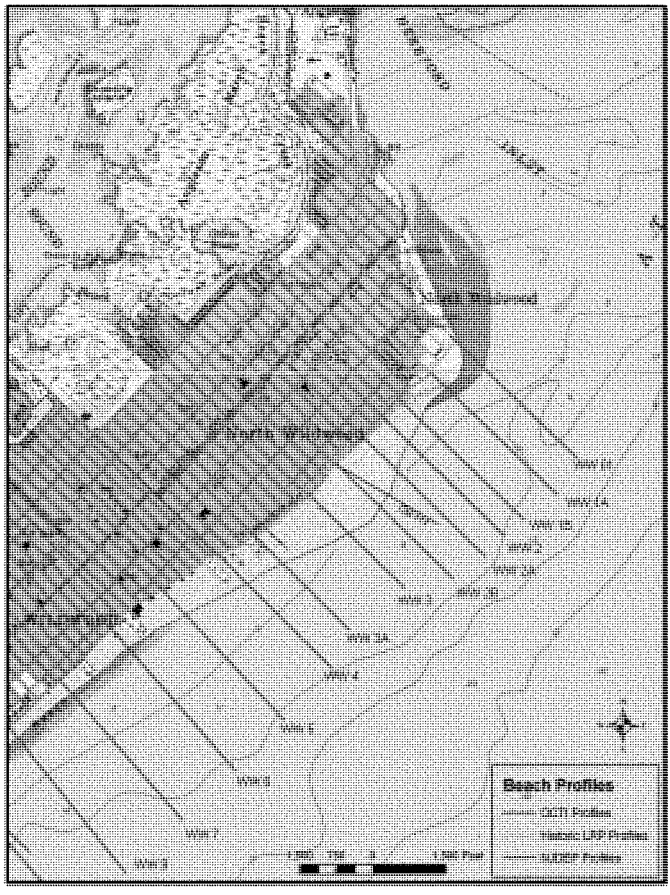
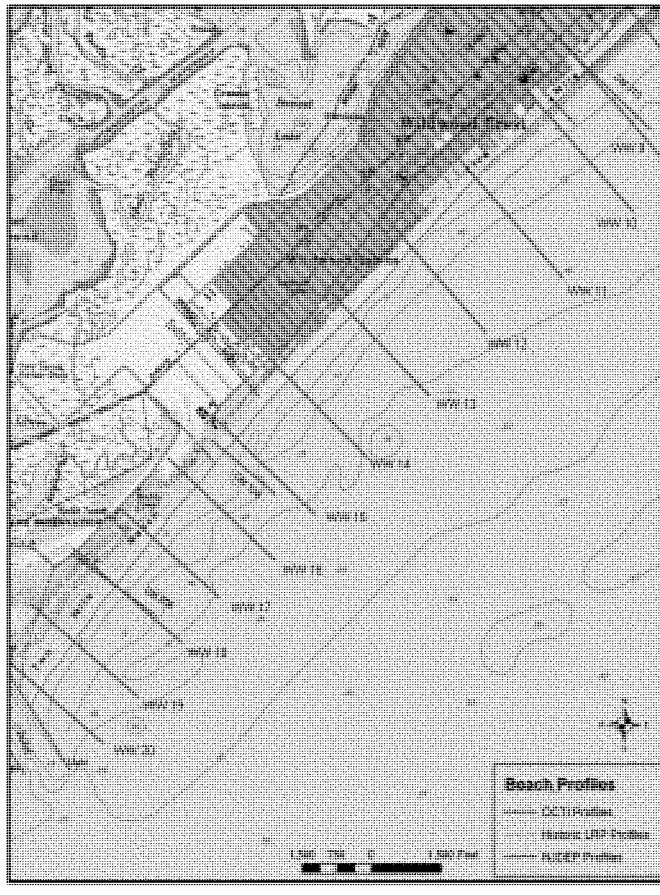


Figure 51continued



2.6.9 Bathymetry

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

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

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

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

Figure 52 Wildwoods Bathymetry 1937-1940

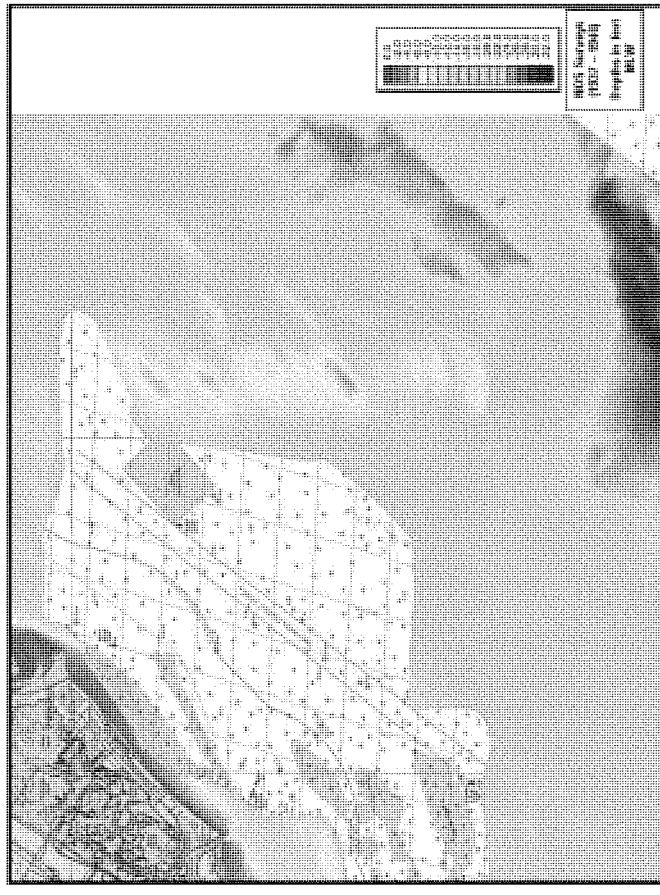


Figure 53 Wildwoods Bathymetry 1970-1977

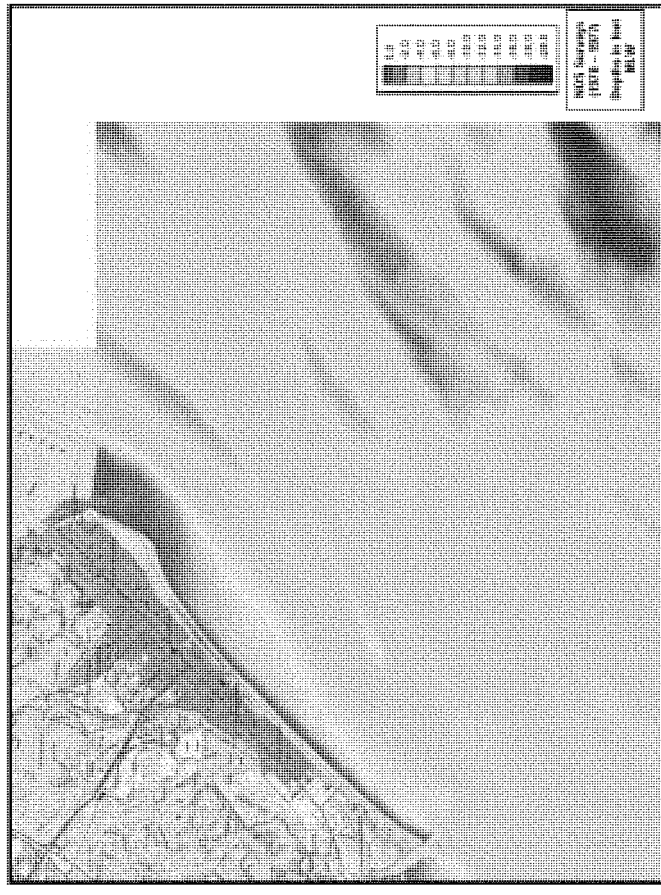


Figure 54 Wildwoods Bathymetry 1999-2004

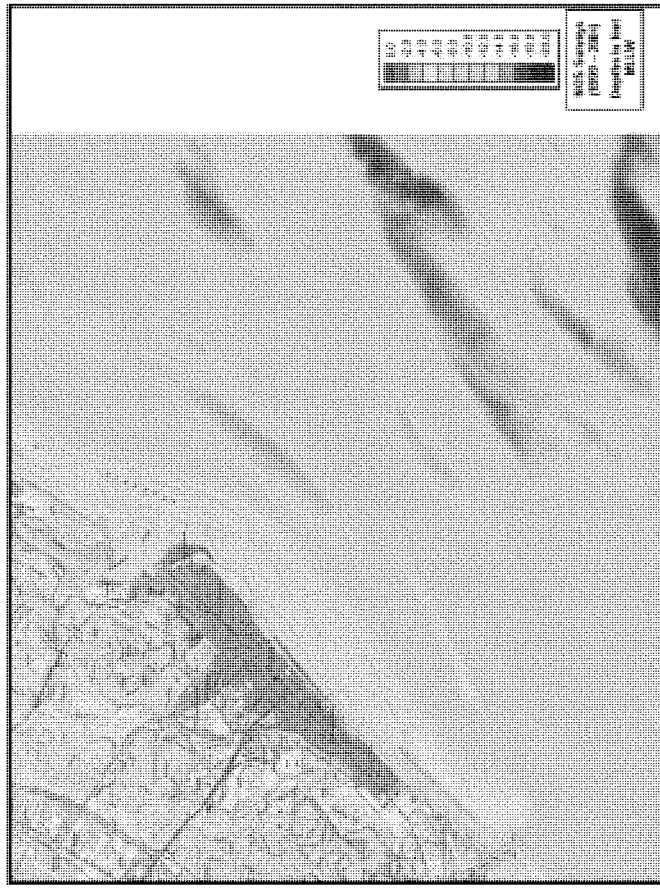


Figure 55 Hereford Inlet Bathymetry 1994

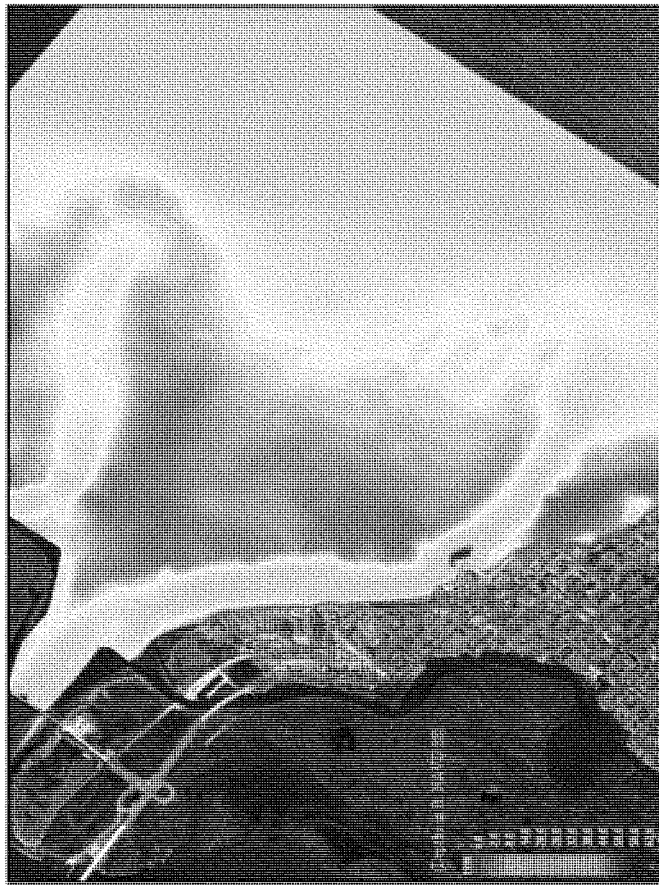


Figure 56 Hereford Inlet Bathymetry 1999

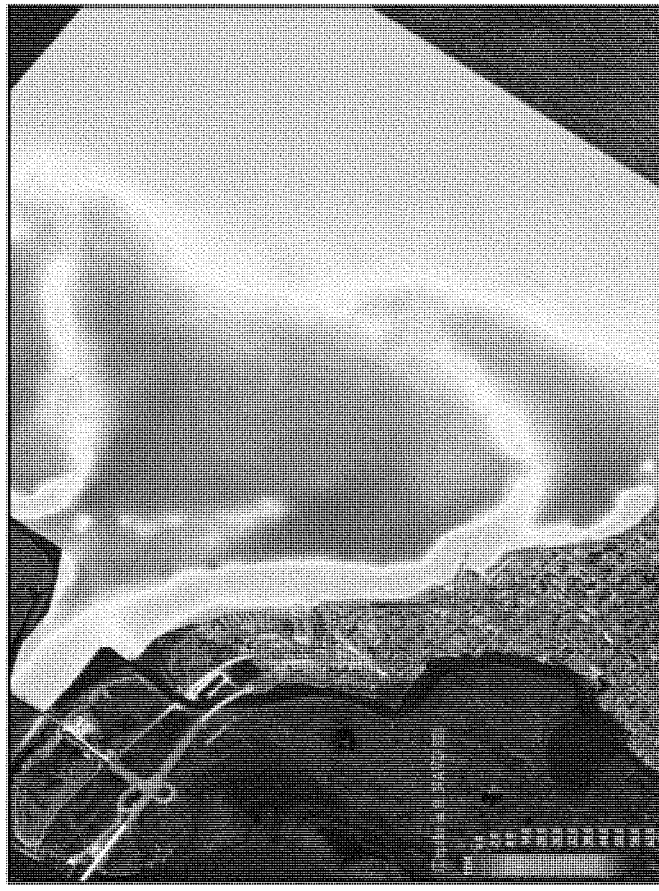


Figure 57 Hereford Inlet Bathymetry 2002

2.6.10 Inlet Sediment Bypassing

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

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

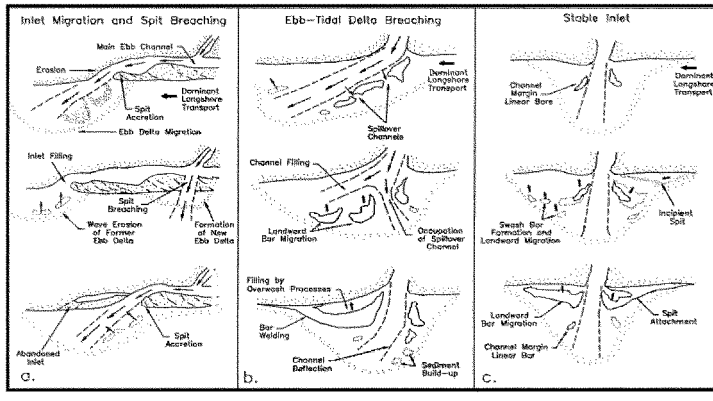
Historic shoreline analysis indicates that Stone Harbor point grows south into Hereford Inlet to a terminal length of approximately 6,000 ft. feet into the inlet, then tidal forces breach the sand spit and the sand is trapped within the Hereford Inlet complex and stored in the ebb and flood shoal. The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

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

over time into Wildwood and Wildwood Crest.

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

Figure 58 Inlet Sediment Bypassing



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

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

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

2.6.12 Section 111—Shore Damage Attributable to Federal Navigatiou Projects

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

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

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

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

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

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

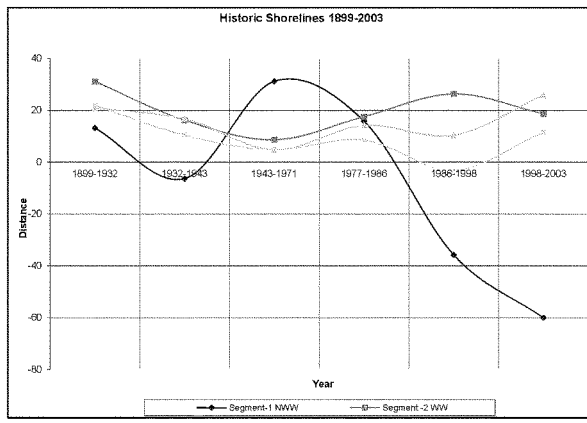


Figure 60 1920 Aerial Photograph

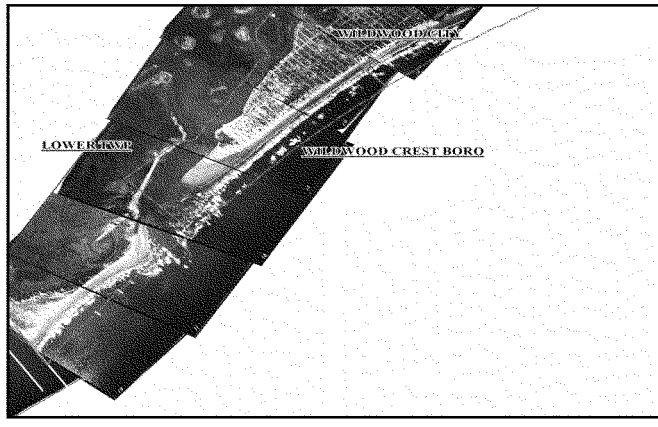
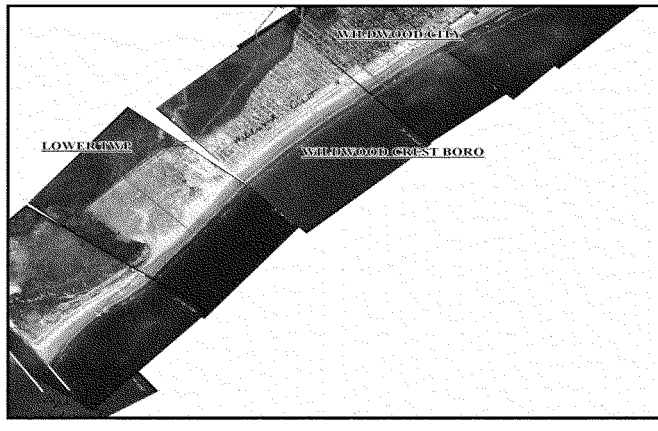


Figure 61 1933 Aerial Photograph



2.7 Summary of Historic Shoreline Conditions

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

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

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

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

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

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

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

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

2.7.1 Prior Shoreline Change Studies

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

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

this area as summarized in the following paragraphs.

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

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

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

2.7.2 Historic Aerial Photography 1933-2012

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

Figure 62 Aerials 1920

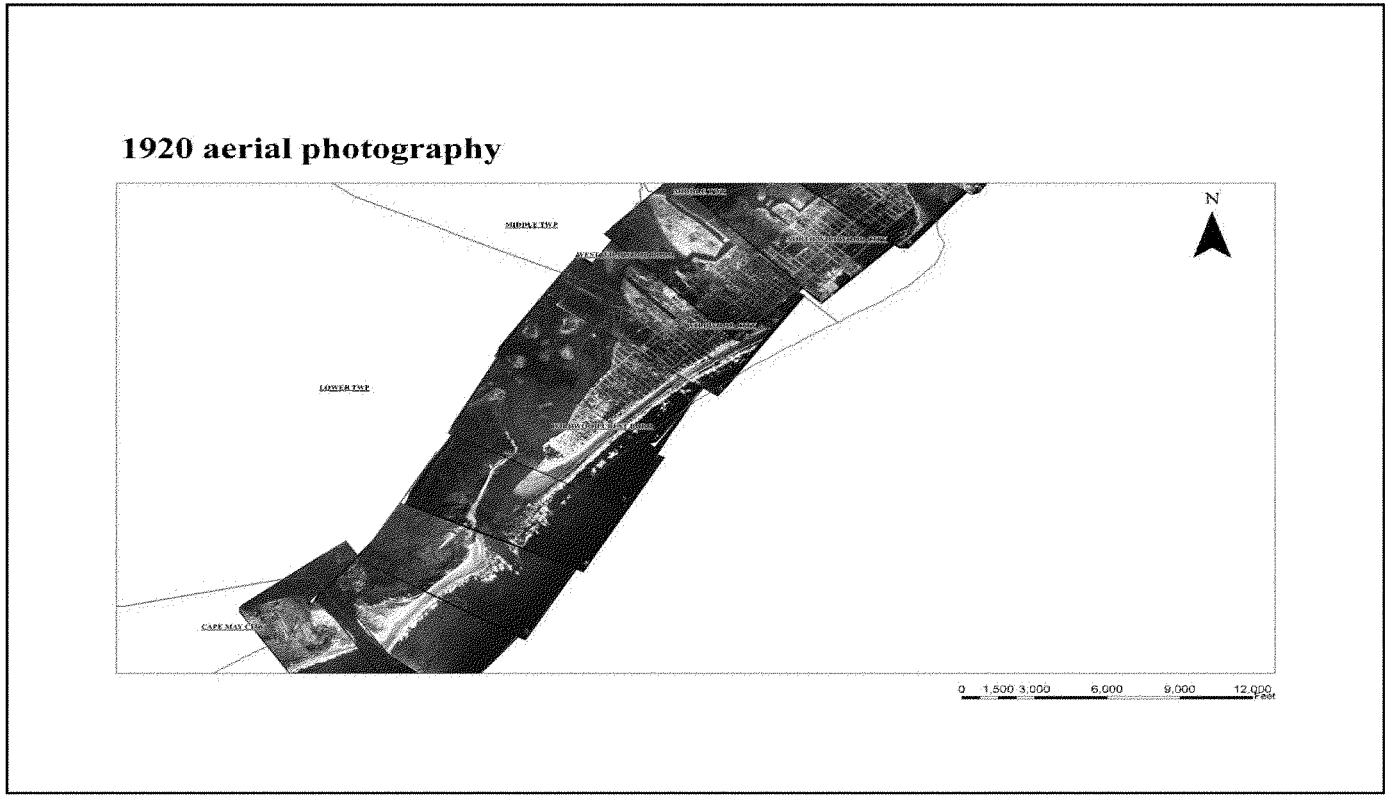


Figure 63 Aerials 1933

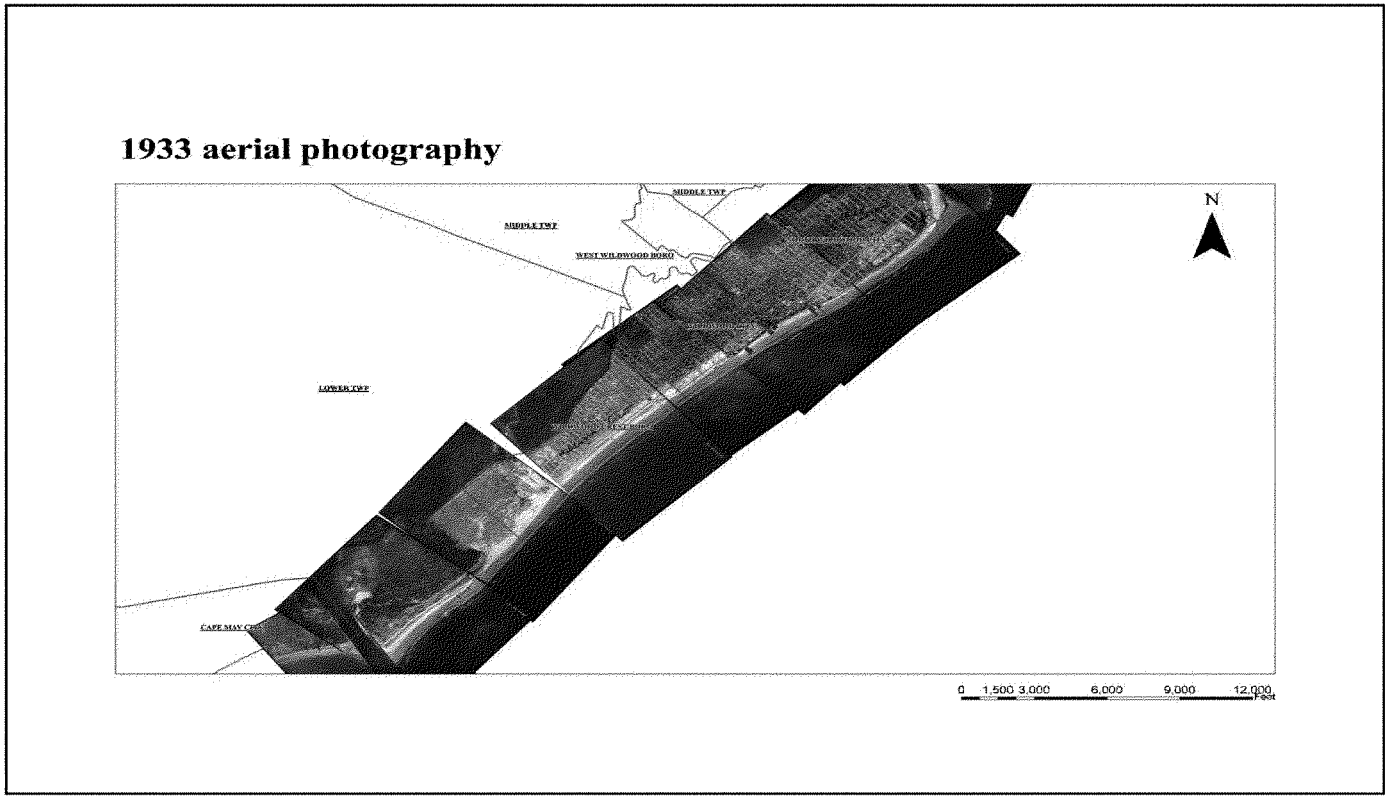


Figure 64 Aerial 1944

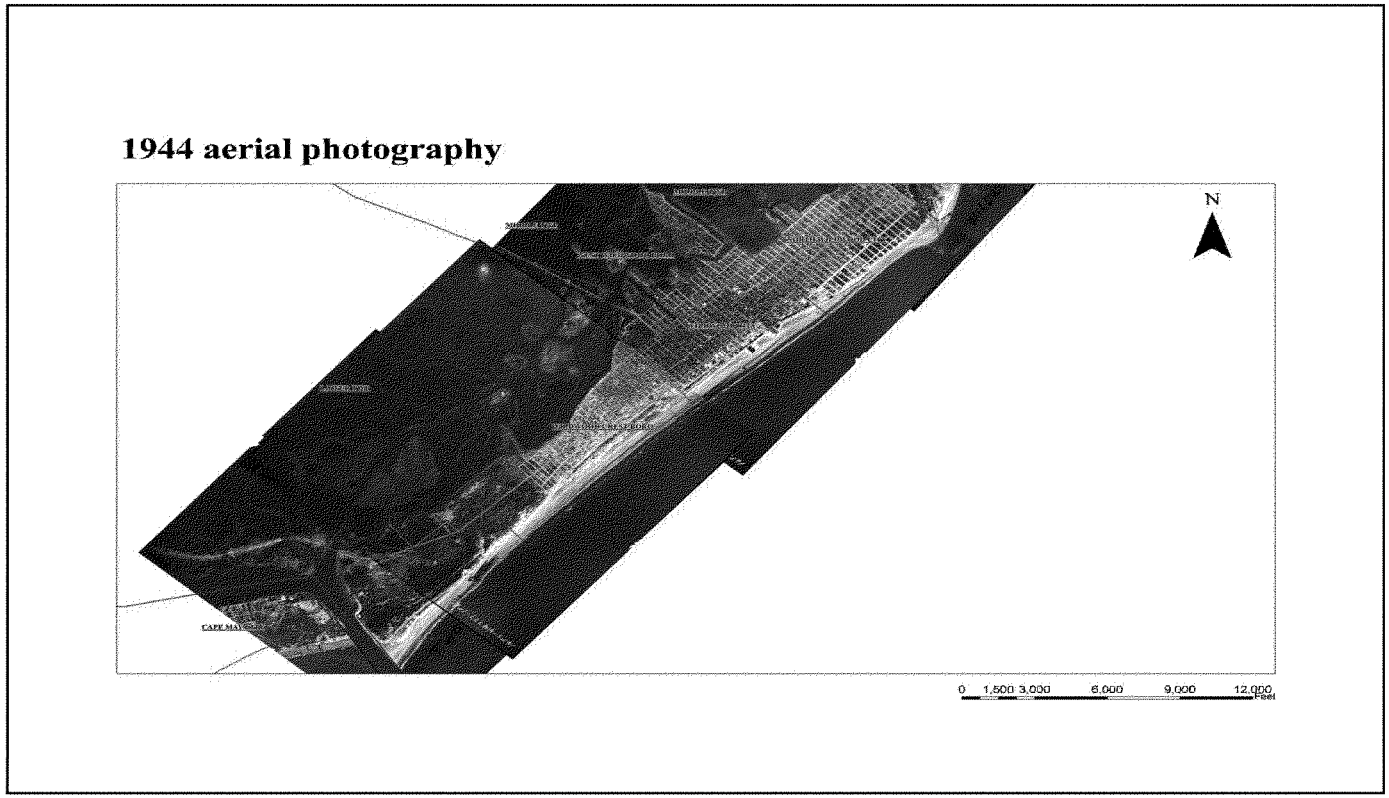


Figure 65 Aerials 1962

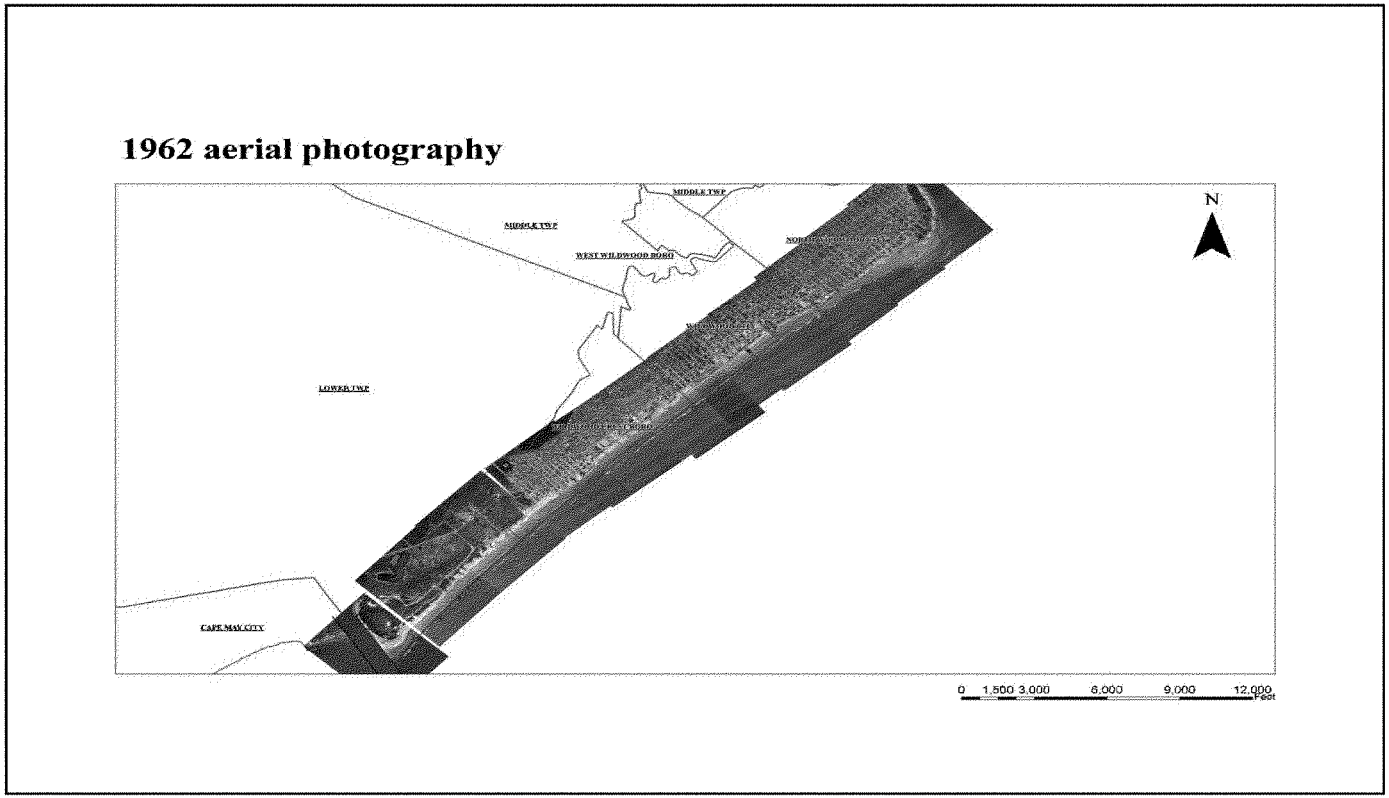


Figure 66 Aerials1970

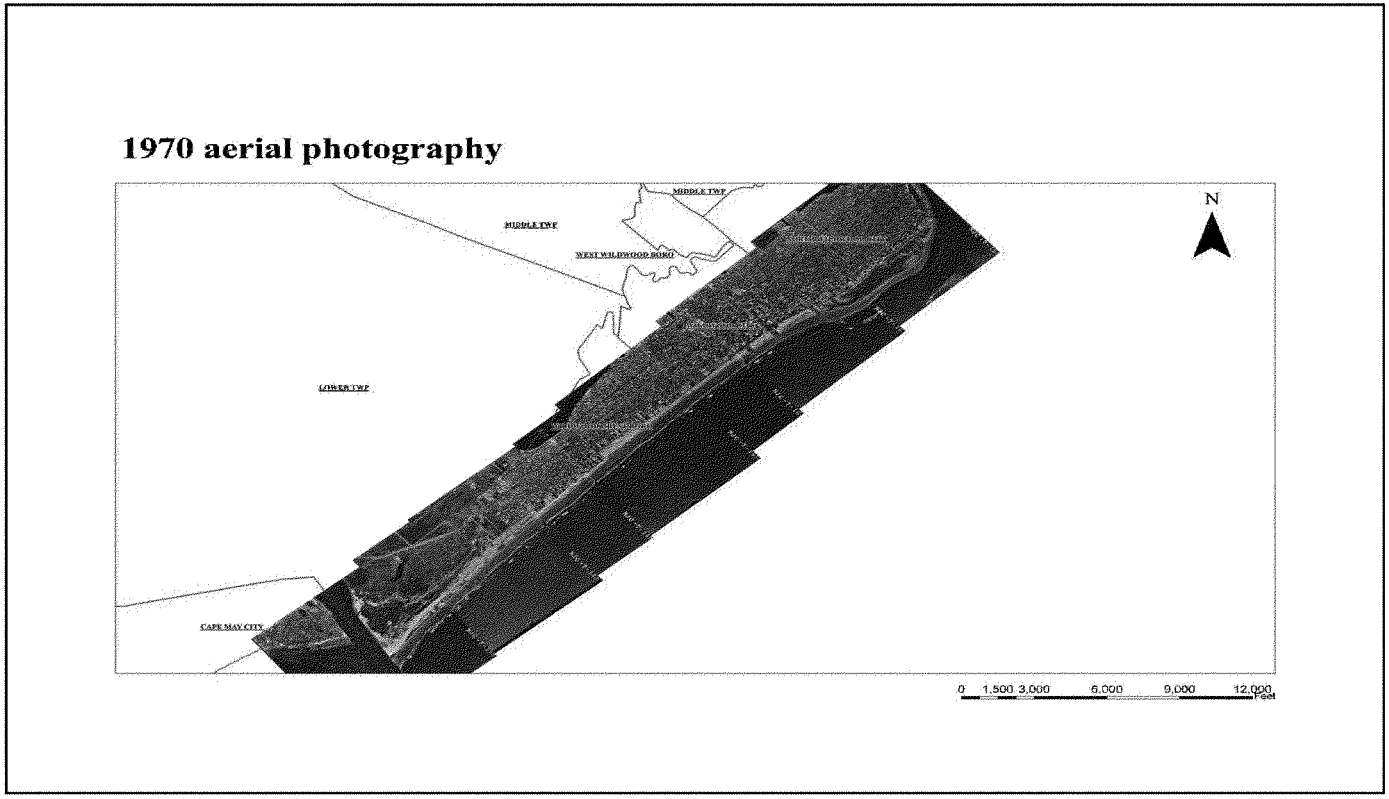


Figure 67 Aerials 2003

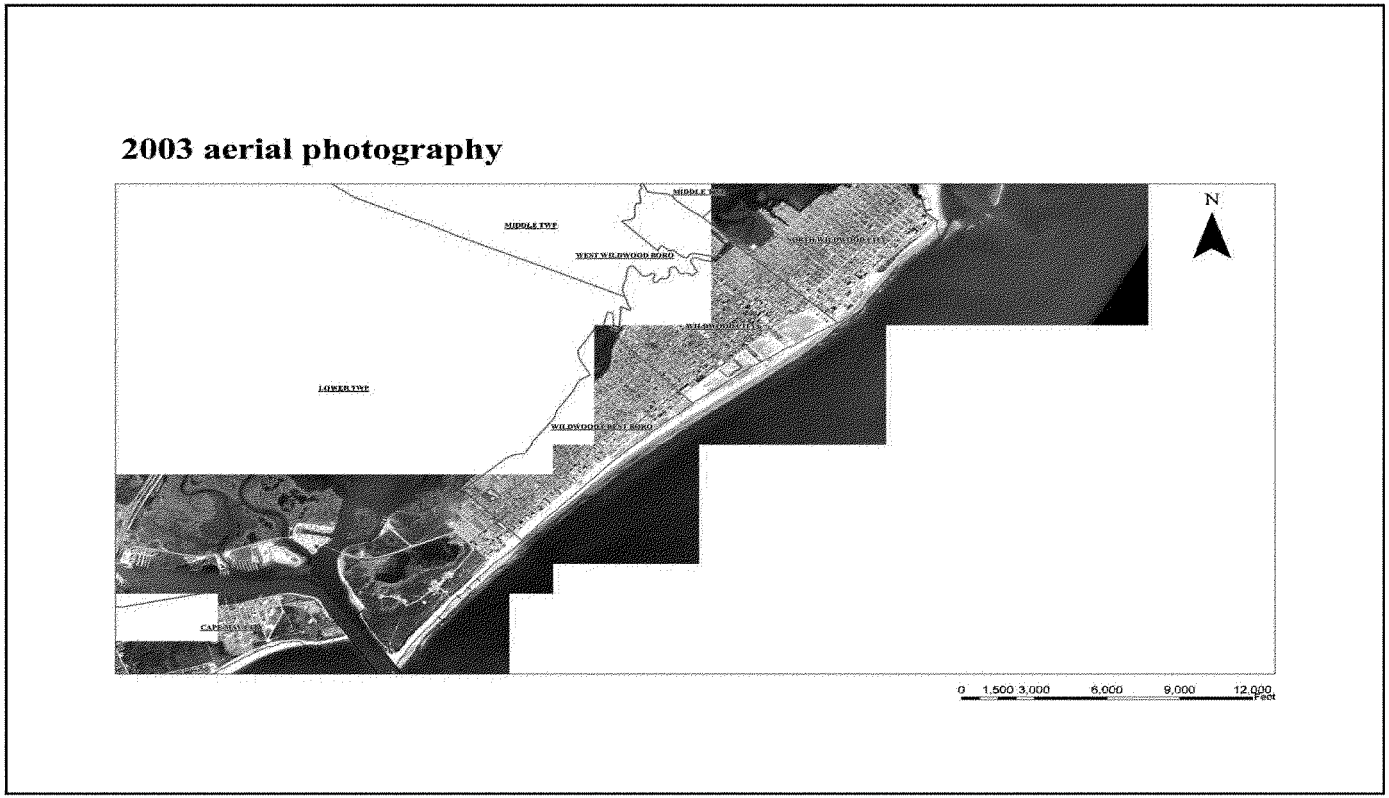


Figure 68 Aerials 2006

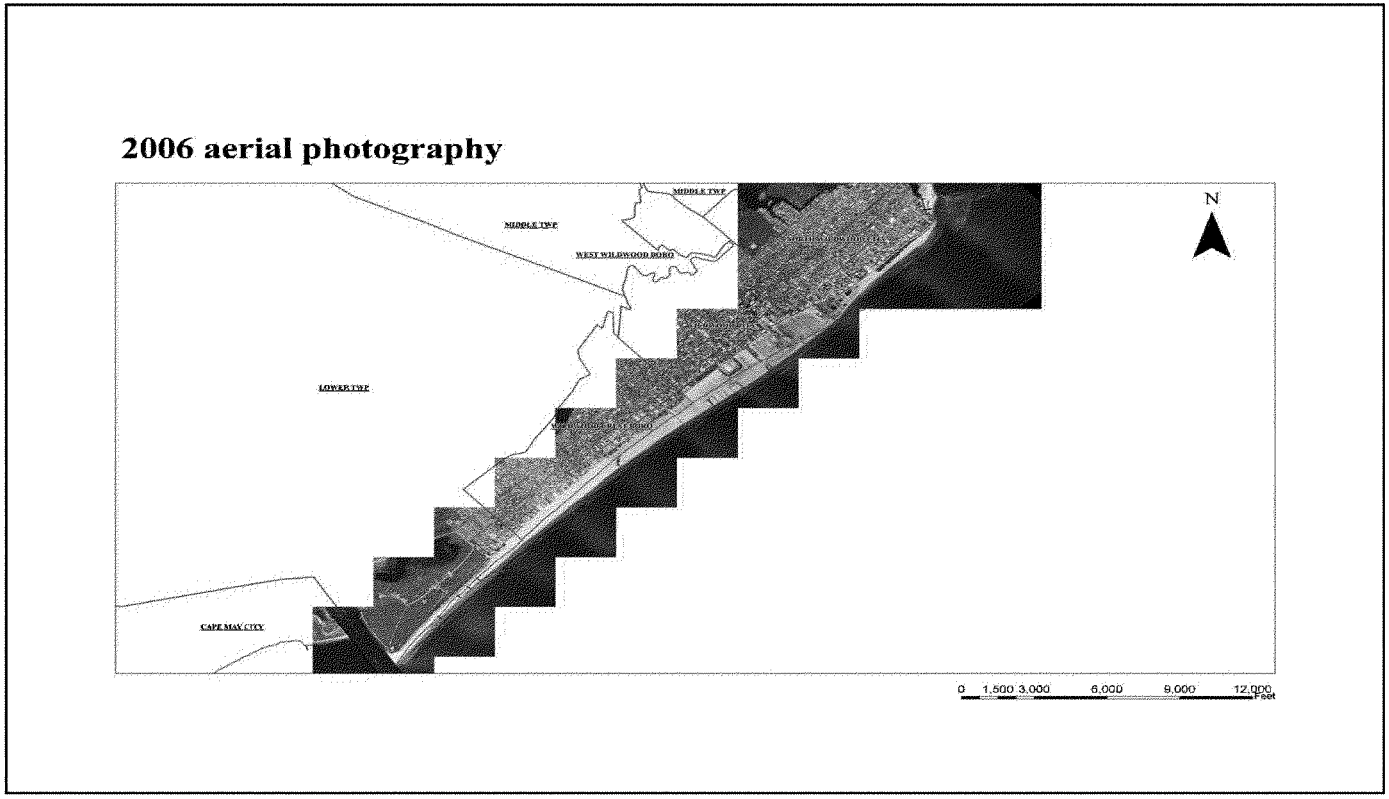
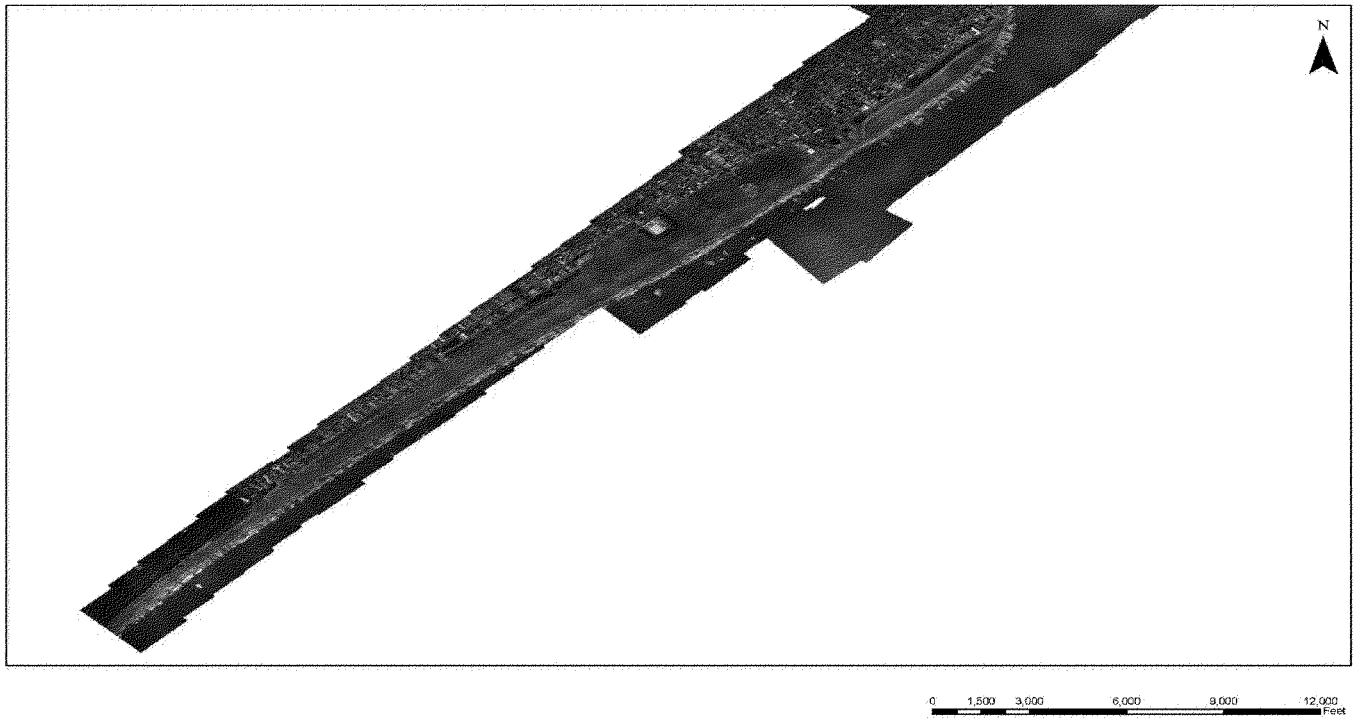


Figure 69 Aerials 2012

Post Sandy Aerial Photography 2012



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

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

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

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

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

Figure 70 1955, 2003 and 2012 Profile comparison in Wildwood

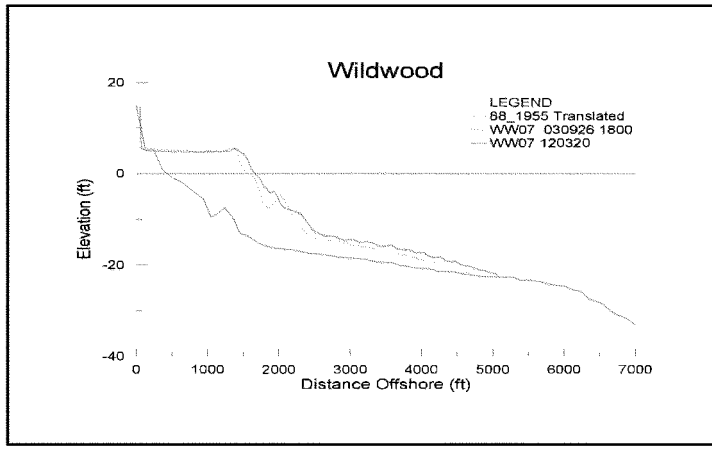


Table 38 1955, 2003, 2012 Volume Comparisons

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

2.8 Shoreline Change Analysis

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

Table 39 Historic Shoreline Analysis Segments

Segment	Avg Historical Shoreline Angle	Municipality	Segment Location	Segment Length (ft)
WW1	46.56	North Wildwood	2nd Ave to 16th Ave	6,800
WW2	37.4	Wildwood	16th Ave to Cresse Ave	6,930
WW3	46.16	Wildwood Crest	Cresse Ave to Jefferson Ave	5,030
WW4	47.1	Lower Township	Jefferson Ave to Cape May Inlet	8,790

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

Figure 71 North Wildwood Shoreline Positions 1899-2003

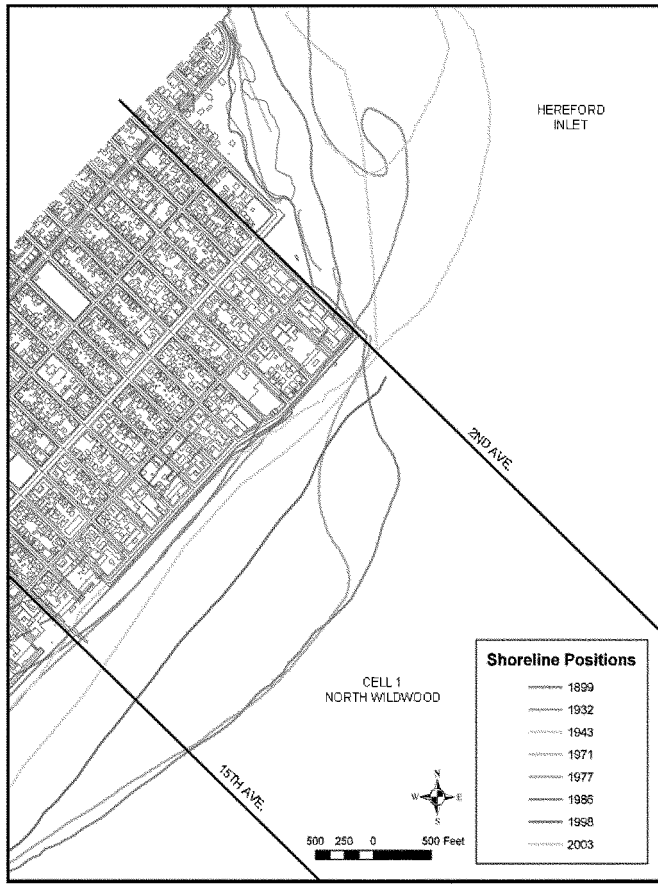


Figure 72 North Wildwood and Wildwood Shoreline Positions 1899-2003

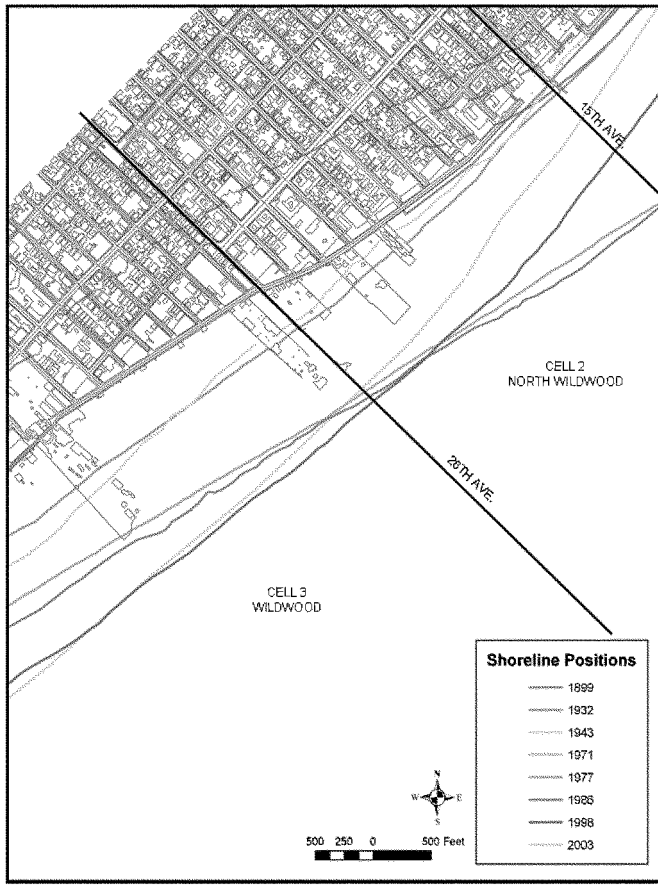


Figure 73 Wildwood and Wildwood Crest Shoreline Positions 1899-2003

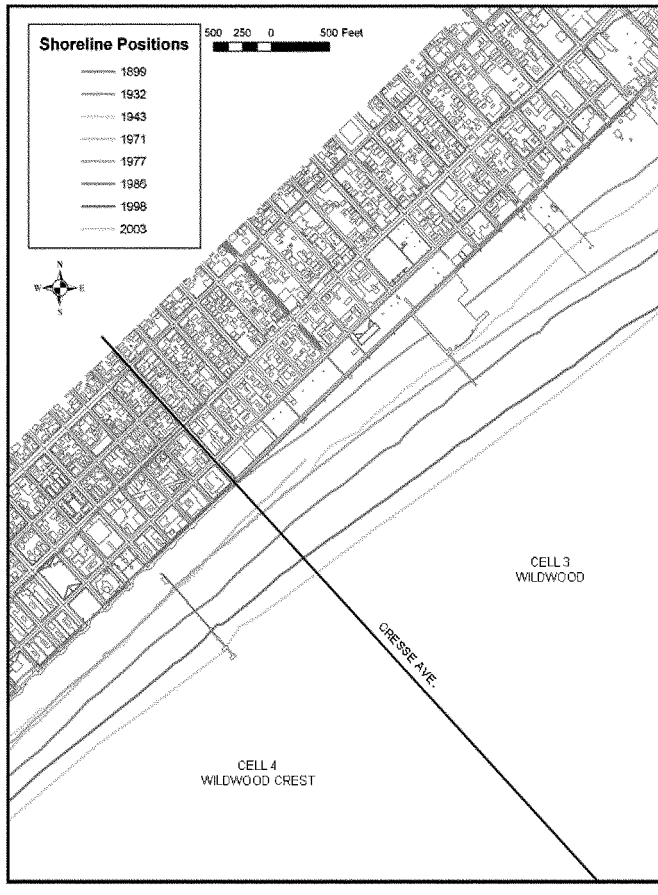


Figure 74 Wildwood Crest Shoreline Positions 1899-2003

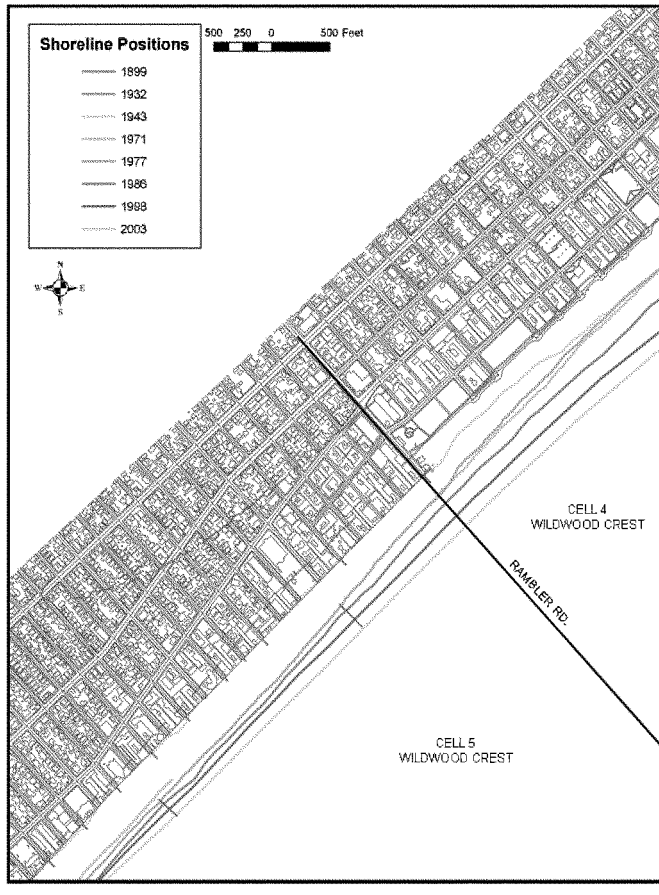


Figure 75 Wildwood Crest and Lower Township Shoreline Positions 1899-2003

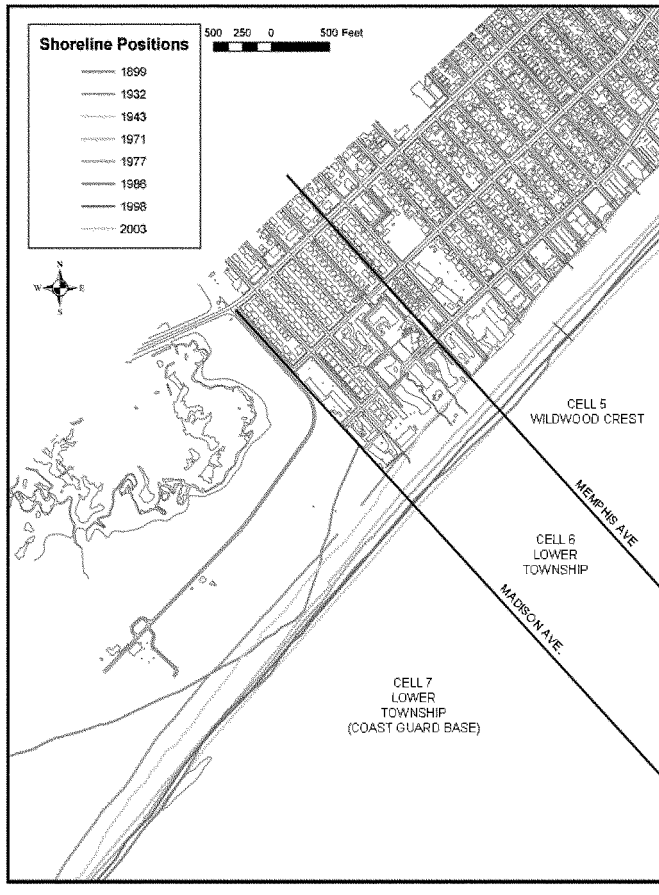
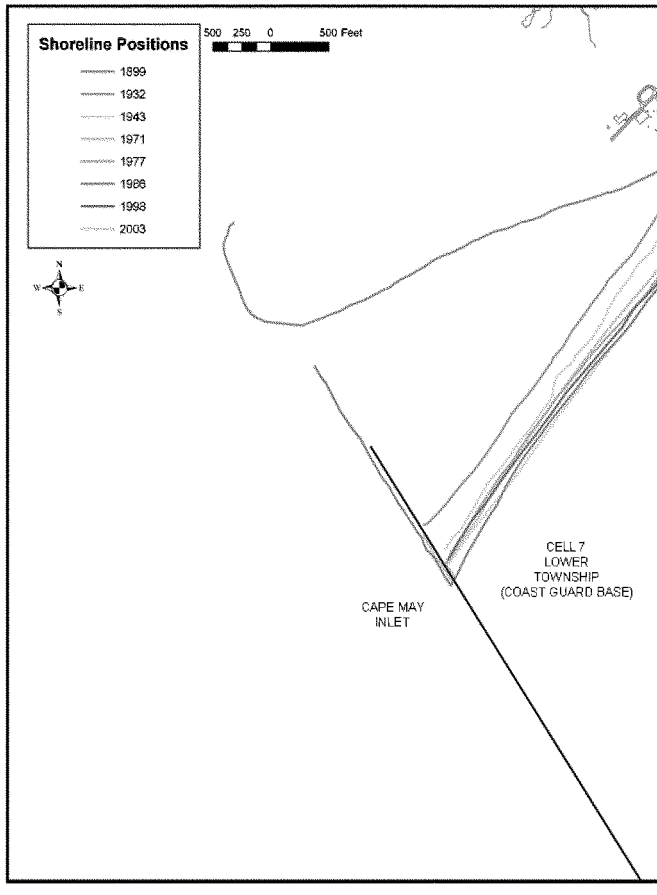


Figure 76 Lower Township Shoreline Position 1899-2003



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

Table 40 Shoreline Change Rates, Segment 1

Adjacent Shoreline Dates (feet / year)							
Comp #	Length (ft)	1899-1932	1932-1943	1943-1977	1977-1986	1986-1998	1998-2003
1	800	4.47	17.96	3.59	48.52	-23.85	-30.57
2	700	2.82	-0.01	23.84	60.62	-67.15	-56.34
3	750	0.28	-11.29	46.19	-0.18	-68.96	-89.13
4	900	0.05	-16.85	47.07	-0.94	-64.32	-90.55
5	700	1.37	-10.71	41.09	4.27	-49.98	-79.23
6	750	7.61	-3.37	33.84	10.49	-33.83	-76.46
7	800	26.17	-9.39	30.84	9.00	-15.70	-58.43
8	600	35.78	-11.80	28.84	4.73	-2.74	-35.71
9	840	39.70	-11.71	25.25	5.58	4.70	-23.78
Avg		13.14	-6.35	31.17	15.79	-35.76	-60.02

Relative to 2003 Shoreline (feet / year)						
Comp #	Length (ft)	1899-2003	1932-2003	1943-2003	1977-2003	1986-2003
1	800	6.26	5.92	3.83	-3.27	-25.45
2	700	8.59	9.41	7.22	-27.52	-64.58
3	750	9.31	10.77	7.75	-51.40	-73.75
4	900	9.37	11.25	9.02	-49.25	-70.55
5	700	10.09	11.92	10.01	-38.06	-56.93
6	750	11.63	12.12	10.41	-26.80	-43.95
7	800	16.11	13.08	13.10	-14.53	-25.85
8	600	18.65	13.94	15.03	-5.29	-10.57
9	840	19.17	13.64	15.25	0.84	-2.06
Avg		12.13	11.34	10.18	-23.92	-41.52

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

The existing conditions within and surrounding the study did not undergo any drastic "changes" that would lead someone to the conclusion that a continued accelerated rate of erosion would continue to happen post 2003. In fact, aerial photography collected since 2003 and profile data

collected in 2012 associated with pre- and post Hurricane Sandy suggests that the rate of erosion has reduced significantly in North Wildwood; reverting back to historical values. More weight should be given to the longer time periods shown in **Table 40** when it comes to describing what the prevailing existing conditions within the study area; especially when in reference to comparing potential re-nourishment values against existing conditions.

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

Table 41 Shoreline Change Rates for Wildwood Segment 2

Adjacent Shoreline Dates (feet / year)							
Comp #	Length (ft)	1899-1932	1932-1943	1943-1977	1977-1986	1986-1998	1998-2003
1	1000	38.66	-4.81	22.37	10.40	12.65	-11.75
2	900	35.97	5.60	16.48	12.58	21.56	1.16
3	600	33.35	14.33	11.15	11.81	28.88	10.59
4	700	31.67	18.08	8.50	17.00	31.74	14.61
5	1000	31.31	19.62	5.86	16.66	33.09	26.87
6	1000	29.54	23.69	2.74	20.88	30.56	33.37
7	1000	26.05	23.43	1.71	25.92	26.90	34.53
8	630	21.92	29.34	-0.08	25.07	24.84	39.76
Avg		31.06	16.16	8.59	17.54	26.28	18.64

Relative to 2003 Shoreline (feet / year)						
Comp #	Length (ft)	1899-2003	1932-2003	1943-2003	1977-2003	1986-2003
1	1000	19.89	14.84	16.43	8.36	5.29
2	900	19.55	15.04	16.13	15.93	16.71
3	600	18.56	14.34	14.93	21.15	24.54
4	700	18.94	15.27	13.80	24.86	27.67
5	1000	17.72	13.84	14.39	27.29	31.61
6	1000	16.74	12.95	13.11	28.08	31.23
7	1000	15.60	12.51	12.66	27.72	28.71
8	630	15.00	14.18	12.10	27.07	28.39
Avg		17.75	14.12	14.19	22.56	24.27

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

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

Table 42 Shoreline Change Rates for Wildwood Crest, Segment 3

Adjacent Shoreline Dates (feet / year)								
Comp #	Length (ft)	1899-1932	1932-1943	1943-1971	1971-1977	1977-1986	1986-1998	1998-2003
1	1000	19.15	30.26	-2.07	8.33	29.21	20.28	37.97
2	1000	18.01	30.48	-0.20	-0.63	23.32	19.45	34.15
3	1000	15.81	28.47	1.46	-4.68	23.60	14.81	33.88
4	1000	15.35	18.35	6.38	-7.08	18.68	12.46	35.55
5	1000	16.87	16.45	7.64	-2.50	12.14	11.57	26.63
6	1000	19.98	13.80	N/A	N/A	9.56	9.00	21.12
7	1000	25.09	11.04	N/A	N/A	5.74	5.96	23.37
8	700	37.00	8.25	N/A	N/A	5.90	4.66	18.25
9	1000	N/A	6.41	10.73	7.80	6.11	3.84	16.97
10	930	N/A	3.35	9.95	9.37	7.97	1.37	10.77
Avg		**20.91**	**16.69**	**4.84**	**1.52**	**14.22**	**10.34**	**25.87**

Relative to 2003 Shoreline (feet / year)							
Comp #	Length (ft)	1899-2003	1932-2003	1943-2003	1971-2003	1977-2003	1986-2003
1	1000	13.68	11.69	10.90	23.32	25.51	24.49
2	1000	12.57	10.65	10.08	19.69	22.73	22.94
3	1000	11.68	10.08	9.36	17.15	20.19	19.34
4	1000	11.33	10.03	9.88	14.43	17.66	17.94
5	1000	11.33	9.47	9.11	11.59	13.92	15.14
6	1000	11.89	9.31	8.97	N/A	10.92	11.88
7	1000	13.15	9.44	9.18	N/A	8.42	10.10
8	700	15.29	8.70	8.60	N/A	7.00	7.88
9	1000	N/A	8.45	8.36	6.50	6.42	6.96
10	930	N/A	7.59	7.69	5.50	4.70	3.60
Avg		**12.62**	**9.54**	**9.21**	**14.03**	**13.75**	**14.03**

Table 43 Shoreline Change Rates for Lower Township, Segment 4

Adjacent Shoreline Dates (feet / year)								
Comp #	Length (ft)	1899-1932	1932-1943	1943-1971	1971-1977	1977-1986	1986-1998	1998-2003
1	800	N/A	0.36	8.93	10.52	13.14	-2.91	11.83
2	800	N/A	-0.53	8.08	10.67	12.58	-4.07	16.04
3	1000	8.30	6.39	4.72	9.23	7.63	0.63	10.35
4	1000	-3.59	7.51	5.62	5.50	4.41	0.80	9.47
5	1000	-0.14	11.39	6.31	2.28	2.33	-0.18	12.07
6	1000	14.41	11.71	5.39	5.08	5.59	-3.45	10.77
7	1000	32.76	13.11	3.26	5.08	8.48	-3.02	9.06
8	750	46.07	16.55	1.49	-0.75	8.20	-2.87	13.33
9	500	56.31	16.05	2.40	-3.13	10.54	-5.96	13.64
10	500	N/A	22.53	2.68	-3.95	13.33	-9.51	8.54
Avg		**22.02**	**10.51**	**4.89**	**4.05**	**8.62**	**-3.05**	**11.51**

Relative to 2003 Shoreline (feet / year)							
Comp #	Length (ft)	1899-2003	1932-2003	1943-2003	1971-2003	1977-2003	1986-2003
1	800	N/A	7.03	7.44	5.46	4.01	0.59
2	800	N/A	6.45	6.95	5.25	3.80	0.71
3	1000	6.07	5.32	5.16	5.00	4.13	2.94
4	1000	3.16	5.00	4.53	3.49	3.13	2.86
5	1000	4.20	5.04	3.99	2.27	2.34	2.73
6	1000	7.46	4.83	3.73	2.04	1.30	-0.08
7	1000	11.44	4.42	3.35	2.95	2.16	-0.15
8	750	13.98	3.52	2.10	2.65	2.77	0.98
9	500	16.39	3.50	1.99	1.73	1.80	-1.30
10	500	N/A	3.87	1.50	0.35	-0.09	-5.22
Avg		**8.96**	**4.90**	**4.07**	**3.12**	**2.54**	**0.41**

2.8.1 Sediment Budget

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

A sediment budget represents an accounting of all sediment movement, both natural and mechanical, within a defined area over a specified time. The defined area is represented by a series of control volumes. Each control volume represents an area of similar geographical and

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

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

2.8.2 Analysis Procedures

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

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

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

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

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

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

2.8.3 Sediment Budget Uncertainty

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

Table 44 Sediment Budget Uncertainty

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

2.8.4 Sediment Budget Balancing

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

2.8.5 Sediment Budget Results

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

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

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

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

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

North Wildwood

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

Hereford Inlet

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

Figure 77 Sediment Budget

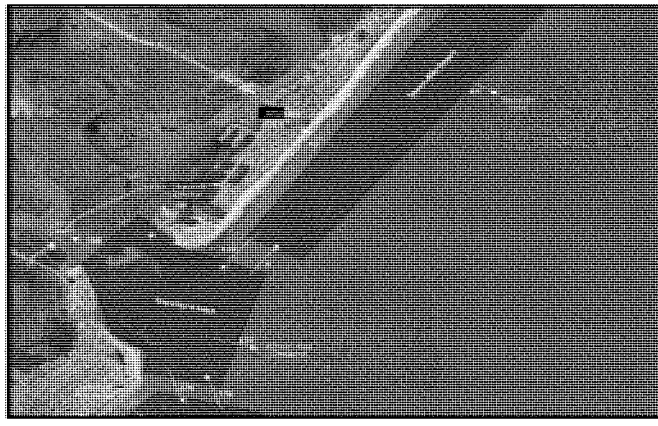


Figure 78 Sediment Budget

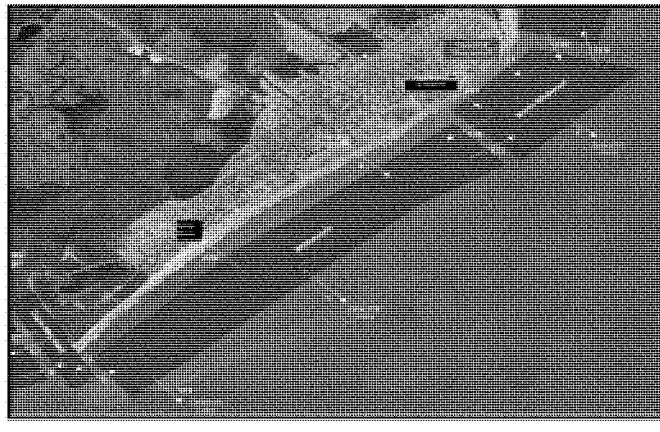


Table 45 Sediment Budget Results

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

3.0 Without Project Analysis

3.1 Hydraulic Analysis

3.1.1 Storm Erosion, Inundation and Wave Attack Analyses

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

3.1.2 Factors Influencing Storm Effects

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

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

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

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

dissipate energy.

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

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

3.1.3 Modeling Storm-induced Erosion

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

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

3.1.4 Overview of SBEACH Methodology

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

Input parameters include varying water levels as produced by storm surge and tide, varying wave

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

3.1.5 SBEACH Calibration

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

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

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

An SBEACH simulation for Hurricane Sandy was performed that compared the estimated volumes lost above MHW from the pre- and post Sandy surveyed profiles versus predicted volume lost from a 20-50-yr storm taken from the existing analysis. It should be noted that not

all the profiles collected pre- and post Sandy were evaluated within the project analysis. The profiles from the analysis were: WW02 (cell 1); WW03 (cell 2); WW07 (cell 3); WW10 (cell 4); WW13 (cell 5); and WW15 (cell 6). The pre- and post Sandy profiles that were collected were: WW01; WW02; WW04; WW07; and WW11. It should be noted that the pre- Sandy surveys were done in the previous Spring, 7 months prior to the hurricane and the post surveys were conducted 1 month afterwards. The volume lost between profiles was determined on a per linear foot basis by the average area end method. **Table 46** summarizes these loss rates as cubic yds per linear foot of shoreline:

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

Table 46 Hurricane Sandy vs. SBEACH Volume Loss Table

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

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

Figure 79 Ocean City NJ 1992 SBEACH calibration Plots-138

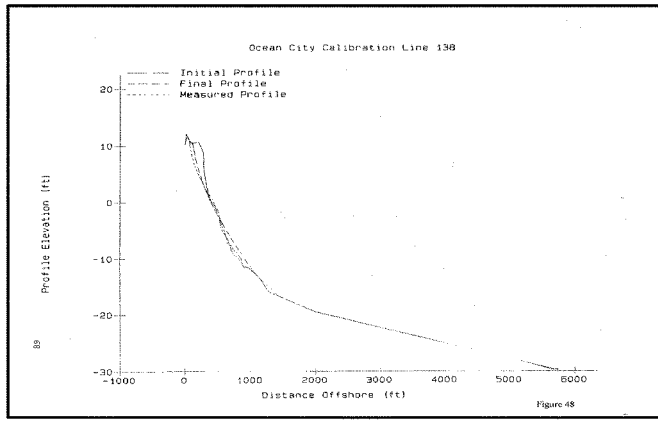
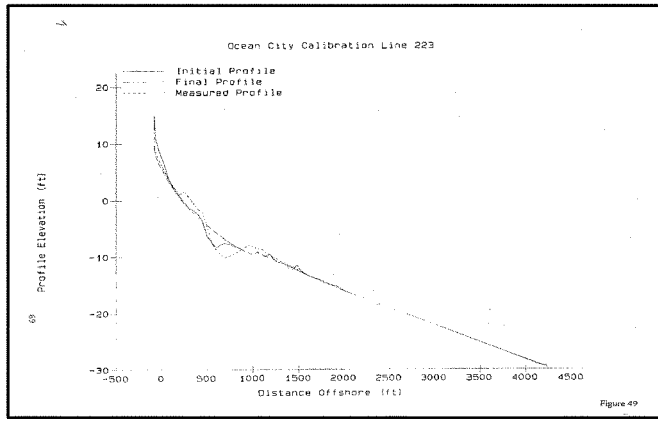


Figure 80 Ocean City, NJ 1992 SBEACH Calibration Plot-223



3.1.6 Development of Input Data for Storm Erosion Modeling

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

3.1.7 Profile Data

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

Table 47 Profiles Used in Hydraulic Analysis

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

Figure 81 Cell 1 Without Project Profile

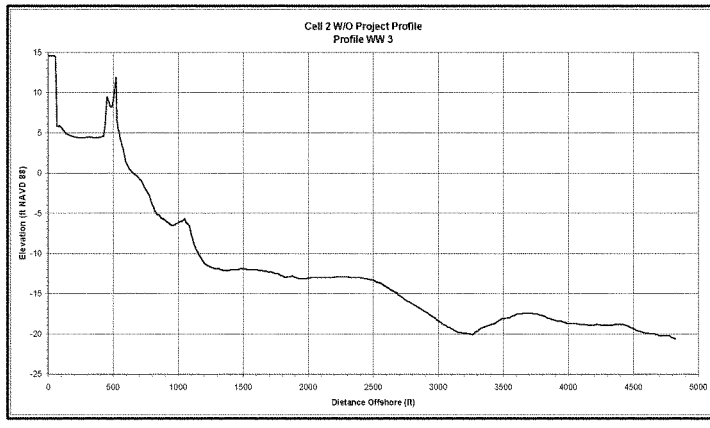


Figure 82 Cell 2 Without Project Profile

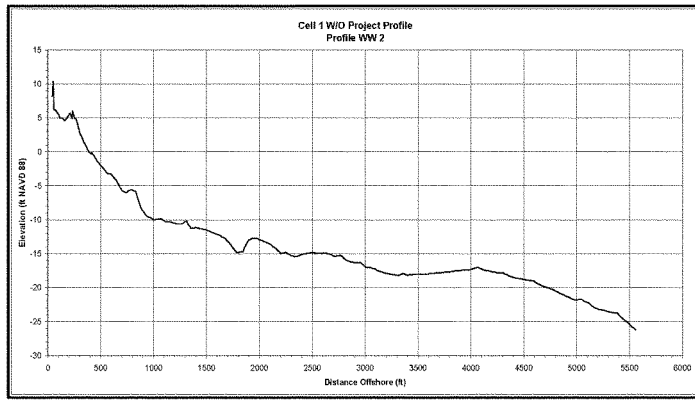


Figure 83 Cell 3 Without Project Profile

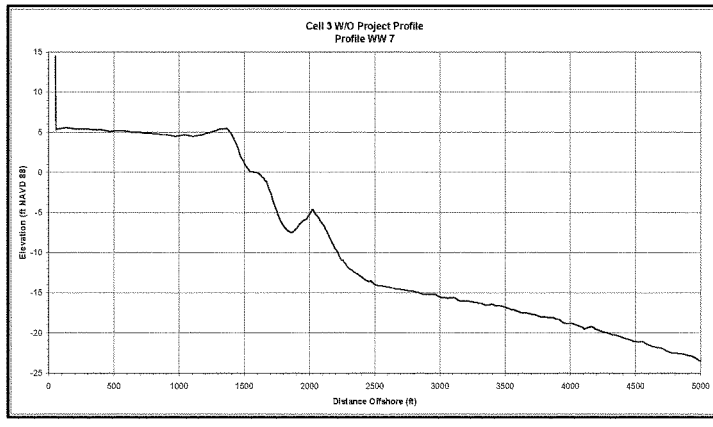


Figure 84 Cell 4 Without Project Profile

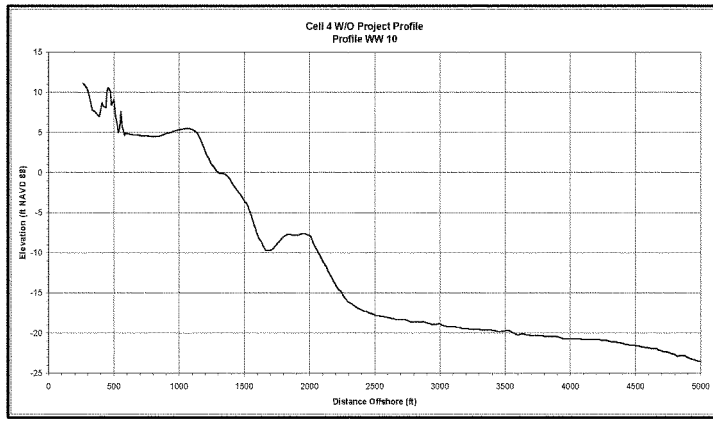


Figure 85 Cell 5 Without Project Profile

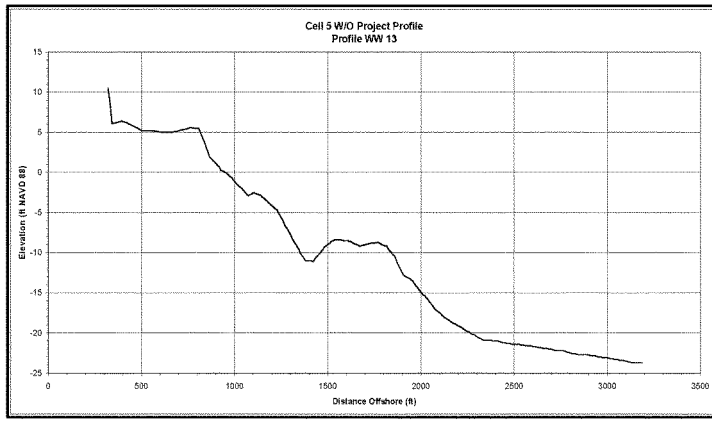


Figure 86 Cell 6 Without Project Profile

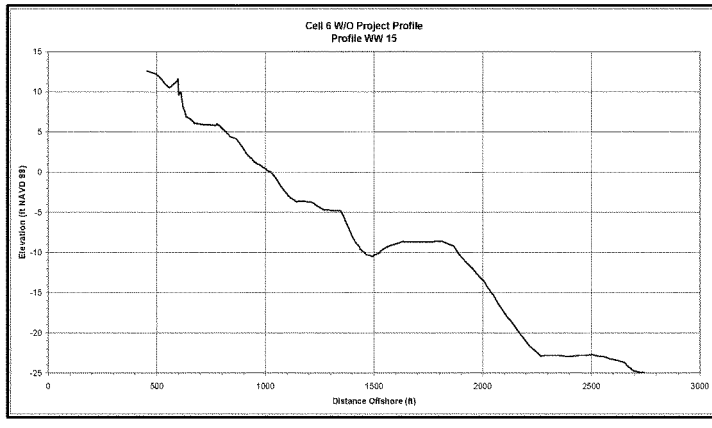


Figure 87 Cell 7 Without Project Profile

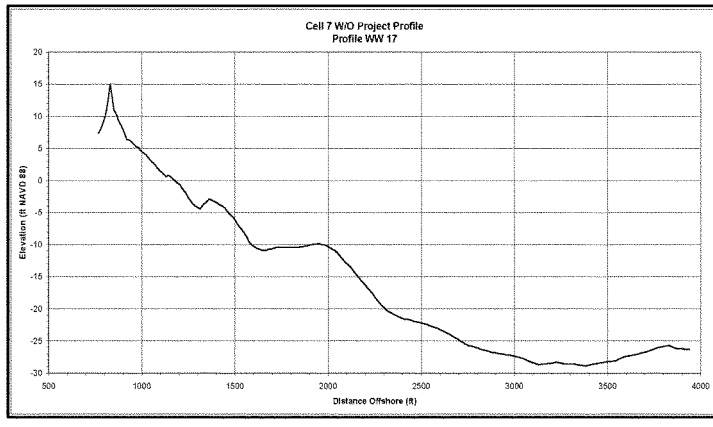
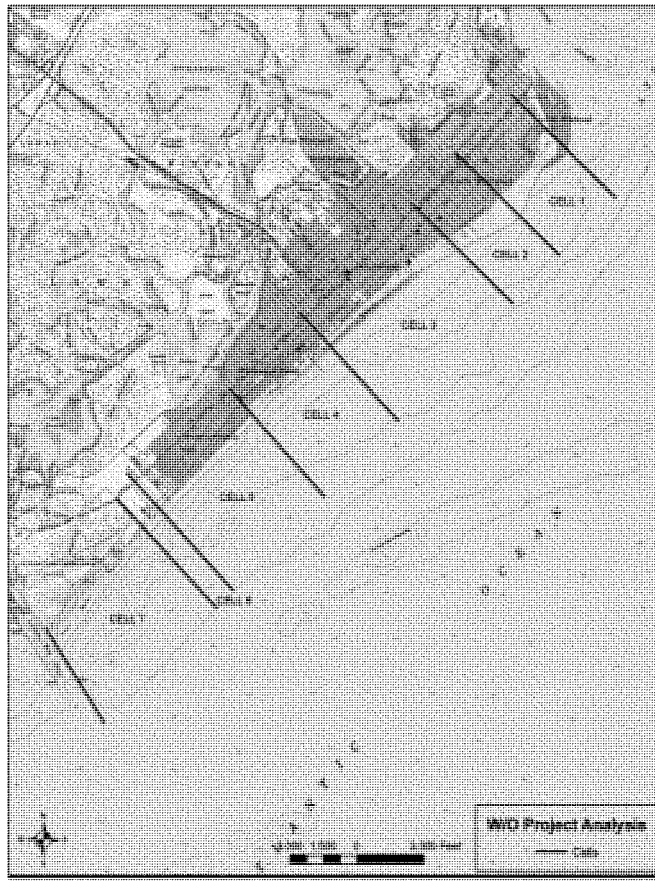


Figure 88 Cells 1-7 Layout



3.1.8 Model Parameters

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

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

3.1.9 Water Elevation

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

3.1.10 Wave Height, Period, and Angle

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

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

3.1.11 Storm Parameters

A variety of data sources were used to characterize the storms used in this analysis. The ten highest ocean stages recorded at the Atlantic City tide gage between 1912 and 2006 were listed

in the Existing Conditions Section *2.7 Coastal Processes.* For each stage, additional information on the storm type causing the water surface elevation and if possible the actual storm surge hydrograph were obtained. The duration of hurricanes along the New Jersey shore is generally less than 24 hours, while the average duration of northeasters is on the order of 40 hours, and in some cases (e.g., 5-7 March 1962) considerably longer. Though actual storm surge hydrographs are not available for all storm events, it was assumed that all hurricanes exhibit similar characteristics to one another. Northeasters demonstrate similar features; however, durations may vary significantly from storm to storm.

3.1.12 Storm Erosion Simulations

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

Figure 89 Storm Conditions 5 year Event

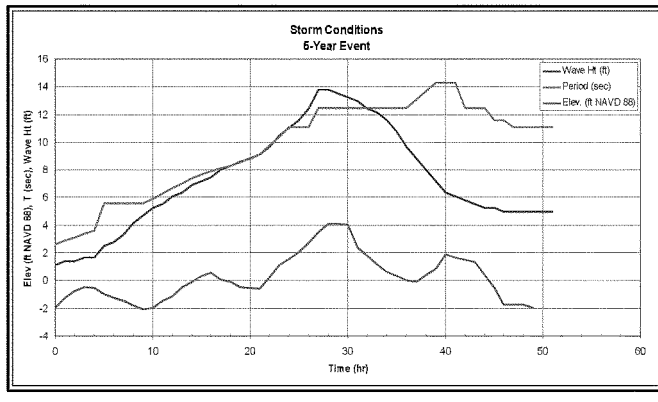


Figure 90 Storm Conditions 10 Year Event

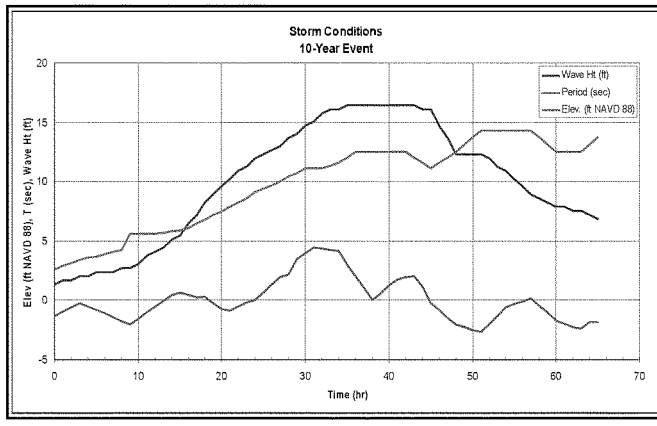


Figure 91 Storm Conditions 20 Year Event

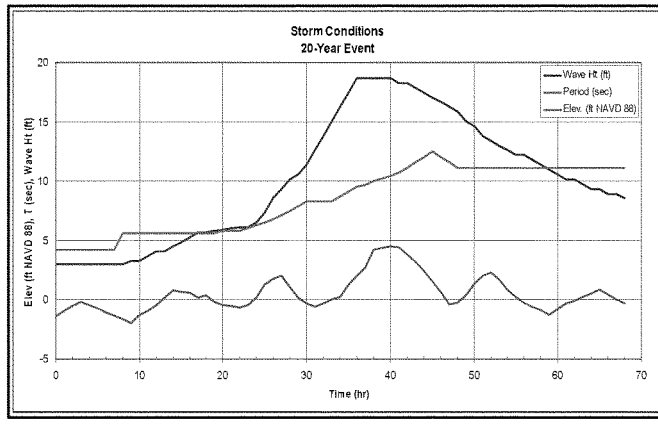


Figure 92 Storm Conditions 50 Year Event

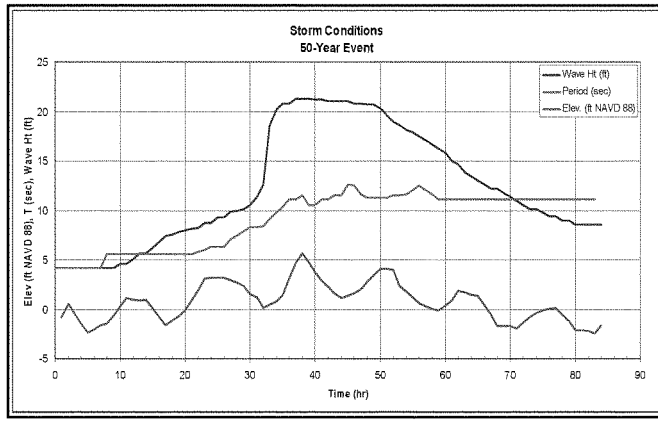


Figure 93 Storm Conditions 100 Year Event

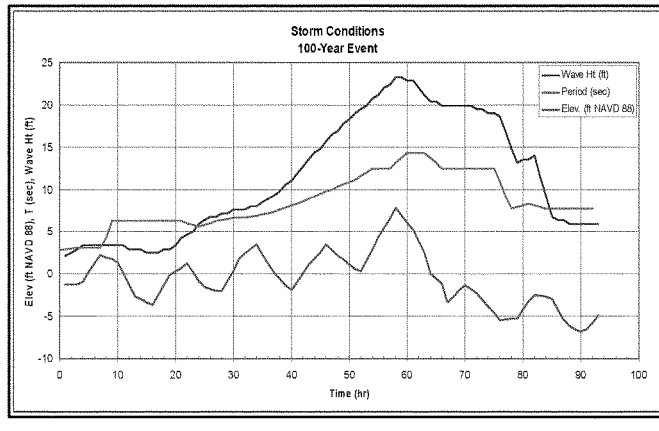


Figure 94 Storm Conditions 200 Year Event

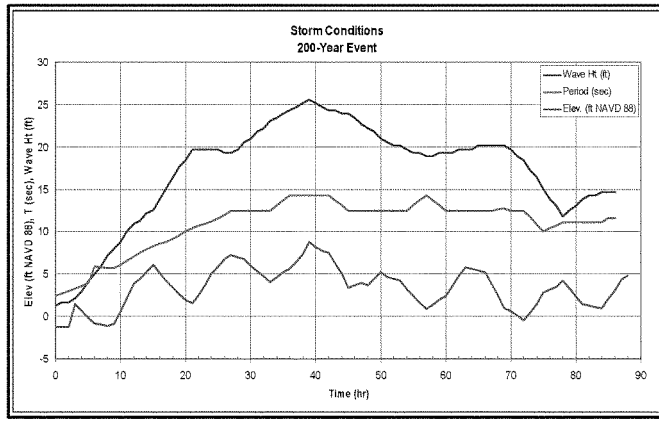


Figure 95 Storm Conditions 500 Year Event

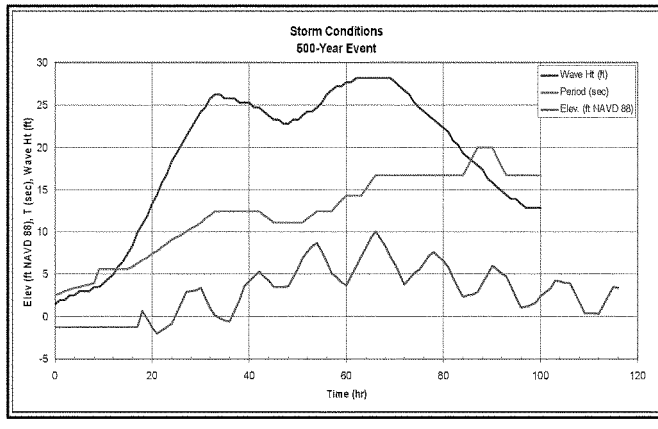


Figure 96 through **Figure 102** contain the results of the without project beach profile change from the fifty year event.

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

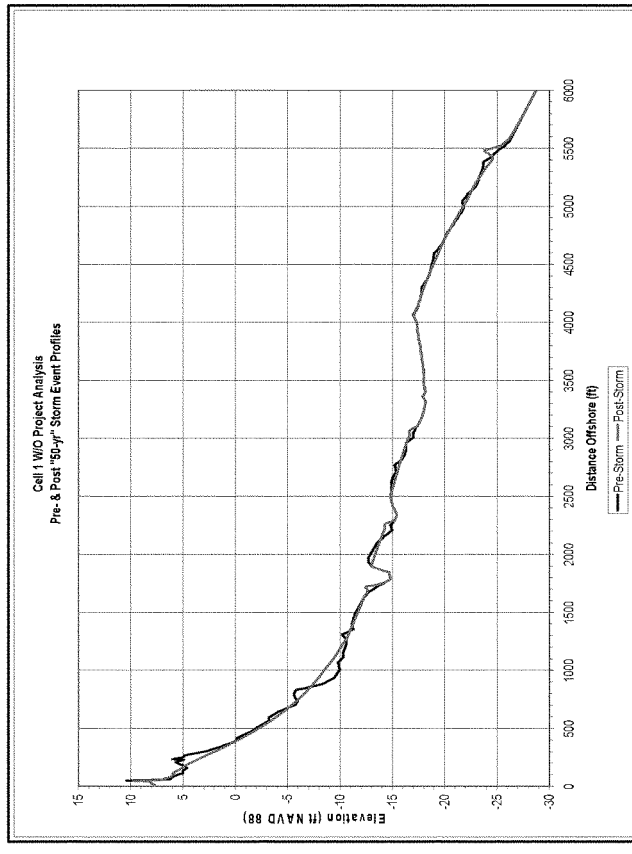


Figure 97 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 2

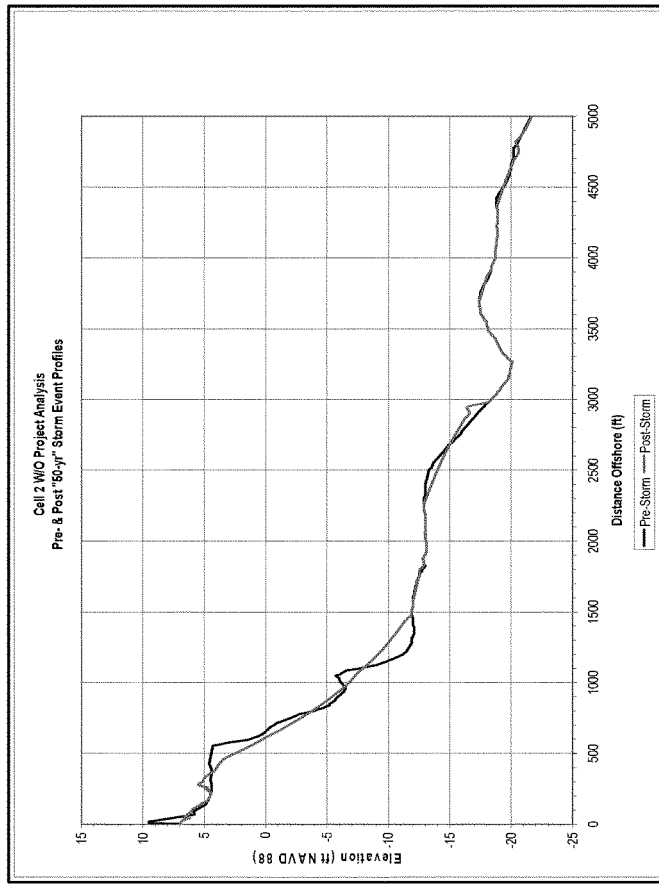


Figure 98 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 3

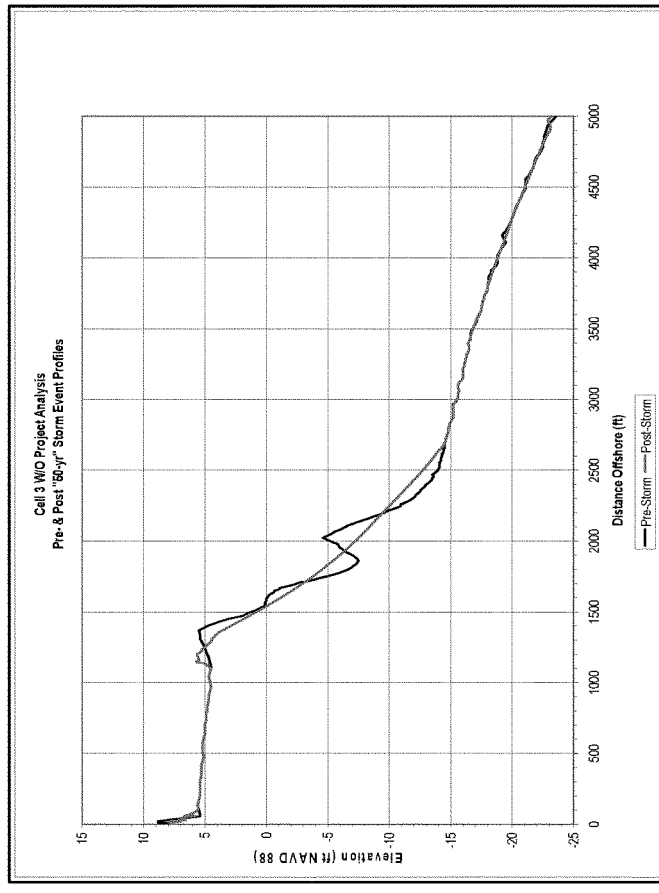


Figure 99 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 4

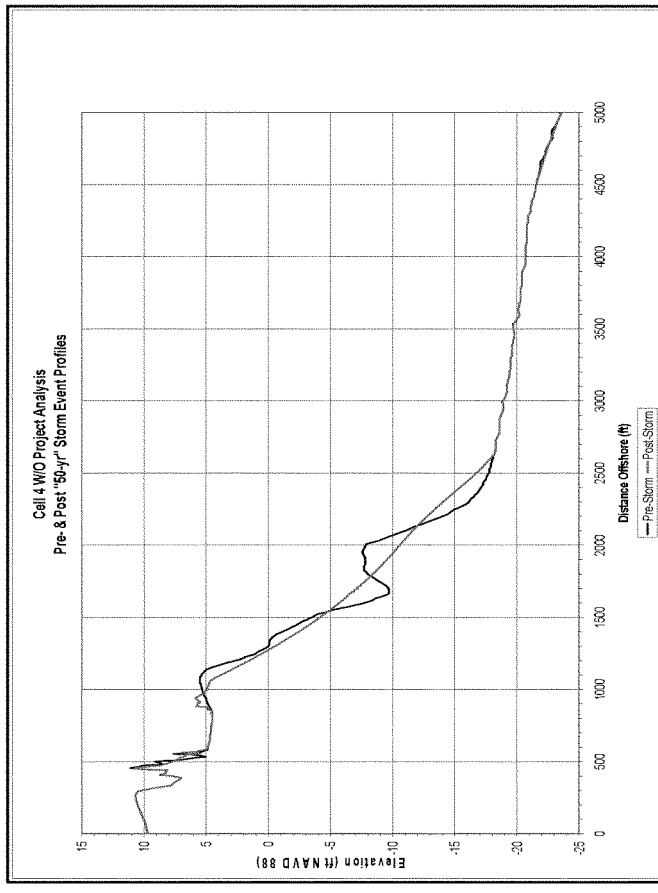


Figure 100 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 5

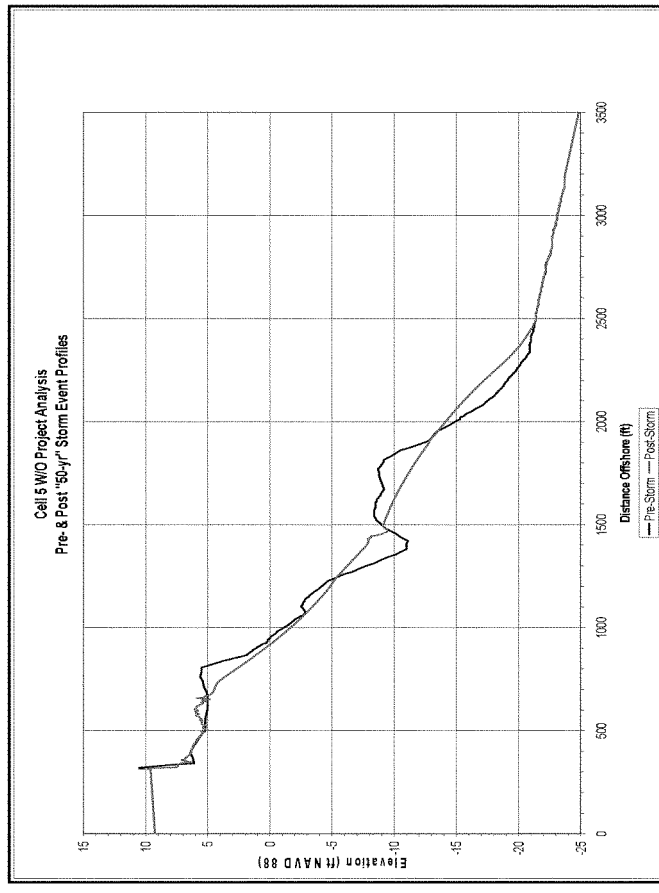


Figure 101 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 6

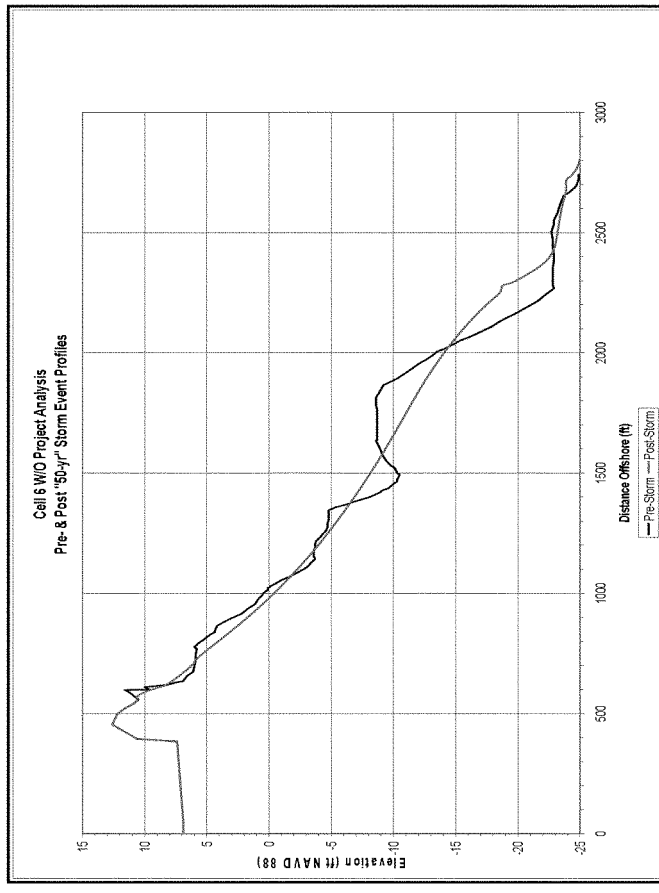
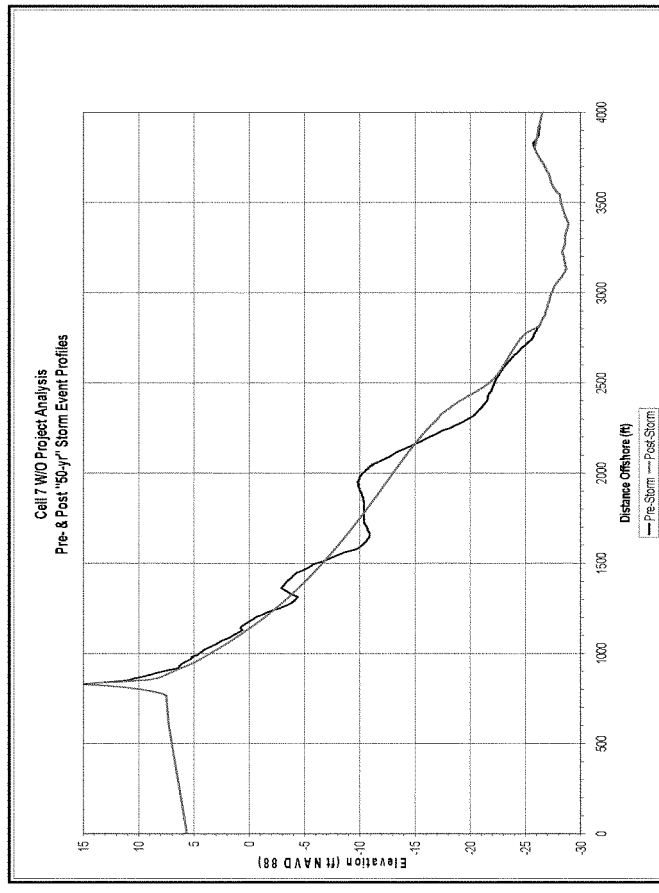


Figure 102 Pre and Post "50 yr" Storm Event Beach Profiles for Cell 7



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

3.1.13 Analysis of Erosion Model Resnlts

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

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

Table 48 Post Storm Erosion Distances

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

3.1.14 Storm Inundation and Wave Attack Evaluation

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

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

3.1.15 Innndation/Wave Attack Methodology

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

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

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

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

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

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

3.1.16 Back Bay Flooding

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

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

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

3.1.17 Other Parameters

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

3.1.18 Without Project Inundation and Wave Attack Results

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

3.2 Economic Analysis

The study area was delineated based on physical setting, hydraulic characteristics, and economic

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

3.2.1 Recent Storms

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

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

Wildwood: Damage in Wildwood has been relatively minor and mostly affected infrastructure. Outfall pipe damage creates street flooding and vehicle damage. A large beach has been the only

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

Table 49 North Wildwood Storm Damages

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

**Dollar loss in September 2007 dollars*

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

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

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

3.2.2 Structure Inventory

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

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

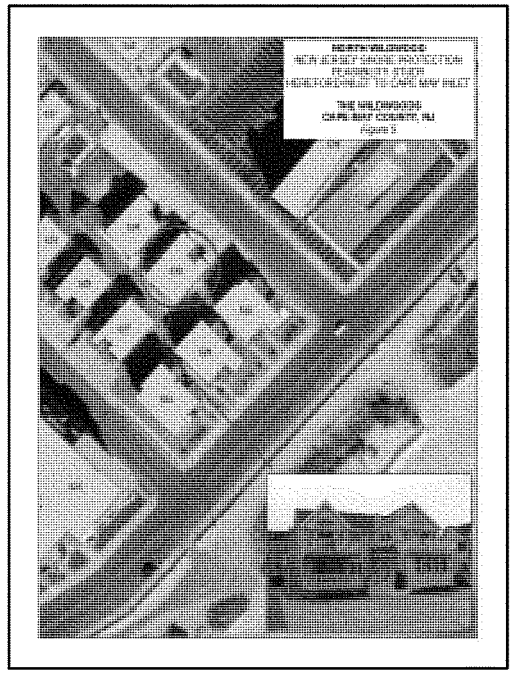
The construction characteristics of each building were entered into the Marshall & Swift Valuation Service software to calculate depreciated replacement cost value. **Table 50** displays total and mean residential and non-residential structure values by foundation type for the study area. The inventory consists of approximately 60% commercial and 40% residential structures. The associated content value of each residential structure is assumed to be 25% of the structural replacement cost. This assumption is based on previous studies that established content value to be about 40% of structural value in primary homes and 15 to 20% of structural value in secondary/vacation homes. The study area consists of a combination of rental or vacation homes, and year round residential homes. However, nearly 70% of the residential structures are vacation and rental homes, and typically the contents of structures with these types of occupancies are insured at a much lower percent, therefore, a conservative weighted content-to-structure value of 25% was adopted. Field observations and site-specific interviews with local residents during the conduct of the Townsends Inlet to Cape May Inlet Feasibility Study, which included a portion of the Wildwoods, substantiate that the ratio is suitable. Also, information from a local insurer confirmed that personal property in secondary homes is typically insured at a lower percentage than that of primary residences. Typically applied in urban areas, affluence is an inundation reduction benefit defined as an increase in residential content-to-structure value

ratio in relation to future increases in residential income. The benefit is based on the prevention of damages to potentially increased content values of residential structures in the future. Affluence is a minor potential benefit which has not been claimed by the District in any coastal studies.

Table 50 Summary of Depreciated Replacement Cost Values

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

Figure 103 Map and Photo of Structure Inventory



3.2.3 Storm Damage Methodology

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

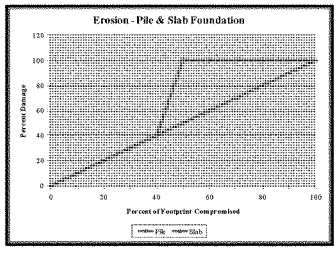
To avoid double counting, if damage occurs by more than one mechanism, COSTDAM takes the maximum damage of any given mechanism (wave, erosion, or inundation) and drops the rest of the damages from the structure's total damages.

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

3.2.4 Erosion Damages

The distance between the reference (profile) line and the oceanfront and back walls were measured in ArcGIS using geo-referenced mapping of the study area. This technique reduces the amount of human error and photographic distortion. For the structure damage/failure analysis, it was assumed that a structure is destroyed at the point that the land below the structure is eroded halfway through the structure's footprint if the structure is not on a pile foundation. If the structure is on piles, the land below the structure must have eroded through the entire footprint of the structure before total damage is claimed. Prior to this, for both foundation types, the percent damage claimed is equal to the linear proportion of erosion under the structure's footprint relative to the total damage point.
Figure 104 depicts the relationship between percent damage and percent of footprint compromised. The damage relationship was developed during the initial assessment of storm erosion damage susceptibility on the Delaware and New Jersey coasts, has been applied regionally, and is considered a reasonable method to estimate aggregate erosion damages to the structure types represented in this coastal environment.

Figure 104 Pile and Slab Foundation Erosion



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

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

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

3.2.5 Wave-Inundation Damages

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

Table 51 Beginning Damage Event

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

3.2.6 Emergency Clean-Up Information

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

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

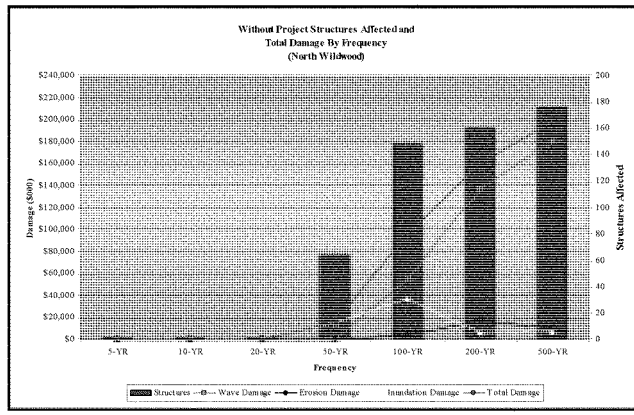
3.2.7 Damage Zone Structures

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

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

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

Figure 105 Without Project Structures and Total Damage in North Wildwood



3.2.8 Structure Damages

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

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

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

3.2.9 Infrastructure and Improved Property Damages

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

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

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

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

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

3.2.10 Summary of Damages

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

Table 56 Average Anuual Damages (Dollars in thousands)

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

3.2.11 Emergency/Clean-Up Costs

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

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

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

3.2.12 Back Bay Flooding

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

3.2.13 Wildwood, Wildwood Crest and Lower Township

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

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

3.2.14 Accreted Area Damage Summary

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

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

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

3.2.15 Amusement Piers Damages

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

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

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

3.2.16 Estimated Total Damages

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

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

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

3.2.17 Beach Maintenance

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

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

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

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

municipal workers, for 3 1/2 hours, with 1 backhoe, and fencing repairs , was approximately $115,000 per year.

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

Table 61 Drainage Issue Options

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

Wildwood Crest

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

Table 62 Wildwood Crest Outfall Exteusions

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

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

3.3 Future Without Project Conditions

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

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

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

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

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

3.3.1 Future Without Project Hydraulic Conditions

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

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

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

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

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

3.3.2 Future Without Project Economic Conditions

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

3.3.2.1 Additional Study Efforts as a Result of Hurricane Sandy

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

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

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

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

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

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

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

3.3.2.3 Commnnity Rating System (CRS)

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

3.3.2.4 The Hazard Mitigation Program (HMP)

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

3.3.2.5 Increased Cost of Compliance Grant

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

3.3.2.6 Impacts of FEMA grants and Floodplain Maps on Structure Database

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

the highest level of NFIP and SBA assistance on the island, followed by Wildwood Crest and Wildwood. But most of these structures were likely not in the project database used for the economic evaluation since this table also includes back bay properties. Lower Township data was excluded since a large portion of Lower Township is on the mainland, and the data does not separate the claims based on location within the Township.

Table 63 NFIP and SBA claims after Hurricane Sandy

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

3.3.2.7 Executive Order (EO) 11988

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

4.0 With Project Analysis

4.1 General

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

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

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

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

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

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

4.2 Planning Objectives

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

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

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

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

4.3 Constraints

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

4.3.1 Planning Constraints

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

4.3.2 Technical Constraints

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

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

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

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

- Plans must comply with USACE regulations.

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

4.3.3 Economic Constraints

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

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

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

maximum practicable extent.

4.3.4 Environmental Constraints

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

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

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

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

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

4.3.5 Institntional Constraints

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

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

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

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

- Private beaches owned by beach clubs and hotels cannot be included in Federal shore protection activities if the beaches are limited to use by members or paying guests.

- Publicly owned beaches which are limited to use by residents of the community are not considered to be open to the general public and cannot be considered for Federal involvement

4.3.6 Regional and Social Constraints

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

4.4 Problems Within the Study Area

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

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

Table 64 Problems, Opportunities and Objectives Within the Study Area

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

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

4.5 Cycle 1 - Initial Screening of Solutions

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

The initial screening addressed both non-structural and structural measures. Non-structural measures control or regulate the use of land such that damages may be reduced or eliminated. When implementing non-structural measures, no attempt is made to reduce, divert or otherwise

control coastal processes or storm damage mechanisms. Typically, specific non-structural solutions include: regulation of any future development (setback limits, building elevation restrictions etc.), and permanent evacuation of the study area. These options are typically not feasible due to the level of development of a region.

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

Non –Structural Measures
- No action
- Regulation of future development
- Permanent evacuation

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

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

Non Structural Measures

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

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

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

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

Structural Measures

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

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

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

migration of sand into Wildwood and Wildwood Crest.

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

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

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

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

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

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

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

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

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

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

objectives and planning criteria were all weighted equally.

Table 65 Study Measures Measured Against the Fonr Planning Criteria

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

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

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

Table 66 Study Measures Measured Against the Objectives

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

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

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

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

249

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

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

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

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

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

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

Measures that were excluded from further analysis are listed here. Extending the Outfalls was excluded since this is not within the authority of the Army Corps of Engineers. Constructing a Seawall was excluded due to costs, and the potential erosion impacts it may cause. Elevating and Removing the Amusements was excluded since it is not likely feasible at this stage of

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

4.6 Cycle-2

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

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

Table 68 System of Accounts

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

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

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

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

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

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

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

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

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

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

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

Table 69 Cost Estimates for a Groin field

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

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

of each feature. The range of potential costs vs. savings for a stone groin field would be cost prohibitive based on this estimate.

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

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

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

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

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

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

4.7 Cycle-3

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

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

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

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

4.7.1 Beachfill Design Parameters

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

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

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

height in the study area would be set at + 6.5 ft. NAVD. This elevation was used for all designs.

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

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

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

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

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

Dune heights under the amusement piers that run perpendicular to the boardwalk are limited above 14.75' NAVD 88 due to the maximum elevation under the piers. Dune elevations above that height will not be able to be constructed to their full height under the piers because the pier elevation (14.75 NAVD 88) is below the top of the dune elevation. Past practices involved constructed dunes to the full elevations on the sides of the piers and at lower elevations under the

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

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

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

4.7.2 Berm and Dune Heights for Previously Authorized Federal Projects

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

Table 70 Previously Authorized Project Dimensions

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

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

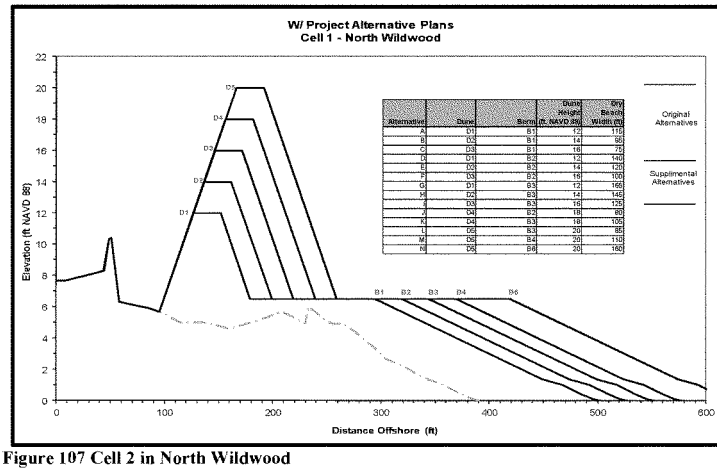
The City of North Wildwood has been participating in beach nourishment activity with the State of New Jersey and FEMA since 2009. The dune height for this beachfill was +14.75 NAVD 88 and the berm elevation was +6.75 NAVD 88. A listing of the nourishment activity, general location of the placement of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

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

Table 71 Dune and Berm Configurations

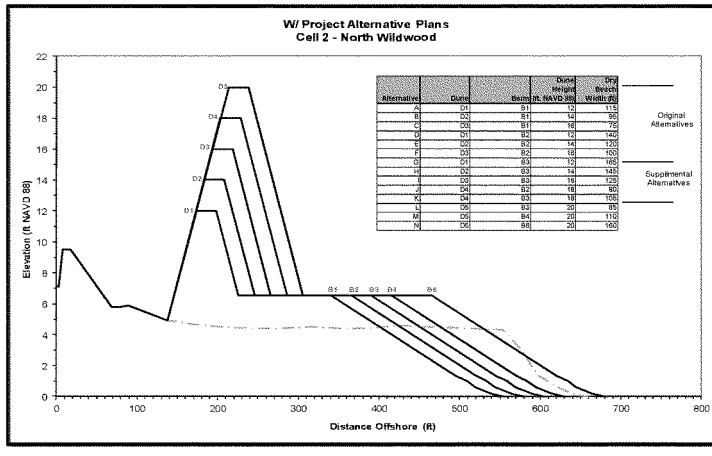
Measure	Dune Height, ft NAVD	Dry Beach Width, ft
A	12	115
B	14	95
C	16	75
D	12	140
E	14	120
F	16	100
G	12	165
H	14	145
I	16	125
J	18	80
K	18	105
L	20	85
M	20	110
N	20	160

Figure 106 Cell 1 in North Wildwood



Alternative	Dune	Berm	Dune Height (ft. NAVD 88)	Dry Beach Width (ft)
A	D1	B1	12	115
B	D2	B1	14	95
C	D3	B1	16	75
D	D1	B2	12	140
E	D2	B2	14	120
F	D3	B2	16	100
G	D1	B3	12	165
H	D2	B3	14	145
I	D3	B3	16	125
J	D4	B2	18	80
K	D4	B3	18	105
L	D5	B3	20	85
M	D5	B4	20	110
N	D5	B5	20	160

Figure 107 Cell 2 in North Wildwood



Alternative	Dune	Berm	Dune Height (ft. NAVD 88)	Dry Beach Width (ft)
A	D1	B1	12	115
B	D2	B1	14	95
C	D3	B1	16	75
D	D1	B2	12	140
E	D2	B2	14	120
F	D3	B2	16	100
G	D1	B3	12	165
H	D2	B3	14	145
I	D3	B3	16	125
J	D4	B2	18	80
K	D4	B3	18	105
L	D5	B3	20	85
M	D5	B4	20	110
N	D5	B5	20	160

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

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

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

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

Table 72 Initial Formulation Quantities

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

4.7.3 Pier Protection Measures

In addition to analyzing beach fill measures for Cells 1 and 2 in North Wildwood, beach fill measures were also examined to protect the amusement piers in North Wildwood and Wildwood against storm damages (**Figure 108** and **Figure 109**). Historic efforts to protect these piers with a dune by the NJDEP were not successful. Two piers are located in North Wildwood at 23rd Ave. and 25th Ave. respectively, and the other three piers are in Wildwood at Juniper Ave, Cedar Ave. and Spencer Ave, respectively. The two North Wildwood piers along with the Wildwood pier at Juniper Ave. were considered together in one analysis group, and the other two Wildwood piers were considered together in another analysis group. As with the beach fill design measures for Cell 1 and Cell 2, the beach nourishment measure for the amusement piers required optimization of the design parameters. The analysis incorporated the fact that the beach fill

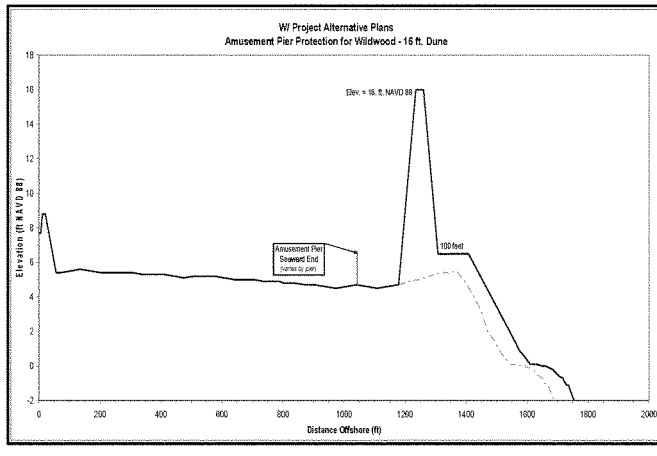
parameters would be more susceptible to the prevailing natural processes due to the fact that the location is adjacent to the natural mean high water line. The beach fill parameters of beach slope, berm elevation, dune width, dune height and dune side slopes were kept consistent from the analysis of Cell 1 and Cell 2 in North Wildwood. A single dry beach width of 100' seaward of the piers was analyzed. The 100' was determined to be the minimum dry beach width necessary in order to protect the dune footprint from being compromised seaward of the amusement piers against the natural processes. This represented an increase of 25' from the minimum dry beach width requirement utilized in Cell 1 and Cell 2. Due to the location of the design berm seaward of the amusement piers, quantities of sand required to construct and maintain the berm increased significantly as berm widths increased. Wider berm widths seaward of the amusement piers were considered but were determined not be feasible because the incremental increases in beach fill material (costs) exceeded the incremental increases in net benefits.

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

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

Figure 108 Pier Protection Plan View

Figure 109 Pier Protection Cross Section



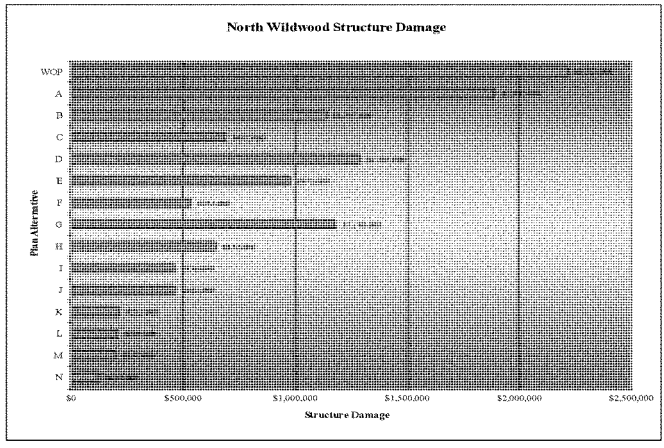
4.7.4 Storm Damage Reduction Benefits

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

Table 73 North Wildwood Storm Damage Reduction Benefits by Measure

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

Figure 110 North Wildwood Structure Damage



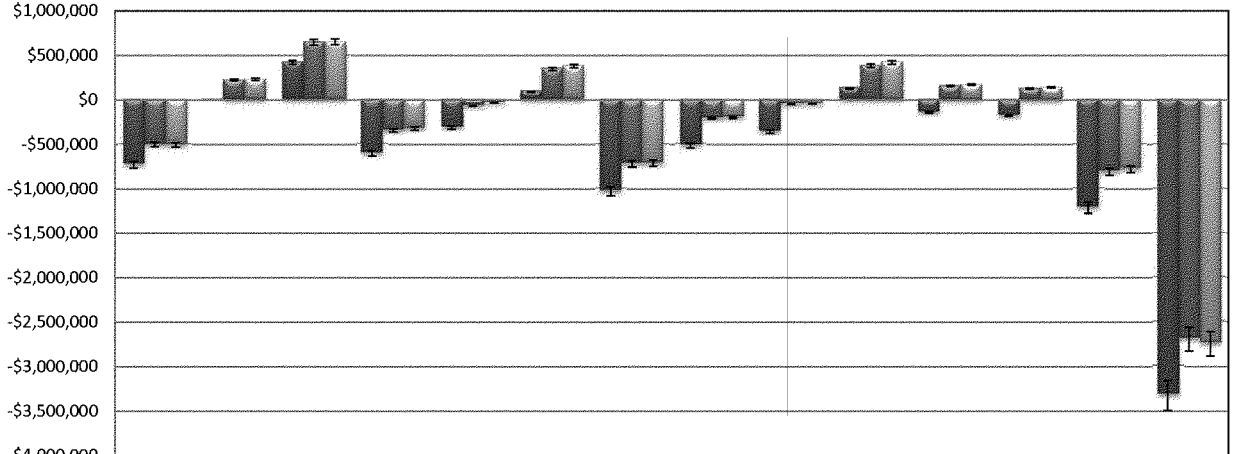
4.7.5 Optimization

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

Table 74 AAB/AAC/Net Benefits for Backpass Alternative

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

Figure 111 Benefits Optimization for North Wildwood



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

3 year cycle 4 year cycle 5 year cycle

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

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

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

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

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

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

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

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

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

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

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

4.8 Summary of Optimized Plan

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

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

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

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

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

4.9 Resiliency, Risk Reduction and Snstainability

4.9.1 Resiliency

Resiliency can be measured by post storm engineering resilience, ecological resilience and community resilience. Given the absence of an explicit definition of the term we evaluated the definition of

"resilience" presented in the February 2013 USACE-NOAA white paper "Infrastructure Systems Rebuilding Principles.

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

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

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

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

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

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

In this regard, it is apparent that shore protection projects involving beach replenishment possess intrinsic "resilience", in light of the large volume of sediment that remains within the system after a major disturbance and the associated repair or replenishment that is included to restore the protective features to the project design dimensions.

Community Resilience. Although shore protection projects including beachfill are sacrificial by nature with the degree of resiliency described above, they *do* provide storm damage risk reduction that contributes significantly to the "resilience" of the community in which the project is located. Beach fill projects reduce coastal storm damages, as was amply demonstrated in October 2012 during Sandy at constructed projects (see USACE "Project Performance Evaluation Study" dated 6 November 2013). Engineered beaches prevent damages that would have occurred in the absence of the project. In doing so, they significantly contribute to the larger notion of "community resilience". That is, by reducing damages from coastal storms they provide the community with the "*ability to adapt to changing conditions and withstand and rapidly recover from disruption due to emergencies*" (per Definition 1 above).

With a project in place, storm damages are less severe than would have been the case in the absence of the project. With a project in place, fewer homes, businesses, and public infrastructure elements are damaged and destroyed, and fewer lives are disrupted or lost. Transportation and critical health and public safety assets return to full function after a storm more quickly. All of tbese considerations lessen the duration and reduce the costs of the recovery period, and consequently make the community more resilient than would have been the case without the project in place.

4.9.2 Risk Analysis

ER 1105-2-101, "Risk Analysis for Flood Damage Reduction Studies" (3 January 2006) provides guidance on the framework to be used in Corps of Engineers flood damage reduction studies in order to incorporate risk and uncertainty into project planning and design. This ER updates and expands on guidance in EM 1110-2-1619, "Risk-based Analysis for Flood Damage Reduction Studies" (1 August 1996).

The 2006 publication recommends varying certain input parameters that could have an impact on study conclusions. This analysis was included as part of the risk and uncertainty analysis in **Section 5** of this report. Key economic and hydrologic parameters were varied to produce a range of potential benefits and costs of the selected plan. The greatest contributor to deviations from the selected plan's benefits was from the extreme high sea level rise calculation and a future without project projected erosion rate on the projects profile. These factors contributed to a dramatic increase in project benefits and BCR.

4.9.3 Risk Reduction

This project contributes to long term risk reduction over the fifty year period of analysis by reducing the impacts from coastal storms. Storm damages without a project in place will be more frequent and with greater impact than with a project in place. The study are will see less damages with a berm and dune in place, indicating a risk reduction from the without project condition. **Table 77** indicates that storm damages are reduced significantly island wide with the implementation of the selected plan.

Table 77 Risk Reduction for Without Project and With Project by Cell

	Without Project Damage Initiation			With Project Damage Initiation	
Community	**Cell**	**Probability of Occurrence**	**Type**	**Probability of Occurrence**	**Type**
North Wildwood	1	2%	Flooding	0.50%	Flooding
North Wildwood	2	20%	Flooding	5%	Flooding
Wildwood	3	20%	Flooding	0.20%	Wave/Flooding
Wildwood Crest	4	1%	Erosion/Flooding	0.20%	All
Wildwood Crest/LT	5	2%	Flooding	0.50%	Flooding
Lower Township (LT)	6	2%	Flooding	2%	Flooding

This project will not completely eliminate damages within the study area. Even with the project in place the study area still has the risk of residual damages. These are damages that we cannot prevent with the project in place. These damages occur from overtopping of the dune and berm as a result of a storm that exceeds the identified NED plan and back bay flooding. Damages will also occur in areas of the project that could not be protected like the amusement piers. The with project condition will still have damages from coastal storms for the communities on the island.

4.9.4 Sustainability

There are multiple definitions of the word sustainable and several definitions of the term sustainability are presented below, along with references to their source.

> Definition 1.- *Sustainability refers to the capacity to endure and remain productive over time, which is very well aligned with the concept of adaptation, which is "Adjustment in natural or human systems to a new or changing environment that exploits beneficial opportunities or moderates negative effects."* (USACE CLIMATE CHANGE ADAPTATION PLAN AND REPORT 2011).

> Definition 2- *Everything that we need for our survival and well-being depends, either directly or indirectly, on our natural environment. Sustainability creates and maintains the conditions under which humans and nature can exist in productive harmony, that permit fulfilling the social, economic and other requirements of present and future generations. Sustainability is important to making sure that we have and will continue to have, the water, materials, and resources to protect human health and our environment.* (Environmental Protection Agency)

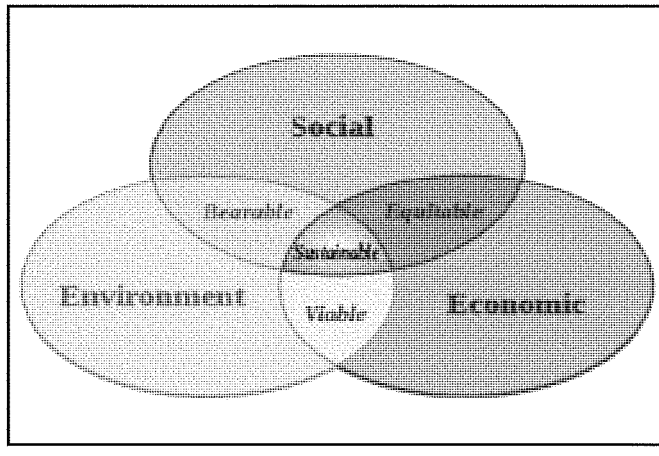
> Definition 3- *Relating to, or being a method of harvesting or using a resource so that the resource is not depleted or permanently damaged* (Merriam Webster)

A common thread to these definitions is the need to promote productivity and well being over time, the need to promote the coexistence of humanity and nature, and the need to minimize negative effects on the environment so it will be available for future generations. At the 2005

World Summit on Social Development it was noted that sustainability requires the reconciliation of environmental, social and economic demands . This view has been expressed as an illustration using three overlapping ellipses indicating that the three pillars of sustainability are not mutually exclusive and can be mutually reinforcing.

The Hereford Inlet to Cape May Inlet project meets sustainability goals across multiple definitions of the term since it is required to incorporate these three pillars of sustainability in a feasibility analysis for the fifty year length of the project. Environmental concerns are evaluated in the Environmental Assessment and through coordination and review by the resource agencies including the Environmental Protection Agency, the US Fish and Wildlife Service and the New Jersey Department of Environmental Protection as part of the feasibility process. Economic principals are used in benefit calculations, plan formulation ranking, and project justification by their contributions to the National Economic Development account. Social accounts are intrinsic in beach nourishment projects since they maintain habitat for beach patrons. The nexus of these three pillars indicates that a project is sustainable.

Figure 112 The Three Pillars of Sustainability, World Summit on Social Development



5.0 Selected Plan

5.1 Identification of the Selected Plan

The Planning Guidance Notebook (1105-2-100) recommends "*selecting the alternative plan that reasonably maximizes net economic benefits consistent with protecting the Nation's environment*". This criteria was used to select a plan for implementation. Design parameters for the selected plan can be seen in section 4.7.1 of this report.

5.1.1 Description of the Selected Plan

The selected plan is a dune and berm constructed using sand obtained from an onshore borrow source located a the southern end of Five Mile Island **Table 79**. The plan extends approximately 4.5 miles from Hereford Inlet to Cape May Inlet and will encompass the towns of North Wildwood, Wildwood, Wildwood Crest and Lower Township. The southernmost beach section, which contains US Fish and Wildlife Property, is not included in the selected plan. The project will include a +16' NAVD 88 dune, with a 25' crest on a 75' berm that is + 6.5' NAVD88 in elevation in North Wildwood, Wildwood, Wildwood Crest and Lower Township. Side slopes for the dune will be 1V:5H. The plan includes approximately 64 acres of dune grass, 28,000 linear feet of sand fence, 44 extended crossovers, 7 new pedestrian crossovers, 7 extended handicap crossovers, 6 new handicap crossovers, 8 existing vehicle crossover extensions and 5 new vehicular crossovers. The dune appurtenances requirements were based on existing pedestrian pathways, existing vehicular pathways and the inclusion of Americans with Disabilities Act complaint crossover structures to accommodate the fact that based on the existing profile, the beach is almost 100% ADA compliant. Without the proposed ADA access the dune would not be ADA compliant. The sand for the dune and berm will be pumped from the southern borrow area using mobile backpassing technology to hydraulically pump the sand from the Wildwood and Wildwood Crest borrow source to the placement area on a four year nourishment cycle. The initial sand quantity is estimated at 1,527,250 cubic yards, which includes a design quantity of 1,136,000 and advanced nourishment of 391,000 yards.

The backpass option will be less costly than the offshore dredging option based on lower sand unit costs, lower mobilization costs and higher Local Costs Forgone benefits associated with sand backpassing. A recent comparison to 3 dredging projects in New Jersey based on 2014 Limited Reevaluation Reports indicates that pumping sand from NJ offshore dredging sites ranges in costs from $9.32 cyd to $15.18 cyd depending on location and pumping distance, while the current backpass estimate is $3.61- $6.05cyd (2014 P.L.). Mobilization costs for Hereford backpassing operations are $1,284,000 (2014 P.L.) for the current Hereford estimate, while mobilization costs for an inlet/offshore dredging job is averaging approximately $2,500,000 (2014 P.L.). Local Costs Forgone benefits will also decrease under an offshore dredging scenario since local benefits such as elimination of outfall clearing ($75,000 per year in Wildwood) and reduced outfall extensions ($148,000 per year in Wildwood Crest) (**Section 5.4.4**) will not be achievable under an offshore dredging operation.

Impacts to recreation in Wildwood City were raised by the Mayor of Wildwood during the Public Comment period. The selected plan proposes to shorten the beach with sediment backpassing and elevate the berm and construct dune to create a storm damage reduction feature, which may reduce the opportunities the mayor has for recently developed recreation plans. The mayor of Wildwood had

planned a Recreational Vehicle (RV) park on the beach, had held a summer concert series in 2013, and has other existing recreation events on the heach including sporting and youth events. With the project in place - the recreational area of the berm will still range from 300-1,100 ft depending on location, and the Corps believes that a storm damage reduction feature and recreation opportunities can co-exist in the study area. We will work with the Mayor to make every effort to have zero impact to his plans.

5.1.2 Periodic Nourishment Requirements

In order to maintain the integrity of the design beachfill alternatives, beachfill nourishment must be included in the project design. If periodic nourishment was not performed throughout the life of the project, longshore and cross shore sediment transport mechanisms, separate from storm induced erosion, would act to erode the design beach. A four year nourishment cycle was chosen as the cycle interval over the five year plan even though the 5 year cycle had annual net benefits that were $8,000 greater. The basis for this decision was in the application of Local Costs Forgone benefits of the backpassing operation was annualized at $75,000 per year in Wildwood and $148,000 per year in Wildwood Crest (**Section 5.4.4**). Longshore transport direction indicates that material would arrive in the study area through natural processes and eventually build the shoreline seaward, eventually clogging the outfalls. Once the outfalls are clogged the municipalities would have to expend funds to remove the excess sediment equal to the amount outlined in the Local Costs Forgone estimate, which exceeds the annualized $8,000 difference between the 4 year and 5 year nourishment cycles. The decision to recommend the 4 year cycle over the 5 year cycle is therefore policy compliant since the application of the annualized Local Costs Forgone benefits in a systems context would elevate the 4 year cycle benefits over the 5 year cycle benefits by reducing outfall maintenance costs.

The nourishment parameters were developed by considering background erosion losses using shoreline recession rates developed in the historic shoreline change analysis, losses due to the predicted rate of sea level rise, and "spreading out" losses due to diffusion of the beachfill through longshore transport gradients.

The first step in the calculation of nourishment rates was to compute representative wave characteristics and potential net longshore transport rates based upon the OCTI wave hindcast. A WIS phase III transformation was done to transform the deepwater waves from the OCTI hindcast described in Section 2.6.1 to shallower water. The program SEDTRAN was then used as discussed in Section 2.6.7 along with representative shoreline angles for each community on the barrier island to calculate potential net transport rates for each community along with representative wave characteristics along the barrier island. The representative wave characteristics computed by SEDTRAN included: effective wave height, mean wave period and wave angle.

A planform evolution model (**Table 78**) was then developed that required the following inputs: The effective wave height, period, angle, and longshore transport rates from the SEDTRAN simulations, a representative shoreline angle, and an equivalent beachfill width representing the size of the berm of the proposed beachfill. Beachfill percent remaining after any given year was output from the planform evolution model. Inputs to the planform evolution model are summarized below .

Table 78 Planform Evolution Model Inputs

Parameter	Value
Effective Wave Height	2.8 ft.
Mean Period	4.7 sec.
Wave Angle	133 deg. wrt North
Representative Shoreline Angle	47 deg. wrt North
Background Transport Rate	420,000 cy / yr
Nourished Beach Width	75 ft.

The background transport rate of 420,000 cy/yr is consistent with the value reported previously in **Table 34** for North Wildwood. The planform evolution model is a grid based model, and to account for end losses and diffusion of the beachfill, the grid was extended to the south. A zero nourished beach width was simulated in this grid extension. The grid was not extended to the north due to the presence of Hereford Inlet. The planform evolution model did not consider the down drift borrow area at Wildwood and Wildwood Crest. It was assumed that the borrow area would have minimal impact on the fill area given the distance between the northern most outfall as shown in **Figure 117** and end of the fill area as shown in **Figure 118** (Magnolia Drive). These plan sheets do show that the fill and borrow areas are adjacent to each other. However, it should be noted that emphasis when it comes time to take sand within the borrow area will be at outfall locations, and it should also be noted that the constructed berm as shown on the plans that is adjacent to the borrow area is relatively small compared to the larger berm that is required at the northern end of the project. This smaller constructed berm was assumed to have a negligible impact on the borrow area especially since the outfall where most likely material will be taken from is a significant distance away from Magnolia Ave. (approx. 2200 ft).

Output from the planform evolution model includes percent of original beachfill remaining after a given year. Experience gained by District personnel from ongoing monitoring of similar beachfills for neighboring northern parts of barrier islands in New Jersey suggest that approximately 70% of a beachfill remains after 4-years. Output from tbe model suggested that the percent of the original fill remaining after 4-years should be approximately 64% for the selected plan. To be conservative, the study team lowered the beachfill remaining percentage slightly to 60% in order to account for the location of the beachfill in relation to Hereford Inlet.

The 60% was applied to the initial quantity used in the model which resulted in a 4-year nourishment rate of approximately of 305,000 cy (no overfill factor applied) for Cells 1 and 2 combined with the majority of it being for Cell 1. Since the borrow area is the beach itself in front of Wildwood and Wildwood Crest and that the sand characteristics are similar along the entire barrier island, a 1:1 overfill factor was assumed for future nourishment cycles.

It should be noted that tbe 305,000 cy every 4-years may appear to be low and inconstant when compared to tbe potential net transport rate of 420,000 cy every year and the most recent erosion rates quantified in the shoreline change analysis for North Wildwood presented in the **Table 40** as 60 ft/yr. However, the value can be considered to be reasonable based upon a couple of

factors:

1. A comparison was done of computed nourishment quantities against other projects the District has done in New Jersey. For this study the computed nourishment rate was calculated to be 19 cy per foot per year. This value was based upon a 4,000 foot beachfill length that covers Cells 1 and a small part of Cell 2. This value of 19 cy per foot per yr is slightly higher than other rates computed for the District's New Jersey's constructed projects which ranged from 7 to 15 cy per foot per yr and New Jersey's authorized but unconstructed projects which ranged from 3 to 13 cy per foot per yr. It is reasonable to assume that re-nourishment for North Wildwood be higher than other projects within the District; however to assume a significantly higher rate is most likely erroneous because as the long-term history has shown, the shoreline of North Wildwood has experienced periods of natural accretion in the past.

2. The reported net transport value of 420,000 cy/yr for North Wildwood is based upon several assumptions as the report suggests in Section 2.6.7. Namely that the rate assumes an "endless" supply of sand, free from influences of adjacent inlets or structures. As it is stated in Section 2.6.7, the actual sediment transport rate for North Wildwood could be less when considering the impact of Hereford Inlet. It should also be noted that the calculated transport rate was based upon wave characteristics and shore alignment for the years of 1986 – 1998. Long-term history suggests that transport rates could be smaller based upon the other longer time periods relative to 2003 that are shown in **Table 40**.

3. The reported erosion rate of 60 ft/yr for North Wildwood between the years of 1998-2003 as shown in **Table 40** is relative to a small time period of accelerated erosion that is not typical of the long-term trends of the shoreline in North Wildwood. For example in **Table 40**, the longer time period of 1977-2003 suggest that the erosion in North Wildwood was around 24 ft/yr (longer time periods relative to 2003 even suggest shoreline accretion). This value of 24 ft/yr is less than half of the more recent accelerated rate of 60 ft/yr. To disregard the erosion trends over the longer time periods and to focus solely on the most recent shorter trend of accelerated erosion could lead to the conclusion that nourishment should be higher. Only further data collection and monitoring efforts will indicate if the recent accelerated shoreline erosion rates in North Wildwood are a trend or an anomaly.

Table 79 Description of the Selected Plan

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

5.1.3 Borrow Area Infilling Analysis

An analysis to determine potential longshore sediment transport was done in order to ascertain possible infilling rates post dredging of the borrow area along the beaches of Wildwood and Wildwood Crest (**Table 80**). Longshore or littoral transport can both supply and remove sand from coastal areas. In order to determine the balance of sediment losses and gains for an area such as the borrow area, net, rather than gross, transport rates are required. Net longshore transport refers to the difference between volume of material moving in one direction along the coast and that moving in the opposite direction. The design of the selected plan is consistent with accepted coastal engineering practice and Corps criteria described in the Coastal Engineering Manual. Implementation of the selected plan may cause temporary steep drop offs and small depressions along the beach during the initial construction. All construction areas are roped off and secure during construction, and the design profile is a smooth beach profile that mimics the existing slope. Beach conditions that could temporarily be hazardous to the community will be avoided by creating a profile that mimics the natural topography as planned in this document and designed in the project specifications. Safety zones will also be established around active construction areas.

The time period analyzed based upon available data was from 1986 to 1998. As part of the investigation, potential longshore transport rates due to waves were computed. The resulting longshore transport rates are shown in the table below.

Table 80 Potential Longshore Transport Rates

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

The values in the table indicate that generally, there is a net southward transport which may vary from 370,000 to 440,000 cubic yards per year within the study area. The trends in the estimates for the net longshore transport show southward transport to be almost doubled of northward transport. The rates computed can be used as a potential infilling rate for the borrow area along the beaches of Wildwood and Wildwood Crest.

The values in the table should be viewed as representative of potential average conditions over a span of 12 years from 1986 to 1998 It can be expected, however, that changes in longshore sediment transport could happen in a seasonal timeframe and could contribute significantly to both the short- and long-term infilling rates of the borrow area. It would be anticipated that shortly after removing any sand from the borrow area that there would be a short-term accelerated infilling rate of sand coming from the north followed by a period of time that is more representative of the long-term average infilling rate. It is recommended that any removal of sand from the borrow area be done over as wide of an area as possible within the borrow area as

oppose to removing sand in a small concentrated area. This would help maintain the natural coastal processes in the area.

A periodic nourishment quantity of 305,000 cu yds (minus overfill) was estimated by modeling the selected plan layout as a single domain using the *Planform Evolution Model*, a numerical tool that calculates background erosion and alongshore spreading losses associated with beach fill construction. Advanced and periodic nourishment quantities include an overfill factor of 1.25 based on the use of sand from the selected borrow areas.

5.1.4 Project Construction Template

The constructed beach fill template typically varies from the design template because of working limitations of equipment used to place and shape the fill. After placement, sorting of the fill by waves and currents will naturally shape the constructed fill profile to an equilibrium form consistent with the design template. To account for these factors, the construction template is developed based on the "overbuilding method."The overbuilding method involves placing the required design quantity at the proposed berm elevation, but with a berm width greater than the design width. The seaward slope of the construction berm is generally equal to or steeper then the natural existing equilibrium slope. The constructed berm is "overbuilt" in the sense that it is wider than the intended design berm. Coastal processes readjust the profile to a natural equilibrium state. In this case much of the overbuilt berm sand moves offshore to form the intended design profile. The proposed construction and design templates for the selected plan are shown in **Figure 116** through(**Figure 121)**. In these figures the part of the design template labeled "Design Offshore Volume" is the quantity that is placed up on the beach as a part of the overbuilt berm, labeled "Design Offshore Volume Placed Onshore". The advanced nourishment quantity is also included in the overbuilt construction berm template. Beach fill construction using the overbuilding method often leaves the impression that much of the project sand has been lost soon after construction due to rapid readjustment of the construction profile. However, rather than being "lost," this offshore movement of sand is an indication that the construction profile is functioning as intended to naturally form the design template. During the review a commenter pointed out that there was a concern with regards to the stability of the proposed berm where it connects to the existing berm which surrounds the convention center dune. Without sufficient design information to evaluate with regards to the existing berm, a hard 90 degree berm connection to existing berm can be a weak point and may fail during a large storm event. During the PED phase the design section at the junction of the existing dune and the new dune will be refined to show a larger than 90 degree radius turn at that junction.

Figure 113 North Wildwood Cross Section

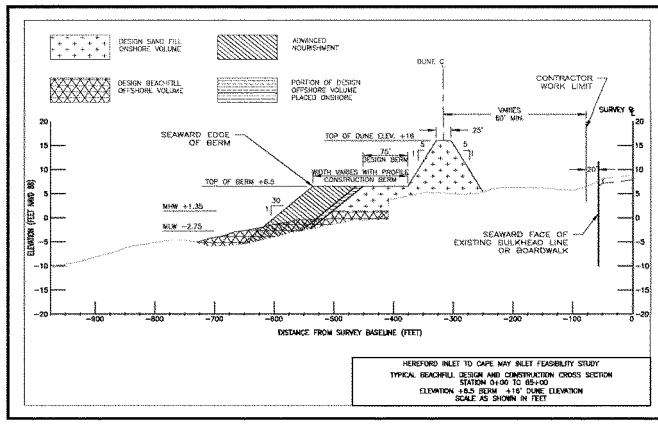


Figure 114 Wildwood and Wildwood Crest Cross Section

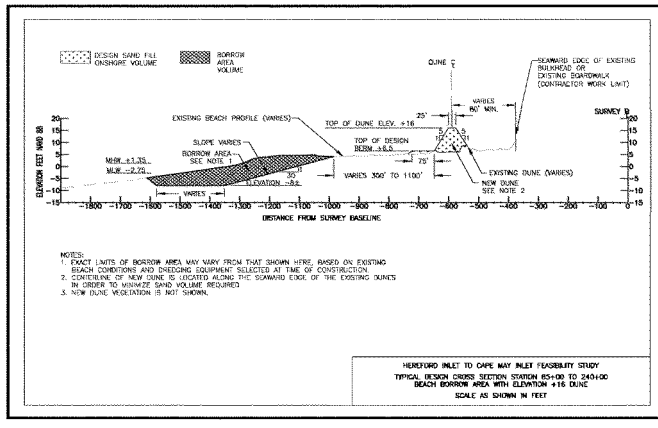


Figure 115 Lower Township Cross Section

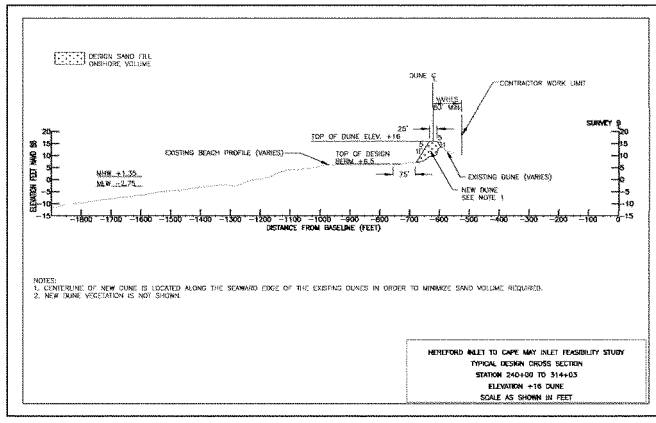


Figure 116 North Wildwood Plan View

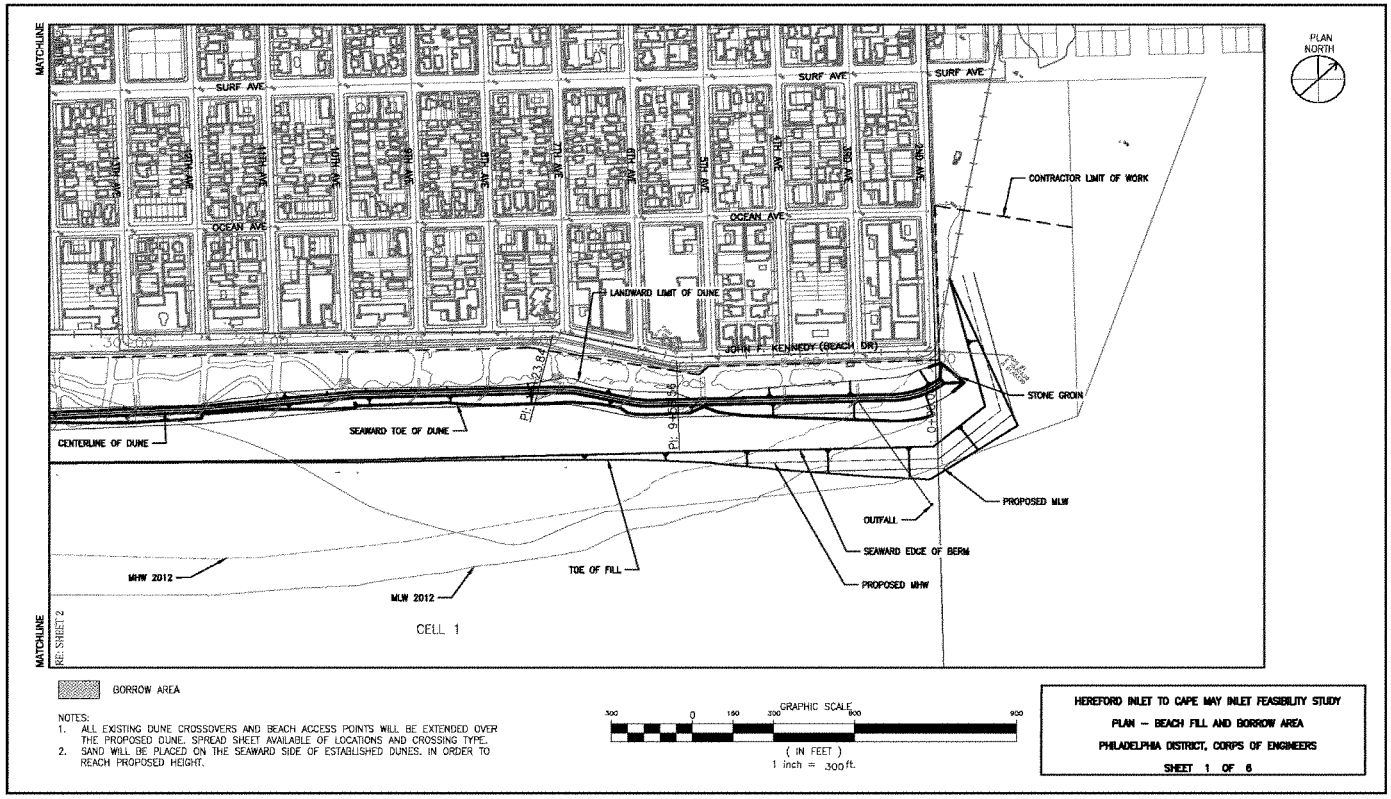
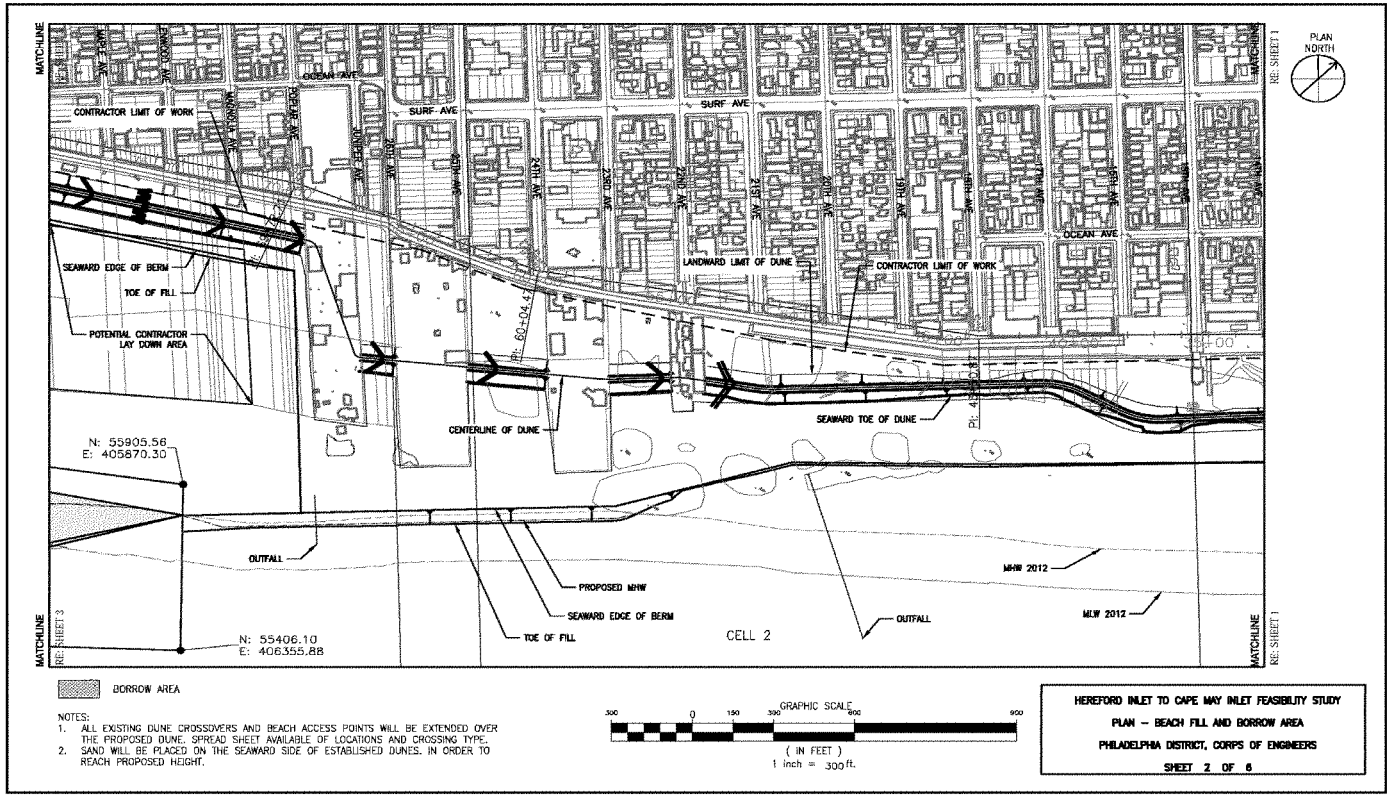


Figure 117 North Wildwood/Wildwood Plan View



NOTES:
1. ALL EXISTING DUNE CROSSOVERS AND BEACH ACCESS POINTS WILL BE EXTENDED OVER THE PROPOSED DUNE. SPREAD SHEET AVAILABLE OF LOCATIONS AND CROSSING TYPE.
2. SAND WILL BE PLACED ON THE SEAWARD SIDE OF ESTABLISHED DUNES. IN ORDER TO REACH PROPOSED HEIGHT.

Figure 118 Wildwood Plan View

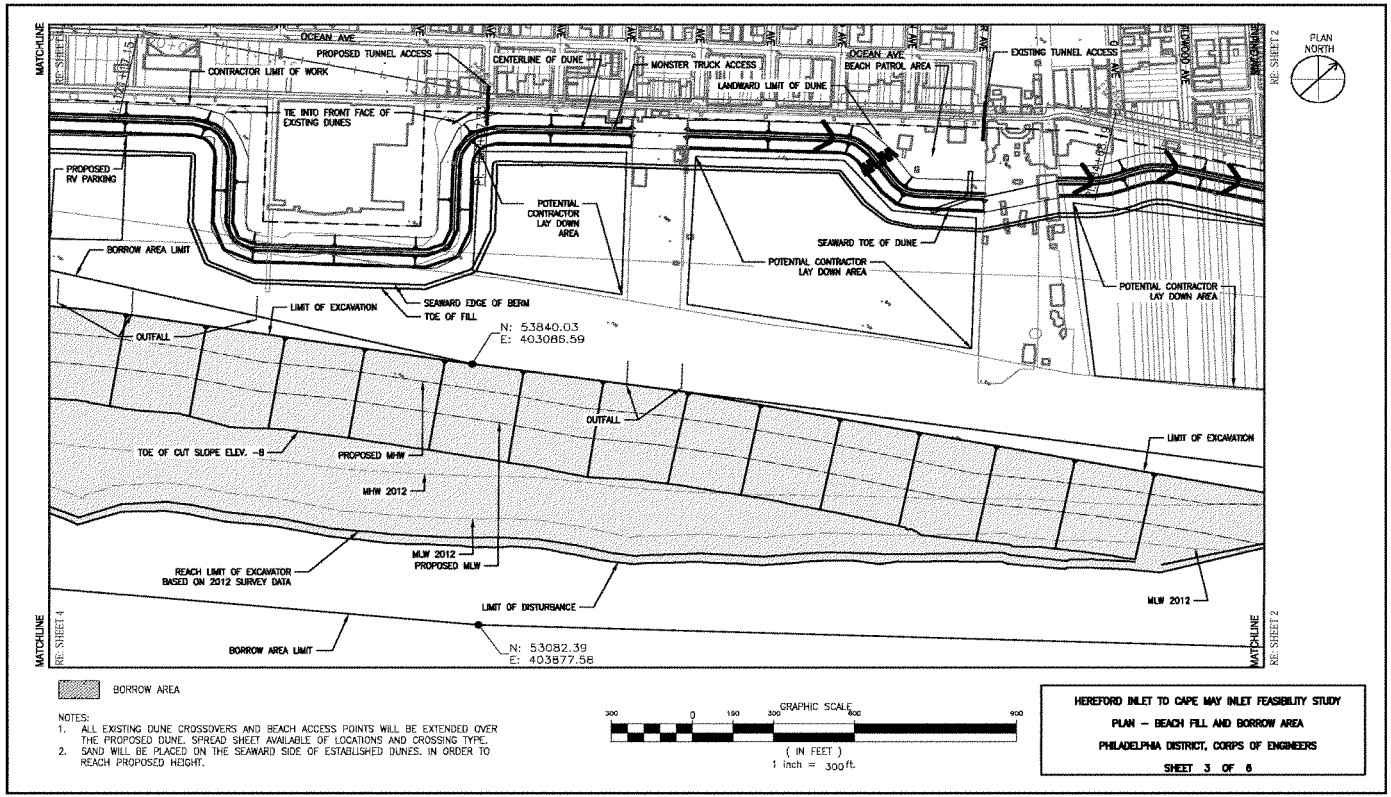


Figure 119 Wildwood Crest Plan View (2)

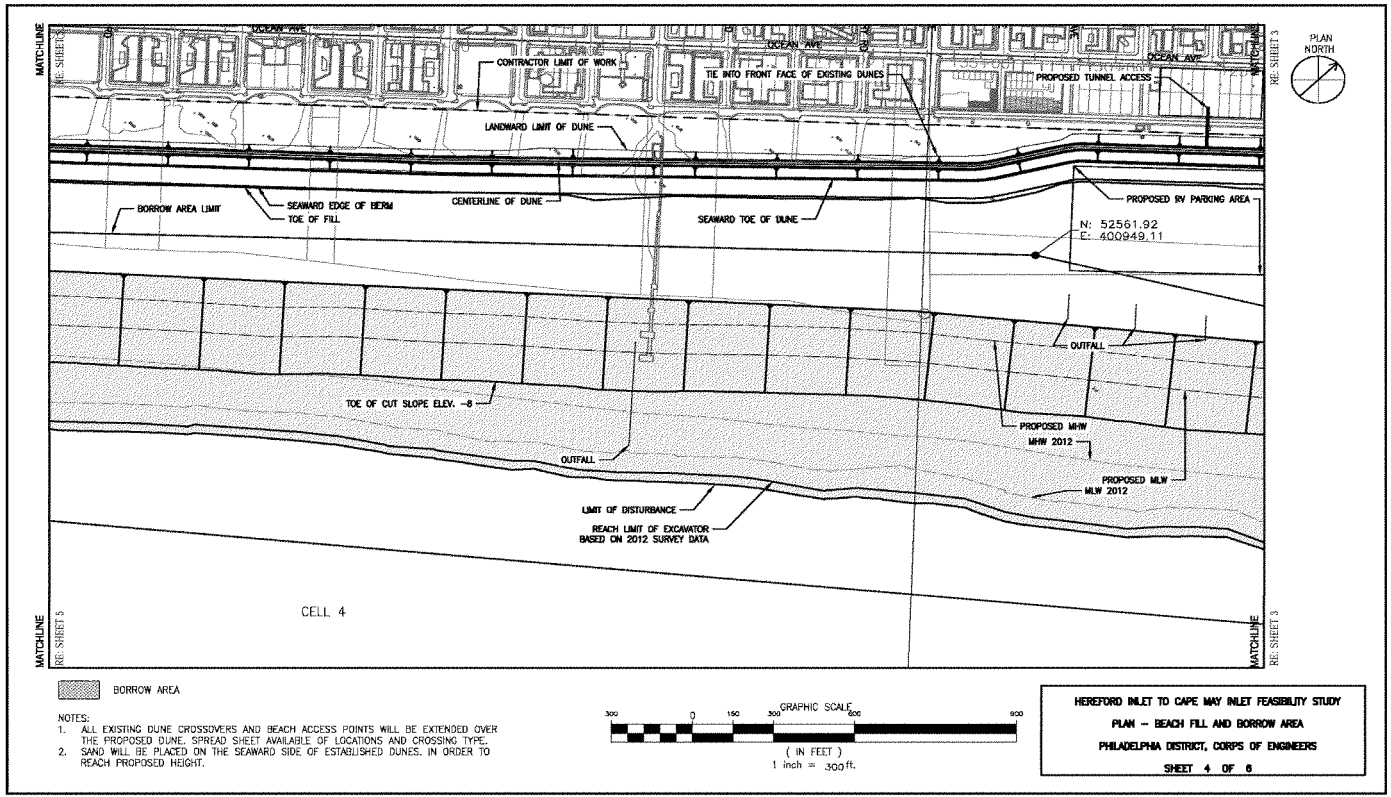


Figure 120 Wildwood Crest Plan View

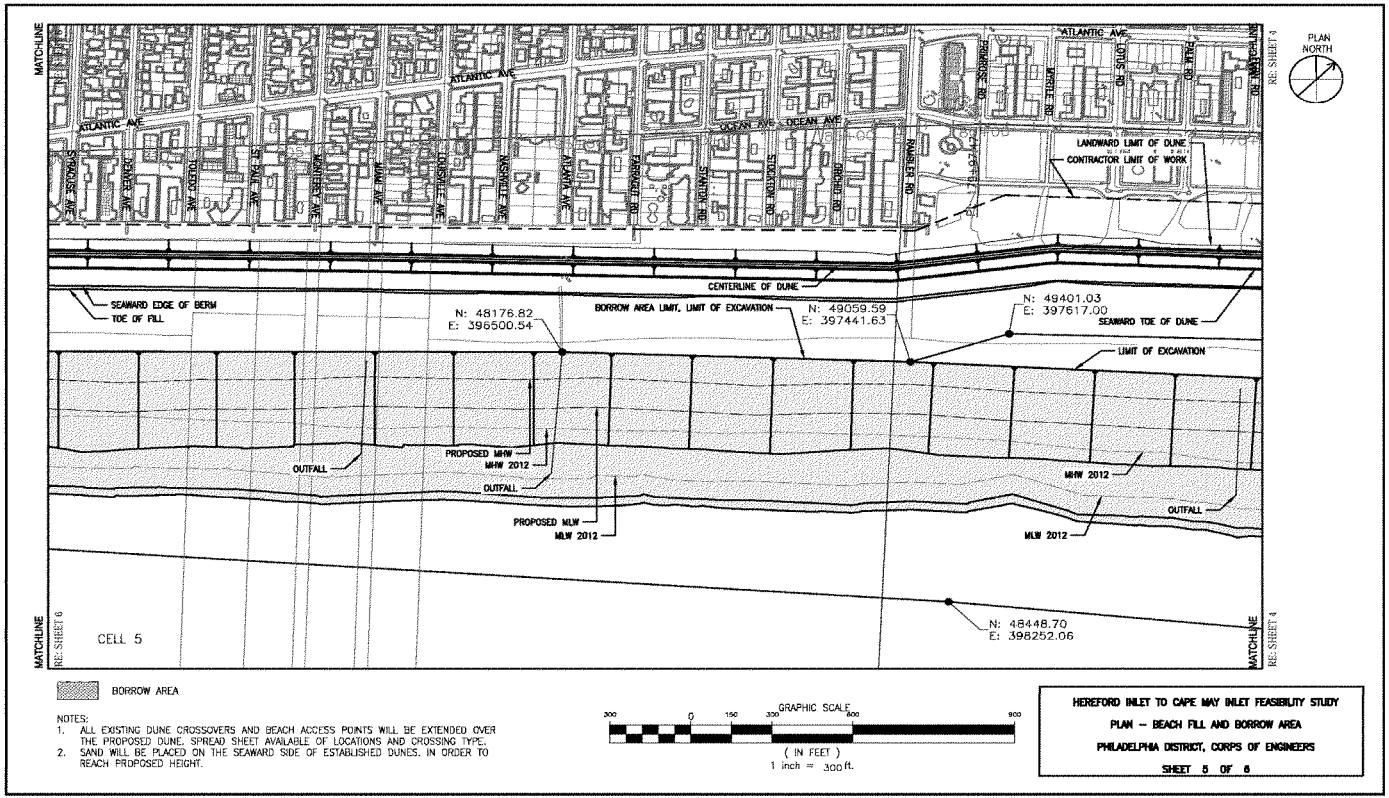
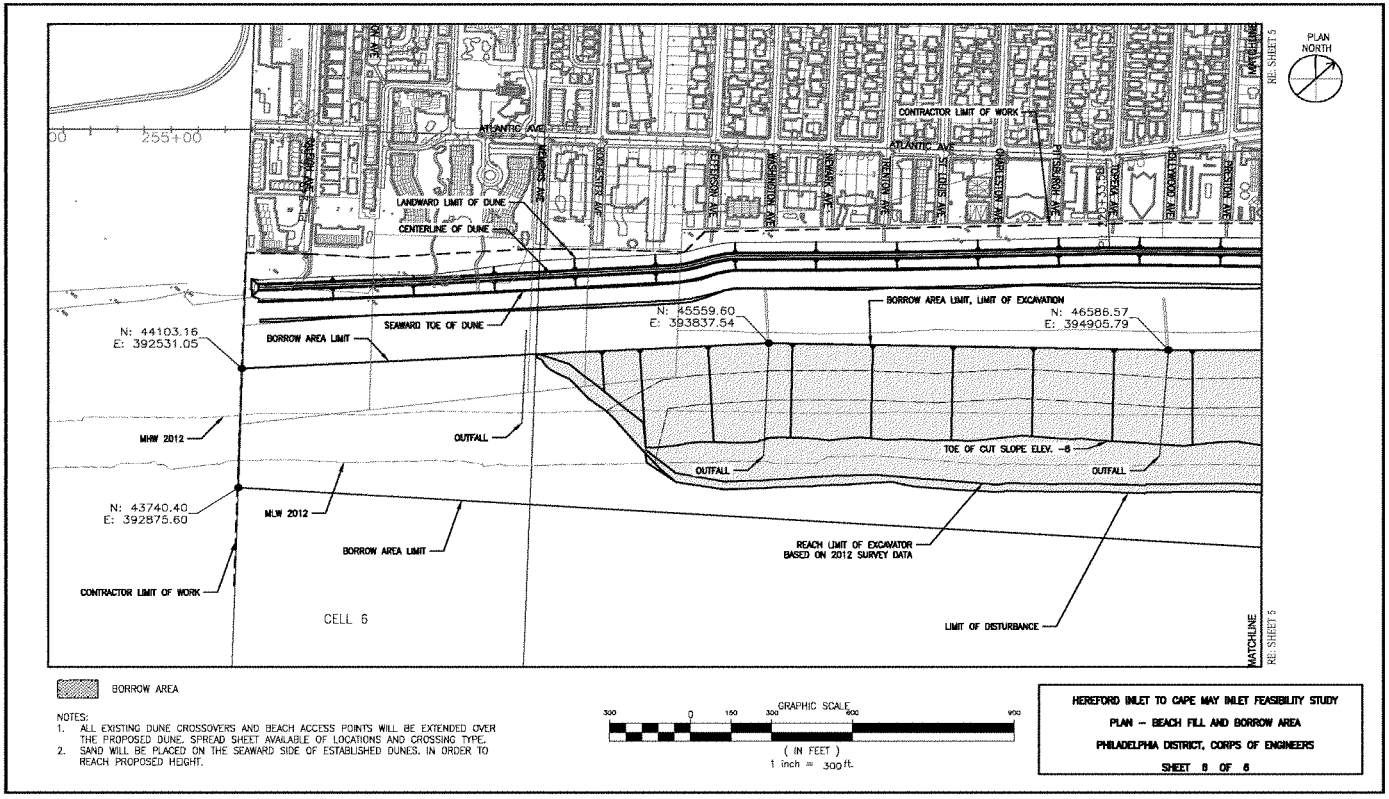


Figure 121 Wildwood Crest and Lower Township Plan View



5.1.5 Backpass Methodology

Sediment backpassing involves the removal of sand from an area in a sand surplus to an area in a sand deficit, usually in the opposite direction of long-shore transport. Longshore sediment transport is dominant in the southerly direction in this area, and we propose backpassing sediment from the south to the north, in the opposite direction of natural transport. This can be accomplished with scraping and truck hauling the material to the deposition site or with mobile hydraulic backpassing techniques. The latter is being recommended for the Hereford Inlet to Cape May Inlet project. Mobile hydraulic sediment backpassing will involve the use of 1 to 2 crawler cranes deploying a submersible or centrifugal pump in the surf zone to remove sediment from a source area, pump it through an 12 inch pipeline to a the placement area, and shape the sand into a dune and berm.

5.1.6 Existing Backpass Systems

The Worldwide Systems Data Report by PK Bosswood and RJ Murray, 1997 indicated that as of 1997 there were 53 sediment backpass, and by-pass systems worldwide. These systems remove material from areas of surplus sand to deficit areas in order to manage the resource more efficiently. Locally, two systems are employing backpass methodology successfully, The Indian River Inlet, Delaware project and a project recently constructed by the National Park Service at Sandy Hook, NJ. Sandy Hook, the northernmost 7 miles of beach along New Jersey's coast, has a long history of persistent shoreline erosion and change. After considering many options and measures, all parties agreed that the best plan would be a sand recycling arrangement based on pumping a sand slurry from a point of surplus at Gunnison Beach to the critical eroding zone. Gunnison Beach, in the northern area of Sandy Hook, has been increasing in sediment budget by the same amount of sand being lost in the critical eroding zone. The Gunnison Beach shoreline also has access to large migrating shoals, which makes it an ideal source of sand.

The Indian River Inlet project was authorized in the Flood Control Act of 1968 and the Water Resources Development Act of 1986 (P.L. 99-662). The plan of improvement consists of constructing a sand bypassing plant and operation of the plant for the periodic nourishment of approximately 100,000 cubic yards of sand annually to nourish approximately 3,500' of shoreline on the north side of the inlet and protect the Delaware Route 1 highway. The Indian River Inlet project is authorized for nourishment until September 2021.

5.1.7 Sediment Backpassing Technology

Design decisions for the backpass system were assisted with a letter report by the Corps James Clausner P.E., and Time Welp of the U.S. Army Engineer Research and Development Center (ERDC), in Vicksburg Miss., as well as Engineering Instruction Report HL-81-1 (**Appendix 16, Volume 2**). The ERDC letter report compiled data on dredging rates, pumping technology, the industry's ability to complete the work based on similar projects, the conceptual layout and the design. The report assisted in the details of the design including pump size, booster spacing requirements based on distance and grain size of the native material and pipeline diameter.

A conceptual layout of a sediment backpass system for the Hereford Inlet to Cape May Inlet

project is contained in **Figure 122** and **Figure 123.** The system would involve a crawler crane mounted with a pump on a 100' boom that would excavate material from the beach and nearshore in Wildwood and Wildwood Crest. This crane and pump system would be attached to an 8" High Density Polyethylene Pipe (HDPE) with a series of boosters that would transport the material to the design locations.

Figure 122 Schematic of Hydraulic Backpassing System courtesy of ERDC

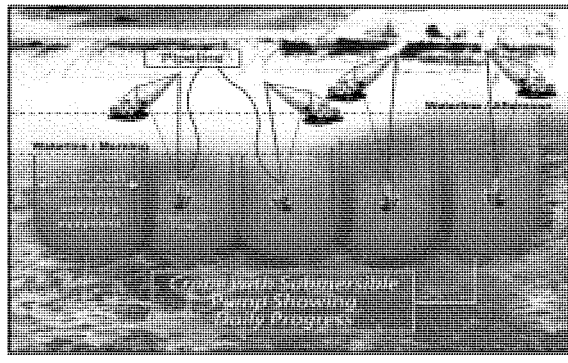
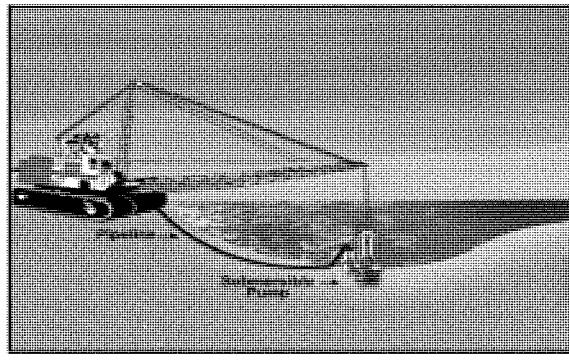


Figure 123 Side View of Crawler Crane and Crater



The crater size generated by the pump is shown in the figure above and equal to three times the depth of the crater. Dredging rates and volumes in cubic yards per hour are contained the in the Dredging Technology Appendix provided by Clausner and Welp of the Corps of Engineers, Engineering Research and Design Center. Tables from that report are contained on the following page (**Table 81** and **Table 82**).

5.1.8 Pumps

There are two types of pumps used for most sediment backpassing and by-passing operations; centrifugal and eductor. Centrifugal pumps operate with a combination of an agitator with spinning blades or high pressure water injected into the sand in combination with a spinning blade within a chamber that causes negative pressure in the chamber and entrainment of a sand/water mixture. Centrifugal pumps do not require a 100% clear water mixture and have a high discharge capability compared to eductor pumps. Eductor, or jet pumps, use the acceleration of water through a restrictor nozzle to entrain and transport sand. Clear, 100% sediment free water enters the eductor pump through the supply line and is forced through a restrictor nozzle. This restrictor nozzle increases the water velocity, and this increase in velocity over a bed of unconsolidated material will entrain the sand/water mixture into the pump, through the suction tube, through the mixing chamber and eventually through the discharge pipeline. Jet pumps require a 100% clean water supply to operate, and have a lower cubic yards per hour discharge rate than centrifugal pumps. Eductor pumps are employed at Indian River Inlet, DE for the sand by-passing project across Indian River Inlet.

The Corps Engineering and Research Design Center (ERDC) evaluated 88 different scenarios for transporting between 100,000- 1,000,000 cubic yards of sand based on production rates, working days and pumping hours .

For the initial construction cost estimate and design, the District is estimating two crawler cranes, each with a 100' boom suspending a centrifugal pump that is capable of pumping approximately 400 cubic yards an hour (cyh). The initial construction is estimated to be approximately 8 months. These cranes will work in the intertidal zone, and move in and out with the tides in order to reach the outer limits of the near shore borrow area. The excavated material will be shaped into a dune and berm in North Wildwood, Wildwood, Wildwood Crest and a portion of Lower Township.

Table 81 Sediment Backpassing Production, 300 cyh

Scenario	Volume	Average production	Working hours	Avg Daily	Working days	Avg Weekly	Job Duration
1	1,000,000	300	8	2,400	5	12,000	18.9
2	1,000,000	300	9	2,700	5	13,500	16.8
3	1,000,000	300	10	3,000	5	15,000	15.2
4	1,000,000	300	12	3,600	5	18,000	12.6
5	1,000,000	300	16	4,800	5	24,000	9.5
6	1,000,000	300	8	2,400	6	14,400	15.8
7	1,000,000	300	9	2,700	6	16,200	14
8	1,000,000	300	10	3,000	6	18,000	12.6
9	1,000,000	300	12	3,600	6	21,600	10.5
10	1,000,000	300	16	4,800	6	28,800	7.9
11	1,000,000	300	24	7,200	7	50,400	4.5
12	500,000	300	8	2,400	5	12,000	9.5
13	500,000	300	9	2,700	5	13,500	8.4
14	500,000	300	10	3,000	5	15,000	7.6
15	500,000	300	12	3,600	5	18,000	6.3
16	500,000	300	16	4,800	5	24,000	4.7
17	500,000	300	8	2,400	6	14,400	7.9
18	500,000	300	9	2,700	6	16,200	7
19	500,000	300	10	3,000	6	18,000	6.3
20	500,000	300	12	3,600	6	21,600	5.3
21	500,000	300	16	4,800	6	28,800	3.9
22	500,000	300	24	7,200	7	50,400	2.3
23	200,000	300	8	2,400	5	12,000	3.8
24	200,000	300	9	2,700	5	13,500	3.4
25	200,000	300	10	3,000	5	15,000	3
26	200,000	300	12	3,600	5	18,000	2.5
27	200,000	300	16	4,800	5	24,000	1.9
28	200,000	300	8	2,400	6	14,400	3.2
29	200,000	300	9	2,700	6	16,200	2.8
30	200,000	300	10	3,000	6	18,000	2.5
31	200,000	300	12	3,600	6	21,600	2.1
32	200,000	300	16	4,800	6	28,800	1.6
33	200,000	300	24	7,200	7	50,400	0.9
34	100,000	300	8	2,400	5	12,000	1.9
35	100,000	300	9	2,700	5	13,500	1.7
36	100,000	300	10	3,000	5	15,000	1.5
37	100,000	300	12	3,600	5	18,000	1.3
38	100,000	300	16	4,800	5	24,000	1
39	100,000	300	8	2,400	6	14,400	1.6
40	100,000	300	9	2,700	6	16,200	1.4
41	100,000	300	10	3,000	6	18,000	1.3
42	100,000	300	12	3,600	6	21,600	1.1
43	100,000	300	16	4,800	6	28,800	0.8
44	100,000	300	24	7,200	7	50,400	0.5

Table 82 Sediment Backpassing Production, 450 cyh

Scenario	Volume	Average production	Working hours	Avg Daily	Working days	Avg Weekly	Job Duration
1	1,000,000	450	8	3,600	5	18,000	12.6
2	1,000,000	450	9	4,050	5	20,250	11.2
3	1,000,000	450	10	4,500	5	22,500	10.1
4	1,000,000	450	12	5,400	5	27,000	8.4
5	1,000,000	450	16	7,200	5	36,000	6.3
6	1,000,000	450	8	3,600	6	21,600	10.5
7	1,000,000	450	9	4,050	6	24,300	9.4
8	1,000,000	450	10	4,500	6	27,000	8.4
9	1,000,000	450	12	5,400	6	32,400	7
10	1,000,000	450	16	7,200	6	43,200	5.3
11	1,000,000	450	24	10,800	7	75,600	3
12	500,000	450	8	3,600	5	18,000	6.3
13	500,000	450	9	4,050	5	20,250	5.6
14	500,000	450	10	4,500	5	22,500	5.1
15	500,000	450	12	5,400	5	27,000	4.2
16	500,000	450	16	7,200	5	36,000	3.2
17	500,000	450	8	3,600	6	21,600	5.3
18	500,000	450	9	4,050	6	24,300	4.7
19	500,000	450	10	4,500	6	27,000	4.2
20	500,000	450	12	5,400	6	32,400	3.5
21	500,000	450	16	7,200	6	43,200	2.6
22	500,000	450	24	10,800	7	75,600	1.5
23	200,000	450	8	3,600	5	18,000	2.5
24	200,000	450	9	4,050	5	20,250	2.2
25	200,000	450	10	4,500	5	22,500	2
26	200,000	450	12	5,400	5	27,000	1.7
27	200,000	450	16	7,200	5	36,000	1.3
28	200,000	450	8	3,600	6	21,600	2.1
29	200,000	450	9	4,050	6	24,300	1.9
30	200,000	450	10	4,500	6	27,000	1.7
31	200,000	450	12	5,400	6	32,400	1.4
32	200,000	450	16	7,200	6	43,200	1.1
33	200,000	450	24	10,800	7	75,600	0.6
34	100,000	450	8	3,600	5	18,000	1.3
35	100,000	450	9	4,050	5	20,250	1.1
36	100,000	450	10	4,500	5	22,500	1
37	100,000	450	12	5,400	5	27,000	0.8
38	100,000	450	16	7,200	5	36,000	0.6
39	100,000	450	8	3,600	6	21,600	1.1
40	100,000	450	9	4,050	6	24,300	0.9
41	100,000	450	10	4,500	6	27,000	0.8
42	100,000	450	12	5,400	6	32,400	0.7
43	100,000	450	16	7,200	6	43,200	0.5
44	100,000	450	24	10,800	7	75,600	0.3

5.1.9 Major Replacement Requirements

Major replacement quantities were developed in accordance with ER 1110-2-1407 to identify additional erosion losses from the project due to higher intensity (low frequency) storm events. The nourishment rates developed for the project measures include losses due to storms that have occurred within the analysis period. Storms of approximately 50-year return period and more frequent are encompassed in those rates. Major replacement losses are computed as the losses that would occur from the 50% risk event over the period of analysis. The annual percent frequency event with a 50% risk during the 50-year period of analysis is 1.37%. The period of record of stages recorded at the study area is approximately 73 years. SBEACH was employed to compute volumetric erosion from the selected beach alternative design profile utilizing the 50- and 100-yr return period storm parameters utilized in the without- and with project analyses. Volumetric erosion quantities for the 73-yr event were obtained by interpolating between the 50- and 100-yr events. Water levels and waves were hindcast at the study area for the storm, and all model parameters were identical to the without and with-project analyses. Volumetric storm induced erosion was computed for each reach for the design beach profile. Based on local profile analyses and experience developed at the Philadelphia, and other Corps coastal Districts, it is estimated that approximately 60% of the material displaced during large storms will return to the foreshore within weeks and only the remaining 40% will require mechanical replacement onto the sub aerial beach to regain the design cross-section and insure the predicted level of storm damage reduction. It is estimated that a volume of approximately153,000 cu yds would be required to perform major rehabilitation in response to the 50% risk event. This quantity is added to the periodic nourishment quantity discussed above at year 24 for cost estimating purposes. Therefore, total major replacement sand quantity in year 24 is **153,000** cu yds **Table 83**, minus periodic nourishment. Because a high intensity storm would likely impact dune grass, crossovers, and sand fence, these items were included in the total major replacement costs.

Table 83 Major Replacement Volumes

Cell	Quantity cubic yards
1	57,000
2	60,000
3	13,000
4	9,000
5	12,000
6	2,000
TOTALS	153,000

5.1.10 Project Transitions and Tapers

There is one taper section at the northern end of the project area. At the northern end, the project terminates at second street and JFK boulevard, with the terminus extending into Hereford Inlet along the North Wildwood Seawall for approximately 200'. On the southern end the project

will terminate at the northern terminus of the United States Fish and Wildlife property in Lower Township. Beach fill transitions between different design berm and dune dimensions are included in the selected plan layout and are reflected in the total quantity estimates. .

5.2 Environmental Impacts

5.2.1 Physical Environment

Mobile hydraulic backpassing of sand from the beaches in Wildwood and Wildwood Crest would result in the temporary excavation of shallow pits deeper than the surrounding bathymetry within the intertidal zone. This is due to the existing flat nature of the bottom. Initially, backpassing cuts may produce abrupt edges. However, these cuts will quickly become reworked by the wave action in the intertidal zone and refilled with sand from the surrounding area, resulting in a landward shift of the mean high water (MHW) line. Based on the location of the sand removal, similar substrate characteristics would remain following dredging. The average depth of excavation will be 4-8' and will vary based on the existing ground elevation. Sand will be removed from the intertidal zone to a maximum depth of -8' NAVD.

5.2.2 Water Quality

The backpassing associated with the beach nourishment alternative would result in short-term adverse impacts to water quality in the immediate vicinity of the excavation and beach nourishment operations. Excavating sand from within the proposed intertidal borrow area will generate turbidity, resulting in sedimentation impacts within the immediate vicinity of the operations. Short-term increased turbidity can affect organisms in several ways. Primary production in phytoplankton and/or benthic algae may become inhibited from turbidity. Suspended particulate matter can clog gills and inhibit filter-feeding species. Reilly *et.al.* 1983 determined that high turbidity could inhibit recruitment by pelagic larval stocks. In addition, mid-water nekton like finfish and mobile benthic invertebrates may migrate outside of the area where turbidity and deposition occur.

The amount of turbidity and its associated plume is mainly dependent on the grain size of the material. Generally, the larger the grain-size, the smaller the area of impact. The period of turbidity is also less with larger grain-sized materials. The proposed borrow location contains medium to fine sands, which are coarser grained than silts and clays. Turbidity resulting from the re-suspension of these sediments is expected to be localized and temporary in nature. Utilization of a bydraulic pump with a pipeline delivery system will help minimize tbe impact, however, some disturbance will occur.

Similar water quality effects on aquatic organisms could likely be incurred from the deposition of borrow material on the beach. Increased turbidity resulting from the deposition of a slurry of sand will be temporary in nature and localized. This effect will not be significant as turbidity levels are naturally high in the high-energy surf zone. Organisms in the surf zone versus deep water areas will be less likely to suffer adverse effects from turbidity because they have already adapted to these conditions. Fine sediments sifted from the deposited material would be transported by waves and currents into the nearshore with varying environmental impacts from a few months to at least several years (Hurme and Pullen, 1988). Parr *et. al.*, 1978 determined that

fine materials were rapidly sorted out and transported offshore after beach deposition. In their study, the dredged material had a much higher silt content than the beach, however, all of the silt was removed within 5 months. The selection of borrow material from a high energy beach environment should minimize the fine particle content. Material taken from the proposed borrow area will have low quantities of silt, therefore, high levels of turbid waters after deposition should not persist.

5.2.3 Biological Environment

5.2.3.1 Terrestrial

Impacts on terrestrial flora and fauna will be minimal within the project area. Existing dune vegetation, where present, would not be disturbed by renourishment activities. New dunes will be planted with dune grass following construction activities. Rapid recolonization of other types of vegetation on the beach face such as sea rocket and seaside goldenrod is expected. Impacts to wildlife species inhabiting the beach and dune areas are expected to be short-term and minor as most species are highly mobile and capable of moving outside the impacted areas until construction ceases.

5.2.4 Aquatic

5.2.4.1 Effects on Benthos

The majority of the impacts of beach fill borrow and placement will be felt on organisms in the intertidal zone and near shore zones. The near shore and intertidal zone is highly dynamic, harsh, and is characterized by great variations in various abiotic factors. Fauna of the intertidal zone are highly mobile and respond to stress by displaying large diurnal, tidal, and seasonal fluctuations in population density (Reilly *et al.* 1983). Despite the resiliency of intertidal benthic fauna, the initial effect of beach fill deposition will be the smothering and mortality of existing benthic organisms within the shallow near shore (littoral) zone on the oceanfront. This will initially reduce species diversity and number of animals. Burial of less mobile species such as amphipods and polychaete worms would result in losses, however, densities and biomasses of these organisms are relatively low on beaches. Beach nourishment may also inhibit the return of adult intertidal organisms from their near shore-offshore overwintering refuges, cause reductions in organism densities on adjacent unnourished beaches, and inhibit pelagic larval recruitment efforts. Parr *et al.* (1978) notes that the near shore community is highly resilient to this type of disturbance. The ability of a nourished area to recover depends heavily on the grain size compatibilities of material pumped on the beach (Parr *et al.*,1978). Due to the fact that the sand being placed in North Wildwood is coming from similar intertidal habitat and has accumulated as a result of the sediment transport mechanisms in the project area, grain size compatibility will allow for rapid re-colonization.

Over the life of the project, it is estimated that approximately 415 acres of intertidal benthic habitat will be impacted in Wildwood and Wildwood Crest during the life of the hydraulic backpassing activities. Approximately 250 acres will be impacted during initial construction as sand is removed from the intertidal zone and the MHW line is moved landward. Dredging will primarily impact the benthic organisms in the surf zone. Mortality of some of these organisms

may occur as they pass through the dredge device. A secondary disturbance would be the generation of turbidity and deposition of sediments on the benthic community adjacent to the backpassing. Despite the initial effects of dredging on the benthic community, recolonization is anticipated to occur quickly due to the dynamic nature of the intertidal zone. Due to the location of the borrow zone within the intertidal zone, any pits created by the removal of sand are expected to fill in quickly as a result of wave action in the surf zone. It is important that for recovery, the bottom sediments are composed of the same grain sizes as the pre-dredge bottom. Since waves will quickly fill the borrow area with sand from the adjacent surf zone, grain size within the borrow area after excavation is expected to be nearly identical to sand removed. It should be noted that the backpassing operation will utilize an eight-inch pipe for sand transport which is much smaller than the 24-36" pipes used for traditional dredging projects. The smaller pipe size equates to a lower velocity within the pipe and a lower volume of material placed on the beach on any given day. These lower volumes and velocities will reduce benthic impacts associated with the operations.

5.2.5. Impacts on Fisheries

5.2.5.1 Finfish

With the exception of some small finfish, most fish found in the surf zone are highly mobile, and should be capable of avoiding entrainment into the dredging intake stream. It is anticipated that some finfish would avoid the turbidity plume while others may become attracted to the suspension of food materials in the water column. Little impact to fish eggs and larvae are expected because these life stages are widespread throughout the Middle Atlantic Bight, and not particularly concentrated in the surf zone of the project area (Grosslein and Azarovitz, 1982). The primary impact to fisheries will be felt from the disturbance of benthic community. The loss of benthos entrained or smothered during the project will temporarily disrupt the food chain in the impact area. This effect is expected to be temporary as these areas become rapidly recolonized by pioneering benthic species.

5.2.5.2 Essential Fish Habitat

As discussed previously, there are a number of Federally managed fish species where essential fish habitat (EFH) was identified for one or more life stages within the project area. Fish occupation of waters within the project area is highly variable spatially and temporally. Some of the species are strictly offshore, while others may occupy both near shore and offshore waters. In addition, some species may be suited for the open-ocean or pelagic waters, while others may be more oriented to bottom or demersal waters. This can also vary between life stages of Federally managed species. Also, seasonal abundances are highly variable, as many species are highly migratory.

In general, adverse impacts to Federally managed fish species may stem from alterations of the bottom habitat, which would result from backpassing and beach fill placement in the intertidal zone and near sbore area. EFH may also be adversely impacted temporarily through water quality impacts such as increased turbidity and decreased dissolved oxygen content in the dredging and placement locations. These impacts would subside upon cessation of construction activities.

Biological impacts on EFH are more indirect involving the temporary loss of benthic food prey items or food chain disruptions. Turbidity at the placement site could impact the ability of sight feeders to find prey and construction activities in general could cause certain species to avoid the area. As previously stated, however, the affect on benthic food-prey organisms present in the borrow area and sand placement areas is considered to be temporary as benthic studies have demonstrated recolonization occurs quickly in the dynamic near shore environment. In addition, the impact area is a naturally turbid environment and species found in this zone are accustomed to a certain level of suspended sediments in the water column. The sandy nature of the borrow material, and the fact it is already well sorted from being in the intertidal zone, will keep excess turbidity to a minimum.

Direct impacts could also occur to Federally managed species if they were to become entrained in the dredge pump. Only egg, larvae and very small fish that would be found in the intertidal zone would be susceptible to entrainment as most species and life stages would be able to avoid the dredging activity. The small size (8-inch) of the pipeline makes entrainment less likely than with a traditional dredge apparatus.

5.2.6 Threatened and Endangered Species

The piping plover, which is State listed as endangered and Federally listed as threatened, is a frequent inhabitant of New Jersey's sandy beaches. Plovers have nested in North Wildwood for at least the past 10 years. Plovers have also nested at the Cape May National Wildlife Refuge and the adjacent Coast Guard property during this time period, but not on a regular basis. It is expected that plovers will continue to nest in these areas, especially following beach restoration activities. Currently, piping plover monitoring is being conducted in North Wildwood, through the New Jersey Department of Environmental Protection, Division of Fish and Wildlife and the U.S. Fish and Wildlife Service. This practice will continue throughout the life of the project, or until such time as the duty is handed over to the local municipalities. In addition, protection measures laid out by NJDEP, Division of Fish and Wildlife and the U.S. Fish and Wildlife Service will be followed during all renourishment activities in order to protect the piping plovers from being disturbed. These measures may include establishing a buffer zone around the nest, and limiting construction to be conducted outside of the nesting period (15 March - 15 August).

Beach replenishment activities can potentially have significant direct and indirect adverse impacts on piping plovers. Sand placement can bury nests, and machinery and vehicles on the beach can crush eggs, nestlings, and adults. Human disturbance related to recreational activities can disrupt successful nesting of these birds by preventing birds from feeding and scaring adults off established nests. Also, pipelines used during construction may become barriers to young chicks trying to reach intertidal areas to feed. It is believed that in New Jersey, predation is probably the primary cause of mortality for plover chicks. Observations by NJDEP, however, support the finding that chick survival and susceptibility to predation is strongly influenced by other factors, especially human disturbance and the availability and access to optimal foraging areas (Jenkins, 1999).

Other indirect impacts associated with the proposed plan include the temporary reduction in the quality of forage habitat for piping plover and other shorebirds within the intertidal zone until the area becomes recolonized by benthic fauna such as polychaete worms, mollusks, and crustaceans. This impact will be short-lived as the benthic invertebrates can immediately recolonize the newly created habitat (Burlas *et al*, 2001). The construction of a wider beach may result in the beach becoming more attractive to nesting birds such as piping plover, least tern, and black skimmers. Although this may appear to be beneficial, it is believed that this could have adverse impacts on these species. This is based on the fact that a replenished wider beach may attract these birds away from natural areas where human disturbance effects are less.

Another species which may be found within the project area is the Federally-listed threatened plant, seabeach amaranth, which inhabits overwash flats, accreting ends of coastal barrier beaches and lower foredunes of non-eroding beaches. While no extant populations are known to currently exist within the study area, this species has recently recolonized or has been observed in coastal sites within New York, Delaware, Maryland, and most recently New Jersey (USFWS,1999). Therefore, it is possible that seabeach amaranth may become naturally established within the project area within the life of the project. Since the proposed project may actually create habitat for the seabeach amaranth, impacts to this species are also possible related to construction of beach stabilization structures, beach erosion and tidal inundation, beach grooming, and destruction by off-road vehicles (USFWS, 1999).

To address these issues, the Philadelphia District developed a programmatic Biological Assessment (BA) for the piping plover and seabeach amaranth as part of formal consultation requirements with the U.S. Fish and Wildlife Service (USFWS) under Section 7 of the Endangered Species Act. The USFWS reviewed the BA and subsequently issued a Biological Opinion in December 2005. The requirements outlined in the Biological Opinion have been adopted in order to comply with this statute. Formal consultation will be ongoing throughout the period of analysis since the USFWS recommends formal consultation be reinitiated at least 135 days prior to construction and each periodic nourishment cycle. The Section 7 consultation process is expected to result in monitoring before, during and after construction, imposing timing restrictions if nests are found, construction of temporary protective fencing, and avoidance during construction. It is anticipated, however that nourishment activities will usually take place outside of the plover nesting season due to the quantity of fill required. Other issues to be addressed through community developed plover management plans include local practices such as beach raking, off-road vehicles, and general public access in or near nesting locations. The project area, specifically the foredune area, would be periodically monitored for the seabeach amaranth. Contingency plans for the presence of seabeach amaranth at the time of periodic maintenance may involve avoidance of the area (if possible), collection of seeds to be planted in non-impacted areas, and timing restrictions.

The red knot, which is a Federally-listed Candidate species may be present at the site during the spring and fall migration, with some birds still being present in the early winter time period. As is the case with plovers, the project has the potential to temporarily impact food resources within the borrow and placement areas. Since portions of the projects will not be impacted during nourishment cycles, sufficient food should still be readily available within the project area. In addition, due to the timing of initial construction, which will take approximately 8 months, it is

possible that birds will be present during construction activities. If any birds are present, they will easily be able to move away from the construction activities to another portion of the beach where they will not be disturbed.

From June through November, New Jersey's coastal waters may be inhabited by transient sea turtles, especially the loggerhead (Federally listed threatened) and the Kemp's ridley (Federally listed endangered). Sea turtles have been known to be adversely impacted during hopper dredging operations. Endangered whales, such as the highly endangered Right whale, may also be transient visitors within the project area.

The Federally listed Atlantic sturgeon is a migratory species along the Atlantic coast and has the potential to be found within the project area. While it is possible for Atlantic sturgeon to become entrained in the hydraulic pump during dredging operations, this is highly unlikely due to the transient nature of the species in the marine environment and their tendency to avoid dredging operations (O'Herron et al.1985). Minor and temporary impacts to water quality and prey resources are expected within the borrow and placement areas. Minor and temporary impacts associated with regard to noise are also expected.

Due to the fact that sand for this project will be obtained by hydraulic back-passing using a land-based dredge pump, no impacts to sea turtles, sturgeon or whales are expected. NMFS agreed with this assessment during their review of the Draft Feasibility Report and EA in a letter dated 19 February 2014 which stated that no further ESA coordination would be necessary for this project.

5.2.7 Cultural Resources

Coordination with the New Jersey State Historic Preservation Office (SHPO) has been ongoing since the initiation of the Feasibility study. More recently, a letter was drafted on 2 July 2 2013 outlining the potential Area of Potential Effect (APE) and sent to the Historic Preservation Offices in Trenton. The District received a concur on this letter on 6 August 2013 from David Saunders, the State Historic preservation Officer, Volume 3, Appendix G., p 49 .

The USACE has determined that the Area of Potential Effect (APE) for the selected plan includes the beaches and intertidal areas from Hereford Inlet to Cape May inlet, marking the northern and southern limits, and from the existing dunes to the intertidal area marking the eastern and western limits. The limits of construction disturbance for the selected plan are located within the APE (Enclosure 2).

Although there are several recorded historic properties eligible for or listed on the National Register of Historic Places (NRHP) within the vicinity of the APE for the selected plan, the USACE has determined that dune and berm construction along approximately 4.5 miles from Hereford Inlet to Cape May Inlet using recently accreted sand from the intertidal zone from the southern end of Five Mile Island will have No Effect.

A cultural resource assessment of the proposed intertidal sand source was conducted by FEMA as part of the Section 106 review for post-Hurricane Irene beach restoration of North Wildwood. An assessment of the beach in the adjacent communities of Wildwood Crest in the south to North

Wildwood was conducted to determine the sensitivity of below ground archaeological resources. Several aspects were analyzed including the project's proximity to know archaeological resources, waterways and historic properties as well as the site's environmental characteristics such as spoil analysis and previous ground disturbing activities within the project APE, which is roughly the APE of the selected plan. Remnants of the Nancy, a revolutionary war brig set afire by troops at Turtle Gut Inlet (Site 28CM0013) are located southwest of the APE and site 28CM0008 is currently underneath the existing Wildwood Boardwalk.

There are no structures within the project APE; however the Chateau Blue Motel, the Hereford Inlet Lighthouse and the J. Thompson Baker House are all listed on the NRHP, but will not be affected. Also, the Wildwood Shore Resort Historic District runs parallel to the beach and is within the project view shed but will also not be affected. The APE is a previously disturbed, engineered beaches. The proposed project will collect, transport and place sand entirely within the previously disturbed areas. No part of the proposed undertaking is located within an archaeologically sensitive area, and no historic properties are within the APE.

A copy of this July 2013 letter and the concurrence from the State Historic Preservation Office is contained in the General Correspondence Appendix (G) of this document.

5.2.8 Impacts on Air and Noise Quality

Short-term impacts to air quality and noise levels would result from the construction phases of the beach nourishment alternative. Dredging activities and grading equipment use would produce noise levels in the 70 to 90 dBA (50' from the source) range, but these would be restricted to the beach area. These noises would be masked by the high background levels of the surf or dissipated by distance. Ambient air quality would also be temporarily degraded, but emission controls and limited duration aid in minimizing the effects. In the case of equipment use associated with the periodic nourishment efforts, conducting the work in the off-season would further minimize the impact.

Noise and air quality impacts would be restricted to site construction preparation (generally beginning two weeks prior to dredging) and the actual dredging and placement operation. Noise is limited to the utilization of heavy equipment such as bulldozers to manipulate the material during placement. Depending on future circumstances, the construction may be conducted overnight to meet construction schedules. An analysis of the project emissions may be found in Appendix C. Air quality impacts would similarly be limited to emissions from the heavy equipment. No long-term significant impacts to the local air quality are anticipated. The Clean Air Act Statement of Conformity is included in this Report in Section 9.0.

Cape May County, New Jersey is within the Philadelphia-Wilmington-Atlantic City, PA-NJ-MD-DE area, which is classified as moderate nonattainment for ozone. As such, emissions from the Hereford Inlet to Cape May Inlet project must be below 100 tons of NOx and 50 tons of VOC per year. . The results of these analyses indicate that the total estimated emissions that would result from the construction of the Hereford project are 91 tons of NOx and 12.8 tons of VOCs. The emissions for the project are below the General Conformity trigger levels of 100 tons per year of NOx and 50 tons per year of VOCs. In addition, due to the fact that initial construction of this project will most likely be completed during the fall/winter months, the

emissions for the project will actually be spread out over two calendar years which further minimizes the per year emissions.

5.2.9 Environmental Justice

All of the measures identified in this document are expected to comply with Executive Order 12989 – Environmental Justice in Minority Populations and Low-Income Populations, dated February 11, 1994. The selected plan is not located in close proximity to a minority or low-income community, and no impacts are expected to occur to any minority or low-income communities in the area.

5.2.10 Cumulative Impacts

Cumulative Impacts, as defined in CEQ regulations (40 CFR Sec. 1508.7), are the "impacts on the environment which result from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time."

Along the Atlantic Coast of New Jersey, several existing Federal, state and municipal beach replenishment projects that utilize inlet shoals or offshore areas have been completed in the recent past or are currently active. Nine active Federal projects are located along the coast of New Jersey that each utilize either an offshore sand source or an adjacent inlet. The Hereford Inlet to Cape May Inlet project is currently the only project utilizing a beach borrow area. non-Federal projects have been conducted recently by NJDEP and several municipalities in Avalon, Stone Harbor, Sea Isle City, Strathmere, Southern Ocean City, and Brigantine. These areas have all used either inlet borrow sites or offshore sites, which have impacted over 3,000 acres of marine habitat. The proposed Federal projects combined with the existing project would affect approximately 68 miles of beach along the New Jersey coast (south of Manasquan Inlet). This represents nearly 71% of beaches along this segment of coast.

In recent years, the New Jersey Coast has been affected by catastrophic coastal storms, most notably Hurricane Sandy in October 2012. In response to the devastation of the Atlantic coastal communities in New Jersey from Hurricane Sandy, the USACE and the Federal Emergency Management Agency (through aid to State and local municipalities) have undertaken unprecedented measures to repair and/or restore the affected beaches under P.L. 84-99 Flood Control and Coastal Emergencies (FCCE) and P.L. 113-2: Disaster Relief Appropriations Act. P.L. 84-99 allows for the repair of beaches with active Federal projects to pre-storm conditions and P.L. 113-2 allows for the restoration of affected beaches to full template that have existing active Federal projects. Also, as part of P.L. 113-2, there is the funding to complete authorized, but unconstructed projects, which include the Great Egg Harbor Inlet to Townsends Inlet and the Manasquan Inlet to Barnegat Inlet projects.

Since November of 2012, several of the authorized and constructed projects within the Philadelphia District have been completed or are currently undergoing repairs and restoration in accordance with P.L. 84-99 and P.L. 113-2. These projects include: portions of the Barnegat

Inlet to Little Egg Inlet (Harvey Cedars, Surf City, and Brant Beach), Brigantine Island, and Absecon Island (Atlantic City and Ventnor), and Townsends Inlet to Hereford Inlet (Avalon and Stone Harbor). The Ocean City - Peck Beach (Northern Ocean City) project and Lower Cape May Meadows were already scheduled for periodic nourishment at the time Hurricane Sandy struck. Cape May City is scheduled to start repair and restore activities in September 2013. The remaining authorized, but unconstructed projects are Great Egg Harbor Inlet to Townsends Inlet (Southern Ocean City, Strathmere, Upper Township, and Sea Isle City) and Manasquan Inlet to Barnegat Inlet (Seaside Park, Seaside Heights, Normandy Beach, Mantoloking, and Point Pleasant Beach). Some minor and temporary impacts would result in a loss of food source in the affected areas (**Figure 124**).

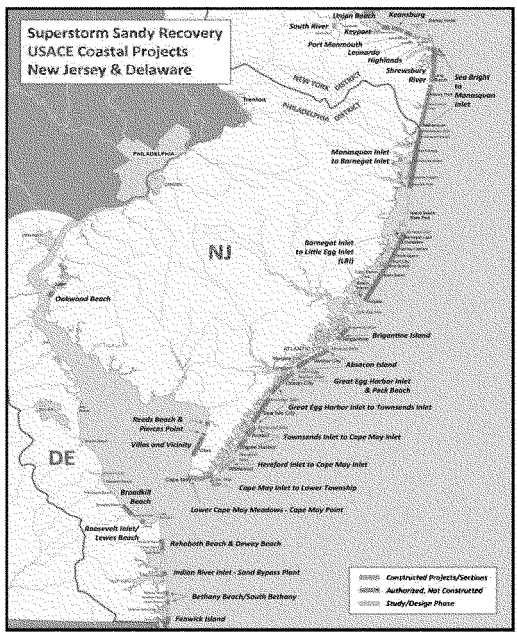
In addition to the potential impacts to benthic and fisheries resources discussed, the proposed and active Federal projects also have the potential of cumulative impacts to the Federally listed piping plover and seabeach amaranth. Due to the amount of uncertainty that exists regarding when and how any of the active and proposed projects will be built, and the uncertainty of the number and location of plover nests in any given year, it is extremely difficult to quantify the potential impacts to piping plovers for any, and all of the projects. If the majority of the ongoing and proposed construction activities are accomplished outside of the nesting season, the overall impacts to plovers will be minimal, and the birds most likely will benefit from the additional beach areas. Through the implementation of plover management plans and the monitoring program, impacts related to human activities on the new beaches will be greatly reduced.

Although nearly 71% of the beaches along the N.J. coast south of Manasquan Inlet could potentially be impacted by beach fill placement activities, the cumulative effect of these combined activities is expected to be temporary and minor on resources of concern such as benthic species, beach dwelling flora and fauna, water quality and essential fish habitat. This is due to the fact that flora and fauna associated with beaches, intertidal zones and near shore zones are adapted to and resilient to frequent disturbance as is normally encountered in these highly dynamic and often harsh environments. Among the existing and proposed projects along this stretch of coast, renourishment cycles vary from two to seven years, which would likely preclude all of the beach fill areas being impacted at one time.

The majority of impacts associated with all these projects are related to the temporary disturbance to the benthic community, and do not represent a permanent loss of marine benthic habitat. The borrow areas for each project would be impacted incrementally over the 50-year period of analysis with each periodic nourishment cycle. It is anticipated that the benthic community in offshore borrow areas would be recovered within several years after disturbance. For the Hereford project, recovery is expected to occur more quickly due to the dynamic nature of the beach borrow area. The cumulative impacts on Essential Fisb Habitat (EFH) are not considered significant. Like the benthic environment, the impacts to EFH are temporary in nature and do not result in a permanent loss in EFH. The borrow site proposed for this project does not contain prominent shoal habitat features, wrecks and reefs, or any known hard bottom features that could be permanently lost due to the impacts from dredging. Some minor and temporary impacts would result in a loss of food source in the affected areas.

In addition to the potential impacts to benthic and fisheries resources discussed, the proposed and active Federal projects also have the potential of cumulative impacts to the Federally listed piping plover and seabeach amaranth. Due to the amount of uncertainty that exists regarding when and how any of the active and proposed projects will be built, and the uncertainty of the number and location of plover nests in any given year, it is extremely difficult to quantify the potential impacts to piping plovers for any, and all of the projects. If the majority of the ongoing and proposed construction activities are accomplished outside of the nesting season, the overall impacts to plovers will be minimal, and the birds most likely will benefit from the additional beach areas. Through the implementation of plover management plans and the monitoring program, impacts related to human activities on the new beaches will be greatly reduced and in

Figure 124 Sandy Recovery Projects, NJ and DE



some cases eliminated. The results of the Ocean City nearshore benthic sampling which was conducted in 2001 indicated that while the abundance of major taxa within the benthic

community of the lower intertidal zone was reduced 4 months after sand placement, 6 months after placement, the community appeared to be recovering to pre-placement conditions. Impacts within the upper intertidal area, where plovers directly feed, were not detected in either the 4 or 6 month sampling periods. Based on this data, it is possible that plover habitat may be negatively impacted on a temporary basis during the nesting season immediately following construction due to diminished food resources. This impact is more likely following the initial construction due to the quantity of fill and duration of the activities. The timing of the fill will also play a role in the rate of benthic recovery. Following initial fill, nourishment activities will take place only in areas with a high rate of erosion. Areas which have not eroded past the design template will not be filled. For this reason, it is even less likely that nourishment activities will affect areas with nesting plovers since it is unlikely that the birds will be nesting in areas with more narrow beaches and greater erosion. This has been the case in Ocean City where fill has not been placed south of 14th street for several cycles since this area is fairly stable.

In addition, due to the short duration of nourishment activities, and the limited quantity of sand associated with most cycles, it is anticipated that most, if not all, of these activities will take place outside of the plover nesting season. The possibility does still exist however that the fill activities may result in a reduction of prey resources available to plovers during the next nesting season. Due to the fact that, on average, only two or three of the existing or proposed locations will be impacted during any given year, however, these activities should not cause the species any undue risk or greatly impact the species as a whole. Since newly placed sand will most likely create additional habitat for the plovers and seabeach amaranth that does not currently exist, it is expected that even with these activities, more undisturbed habitat will be available to the species than currently exists. It should be noted that large portions of the New Jersey coast will still be available for use as nesting habitat on any given year.

Similar uncertainty exists when trying to quantify the potential impacts to seabeach amaranth since the species has a very patchy distribution within southern New Jersey. The protection measures being developed with USFWS, however, should ensure that impacts are avoided or minimized to the greatest extent possible and therefore construction activities should not jeopardize the species and may actually create suitable habitat for the species. The Corps will work closely on this issue with the Service in order to develop the best protection plan for the species should it become re-established.

5.2.11 Coordination

Pubic coordination for the proposed project took place through the circulation of the Draft Feasibility Study and Environmental Assessment that was released on 20 December 2013 and closed for review on 10 March 2014. Coordination with various resource agencies has been ongoing throughout the Feasibility phase and has included correspondence, meetings and field visits. Multiple meetings were held in Wildwood Crest, Wildwood and Lower Township with the respective mayors, their engineering firms and council representatives to explain the project and answer questions or comments. The NJDEP coordinated a Public Hearing on 21 February 2014.

This EA was circulated to Federal, State, and local resource agencies with particular jurisdiction and interest over the affected resources and applicable statutes. In addition, the public was

notified of the availability of this document for public review via a public notice, which was distributed to interested individuals, organization, and media outlets listed on the Philadelphia District's coastal New Jersey mailing list. Comment letters received from the various agencies and the general public during the review period can be found in Appendix G.

5.2.12 Compliance with Environmental Statutes

Compliance with applicable Federal Statutes, Executive Orders, and Executive Memoranda is summarized in which shows a complete listing of compliance status relative to environmental quality protection statutes and other environmental review requirements.

A Section 404(b)(1) evaluation in compliance with Section 404 of the Clean Water Act was prepared and is provided in **Section 10.0** of this document. A Section 401 Water Quality Certification was received from NJDEP on 7 March 2014 and can be found in Appendix G.

The proposed sand back-passing and maintenance activities comply with, and will be conducted in a manner consistent with New Jersey's requirements with regard to the Coastal Zone Management Act. A Federal Consistency Determination was obtained from NJDEP can be found in Appendix G.

The use of the sand borrow source described in this document is not expected to have significant air quality impacts. A Clean Air Act Statement of Conformity has been prepared and is presented in **Section 9.0** of this document. The Conformity Determinations prepared for this project can be found in **Appendix B**. The proposed action is expected to comply with Section 176(c)(1) of the Clean Air Act amendments of 1990.

Table 84 Compliance with Environmental Statutes

COMPLIANCE WITH ENVIRONMENTAL QUALITY PROTECTION STATUTES AND OTHER ENVIRONMENTAL REVIEW REQUIREMENTS	
FEDERAL STATUTES	**COMPLIANCE W/PROPOSED PLAN**
Archeological - Resources Protection Act of 1979, as amended	Full
Clean Air Act, as amended	Full
Clean Water Act of 1977	Full
Coastal Barrier Resources Act	N/A
Coastal Zone Management Act of 1972, as amended	Full
Endangered Species Act of 1973, as amended	Full
Estuary Protection Act	N/A
Federal Water Project Recreation Act, as amended	N/A
Fish and Wildlife Coordination Act	Full
Land and Water Conservation Fund Act, as amended	N/A
Marine Protection, Research and Sanctuaries Act	Full
Magnuson-Stevens Fishery Conservation and Management Act	Full
National Historic Preservation Act of 1966, as amended	Full
National Environmental Policy Act, as amended	Full
Rivers and Harbors Act	Full
Watershed Protection and Flood Prevention Act	N/A
Wild and Scenic River Act	N/A
Executive Orders, Memorandums, etc.	
EO 11988, Floodplain Management	Full
EO 11990, Protection of Wetlands	Full
EO12114, Environmental Effects of Major Federal Actions	Full
EO 12989, Environmental Justice in Minority Populations and Low-Income Populations	Full
County Land Use Plan	Full

Full Compliance - Requirements of the statute, EO, or other environmental requirements are met for the current stage of review.
Ongoing Compliance - Some requirements and permits of the statute, E.O., or other policy and related regulations remain to be met.
Noncompliance - None of the requirements of the statute, E.O., or other policy and related regulations have been met.
N/A - Statute, E.O. or other policy and related regulations are not applicable.

5.3 Project Cost Estimate

All costs required to implement the selected plan were calculated by a cost engineer. Project costs were initially calculated at a June 2007 price level. The final cost analysis was updated to a March 2014 price level.

5.3.1 Cost Contingencies

The estimated cost for each major element or feature of the selected plan includes an item for "contingencies." Contingencies are allowances against some adverse or unanticipated condition not susceptible to exact evaluation from the data at hand, but which must be represented in the project cost estimate. Contingency allowances used in the development of the cost estimate were estimated as percentages. Twenty five percent was applied to beach placement work to account for potential variations in pumping distances and borrow area selection, and to account for potentially larger required beach fill quantities at the time of construction due to future preconstruction erosion. Twenty five percent was applied to mobilization, demobilization, and preparatory work to account for availability of dredges and variances in travel distance for the dredge plant. Twenty percent was applied to dune grass, sand fence, dune crossover, and vehicle crossover quantities to account for variances in the beach profile at the location of the dune due to possible preconstruction shifting and/or eroding beach conditions

5.3.2 Initial Construction Costs

The estimated initial construction cost for the selected plan is $21,605,000 (March 2014 price level) which includes real estate acquisition costs (including administration costs); planning, engineering, and design (P,E,&D), construction management (S&A), and associated contingencies. A summary of initial construction costs is presented in **Table 85.**

Table 85 Initial Construction Cost Summary

Total First Cost - Selected Plan							Price Level: Mar 14
Plan C (75' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)							Construction duration: 9-months
ACCOUNT	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED	CONTINGENCY	TOTAL COST
						@ 25.0%	
01.	Lands and Damages	1	Job	LS	$1,018,972	$254,539	$1,273,511
17.	Beach Replenishment					@ 25.1%	
17.01	Mobilization, Demob. And Preparatory Work	1	Job	LS	$1,026,656	$257,691	$1,284,346
17.70	Beach Fill	1	Job	LS	$9,883,656	$2,480,798	$12,364,454
17.99	Associated General Items	1	Job	LS	$2,763,564	$693,655	$3,457,219
	Total Beach Replenishment				$13,673,876	$3,432,143	$17,106,019
						@ 15.0%	
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,617,299	$242,595	$1,859,894
31.	Construction Management (S & A)	1	Job	LS	$1,187,843	$178,177	$1,366,020
	Total Project First Cost				$17,497,990	$4,107,453	$21,605,444
	Rounded				$17,498,000	$4,107,000	$21,605,000

5.3.2.1 Real Estate

The project will be constructed on existing beachfront lands that include private, commercial, and public ownerships. The project will impact 91 privately owned parcels within the project area, 10 within North Wildwood, 49 within Wildwood, 27 within Wildwood Crest and 5 within Lower Township. Detailed ownership data is provided in The Real Estate Appendix (Appendix F) of this report. The construction area excludes any existing structures.

Submerged lands below the Mean High Water Line (MHWL) of the Atlantic Ocean are owned by the State of New Jersey and managed by the New Jersey Department of Environmental Protection Bureau of Tidelands Management, except lands below MHWL where riparian grants exist.

Prior to construction of the project, the non-Federal Sponsor will acquire a non-standard Perpetual Beach Storm Damage Reduction Easement along the length of the project, including all privately owned parcels. A standard Temporary Work Area Easement with a duration of 2

years will be required for staging during construction. No facility or utility relocations are required. Real estate costs were estimated at $1,273,987 for project construction.

5.3.2.2 Public Access

Engineering Regulation 1165-2-130, Federal Participation in Shore Protection Projects, requires that reasonable public access be provided in accordance with the recreational use objectives of the particular area and public use is "*construed to be effectively limited to within one-quarter mile from available points of public access to any particular shore.*" No two public access points can be further than 1/2 mile (.5) apart, and no visitor can be further than 1/4 (.25) mile from an individual access point.

Public access within Hereford Inlet to Cape May Inlet is provided at each street end along the beach front in North Wildwood, Wildwood, Wildwood Crest and Lower Township. These public access points are within the Federal Access requirement in ER 1165-2-130. Access points and the average distance between each point are outlined below for each municipality (**Table 86**) and in the Public Access section of Volume 3 of this report.

Table 86 Public Access by Municipality

Access Points	North Wildwood	Wildwood	Wildwood Crest	Lower Township
Distance (feet)	6,600	7,705	9,768	1,689
Number of Access Points	25	24	41	4
Average Distance Between Access Points (miles)	0.05	0.06	0.05	0.08

The regulation described above also discusses parking requirements and states that parking on free or reasonable terms should be available within a reasonable walking distance of the beach. The study area contains approximately 7,000 parking spaces within ¼ mile of the access points identified above with street parking, metered parking, or public parking lots based on aerial photography interpretation and estimating. An estimate of the location of these areas by municipality and by street can be seen in the Public Access Plan of Volume 3 of this report. The area is also served by public transportation with NJ Transit providing regional access to tbe Wildwood Bus Terminal between Davis and Burk Avenue in Wildwood, and local access via bus stops located along New Jersey Avenue in North Wildwood and Wildwood.

Based on this analysis the study area from Hereford Inlet to Cape May Inlet meets the access and parking requirement outlined in ER 1165-2-130 since it contains access points less than ½ mile apart and reasonable parking and public transportation.

5.3.3 Periodic Nourishment and Major Replacement Costs

The selected plan includes periodic nourishment at 4-yr intervals subsequent to the completion of initial construction (year 0) of the project. Major replacement is included in the design to replace project losses in response to a major storm event. For cost calculation purposes, major

replacement is assumed to occur in year 24 together with periodic nourishment.
Table 87 - Table 89.

Table 87 Periodic Nourishment Costs Years 4 and 8

Periodic Nourishment Cost (Years 4 and 8)							Price Level: Mar 14
Plan C (75' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)							Construction duration: 4-months
ACCOUNT	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT	ESTIMATED	CONTINGENCY	TOTAL COST
17.	Beach Replenishment					@ 25.1%	
17.01	Mobilization, Demob. And Preparatory Work	1	Job	LS	$895,921	$224,876	$1,120,797
17.70	Beach Fill	1	Job	LS	$2,904,614	$729,058	$3,633,672
17.99	Associated General Items	1	Job	LS	$257,874	$64,726	$322,600
	Total Beach Replenishment				$4,058,408	$1,018,661	$5,077,069
						@ 15%	
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$221,632	$33,245	$254,877
31.	Construction Management (S & A)	1	Job	LS	$539,552	$80,933	$620,485
	Total Project First Cost				$4,819,593	$1,132,838	$5,952,431
	Rounded				$4,820,000	$1,133,000	$5,952,000

Table 88 Periodic Nourishment Costs remaining 8-50

Periodic Nourishment Cost (Years 12, 16, 20, 28, 32, 36, 40, 44 and 48)							Price Level: Mar 14
Plan C (75' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)							Construction duration: 4-months
ACCOUNT	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT	ESTIMATED	CONTINGENCY	TOTAL COST
17.	Beach Replenishment					@ 31%	
17.01	Mobilization, Demob. And Preparatory Work	1	Job	LS	$895,921	$277,735	$1,173,656
17.70	Beach Fill	1	Job	LS	$2,904,614	$900,430	$3,805,045
17.99	Associated General Items	1	Job	LS	$257,874	$79,941	$337,814
	Total Beach Replenishment				$4,058,408	$1,258,107	$5,316,515
						@ 15%	
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$221,632	$33,245	$254,877
31.	Construction Management (S & A)	1	Job	LS	$539,552	$80,933	$620,485
	Total Project First Cost				$4,819,593	$1,372,284	$6,191,877
	Rounded				$4,820,000	$1,372,000	$6,192,000

Table 89 Major Rehabilitation Costs

Major Replacement Cost (Yr. 24)							Price Level: Mar 14
Plan C (75' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)							Construction duration: 5-months
ACCOUNT	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT	ESTIMATED	CONTINGENCY	TOTAL COST
17.	Beach Replenishment					@ 31%	
17.01	Mobilization, Demob. And Preparatory Work	1	Job	LS	$935,261	$289,931	$1,225,192
17.70	Beach Fill	1	Job	LS	$3,961,931	$1,228,199	$5,190,130
17.99	Associated General Items	1	Job	LS	$332,175	$102,974	$435,149
	Total Beach Replenishment				$5,229,368	$1,621,104	$6,850,472
						@ 15%	
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$264,697	$39,705	$304,402
31.	Construction Management (S & A)	1	Job	LS	$665,719	$99,858	$765,577
	Total Project First Cost				$6,159,784	$1,760,666	$7,920,450
	Rounded				$6,160,000	$1,761,000	$7,920,000

5.3.4 Construction Management (S&A)

Costs for construction management include supervision and administration activities in overseeing project construction efforts.

5.3.5 Planning Engineering and Design

Planning Engineering & Design (PED) costs include; preparation of plans and specifications, development and execution of the Project Cooperation Agreement (PCA), value engineering, engineering and design during construction, and project monitoring.

5.3.6 Project Monitoring

A beach fill project has a specific longevity and must undergo periodic inspection, maintenance and nourishment in order to preserve and project functionality over the design life. The project monitoring plan will document beach fill performance and evaluate conditions within the borrow areas over the period of analysis. Periodic assessments and monitoring data analysis will assist in producing recommendations for modifications to the quantities, location and cycle of future fills based on actual trends of fill behavior. The program was developed in accordance with EM-1110-2-1004, ER-1110-2-1407, CETN-II-26 and the draft CETN-II-35. The following items are to be included in the project monitoring plan: beach profile surveys, surveys of borrow areas, sediment sampling of the beach and borrow areas, aerial photography, and tidal data collection. The field data will be regularly analyzed to support engineering and design of ongoing nourishment. The proposed monitoring program will begin with initial construction and continue throughout the period of analysis. The monitoring program includes environmental and physical monitoring.

5.3.6.1 Project Performance Monitoring

Beach fill project will be monitored to support project engineering and design activities. Beach profile data will be collected to determine long shore erosion rates, define renourishment quantities, and indentify cross shore and long shore transport patterns in the project area. Approximately 30 lines will be surveyed and monitored for the project monitoring phase.

Beach Profiles

Beach profiles will be monitored to support project engineering and design activities. Beach profile data will be used to quantify sand losses from the project, define periodic nourishment quantities, and identify cross-shore and long shore transport patterns of the beach fill. Approximately 37 profile lines along the project reach will be surveyed annually.

Inlet Hydrographic Surveys

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

Borrow Site Surveys

Borrow site surveys of the Wildwood and Wildwood Crest beaches will be performed before and after initial construction and nourishment and annually in between nourishment years. Data will be used to monitor borrow area changes, evaluate infilling rates, and quantify availability of borrow material for future nourishment activities.

Aerial Photography

Routine flights along study area are already conducted by the State of New Jersey and other agencies. Aerials collected for these other efforts will be utilized to analyze the performance of the project.

Tide Data

Tide and storm water level information is available from existing tide gages at Cape May and Atlantic City. Tide and water level data from these sources will provide a record of background and storm conditions controlling project response

Sediment Sampling

Beach sediment samples will be collected before and after initial construction and each nourishment to identify existing and fill sand sizes, determine sorting characteristics, and evaluate overfill factor design procedures.

5.3.6.2 Environmental Monitoring

To insure compliance with Section 7 of the Endangered Species Act, the U.S. Fish and Wildlife Service (USFWS) and the conditions of the 2005 Programmatic BO, Tier 2 consultation be initiated at least 135 days prior to construction. If construction activities are to take place during the nesting and brooding season of the Federally listed (threatened) piping plover (*Charadrius melodus*), the USFWS recommends that a survey be conducted to determine whether piping plovers are actively nesting in the project area. As part of the survey, any previous nesting locations will be identified. This would provide the basis for delineation (e.g., fencing and signing) of protective zones around identified piping plover nests. This survey may also include identification and location of State listed (endangered) species such as the least tern (*Sterna antillarum*) and black skimmer (*Rynchops niger*).

As recommended by the USFWS, a survey will be performed to identify and locate the Federally listed (threatened) plant, seabeach amaranth (*Amaranthus pumilus*) within the project area prior to initial construction and subsequent nourishment cycles.

Endangered Species Survey

To insure compliance with Section 7 of the Endangered Species Act, the U.S. Fish and Wildlife Service (USFWS) recommends that consultation be reinitiated at least 135 days prior to construction. If construction activities are to take place during the nesting and brooding season of the Federally listed (threatened) piping plover (*Charadrius melodus*), the USFWS recommends that a survey be conducted to determine whether piping plovers are actively nesting in the project area. As part of the survey, any previous nesting locations will be identified. This would provide the basis for delineation (e.g., fencing and signing) of protective zones around identified piping plover nests. This survey may also include identification and location of State listed (endangered) species such as the least tern (*Sterna antillarum*) and black skimmer (*Rynchops niger*).

As recommended by the USFWS, a survey will be performed to identify and locate the Federally listed (threatened) plant, seabeach amaranth (*Amaranthus pumilus*) within the project area prior to initial construction and subsequent nourishment cycles.

Sea Turtle/Marine Mammal Monitoring

Monitoring for Federally protected sea turtles and marine mammals will not be necessary for this project due to the location of the borrow area in the intertidal zone.

Piping Plover Monitoring

If construction takes place during the nesting season of the piping plover, monitoring will be conducted in conjunction with NJDEP Division of Fish and Wildlife to determine the presence and locations of nests. Based on this monitoring, appropriate measures in accordance with findings of the 2005 USFWS Biological Opinion will be taken to ensure that adequate protection is provided. This monitoring will continue throughout the duration of construction during the nesting season as well as nesting seasons after initial construction and subsequent nourishment

activities. Tier 2 consultation with the USFWS will be reinitiated at least 135 days prior to any periodic nourishment in order to update project details.

Seabeach Amaranth Monitoring

A survey for seabeach amaranth will be conducted prior to initial construction and each periodic renourishment. If seabeach amaranth populations are located within the project area prior to construction, monitoring shall be conducted to ensure that these plants are not adversely impacted during project construction. This monitoring will be conducted in accordance with findings of the 2005 Biological Opinion. Tier 2 consultation with the USFWS will be reinitiated at least 135 days prior to any periodic nourishment in order to update project details.

Cultural Resources Monitoring

The District will periodically monitor sand placement activities during project construction to identify subsurface fill materials that could indicate the presence of buried prehistoric land surfaces within sand borrow areas. Any significant cultural resources that exist within the near shore project area will be monitored to determine impacts from sand movement offshore from the construction template. Monitoring results will be coordinated with NJSHPO and NJDEP, and adaptive management will be completed as necessary.

5.3.6.3 Total Monitoring Costs

Monitoring costs for the entire length of the period of analysis was estimated to be $6,874,500. This includes initial construction, periodic nourishment and major replacement monitoring. Total average annual costs for all monitoring are estimated at $140,000 over the 50-year period of Federal participation .

5.3.7 Operation, Maintenance, Repair, Replacement and Rehabilitation (OMRR&R)

Routine operation and maintenance of the project is the responsibility of the non-Federal Sponsor and includes maintenance of dunes (including sand fence and dune grass), pedestrian and vehicle accesses, and beach shaping. Beach shaping will be performed by heavy equipment to maintain the design template. Based on experience with similar projects, the average annual maintenance costs were estimated at $150,000.

5.3.8 Constrnction and Fnnding Schednle

The duration of initial construction was estimated at 8 months, including mobilization and demobilization. Construction duration for periodic nourishment was estimated at 4 months per cycle. Major replacement was estimated to take 5 months.

5.3.9 Interest During Construction

Interest During Construction (IDC) was computed in accordance with Engineering Regulation 1105-2-100. Construction costs were assumed to be evenly distributed over the construction period. Planning, Engineering & Design (PED) and real estate acquisition costs were included in the calculations (March 2014 P.L.) .

Table 90 Total Estimated Costs

Total Estimated Costs	
Discount Rate	3.50%
Period of Economic Analysis	50 years
Price Level	Mar-14
Base Year	2016
Initial Construction Cost (including R.E.)	$21,605,000
Interest During Construction	$349,000
Total Periodic Nourishment	$82,428,000.00
Average Annual Costs (AAC)	
Initial Construction (without IDC)	$921,000
Periodic Nourishment	$1,462,000
Interest During Construction (IDC)	$15,000
Subtotal Average Annual Costs	$2,398,000
Monitoring Costs	$140,000
Operations and Maintenance (OMRR&R)	$150,000
Total Average Annual Cost	**$2,688,000**

5.4 Project Benefits

Total project benefits include storm damage reduction benefits, local costs foregone and recreation benefits. All benefits are the March 2014 price level. The project was economically justified on hurricane and storm damage reduction benefits but also included benefits such as recreation and Local Costs Forgone. Interior flood damage reduction was not included in the benefits calculation since interior drainage is a non-Federal responsibility.

5.4.1 National Economic Development Benefits

The selected plan was optimized based on storm damage reduction benefits to structures. Total NED benefits include storm damage reduction benefits to structures, improved property and infrastructure. Average Annual NED benefits are at a discount rate of 3.5% March 2014 P.L, for the base year of 2016 for the fifty year length of the project

5.4.2 Local Costs Forgone

The Local Costs Forgone benefits described in the following paragraphs are expected to be realized with implementation of any proposed project. Benefits of coastal storm management

projects include reductions in non-physical damages as well as reductions in physical damages to homes, commercial buildings, public property and critical infrastructure. The Coastal Storm Risk Management National Economic Development (NED) Manual includes reduced costs for public protective measures or Local Costs Forgone, as it is referred to in this document, as a benefit category. This benefit captures future costs that would be expended by the state and local municipalities to protect coastal property in the absence of a plan of protection.

The beaches of *The Wildwoods* have been historically protected and maintained through state and local government-sponsored beach fill projects in North Wildwood to allay erosion, daily outfall maintenance to remove sand and place barriers around water that ponds at clogged outfalls, and construction projects in Wildwood and Wildwood Crest to extend outfall pipes beyond the accreted shoreline. In 2009, the State of New Jersey constructed a beach fill project of over one million cubic yards of sand at the northern section of *The Wildwoods* to control erosion with subsequent emergency sand placements after other storm events. The future without project condition was based on the expectation that the state would continue to partner and provide protection to the communities. The implementation of a federal project will preclude this action and provide a savings from public protective measures to the State of New Jersey and the local municipalities.

Savings to the State of New Jersey and local communities could potentially be, depending upon the source of material, an estimated average annual $1,140,000 as a result of the beach fill and nourishment components of a proposed plan and $75,000 and $148,000 in Wildwood and Wildwood Crest from reduced outfall maintenance. Acquisition of sand from Hereford Inlet (dredging option) would eliminate realization of Local Costs Forgone benefits to Wildwood or Wildwood Crest. Local Costs Forgone were included in the average annual benefits for the backpass measures since the protective dune and berm will be constructed with the accreted beach material from Wildwood and Wildwood Crest. The estimated average annual benefits include storm damage reduced and Local Costs Forgone or reduced maintenance costs from a 16' dune and 75' berm with excess sand conveyed from Wildwood and Wildwood Crest to an engineered 16' dune to supplement oceanfront protection in North Wildwood, Wildwood, Wildwood Crest, and Lower Township. The estimated costs include initial construction, periodic nourishment, and interest during construction.

5.4.3 Incidental Benefits

Incidental benefits are benefits that are not directly attributable to storm damage reduction in the initial economic analysis. They include Recreation Benefits, the benefits that beachgoers enjoy as a result of an improved beach experience and Benefits During Construction which consist of benefits from partially constructed portions of the beach prior to completing the initial construction. These benefits are summarized below.

5.4.3.1 Recreation Benefits

Beaches are consistently the number one travel destination in New Jersey. Tourist dollars contribute directly and indirectly to the regional economy. In 2008, the New Jersey Division of

Travel and Tourism reported that travel and tourism generated 359,000 jobs in the state with a total payroll of $11.8 billion.

The Rutgers State University completed in 1994, for previous New Jersey coastal studies, a contingent valuation method survey for the New Jersey Department of Environmental Protection and Energy and the U.S. Army Corps of Engineers (Corps) to determine willingness to pay for the existing beach and an enhanced beach. This was done on a regional basis, encompassing the major beach communities of the New Jersey Atlantic coast such as the communities of Absecon Island, Seven Mile Island, Brigantine, as well as Stone Harbor and Avalon which is just north of *The Wildwoods*. The survey was designed in accordance with the NED Procedures Manual – Recreation II (A Guide for Using the Contingent Value Methodology in Recreation Studies). The original report is included as an attachment to this appendix. The survey consisted of 1,063 interviews of a random sample of recreational beach users. The interviews were conducted in person on the beach. The survey scope was intended for use with all South Jersey shore feasibility studies. *The Wildwoods* is also close, both qualitatively and geographically, to Stone Harbor therefore, it is reasonable that survey results can be representative of the conditions on the island.

Beachgoers were asked to indicate how important different factors were in deciding whether to visit a New Jersey beach. Respondents voiced similar desires. The primary factors of consideration were the quality of the beach scenery, the maintenance of the beach, the width of the beach, the number of lifeguards, and the family-friendliness of the beach.

The survey also used a density measure developed in cooperation with the Corps to determine if crowding was a problem. It was found that over 60% of the time there was at least several yards of space between beach towels or blankets, and only 7% of the time was it very crowded (only 2' between towels). Further it was determined that crowding was not considered a very important issue to the majority of beachgoers by asking respondents how important being alone is and how important is it to be with a large number of people. As might be expected, areas with more crowding tended to be frequented by people who like large numbers. People who like to be alone frequented areas that tended to have little crowding

To estimate the value of the beach, as it exists currently, an iterative bidding process was applied. Beachgoers were first asked if a day at the beach would be worth $4.00 to each member of their household. Based on their answers, they were then asked progressively higher or lower amounts until the amount they value the beach was determined. It was determined that the average value of a day at the beach is $4.22.

Beachgoers were asked how much more they were willing to pay if the beach were widened. While the majority was unwilling to pay any extra, approximately 16% of Stone Harbor beachgoers were willing to pay, on average, $2.47 more per visit. This would be equivalent to an average of $0.39 for all beachgoers. This willingness to pay value for Stone Harbor was adopted because it is the nearest beach to North Wildwood. This value was indexed to a June 2007 price level for the purposes of this study. Since access to the beaches of *the Wildwoods* is free, the number of visitor days was obtained from City of North Wildwood estimates and by comparing beach size within the project area of North Wildwood with that of Stone Harbor. The total number of visitor days for the beach within the project area is estimated at 1,000,000

Benefits were not found to accrue from increased capacity because crowding was found not to be a significant factor and the selected plan involves conveying accreted sand from Wildwood and Wildwood Crest. Removal of sand from the down drift areas is not expected to negatively affect the recreation experience because the beaches are extremely wide and require beachgoers to walk quite some distance to reach the water's edge. Benefits do arise from an increase in the value of the recreational experience in North Wildwood. Recent recreation proposals in the downdrift beaches cannot be impacted with the implementation of our selected plan and efforts are being made to determine how storm damage reduction and recreation can co-exist in this portion of the project area.

Benefits resulting from this increase in recreational experience were calculated by multiplying the average daily value per beachgoer by the number of visitor days within the project area. This gives total recreational benefits of $693,000.

5.4.3.2 Benefits Dnring Construction

The proposed project will be constructed over nine months with an additional month before and after construction for mobilization and demobilization. Portions of the beach will be fully nourished before the project is completed in its entirety. The portions of the beach nourished early in the construction phase will provide storm damage reduction benefits. The summary shows the monthly benefits during construction (BDC) and the resulting estimated average annual benefit of $102,000.

5.4.4 Benefit-Cost Summary

BENEFITS AND COSTS FOR THE SELECTED PLAN

DISCOUNT RATE (FY14)	3.50%
PERIOD OF ANALYSIS	50 YEARS
PRICE LEVEL	March 2014
BASE YEAR	2016

AVERAGE ANNUAL BENEFITS:

Storm Damage Reduction	$4,095,000
Local Costs Forgone (1)	1,363,000
Recreation	693,000
Benefits During Construction	102,000

TOTAL NED BENEFITS $6,253,000

TOTAL COSTS:

Initial Construction Costs (2)	$21,605,000
Interest During Construction	349,000
Periodic Nourishment (cycles 1, 2)	5,952,000
Periodic Nourishment (other cycles)	6,192,000
Major Rehabilitation (3) (year 24)	7,920,000
Average Annual Construction Costs	$2,398,000
Average Annual Monitoring Costs	140,000
Average Annual OMRR&R Costs	150,000

TOTAL AVERAGE ANNUAL COSTS	**$2,688,000**
NET BENEFITS	**$ 3,565,000**
BENEFIT-COST RATIO	**2.3**
BENEFIT-COST RATIO (computed at 7%)	**1.9**
RESIDUAL DAMAGES	**$ 5,818,000**

(1) Local Costs Foregone include updated March 14 P.L. costs from Table B-38 in the Economics Appendix for North Wildwood ($1,140,000), Wildwood ($75,000), Wildwood Crest ($148,000) for a total of $1,363,000.
(2) Initial constrcution includes Real Estate costs
(3) Periodic Nourishment totals $82,248,000

5.5 Risk and Uncertainty Associated with Coastal Projects

Engineering Regulation 1105-2-101, dated January 2006, states "all flood damage reduction studies must address risk and uncertainty." This is due to the fact that natural systems are complex and measured variables, are to some degree, inaccurate. These inaccuracies could have impacts on project outputs including the BCR and NED benefits. Risk analysis incorporates these uncertainties so the engineering and economic performance of a project can be expressed in terms of a probability distribution instead of a traditional "point value" or single value for AAD, AAB, NED benefits and BCR.

5.5.1 Risk and Uncertainty Coordination

This Risk and Uncertainty (R&U) plan was the result of the coordination after the 23 July 2009 Feasibility Scoping Meeting held at the Philadelphia District. This meeting was attended by the Office of Water Policy and Review (OWPR), North Atlantic Division, the NJDEP (Sponsor) and the District Vertical team. At that meeting the attendees came to the conclusion that a plan that should incorporate risk and uncertainty to comply with regulations contained in ER 1105-2-101. This plan was documented in the July 23 District Memorandum For Record (MFR) of the meeting, and later confirmed in correspondence from OWPR attendees in a 3 June 2011 letter to the District. "*HQ, the MSC and District have concurred on the outcome of the FSM and understand the following actions will be required prior commencement of the Alternative Formulation Briefing: a. Certification for one-time use of the SBEACH-COSTDAM methodology for the storm, damage and damage reduction benefits analysis., b. Update the Peer Review Plan to include IEPR., c. Initiation of IEPR process.*" This new Risk and Uncertainty plan and SBEACH-COSTDAM certification was developed by the District Project Development Team, and forwarded to NAD on 17 June 2010. On 17 November 2011 NAD replied "*Pending ATR [Agency Technical Review] team concurrence, the District can complete the updated analysis, to include risk and uncertainty and economic risk considerations. The analysis and results would undergo ATR and the Planning Center of Expertise - Coastal and Storm Damage Reduction will determine if an "approved for one time use" model request to HQUSACE, Office of Water Project Review is warranted and will submit the required materials, as appropriate.*" The District began working on the R&U analysis, and forwarded their results to Jacksonville District for their ATR. The R&U analysis was forwarded to the review team in Jacksonville, and the proposal was modified to incorporate their suggestions, the ATR team then approved the R&U approach and results in a two memoranda dated 2 February 2011 and 7 December 2011. The ATR team found that "*the proposed analysis, if added to the current storm damage reduction model process employing COSTDAM, may be reasonable enough to incorporate the variability associated with economic and hydraulic systems in order to meet the requirement identified at the Feasibility Scoping Meeting of enhancing the existing effort in order to address risk and uncertainty.*" Upon review of the model results the ATR recommendation was a one-time-approval-for-use in accordance with the process established by the Coastal Planning Center of Expertise (PCX) in a letter to the District and North Atlantic Division. Headquarters Planning and Policy Division (CECW-P) approved the model review plan in a memo dated 13 April 2012 stating "*The Hereford Inlet to Cape May Inlet, New Jersey model review plan is approved*" and "*This model will be applicable for use on the Hereford Inlet to Cape May Inlet, New Jersey Feasibility Study*". The Pertinent Correspondence Section of the Appendices, Volume 3, Appendix G, also contains the May 2014 approval for the use of the proposed model and

previous approval memos.

5.5.2 Risk Analysis

The Hereford to Cape May Risk and Uncertainty Analysis explicitly incorporates variations in key H&H (Hydrology and Hydraulics) and economic inputs in order to develop a range of damage levels and determine the impacts these variables play in project outputs.

Outputs from the risk analysis will include a range of Average Annual Damages (AAD), Average Annual Benefits (AAB), Net Benefits and Benefit Cost Ratios (BCR) that will better represent the potential damages and benefits that the project may encounter rather than single AAD, AAB, and BCR values based upon fixed assumptions about the study area.

5.5.3 Risk and Uncertainty Methodology

Sources of risk and uncertainty arise from the underlying variability of complex natural, social, hydraulic, structural and economic systems. The role of a risk analysis is to characterize the extent of these variations so their impact on model outputs can be understood. Outputs include a range of reasonably likely damage and benefit levels rather than a single point estimate. This can be accomplished through a type of risk analysis, the technique of varying assumptions as to alternative factors and examining the effects of these assumptions on the outcomes of benefits and costs (ER 1105-2-100).

By definition, risk is the probability an area will be impacted by undesirable consequences, and uncertainty is the degree of imprecision of measured parameters used to describe the hydraulic, hydrologic and economic aspects of a project plan. Consequently, a R&U analysis determines the level of risk and uncertainty a project can potentially be exposed to throughout its lifetime. The role of this analysis is to quantify the extent of those variations in order to understand their impact on model outputs.

The Hereford to Cape May Risk and Uncertainty Analysis will explicitly incorporate variations in key H&H (Hydrology and Hydraulics) and economic inputs in order to develop a range of damage levels and determine the impacts these variables play in project outputs. H&H inputs to the risk and uncertainty analysis will include variations in eroded dune location, 0.5 foot vertical erosion location, wave impact zone location, eroded dune elevation, maximum water elevation, water run–up elevation and bulkhead performance. Economic inputs to the risk and uncertainty analysis will include variations in the Federal discount rate, depreciated replacement cost value, and content-to-structure percentage. Outputs from the risk analysis will include a range of Average Annual Damages (AAD), Average Annual Benefits (AAB), Net Benefits and Benefit Cost Ratios (BCR) that will better represent the potential damages and benefits that the project may encounter rather than single AAD, AAB, and BCR values based upon fixed assumptions about the study area.

5.5.4 H&H Risk and Uncertainty methodology

The approach to address risk and uncertainty was to quantify a statistical bound representing a +/- 90% confidence interval associated with the storm erosion, wave attack, and inundation

analysis from the SBEACH model runs done for the without project conditions and for the selected plan. Previous outputs from SBEACH for the without project conditions and selected plan were used to develop these bounds. The upper limit of the +90% confidence interval bound represented a "high" risk alternative and the lower limit of the -90% confidence interval bound represented a "low" risk alternative. Previously computed erosion, wave attack, and inundation estimates served as mean conditions for each storm frequency event .

SBEACH generates six "response" parameters for each input beach profile at each frequency event (5- 10-, 20-, 50-, 100-, 200-, and 500-year). These response parameters are:

1. Eroded Dune Location
2. 0.5 foot Erosion Location
3. Wave Impact Zone Location
4. Eroded Dune Elevation
5. Maximum Water Elevation
6. Runup Elevation

These six response parameters are used to generate the three damage mechanisms used by the economics model (COSTDAM) to calculate Average Annual Damages (AAD), Average Annual Costs (AAC), Net Benefits, and the subsequent Benefit Cost Ratios (BCR). The 3 damage mechanisms are:

1. Storm Erosion
2. Storm Wave Attack
3. Storm Inundation (flooding)

Since there is a degree of uncertainty associated with these parameters, the computer program EST (Empirical Simulation Technique) was used to develop the "high" risk and "low" risk statistical bound for each of the response parameters. EST can utilize multiple computed parameters associated with site-specific historical events as a basis for developing a methodology for generating multiple simulations of storm activity and the effects associated with each simulated event. The six response parameters are not independent, but are interrelated to each other in some nonlinear sense. Events follow a Poisson distribution in the EST portion of the modeling.

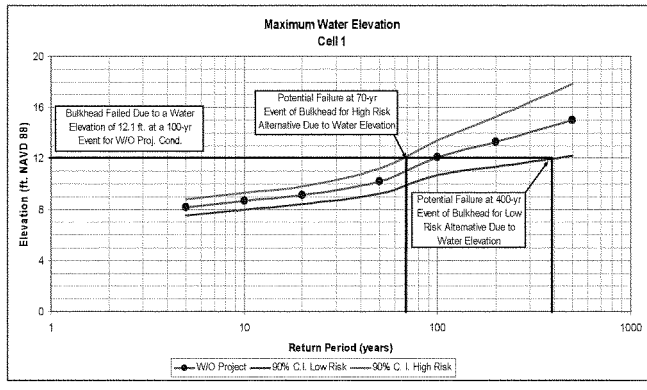
The peak water elevation for each frequency event (5, 10, 20, 50, 100, 200, and 500 year) used in the previous SBEACH simulations along with the corresponding peak wave height and wave period were used as the input variables in the EST analysis. A graph showing the +/-90% confidence interval bands for each output parameter were developed in EST for each frequency within each cell for the "without project" analysis and "selected plan". A "low" and "high" value was picked off the confidence interval curves at each frequency. The "low" values represented a low risk alternative as compared to the mean and the "high" values represented a high risk alternative as compared to the mean.

The H&H risk and uncertainty analysis produced six EST +/- 90% confidence interval curves for the key parameters used to calculate erosion, inundation and wave damages for COSTDAM

inputs. The 90% confidence interval was selected because the magnitude and range of the distribution defined by a 95% and 99% confidence interval was determined to be too large when compared to the 90% confidence interval. An example of the water level curve for the storm events modeled in SBEACH is presented in **Figure 125**. The EST program generated the "high" risk (red line) and a "low" risk (blue line) scenario based on the +/- 90% confidence interval. New control files for the COSTDAM economic model were generated based on the results of these six curves. EST uses a Poisson distribution for the life cycle events to determine the average number of expected events in a given year and it calculated a standard deviation and mean for each of the six response variables.

In order to incorporate uncertainty into the analysis, the failure criteria of the existing shore protection structures were also varied. The original failure criterion assumed that the shore protection bulkhead would fail after being overtopped by 1foot of water. By incorporating a degree of uncertainty into the 1 foot failure threshold, the bulkhead was assumed to fail at a less frequent and more frequent water elevation compared to the original analysis. The "more frequent" (red line in **Figure 125**) and "less frequent" (blue line in **Figure 125**) failure events for shore protection structures were scaled off the graph for the response parameters produced by EST.

Figure 125 Empirical Simulation Technique (EST) 90% confidence curve for water level



The new failure criteria resulted in structure failures that were respectively, less probable and more probable to fail when compared to the previous analysis. Previous without project analysis showed that the bulkhead failed at the 100-year event in North Wildwood. **Figure 125** shows potential failure events at the 70- and 400-year events when uncertainty is applied to the 1 foot failure threshold. It was assumed that by applying uncertainty, the bulkhead could fail at the 50-year event for the "high risk" scenario, and at the 200-year event for the "low risk" scenario.

These events were chosen since a 70 year event and a 400 year event were not run in the SBEACH. These two scenarios were included in low and high risk damage calculations.

The effects of Sea Level Rise (SLR) were incorporated using the guidance provided in Engineering Circular 1165-2-212. That guidance suggests accounting for a historic rate of sea level rise based on tide gauge data; a medium level of SLR; and a high level of SLR based on two National Research Council (NRC) curves. The range of values calculated using the guidance in EC 1165-2-211 was between 0.65 to 2.3' of SLR as a result of 50 years of projected rise at the Atlantic City tide gauge.

Sea-level adjustments were incorporated into the development of the ocean stage frequency which was used for the without project hydraulic analysis for the study. Water elevations from historical storms as recorded at the nearby tide station at Atlantic City, NJ were adjusted for sea level rise accordingly and served as input to the SBEACH models. SLR was incorporated into the R&U analysis by calculating shoreline recession rates for each cell due to each sea-level rise scenario (NRC-Curves I and III) by using the Bruun Rule. This result was then compared to the shoreline recession values that were previously computed for the future without project condition. The larger of the two values was adopted and used in order to adjust the without project beach profile landward. This assumed a worst-case scenario of future beach profile response to accelerated sea-level rise. Any adjusted beach profile took into account the physical limitations of the area such as bulkheads and development locations as well as potential future actions by Locals and/or the State to intervene when beach conditions degrade to a point where action to replenish the beach must be taken. The previously computed future without project erosion value were based upon a calculated long-term erosion rate which examined historical trends in shoreline movement as well as potential future intervention by Locals and/or the State when the beach erodes back to the bulkhead in Cell 1.

The elevations of the storm surge hydrograph used in SBEACH for the without project conditions were increased by an amount that corresponded to the worst-case accelerated sea-level change projection (2.3'). SBEACH was used again using the modified hydrographs and the adjusted beach profile. The values for the six response parameters SBEACH computed were compiled and plotted against the previously computed curves representing the 90% confidence interval that was done for earlier in the risk and uncertainty analysis. The curve that plotted furthest away from the mean was designated to be the "high risk" alternative. The erosion, wave impact zone, and inundation profiles that were used as input for the COSTDAM economics model were then calculated based upon these updated curves.

5.5.5 Economic Risk and Uncertainty Methodology

The economic risk and uncertainty analysis will use the new control files from EST, which will incorporate sea level rise parameter changes as model inputs for COSTDAM while performing a sensitivity analysis by varying key economic parameters that could affect AAD, AAB, Net Benefits and BCRs. Discount rate, depreciated replacement cost value, content-to-structure percentage, and the curves for stage damage will be varied for the economic portion of the analysis. The economic evaluation was performed over a 50-year period of analysis at the plan formulation discount rate and price level.

The federal discount rate is established annually and according to law is not allowed to vary by more than one quarter of one percentage point in any fiscal year. It is recognized that this parameter is likely to change. The discount rate will be varied by -¼ from the baseline rate in effect at the time of the risk and uncertainty analysis for the "low" risk scenario and by +¼ for the "high" risk scenario.

The Marshall and Swift Valuation Service was used for estimating depreciated replacement cost values from a combination of structure characteristics such as square footage, construction material, foundation type, and systems. The current depreciated replacement cost values will serve as the mean value for each structure. Typically, depreciated replacement cost values have been modified by +/- 10% in a sensitivity analysis to determine the "low" and "high" risk scenarios. This approach will be employed to examine the effects on net benefits of the 90% confidence interval bands determined in the H&H analysis. Depreciated replacement cost values will also be varied for the most likely case scenario independently from the revised H&H parameters.

The content-to-structure percentage will be established using existing percentages from previous studies on the topic. Empirical data established a content value to be approximately 40% of structure value in primary homes and 15 to 20% of structure value in vacation homes. Nearly 70% of the residential structures in North Wildwood are vacation or rental homes. A conservative weighted content-to-structure value of 25% was adopted because it was determined that use of a 40% content-to-structure ratio would overestimate damage potential in a predominately vacation coastal community. The current content-to-structure value ratio of 25% for district coastal studies will serve as the mean. A sensitivity to show the impact of varying the ratio to 10% for the "low" risk scenario and 40% under the "high" risk scenario will be performed. The content-to-structure ratio will also be varied for the most likely scenario independently from the EST low and high H&H model results.

The stage damage curves for the mean condition will be varied by a reasonable level to determine the results' sensitivity to changes in this inundation damage variable. Reasonable levels of variation were obtained by prorating the original curves by percentage of change for minimum and maximum saltwater curves empirically observed in another coastal area. The significant coastal hydraulics parameters which determine erosion and wave damage vulnerability will be addressed within the SBEACH and EST models which are incorporated in the storm damage analysis through revised control files, the engineering component of the program. These critical response parameters include, as explained above, sea level rise (SLR), eroded beach volume, shoreline retreat, wave height above dune, and other variables.

The COSTDAM model evaluates structure erosion damage based on the presence of pile or slab foundation. The land below the structure must have eroded through the footprint of the structure before total damage is claimed for structures that are identified as having piles. Prior to this, for both foundation types, the percent damage claimed is equal to the linear proportion of erosion under the structure's footprint also referred to as the percent of the footprint compromised. Variation in pile depths will not be evaluated as part of this analysis because pile depths for each building are not available and actual pile depth or a range of depths is not a model parameter and was not surveyed. Therefore, the R&U for this variable cannot be addressed within the confines

of the COSTDAM model. Also, variation in the first floor elevation surveys will not be evaluated. The level of uncertainty in the parameters of structure first floor elevation and square footage is considered low. Professional surveyors conducted the elevation survey on a structure by structure basis and the square footage was derived from a Geographic Information Systems (GIS) database.

5.5.6 Risk and Uncertainty Results

Primary outputs of the analysis include a range of Average Annual Damages (AAD), Average Annual Benefits (AAB), Net Benefits and Benefit Cost Ratios (BCR) represented by the damage level scenarios: (1) low risk scenarios; (2) the existing baseline damage level; and (3) high risk scenarios. The low risk scenarios will be based on the model inputs from the H&H analysis that incorporate the lower limit 90% confidence interval curve values for the eroded dune location, 0.5 foot erosion location, wave impact zone location, eroded dune elevation, maximum water elevation and run-up elevation from the H&H analysis, coupled with variation in four key economic input variables that include discount rate, depreciated replacement costs, content-to-structure percentage, and stage damage curves. The existing baseline damage level will be based on the previously calculated AAD, AAB, Net Benefits and BCRs. The high risk scenarios will be based on the model inputs from the H&H analysis that incorporate the values from the upper limit 90% confidence interval curve eroded dune location, 0.5 foot erosion location, wave impact zone location, eroded dune elevation, maximum water elevation and run-up elevation from the H&H analysis, coupled with variation in four key economic input variables that include discount rate, depreciated replacement costs, content-to-structure percentage, and stage damage curves. All outputs from the proposed additional risk and uncertainty analyses will be tabulated and plotted to display the potential range of values that result. They will indicate the relative level of risk and uncertainty that would be associated with implementing the selected plan (**Table 91**).

The variables from the risk and uncertainty analysis that are most likely to contribute to the variations in project outputs are the aggregated combined variations that combine low/high discount rates, low/high structure to cost value, low/high stage damage curves etc, are the combined Hydrology and Hydraulic parameters including water level, structure performance, erosion distances that were varied within the Empirical Simulation Technique (EST) Analysis. When combined, these variables have the potential to increase average annual benefits, Benefit Cost Ratios and Net Benefits from the MLS (Most Likely Scenario).

Table 91 Risk and Uncertainty Results

	MLS- Most Likely Scenario (selected plan)	Discount Rate		Structure Depreciated Replacement Cost Value		Content-to-Structure Ratio		Stage Damage Curves		EST Confidence Interval		Combined Variations	
Category	***na***	**3⅞%**	**4⅜%**	**-10%**	**10%**	**10%**	**40%**	**Min**	**Max**	**-90%**	**90%**	**Low**	**High**
Storm Damage Reduction:	*$5,042*	$5,042	$5,042	$4,539	$5,547	$4,460	$5,756	$4,547	$5,624	$1,545	$23,240	$1,040	$34,123
Benefits During Construction:	*$93*	$89	$97	$84	$102	$82	$106	$84	$104	$28	$429	$19	$629
Recreation:	*$580*	$580	$580	$580	$580	$580	$580	$580	$580	$580	$580	$580	$580
Total AAB:	*$5,715*	$5,711	$5,719	$5,203	$6,229	$5,122	$6,442	$5,211	$6,308	$2,153	$24,249	$1,639	$35,332
% Deviation from MLS	***na***	**-0.07%**	**0.07%**	**-8.96%**	**8.99%**	**-10.38%**	**12.72%**	**-8.82%**	**10.38%**	**-62.33%**	**324.30%**	**-71.32%**	**518.23%**
AAB Rank from MLS	***na***	11	10	9	7	9	5	8	6	4	2	3	1
Average Annual Costs													
Avg. Ann. Construction Costs:	*$2,178*	$2,519	$2,602	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178
Avg. Ann. Monitoring Costs:	*$119*	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119	$119
Total AAC:	*$2,297*	$2,638	$2,721	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297
Benefit Cost Ratio													
BCR	*2.5*	2.2	2.1	2.3	2.7	2.2	2.8	2.3	2.7	0.9	10.6	0.7	15.4
% Deviation from MLS	*na*	**-12.00%**	**-16.00%**	**-8.00%**	**8.00%**	**-12.00%**	**12.00%**	**-8.00%**	**8.00%**	**-64.00%**	**324.00%**	**-72.00%**	**516.00%**
BCR Rank from MLS	*na*	6	5	7	7	6	6	7	7	4	2	3	1
Net Benefits													
Net Benefits:	*$3,418*	$3,073	$2,998	$2,906	$3,932	$2,825	$4,145	$2,914	$4,011	-$144	$21,952	-$658	$33,035
% Deviation from MLS	***na***	**-10.09%**	**-12.29%**	**-14.98%**	**15.04%**	**-17.35%**	**21.27%**	**-14.75%**	**17.35%**	**-104.21%**	**542.25%**	**-119.25%**	**866.50%**
Net Benefits Rank from MLS	*na*	10	9	8	7	6	5	9	6	4	2	3	1
Combined Rank	*na*	27	24	24	21	21	16	24	19	12	6	9	3
Final rank against MLS	*na*	**11**	**10**	**9**	**8**	**7**	**5**	**6**	**5**	**4**	**2**	**3**	**1**

The variables with the greatest to least impact (+/-) on Average Annual Benefits, Benefit Cost Ratios and Net Benefits from the Most Likely Scenario (MLS) are ranked below. The ranking was based on the percentage that each variable deviated from the Most Likely Scenario (MLS). These percentages were then ranked based on the absolute value (+/-) of the deviation from the MLS for Average Annual Benefits, Benefit Cost Ratio and Net Benefits. These rankings were then totaled in the row titled Combined Rank, and then the totals from the Combined Rank were ranked from 1-11. The lower values had the highest impact on variables in the table above.

1. Combined High Variation
2. EST +90 Confidence Interval
3. Combined Low Variation
4. EST -90 Confidence Interval
5. Stage Damage Curve Max/ Content to Structure Percentage -40%(tie)
6. Stage Damage Curve Minimum
7. Content to Structure Percentage +10%
8. Structure Depreciated Replacement Costs Value +10%
9. Structure Depreciated Replacement Cost Value -10%
10. Discount Rate at 4 $^{3/8}$
11. Discount Rate at 3 $^{7/8}$

Factors that had the highest contribution to uncertainty based on variation from the most likely scenario in **Table 91** were variations in the EST confidence intervals (sea level rise, structure performance, erosion distances) fluctuations in the Stage Damage Curves and Content to Structure ratio 40%.

The variables that had the least impact on project outputs were related to Discount Rates, Structure Depreciated Replacement Cost Value and Content to Structure Percentages 10%. .

Other key variables that contribute to risk and uncertainty are first floor elevations of structures within the study area. This uncertainty was dealt with by quality control of the surveyed data by district personnel and contractors and it was not explicitly varied in the risk and uncertainty analysis.

Mitigation for variables that will contribute to the increase in project AAB, BCR and Net Benefits are difficult for shore protection projects since natural and engineered berm levels are determined by local water levels, and increasing existing berm levels to deal with future water level increases associated with sea level rise and storm stage will cause the berm to scarp and produce steep beachface cliffs. Also, increasing dune elevations to mitigate for increase water levels during storms would require the selection of an elevation above NED optimized elevations which is in violation of Corps Planning Guidance. Increasing dune heights to created additional "freeboard" above the optimized dune height would require material that is above the NED optimum. Therefore, the PDT decided that adaptive management to future sea level rise was the best measure for mitigation of risk and uncertainty.

There is a very low risk and uncertainty to the recommendation for the selected plan of improvement from the derivation of the recreation benefits by utilizing the somewhat dated Rutgers University Contingent Valuation Method (CVM) report as a key input. This report was contracted by the Philadelphia District to Rutgers University, and was spearheaded by a professor with substantial CVM expertise. The Rutgers University effort entailed a large random sample of interviews with approximately 1000 New Jersey beachgoers. The initial starting point for a visitor day beach experience valuation of $4.22 from the Rutgers report was within the lower range of valuation that could be expected to be applied from an alternate recreation benefit evaluation technique, Unit Day Values. The incremental increase in the willingness to pay, applied as the basis for benefits for an improved recreational experience with a widened with project condition beach berm, was a modest $0.69 per person per day (2014 PL). Also, the recreation benefits are strictly a secondary incidental project purpose for this study and were not used in the formulation/optimization process. The selected plan has positive BCRs for all the communities within the project area (without recreation benefits): North Wildwood (1.4); Wildwood (10.6); Wildwood Crest/Lower Township (5.1); and the Total Project (2.1). The recreation average annual benefits of $693,000 represent only 11% of the total project average annual benefits of $6,253,000. The impact of adding the recreation benefits at the end of the formulation process resulted in the project Benefit-Cost Ratio being adjusted slightly upward from 2.1 to 2.3.

5.6 Cost Sharing and Local Cooperation

Cost Sharing for the selected plan is based on the Water Resource Development Act (WRDA) of 1986. Section 103 (d) of WRDA 86 established the cost sharing percentages for beach nourishment projects. The selected plan is justified based on hurricane and storm damage reduction benefits. No separable recreation features are included with the project. Recreation benefits produced by the selected plan are not required for justification and are assumed to be incidental to the project. In accordance with Section 103 WRDA1986 and appropriate Federal regulations such as ER 1165-2-130, Federal participation in a project formulated for hurricane and storm damage reduction is 65% of the estimated total initial project construction costs including Lands, Easements, Rights-of-way, Relocations, and Dredged material disposal areas (LERRD). The estimated value of LERRD provided by the non-Federal Sponsor is included in total project costs. The non-Federal Sponsor shall receive credit for the value of LERRD cost towards the non-Federal cost share. Operation, Maintenance, Repairs, Replacement, and Rehabilitation (OMRR&R) costs are 100% non-Federal responsibility. Section 215 of the WRDA 1999 amended cost sharing for periodic nourishment of shore protection projects. Under Section 215 of WRDA 1999, periodic nourishment for the selected plan is 50% Federal and 50% non-Federal.

Table 92 Cost Sharing for the Selected Plan

Initial Construction					
Cost share Description	Federal Cost Share %	Federal Cost	Non-Federal Cost Share %	Non-Federal Cost	Project First Cost
Coastal Storm Damage Reduction Costs	65%	$14,043,000	35%	$7,562,000	$21,605,000
Real Estate Costs (LERRD Credit)	0%	$0	100%	$1,274,000	$1,274,000
Cash Portion		$14,043,000		$6,288,000	$20,331000
Periodic Nourishment					
Periodic Nourishment	50%	$41,214,000	50%	$41,214,000	$82,428,000
Initial Constrcution + Periodic Nourishment					
Final Project Cost Share and Cost (50 Years)	53%	$55,257,000	47%	$48,776,000	$104,033,000

5.6.1 Sponsor Cooperation and Financial Capability

In accordance with Section 105(a)(1) of WRDA 1986, the Hereford Inlet Feasibility Study was cost-shared 50%-50% between the Federal Government and the State of New Jersey. The contributed funds of the non-Federal Sponsor, the New Jersey Department of Environmental Protection, demonstrate their intent to support a project for the study area. The State of New Jersey has a $25,000,000 stable source of annual funding for shore protection projects. The sponsor has demonstrated their financial capability through their ongoing cost sharing of current Philadelphia District shore protection projects including; Barnegat Inlet to Little Egg Inlet, Brigantine Inlet to Great Egg Inlet, Absecon Island, Brigantine Inlet to Great Egg Inlet, Brigantine Island, Cape May Inlet to Lower Township, NJ and Great Egg Harbor Inlet to Peck Beach, Ocean City, NJ. The future estimated expenditures based on the initial construction, periodic nourishment, monitoring and operations and maintenance for the 50 period of analysis are shown in **Table 92**. The cost-sharing percentages presented herein are tentative based on the intent of the non-Federal Sponsor to ensure public use and access within the full project area. Public use and access will be addressed during the Preconstruction Engineering and Design (PED) phase and prior to construction. Final apportionment will be based on conditions of public use and access at the time of construction or subsequent nourishment.

Table 93 Estimated Schedule of Federal and non Federal Expenditures

		Federal	Non Federal			Total
Year	**Phase**	**Cost**	**Cash**	**LERRD**	**OMRR&R**	**Total Costs**
2015	PED	$1,394,921	$464,974	$0	$0	$1,859,894
2016	Initial	$14,043,000	$6,288,239	$1,273,511	$0	$21,604,750
2017	Mon.	$140,000	$0	$0	$150,000	$290,000
2018	Mon.	$140,000	$0	$0	$150,000	$290,000
2019	Mon.	$140,000	$0	$0	$150,000	$290,000
2020	Periodic	$2,975,000	$2,975,000	$0	$0	$5,950,000
2021	Mon.	$140,000	$0	$0	$150,000	$290,000
2022	Mon.	$140,000	$0	$0	$150,000	$290,000
2023	Mon.	$140,000	$0	$0	$150,000	$290,000
2024	Periodic	$2,975,000	$2,975,000	$0	$0	$5,950,000
2025	Mon.	$140,000	$0	$0	$150,000	$290,000
2026	Mon.	$140,000	$0	$0	$150,000	$290,000
2027	Mon.	$140,000	$0	$0	$150,000	$290,000
2028	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2029	Mon.	$140,000	$0	$0	$150,000	$290,000
2030	Mon.	$140,000	$0	$0	$150,000	$290,000
2031	Mon.	$140,000	$0	$0	$150,000	$290,000
2032	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2033	Mon.	$140,000	$0	$0	$150,000	$290,000
2034	Mon.	$140,000	$0	$0	$150,000	$290,000
2035	Mon.	$140,000	$0	$0	$150,000	$290,000
2036	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2037	Mon.	$140,000	$0	$0	$150,000	$290,000
2038	Mon.	$140,000	$0	$0	$150,000	$290,000
2039	Mon.	$140,000	$0	$0	$150,000	$290,000
2040	Major	$3,960,000	$3,960,000	$0	$0	$7,920,000
2041	Mon.	$140,000	$0	$0	$150,000	$290,000
2042	Mon.	$140,000	$0	$0	$150,000	$290,000
2043	Mon.	$140,000	$0	$0	$150,000	$290,000
2044	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2045	Mon.	$140,000	$0	$0	$150,000	$290,000
2046	Mon.	$140,000	$0	$0	$150,000	$290,000
2047	Mon.	$140,000	$0	$0	$150,000	$290,000
2048	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2049	Mon.	$140,000	$0	$0	$150,000	$290,000
2050	Mon.	$140,000	$0	$0	$150,000	$290,000
2051	Mon.	$140,000	$0	$0	$150,000	$290,000
2052	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2053	Mon.	$140,000	$0	$0	$150,000	$290,000
2054	Mon.	$140,000	$0	$0	$150,000	$290,000
2055	Mon.	$140,000	$0	$0	$150,000	$290,000
2056	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2057	Mon.	$140,000	$0	$0	$150,000	$290,000
2058	Mon.	$140,000	$0	$0	$150,000	$290,000
2059	Mon.	$140,000	$0	$0	$150,000	$290,000
2060	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2061	Mon.	$140,000	$0	$0	$150,000	$290,000
2062	Mon.	$140,000	$0	$0	$150,000	$290,000
2063	Mon.	$140,000	$0	$0	$150,000	$290,000
2064	Periodic	$3,095,000	$3,095,000	$0	$0	$6,190,000
2065	Mon.	$140,000	$0	$0	$150,000	$290,000

5.6.2 Project Partnership Agreement

A fully coordinated Project Partnership Agreement (PPA) will be prepared subsequent to the approval of the feasibility phase and will reflect final recommendations of this feasibility study. The non-Federal Sponsor, the New Jersey Department of Environmental Protection, has indicated support of the recommended plan and desire to execute a PCA. NJDEP has committed to providing adequate public access for all project lands throughout the life of the project. Should Congress appropriate funds for construction of the project, the non-Federal Sponsor would have to assume non-Federal responsibilities relating to cost-sharing, financing, and other applicable requirements of the Water Resources Development Acts of 1986, 1996, and 1999 as indicated in the following paragraphs:

a. Provide 35 percent of initial project costs assigned to hurricane and storm damage reduction plus 100 percent of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits and 50 percent of periodic nourishment costs assigned to hurricane and storm damage reduction plus 100 percent of periodic nourishment costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits and as further specified below:

(1) Enter into an agreement which provides, prior to construction, the required non-Federal share of design costs;

(2) Provide, during construction, any additional funds needed to cover the non-Federal share of design costs;

(3) Provide all lands, easements, and rights-of-way, and perform or ensure the performance of any relocations determined by the Federal Government to be necessary for the initial construction, periodic nourishment, operation, and maintenance of the project;

(4) Provide, during construction, any additional amounts as are necessary to make its total contribution equal to 35 percent of initial project costs assigned to hurricane and storm damage reduction plus 100 percent of initial project costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits and 50 percent of periodic nourishment costs assigned to hurricane and storm damage reduction plus 100 percent of periodic nourishment costs assigned to protecting undeveloped private lands and other private shores which do not provide public benefits;
b. For so long as the project remains authorized, operate, maintain, and repair the completed project, or functional portion of the project, at no cost to the Federal Government, in a manner compatible with the project's authorized purposes and in accordance with applicable Federal and State laws and regulations and any specific directions prescribed by the Federal Government;

a. Give the Federal Government a right to enter, at reasonable times and in a reasonable manner, upon property that the non-Federal Sponsor, now or hereafter, owns or controls for

access to the project for the purpose of inspecting, operating, maintaining, repairing, replacing, rehabilitating, or completing the project. No completion, operation, maintenance, repair, replacement, or rehabilitation by the Federal Government shall relieve the non-Federal Sponsor of responsibility to meet the non-Federal Sponsor's obligations, or to preclude the Federal Government from pursuing any other remedy at law or equity to ensure faithful performance;

b. Agree to participate in and comply with applicable Federal floodplain management and flood insurance programs

c. Comply with Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), which requires a non-Federal interest to prepare a floodplain management plan within one year after the date of signing a project cooperation agreement, and to implement such plan not later than one year after completion of construction of the project").

d. Hold and save the United States free from all damages arising from the initial construction, periodic nourishment, operation, maintenance, repair, replacement, and rehabilitation of the project and any project-related betterments, except for damages due to the fault or negligence of the United States or its contractors;

e. Keep and maintain books, records, documents, and other evidence pertaining to costs and expenses incurred pursuant to the project in accordance with the standards for financial management systems set forth in the Uniform Administrative Requirements for Grants and Cooperative Agreements to State and Local Governments at 32 Code of Federal Regulations (CFR) Section 33.20;

f. Perform, or cause to be performed, any investigations for hazardous substances that are determined necessary to identify the existence and extent of any hazardous substances regulated under the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA), Public Law 96-510, as amended, 42 U.S.C. 9601-9675, that may exist in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be required for the initial construction, periodic nourishment, operation, and maintenance of the project. However, for lands that the Federal Government determines to be subject to the navigation servitude, only the Federal Government shall perform such investigations unless the Federal Government provides the non-Federal Sponsor with prior specific written direction, in which direction;

g. Assume complete financial responsibility for all necessary cleanup and response costs of any CERCLA regulated materials located in, on, or under lands, easements, or rights-of-way that the Federal Government determines to be necessary for the initial construction, periodic nourishment, operation, or maintenance of the project;

h. Agree that the non-Federal Sponsor shall be considered the operator of the project for the purpose of CERCLA liability, and to the maximum extent practicable, operate, maintain, and repair the project in a manner that will not cause liability to arise under CERCLA;

i. If applicable, comply with the applicable provisions of the Uniform Relocation

Assistance and Real Property Acquisition Policies Act of 1970, Public Law 91-646, as amended by Title IV of the Surface Transportation and Uniform Relocation Assistance Act of 1987 (Public Law 100-17), and the Uniform Regulations contained in 49 CFR Part 24, in acquiring lands, easements, and rights-of-way, required for the initial construction, periodic nourishment, operation, and maintenance of the project, including those necessary for relocations, borrow materials, and dredged or excavated material disposal, and inform all affected persons of applicable benefits, policies, and procedures in connection with said Act;

j. Comply with all applicable Federal and State laws and regulations, including, but not limited to, Section 601 of the Civil Rights Act of 1964, Public Law 88-352 (42 U.S.C. 2000d), and Department of Defense Directive 5500.11 issued pursuant thereto, as well as Army Regulation 600-7, entitled "Nondiscrimination on the Basis of Handicap in Programs and Activities Assisted or Conducted by the Department of the Army", and Section 402 of the Water Resources Development Act of 1986, as amended (33 U.S.C. 701b-12), requiring non-Federal preparation and implementation of flood plain management plans;

k. Provide the non-Federal share of that portion of the costs of mitigation and data recovery activities associated with historic preservation, that are in excess of 1 percent of the total amount authorized to be appropriated for the project, in accordance with the cost sharing provisions of the agreement;

l. Participate in and comply with applicable Federal floodplain management and flood insurance programs;

m. Do not use Federal funds to meet the non-Federal Sponsor's share of total project costs unless the Federal agency providing the funds verifies in writing that such funds are authorized to be used to carry out the project.

n. Prescribe and enforce regulations to prevent obstruction of or encroachment on the project that would reduce the level of protection it affords or that would hinder future periodic nourishment and/or the operation and maintenance of the project;

o. Not less than once each year, inform affected interests of the extent of protection afforded by the project;

p. Publicize floodplain information in the area concerned and provide this information to zoning and other regulatory agencies for their use in preventing unwise future development in the floodplain, and in adopting such regulations as may be necessary to prevent unwise future development and to ensure compatibility with protection levels provided by the project;

q. For so long as the project remains authorized, the non-Federal Sponsor shall ensure continued conditions of public ownership and use of the shore upon which the amount of Federal participation is based;

r. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms;

s. Recognize and support the requirements of Section 221 of Public Law 91-611, Flood Control Act of 1970, as amended, and Section 103 of the Water Resources Development Act of 1986, Public Law 99-662, as amended, which provides that the Secretary of the Army shall not commence the construction of any water resources project or separable element thereof, until the non-Federal Sponsor has entered into a written agreement to furnish its required cooperation for the project or separable element; and

t. At least twice annually and after storm events, perform surveillance of the beach to determine losses of nourishment material from the project design section and provide the results of such surveillance to the Federal Government.

6.0 Conclusions and Recommendations

6.1 Conclusions

A plan was developed to reduce potential ocean-related storm damages. This plan consists of the construction of a beach berm and dune from Hereford Inlet to Cape May Inlet encompassing North Wildwood, Wildwood, Wildwood Crest and Lower Township. This plan includes periodic nourishment every 4 years. Specific project details are presented in Section 5.1 of this report. The selected plan reflects information available at the time and current Corps policies governing formulation of hurricane and storm damage reduction projects. This plan may be modified before being transmitted to Congress as a proposal for authorization and implementation. The project sponsor, interested Federal and non-Federal agencies, and other parties will be advised of any such modification and given an opportunity to comment further prior to transmittal to Congress.

6.1.1 Study Continuation: Needs and Requirements

In the Disaster Relief Appropriations Act of 2013, Public Law 113-2, Congress provided funding and authority for the Corps of Engineers to execute actions related to the consequences of Hurricane Sandy. The Federal share of initial construction of the recommended plan is eligible to be funded using construction funds provided in Public Law 113-2. The Corps will address whether Public Law 113-2 construction funds will be used to complete initial construction of the recommended plan at a later date.

If the Corps determines that Public Law 113-2 funds will be used for the Federal share of initial construction of the recommended plan, initial construction of the project may be completed following notification to the Committees on Appropriations of the House of Representatives and the Senate by the Assistant Secretary of the Army (Civil Works) that the recommended plan is technically feasible, economically justified, and environmentally acceptable. Congressional authorization and appropriations will be required in order to carry out periodic renourishment.

If the Corps, however, determines that Public Law 113-2 funds will not be used for the Federal share of initial construction of the recommended plan, Congressional authorization and appropriations will be required in order to carry out both initial construction and periodic renourishment.

6.1.2 Additional Tasks

Hurricane Sandy impacted the coastline of the mid-Atlantic and northeast United States in October 2012, making landfall less than 40 miles northeast of the Hereford Inlet to Cape May Inlet study area. As a result of Hurricane Sandy, Congress passed Public Law 113-2, the "Disaster Relief Appropriations Act, 2013". Chapter 4 of PL 113-2 specified actions for USACE, including the following [underlining added]:

> *". . .the Secretary of the Army <u>shall expedite and complete ongoing flood and storm damage reduction studies</u> in areas that were impacted by Hurricane Sandy"*

and further that:

> *". . . an interim report identifying . . . <u>any project under study by the Corps</u> for reducing flooding and storm damage risks in the affected area . . . shall be submitted to the appropriate congressional committees".*

USACE transmitted the "Second Interim Report to Congress" on 30 May 2013, which stated:

> *". . . the Secretary of the Army may also use these funds <u>to construct any project under study by the Corps for reducing flooding and storm damage risks</u> in areas along the Atlantic Coast within the North Atlantic Division that were affected by Hurricane Sandy".*

The Second Interim Report to Congress included the Hereford Inlet to Cape May Inlet study as a "Project Under Study", thus making it eligible for study completion funding, as well as authorizing initial project construction funding at 100% Federal expense, with the non-Federal share of initial construction costs repayable over a period of 30 years from the date of project completion. Although PL 113-2 authorized initial construction of the project, it did not include future periodic nourishment of the project, which will require a separate authorization by Congress.

<u>North Atlantic Coast Comprehensive Study (NACCS)</u>

PL 113-2 also directed USACE to perform *"a comprehensive study to address the flood risks of vulnerable coastal populations in areas that were affected by Hurricane Sandy within the boundaries of the North Atlantic Division of the Corps"*. The "North Atlantic Coast Comprehensive Study" (NACCS) is ongoing and is scheduled for completion in January 2015. The focus of the NACCS is to reduce risk to vulnerable coastal populations and the infrastructure it supports.

When the Hereford Inlet to Cape May Inlet study was scoped and initiated, the focus was to address risk of potential storm damage along the oceanfront of Five Mile Island. It was recognized at the time that there was residual risk of back bay flooding to the communities on Five Mile Island and additional residual risk areas that were not able to be protected with the selected plan on the beachfront piers. The back bay shoreline flood risk will be reduced by implementation of a shore protection project (beachfill) along the oceanfront. Nevertheless, back bay shorelines and other residual risk areas remain susceptible to flooding during coastal storms and as a result of ocean storm surge.

However, the magnitude of that problem was determined to be beyond the scope of the feasibility study, in part because the emphasis of the New Jersey Shore Protection Program, and specifically the Hereford Inlet to Cape May Inlet component of that program, was to complete

the line of oceanfront shore protection projects that extend from Sea Bright, NJ on the north to Cape May Point on the south, a distance of about 125 miles. As stated previously in this report, the coastal reach between Hereford and Cape May Inlets was the only segment of the New Jersey ocean coast lacking an authorized shore protection project.

Given that Hurricane Sandy caused significant back bay flooding of the Five Mile Island study area between Hereford and Cape May Inlets, and given the emphasis of the NACCS to identify areas at risk of coastal flooding in the future, an opportunity exists to evaluate risks associated with the back bay flood problem of the study area and other residual risk areas that are not addressed by the recommended plan of this report.

6.2 Recommendations

Overall Assessment

In making the following recommendations, I have given consideration to all significant aspects in the overall public interest, including environmental quality, social effects, economic effects, engineering feasibility, and compatibility of the project with policies, desires, and capabilities of the State of New Jersey and other non-Federal interests. I have evaluated several alternative plans for the purpose of hurricane and storm damage reduction. A project has been identified that is technically sound, economically cost-effective over the 50-year period of analysis, socially and environmentally acceptable, and has support from the non-Federal Sponsor.

Project Benefits

The selected plan has primary benefits based on hurricane and storm damage reduction and provides average annual total net benefits of approximately $3,565,000 and a benefit-to-cost ratio of 2.3

Initial Project Cost

The total initial project cost of construction is estimated at $21,605,000 (March 2014 P.L.). Lands, Easements, Rights-of-Ways, Relocations, and Dredged Material Disposal Areas (LERRD) costs are $1,273,987 and will be credited towards the non-Federal Sponsor cash contribution.

Continuing Construction Cost

Periodic nourishment is expected to occur at 4-year intervals subsequent to the completion of initial construction. Periodic nourishment is estimated to cost $82,428,000 (March 2014 P.L.) over the 50-year period of analysis.

Ultimate Project Cost

The ultimate cost of construction which includes initial construction, project monitoring, and fifty years of periodic nourishment is estimated to be $104,033,000 (March 2014 P.L.), cost-shared 52% Federal and 48% non-Federal based on WRDA 1999 cost-sharing of periodic nourishment at 50% Federal and 50% non-Federal and initial construction at 65% Federal and 35% non-Federal.

Modifications

These recommendations reflect the information available at the time and current Departmental policies governing formulation of individual projects. These recommendations may be modified before they are transmitted to Congress as proposals for authorization and implementation funding. However, prior to transmittal to Congress, the Sponsor, the States, interested Federal agencies, and other parties will be advised of any modifications and will be afforded the opportunity to comment further.

30 May 2014
Date

John C. Becking
Lieutenant Colonel, Corps of Engineers
District Commander

7.0 List of Preparers

The following individuals were responsible for preparation and technical support for the Feasibility Study and Integrated Environmental Assessment.

Brian Bogle, P.M.P, Project Manager
M.S. Applied Geoscience
B.S. Hydro-geology
B.A. Political Science
12 years Project Management Experience

Jeff Gebert, Coastal Planning Chief
B.S. Geology and Geophysics
25 years Engineering and Planning Experience

Bob Selsor, Economist
BA Economics
MBA Finance
34 Years Experience

Sharon Grayson, Economist
B.A. Economics
M.B.A. Information Systems
Certificate Geographic Information Systems
16 years economics experience

Heather Sachs, Real Estate Specialist
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M.S. Real Estate
21 years Federal Real Estate Experience

Beth Brandreth, EA Preparation
B.S. Marine Biology
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Alyssa Dunlap, P.E., Civil Works Design
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B.S. Civil Engineering
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Nichole Minnichbach, EIS Preparation
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B.A. Anthropology
M.S. Anthropology
15 years field experience and 10 years federal experience

William Welk, Cost Estimator
B.S. Civil Engineering
M.S. Mechanical Engineering
19 years cost engineering experience

8.0 Public Involvement

Coordination of this project was done with Federal, State and local resource agencies. Agencies notified for this study included the U.S. Fish and Wildlife Service (USFWS), U.S. Environmental Protection Agency (USEPA), National Marine Fisheries Service (NMFS), New Jersey Department of Environmental Protection (NJDEP), and New Jersey State Historic Preservation Office (NJSHPO).

A Planning Aid Letter, prepared by the USFWS, is provided in Appendix G. A draft Section 2(b) Fish and Wildlife Coordination Act Report was requested from the USFWS and is contained in the technical appendices. A final Section 2(b) was prepared by the USFWS following the final review of this Final document. This report will provide official USFWS comments on the project pursuant to the Fish and Wildlife Coordination Act.

A copy of the Feasibility Study and Integrated Environmental Assessment is being provided to the following individuals/agencies for review in addition to the interested public that requested copies.

Federal

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9.0 Clean Air Act Statement of Conformity

CLEAN AIR ACT
STATEMENT OF CONFORMITY
HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY
CAPE MAY COUNTY, NEW JERSEY

Based on the conformity analysis in the subject report, I have determined that the proposed action conforms to the applicable State Implementation Plan (SIP). The Environmental Protection Agency had no adverse comments under their Clean Air Act authority. The air quality comments received from the New Jersey Department of Environmental Protection were addressed in the final feasibility report and integrated Environmental Assessment (EA). The proposed project would comply with Section 176 C (1) of the Clean Air Act Amendments of 1990.

23 May 2014
Date

John C. Becking
Lieutenant Colonel, Corps of Engineers
District Commander

10.0 District Legal Certification

CERTIFICATE OF LEGAL REVIEW

The Philadelphia District, Office of Counsel has reviewed the:

NEW JERSEY SHORE PROTECTION STUDY, HEREFORD INLET TO CAPE MAY INLET, FEASIBILITY REPORT AND INTEGRATED ENVIRONMENTAL ASSESSMENT, 4/28/2014.

A policy and legal compliance review for the subject document has been completed and all comments have been resolved in the enclosed report. The subject report was prepared in accordance with the requirements of ER 1105-2-100 and meets all applicable requirements.

Date: May 30, 2014

William A. Wilcox, Jr.
Principal Assistant District Counsel

11.0 Evaluation of 404 (B) (1) Guidelines

I. PROJECT DESCRIPTION

A. Location

The proposed project site is located along the Atlantic Coast shoreline of New Jersey from Hereford Inlet to Cape May Inlet and includes the communities of North Wildwood, Wildwood, Wildwood Crest and Lower Township. An onshore borrow site is the source of the nourishment material. This borrow area lies within Wildwood, Wildwood Crest and Lower Township and straddles the MHW line and material will be taken from the intertidal zone and upland beaches. This area has historically accreted sand through natural process associated with long-shore sediment transport.

B. General Description

The purpose of the project is hurricane and storm damage reduction through the placement of dredged material (sand) obtained from the borrow sites on the beachfront in the form of a berm and dune. The plan includes a dune with crest elevation at +16ft NAVD fronted by a 75-ft wide berm at elevation +6.5 ft NAVD. The design template for both dune configurations includes a 25-ft dune crest width with 1V:5H dune side slopes. The design template extends seaward from the berm crest down to mean low water (MLW) at a slope of 1V:10H, and extends further down to a closure depth of 26 ft following the average existing beach profile shape. Initial sand quantity is approximately 1,362,000 cubic yards, which includes overfill factors and advanced nourishment. Periodic nourishment of approximately 305,000 cubic yards is scheduled to occur every 4 years.

C. Authority and Purpose

The Hereford Inlet Feasibility study is part of the overall New Jersey Shore Protection Study, which was authorized under resolutions adopted by the Committee on Public Works and Transportation of the U.S. House of Representatives and the Committee on Environmental and Public Works of the U.S. Senate in December 1987 that states:

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

erosion control, hurricane protection, and related purposes should be undertaken in areas identified as having potential for a Federal project, action, or response.

The House resolution adopted by the Committee on Public Works and Transportation on December 10, 1987 states:

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

See Supplemental Authority in Section 1.0

D. General Description of Dredged or Fill Material

1. General Characteristics of Material. The proposed borrow material is medium to coarse sands with some fines and gravel. Clay, silt, and organic content are low with neutral pH and low fertility. Grain size analyses have demonstrated that the borrow material is comparable to the native beach sand. As such, the borrow material is considered ideal for berm and dune restoration.

2. Quantity of Material. The quantity of beach fill material required for initial fill for the project is estimated to be approximately 1,527,000 cy, which includes overfill factor and advanced nourishment. Periodic nourishment of 391,000 cy is scheduled to occur every 4 years.

3. Source of Material. The proposed source of the beach fill material is from the southern portion of the project area in Wildwood and Wildwood Crest and Lower Township.

E. Description of the Proposed Discharge Site

1. Location. The proposed discharge locations will be from Hereford Inlet to Cape May Inlet along the beachfront and in the near shore environment.

2. Size. The proposed plan will create 64 acres of dune habitat above MHW. Below MHW, sand will cover intertidal and subtidal habitat. These habitats will not be lost however, as the sand placement simply shifts the area seaward.

3. Type of Site. The proposed discharge is comprised of eroding sandy beaches located from Hereford Inlet to Cape May Inlet. The proposed discharge sites are unconfined with placement to occur on shoreline beach areas and open water.

4. Type(s) of Habitat. The type of habitat present at the proposed discharge locations are marine sandy beach intertidal and sub tidal near shore habitats and marine open water.

5. Timing and Dnration of Discharge:

There are no seasonal restrictions for beach fill placement and associated discharges with the exception that certain areas or segments may require avoidance if piping plovers are nesting within the impact area(s) during the nesting season (March – August). For initial construction, the discharge would be continuous for approximately 8 months. Periodic nourishment would occur over approximately 4-6 months every 4 years during the 50-year period of Federal participation. Estimated year of initial construction is 2016.

F. Description of Discharge Method

A land based hydraulic dredge will be used to excavate the sandy material from the borrow area. The material would be transported from the dredge pump using an 8 inch high density polyethylene pipeline (HDPE) to booster pumps stationed every 3,000-4,000 along the beach. The final grading would be accomplished using bulldozers and front end loaders working in the upland beach and near shore area.

II. FACTUAL DETERMINATION

A. Physical Snbstrate Determinations

1. **Snbstrate Elevation and Slope.** For the entire project area the final proposed elevation of the beach substrate after fill placement would be +6.5' NAVD at the top of the berm and +16' NAVD at the crest of the dune. The proposed profile would have a foreshore slope of 1V:10H and an underwater slope that parallels the existing bottom to the depth of closure.

2. **Sediment Type.** The sediment type involved would be sandy beach fill material (consists 90% or greater of fine, medium and coarse sands and gravels) obtained from the intertidal beach area in Wildwood and Wildwood Crest.

3. **Dredged/Fill Material Movement.** The planned construction would establish an initial construction template, which is higher and wider than the final intended design template or profile. It is expected that compaction and erosion would be the primary processes resulting in the change to the design template. Also, the loss of fine grain material into the water column would occur during the initial settlement. These materials may become re-deposited within sub tidal near shore waters.

4. **Physical Effects on Benthos.** The proposed construction and discharges would result in initial

burial of the existing beach and near shore benthic communities when this material is discharged during berm construction. Substrate is expected to be composed of material that is similar to existing substrate, which is expected to become recolonized by the same type of benthos. The dredging within the borrow site would result in the removal of the benthic community from the substrate, however, due to the dynamic nature of the intertidal zone, recolonization will occur quickly following the completion of dredging activities.

5. **Other Effects.** Other effects would include a temporary increase in suspended sediment load and a change in the beach profile, particularly in reference to elevation. Bathymetric changes in the placement sites would raise the bottom several feet, which would be offset seaward. The shoreline in the borrow area will be offset landward.

6. **Actions Taken to Minimize Impacts.** Actions taken to minimize impacts include selection of fill material that is located in an upland site rather than a site from an offshore source. Using upland source will minimize impacts to benthic resources, fisheries, shellfish habitat and cultural resource targets.

B. Water Circulation, Fluctuation, and Salinity Determinations

1.Water. Consider effects on:
a. Salinity - No effect.
b. Water chemistry - No significant effect.
c. Clarity - Minor short-term increase in turbidity during construction.
d. Color - No effect.
e. Odor - No significant effect.
f. Taste - No effect.
g. Dissolved gas levels - No significant effect.
h. Nutrients - Minor effect.
i. Eutrophication - No effect.
j. Others as appropriate - None.

2. Current patterns and circulation

a. **Current patterus and flow** – Minor impacts to circulation patterns and flow in the beach zone and near shore where the existing circulation pattern and flow would be offset seaward the width of the beach fill placement. Minor circulation differences are expected within the immediate vicinity of the borrow area due to the change in the shoreline location.

b. **Velocity** - No effects on tidal velocity and long shore current velocity regimes.

c. **Stratification** - Thermal stratification normally occurs beyond the mixing region created by the surf zone. There is potential for both winter and summer stratification. The normal pattern should continue after construction of the proposed project.

d. **Hydrologic regime** - The regime is largely tidal marine and oceanic. This will remain the case following construction of the proposed project.

3. Normal water level fluctuations - The tides are semidiurnal. The mean tide range for Cape May Inlet is reported to be 4.85' and for Atlantic City it is reported to be 4.02' in the Tide Tables published annually by the National Oceanic and Atmospheric Administration (NOAA).Construction of the proposed plan would not affect the tidal regime.

4. **Salinity gradients** - There should be no significant effect on the existing salinity gradients.

5. **Actions that will be taken to minimize impacts**- None are required: however, the use of sand backpassing techniques for this project will minimize potential impacts associated with the use of an offshore borrow area and will also keep the sand in the littoral system of the project area. The use of a hydraulic pump and 8 inch pipe will minimize potential water quality impacts.

C. Snspended Particulate/Tnrbidity Determinations

1. **Expected Changes in Suspended Particnlates and Tnrbidity Levels in the Vicinity of the Disposal (Beach fill Placement) Site** - There would be a short- term elevation of suspended particulate concentrations during construction phases in the immediate vicinity of the dredging and the discharge locations. Elevated levels of particulate concentrations at the discharge locations may also result from "washout" after beach fill is placed.

2. Effects (degree and duration) on Chemical and Physical Properties of the Water Column -

a. **Light penetration** - Short-term, limited reductions would be expected at the discharge sites from dredge activity and berm washout, respectively.

b. **Dissolved oxygen** - There is a potential for a decrease in dissolved oxygen levels but the anticipated low levels of organics in the borrow material should not generate a high, if any, oxygen demand.

c. **Toxic metals and organics** - Because the borrow material is 90% or more sand, and originates from areas where no known sources of significant contamination exist, the material is expected to be free of any significant contamination in accordance with 40 CFR 227.13(b).

d. **Pathogens** - Pathogenic organisms are not known or expected to be a problem in the borrow area. Therefore, beach fill placement is not expected to significantly increase indicator bacteria levels above normal conditions.

e. **Aesthetics** - Construction activities and the initial construction template associated with the fill placement site would result in a minor, short-term degradation of aesthetics. This is due to the temporary impacts to noise, sight, and smell associated with the discharges and beach de-watering during construction and periodic nourishment.

3. Effects on Biota

a. **Primary production, photosynthesis** - Minor, short-term effects related to turbidity.

b. **Suspension/filter feeders** - Minor, short-term effects related to suspended particulates outside the immediate deposition zone. Sessile organisms would be subject to burial if within the deposition area.

c. **Sight feeders** - Minor, short-term effects related to turbidity.

4. **Actions taken to miuimize impacts** include the selection of clean sand with a small fine grain component and a low organic content. Standard construction practices would also be employed to minimize turbidity and erosion.

D. Contaminant Determinations

The discharge material is not expected to introduce, relocate, or increase contaminant levels at either the borrow or placement sites. This is assumed based on the characteristics of the sediment, the proximity of the borrow site to sources of contamination, the area's hydrodynamic regime, and existing water quality. In accordance with 40 CFR 227.13(b), the dredged material/beach fill is not expected to contain any significant contamination.

E. Aquatic Ecosystem and Organism Determinations

1. **Effects on Plankton** - The effects on plankton should be minor and mostly related to light level reduction due to turbidity. Significant dissolved oxygen level reductions are not anticipated.

2. **Effects on Benthos** – Initially, a removal of the benthic community within the borrow area and burial of benthos within the discharge (beach fill) location. The losses of benthic organisms are somewhat offset by the expected rapid opportunistic recolonization from adjacent areas that would occur following cessation of construction activities. Recolonization is expected to occur rapidly in both the borrow and discharge (beach fill placement) area through horizontal and in some cases vertical migrations of benthos

3. **Effects on Nekton** - Only a temporary displacement is expected, as the nekton would probably avoid the active work area.

4. **Effects on Aquatic Food Web** – Localized significant impacts in the affected areas due to loss of benthos as a food source through burial at the beach fill placement site or removal at the dredging site. This is expected to be short-term as the borrow and beach fill placement sites should become recolonized by benthos within a few days following the impact.

5. **Effects on Special Aquatic Sites** - No special aquatic sites such as sanctuaries and refuges, wetlands, mud flats, vegetated shallows, coral reefs and riffle and pool complexes are present within the project area.

6. **Threatened and Endangered Species** - The piping plover (*Charadrius melodus*), a Federal and State threatened species, has, in the past, utilized some of the sandy beach habitat within the project impact area. This bird nests on the beach and could potentially be impacted by beach fill placement activities if present within the affected area. Monitoring to determine the extent of nesting activity prior to initial construction (if construction will take place during the nesting

season) and periodic nourishment is required to insure that the nesting locations can be avoided during construction until the chicks fledge the nest. If birds do re- establish themselves within the project area following construction, monitoring will be conducted on a yearly basis in conjunction with NJDEP, Division of Fish and Wildlife. Following construction activities, it is also possible that the Federally threatened seabeach amaranth (*Amaranthus pumilus*) could become established within the project area, as it has been recently found north of the project area. Surveys will be conducted prior to any construction or nourishment activities to determine the presence/location of any plants in order to protect them from construction impacts. Additional issues such as local beach-use management after construction and nourishment with regard to the piping plover and seabeach amaranth are addressed through a programmatic Biological Opinion as part of formal consultation with the U.S. Fish and Wildlife Service pursuant to Section 7 of the Endangered Species Act. Several species of threatened and endangered sea turtles, as well as the Atlantic sturgeon may be migrating along the coast adjacent to the project. Sea turtles and sturgeon have been known to become entrained and killed by suction hopper dredges. Since hopper dredges will not be used for this project, no impacts to sea turtles or sturgeon, related to dredging activities, are expected.

7. **Other Wildlife** - The proposed plan would not significantly affect other wildlife.

8. **Actions to minimize impacts** - The use of a borrow area in the intertidal zone will minimize or eliminate potential impacts to most species found within the project area.

F. <u>Proposed Disposal/Discharge (Beachfill Placement) Site Determinations</u>

1. Mixing Zone Determination

a. Depth of water - 0 to-20' mean low water

b. Current velocity - Generally less than 3'per second

c. Degree of turbuleuce - Moderate to high

d. Stratification - None

e. Discharge vessel speed and direction - Not applicable

f. **Rate of discharge** - Typically this is estimated to be 300-400 cubic yards per hour

g. **Dredged material characteristics** - medium-course sand and gravels with low (< 10%) silts, clays and organics

h. **Number of discharge actions per unit time** - Continuous over the construction period

2. **Determination of compliance with applicable water quality standards** -A Section 401 Water Quality Certificate (WQC) and consistency concurrence with the State's Coastal Zone Management (CZM) Program has been obtained from the State of New Jersey (**App. G**).

3. Potential Effects on Human Use Characteristics -

a. Municipal and private water supply - No effect

b. **Recreational and commercial fisheries** - Short-term effect during construction; there would be a temporary loss of surf clam stocks within the near shore placement sites and within the borrow area. Loss of benthos would result in temporary loss of food source for finfish.

c. **Water related recreation** - Short-term effect during construction where potential beachgoers, bathers, and surf-fishermen would be prohibited from accessing active construction locations.

d. **Aesthetics** - Short-term adverse effects to noise sight and smell during construction are

anticipated.

e. **Parks, national and historic monuments, national seashores, wilderness areas, research sites and similar preserves** – The dredging and fill placement will not impact any national sites, however, the U.S. Fish and Wildlife Service is adjacent to the placement site in Lower Township. Since only a small portion of the construction will occur near the Park, but the effects are expected to be zero.

G. **Determination of Cumulative Effects on the Aquatic Ecosystem-** Impacts on benthos and the aquatic ecosystem in general are considered to be temporary and do not represent a significant loss of habitat since the borrow and placement areas are both located in the dynamic near shore and intertidal area.. This project in concert with other existing or proposed similar actions, may produce measurable temporary cumulative impacts to benthic resources. However these impacts are short-term.

H. **Determination of Secondary Effects on the Aquatic Ecosystem** – Secondary impacts such as turbidity on aquatic organisms or temporary loss of food sources through the burial or removal of the benthos are considered to be of short duration.

III. FINDINGS OF COMPLIANCE OR NON-COMPLIANCE WITH THE RESTRICTIONS ON DISCHARGE

A. **Adaptation of the Section 404(b)(1) Guidelines to this Evaluation.** No significant adaptation of the Section 404(b)(1) Guidelines were made relative to this evaluation.

B. **Evaluation of Availability of Practicable Measures to the Proposed Discharge Site, Which Would Have Less Adverse Impact on the Aquatic Ecosystem.** The alternative measures considered for accomplishing the project objectives are detailed in the Feasibility Report and Integrated Environmental Assessment of which this 404(b)(1) analysis is a part. Several measures including No Action, Permanent Evacuation and Regulation of Future Development would likely have less adverse impacts on the aquatic ecosystem. However, these measures were determined to not be practicable or economically justified in meeting the needs and objectives of providing storm damage reduction. Selection of sand sources heavily considered impacts on the aquatic ecosystem, and the source was chosen over other sites, which potentially could have had a higher adverse impact on the aquatic ecosystem.

C. **Compliance with Applicable State Water Quality Standards.** This action is not expected to violate State of New Jersey Water Quality Standards. A Section 401 water quality certificate was obtained from the New Jersey Department of Environmental Protection prior to initiation of discharges associated with this project **(App G.)**.

D. **Compliance with Applicable Toxic Effluent Standard or Prohibition Under Section 307 of the Clean Water Act.** The proposed action is not expected to violate the Toxic Effluent Standards of Section 307 of the Clean Water Act.

E. **Compliance with Endangered Species Act.** The proposed action will comply with the Endangered Species Act of 1973 and be consistent with the Terms and Conditions outlined in the District's Biological Opinion which addresses impacts and mitigation measures for piping plovers and seabeach amaranth.

F. **Compliance with Specified Protection Measures for Marine Sanctuaries Designated by the Marine Protection, Research, and Sanctnaries Act of 1972.** The proposed action will not violate the protective measures for any Marine Sanctuaries designated by the Marine Protection, Research, and Sanctuaries Act of 1972.

G. **Evaluation of Extent of Degradation of the Waters of the United States.** The proposed action is not expected to result in permanent significant adverse effects on human health and welfare, including municipal and private water supplies, recreation and commercial fishing, plankton, fish, shellfish, wildlife, and special aquatic sites. Significant adverse effects on life stages of aquatic life and other wildlife dependent on aquatic ecosystems; aquatic ecosystem diversity, productivity, and stability; and recreational, aesthetic, and economic values is not expected to occur or have long-term effects on impacted resources.

H **Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem.** Appropriate steps to minimize potential adverse impacts of the discharge on aquatic systems include selection of borrow material that is low in silt content, has little organic material, and is expected to be uncontaminated.

I. **On the basis of the guidelines**, the proposed discharge sites for the dredged material are specified as complying with the requirements of these guidelines, with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects on the aquatic ecosystem.

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13.0 Index

1990 Report of Limited Reconnaissance, *25*
7.0 List of Preparers, 350
8.0 Public Involvement, 351
9.0 Clean Air Act Statement of Conformity, 354
ABSTRACT, *3*
Aerial Photograph, *160*
Air Quality, 60
Anglesea, 27, 40, 41, 81, 82
Back Bay Flooding, *215*
Bathymetry, *149, 150, 151, 152, 153, 154*
Beach Maintenance, *229*
beach nourishment, 366, 369
Beach Profile, *44, 142, 147, 161*
Beachfill Design Parameters, *262*
benthos, 368
Birds, 75
black skimmer, 76
Borrow Area Infilling Analysis, *288*
borrow areas, 324
Cape, *1, 2, 3, 25, 27, 38, 39, 40, 41, 42, 43, 45, 51, 53, 54, 55, 56, 58, 79, 80, 81, 82, 83, 85, 86, 88, 99, 100, 119, 140, 142, 158, 159, 161, 162, 173, 182, 183, 184, 185, 186, 189, 215, 238, 244, 264, 265, 283, 298, 330, 331, 346*
Coastal Plain, 90
Conclusions and Recommendations, 346
Constraints, *239, 240, 241*
Continuing Construction Cost, 348
Cost Sharing, 25, 339
COSTDAM, *215, 220, 330, 334, 335, 336*
cultural resources, 324, 368
Cycle 1, *238, 242*
Cycle-2, *251*
Cycle-3, *262*
December 1992, 42
District's Preliminary Financial Analysis, *25*
dunes, 324
DYNLET, *215*
EAD, *222*
EFH, 73
Employment, 53
Environmental Resources, *59*
Erosion Damages, *221*
essential fish habitat, 370
Feasibility, *1, 2, 3, 25, 27, 43, 45, 99, 106, 161, 162, 238, 330*
finfish, 369
FONSI, 10
Hereford, *2, 3, 25, 27, 40, 41, 42, 43, 44, 81, 85, 99, 100, 111, 117, 119, 121, 141, 142, 149, 153, 154, 155, 156, 157, 158, 159, 161, 162, 180, 181, 183, 184, 185, 186, 187, 189, 215, 238, 243, 246, 283, 298, 303, 304, 330, 331, 346*
Historic Shoreline, *161*
Hydraulic Analysis, *190, 195*
Initial Project Cost, 348
Longshore Sediment Transport, *140, 141, 185, 189*
Mammals, 75
monitoring, 321, 323, 324, 369
nearshore zone, 371
New Jersey Shore Protection Study, *2, 3, 25, 26, 42, 161, 238*
non –Federal Sponsor, *39*
Ocean Stage Frequency, 140
Pier Protection, *269*
piping plover, 323
PL 113-2, 233
Planning Objectives, *238*
Population, *51, 52, 53*
Problems, *241*
Project Benefits, 348
Project Construction Template, *289*
Project Cooperation Agreement, 342
Project Cost Estimate, 317
Project Partnership Agreement, 342
red knot, 76
Regional Economy, *55*
Risk Analysis, 331
Risk and Uncertainty, 330, 331, 334, 336
SBEACH, *191, 192, 201, 213, 214, 215, 330, 335*
sea beach amaranth, 76
Sea Level Rise, 129
sea turtles, 77, 323
seabeach amaranth, 323, 324
Section 111, *158, 159*
Sediment Backpassing Technology, *298*
Sediment Budget, *183, 185, 186, 188, 189*
Sediment Bypassing, *156*
Selected Plan, *283, 287*
shellfish, 369
Socioeconomic Resources, *51*
Storms, 131
Structure Inventory, *117, 218*
Study Area, *27, 52, 144, 241*
Study Authorization, *26*
sturgeon, 77
Threatened and Endangered, 76
Volume 1, *1*
Water Elevation, *201*
Water Quality, 63
Wave Attack Analyses, *190*
Wildwood Boardwalk, 27

14.0 Glossary of Terms

Active profile zone - The nearshore zone across which the dominant sediment motion occurs.

Barrier island - A sand body that is essentially parallel to the shore, the crest of which is above normal high water level.

Beach - The zone of unconsolidated material that extends landward from the low water line to the place where there is marked change in material or physiographic form, or to the line of permanent vegetation (usually the effective limit of storm waves). The seaward limit of a beach unless otherwise specified is the mean low water line.

Beach profile - The intersection of the ground surface with a vertical plane; may extend from behind the dune line or the top of a bluff to seaward of the breaker zone.

Beach renourishment - Pumping sand onto the beach and building up former dunes and upper beach after construction of an initial nourishment.

Benthic community - Organisms that live on the sub-aquatic bottom.

Biogenically derived sediments - Biogenous sediments consist of the remains of either marine plant or animal skeletons, either coarse grained as found in shallow coastal waters, or fine grained as found in deeper waters.

Borrow site - A term used to describe the site identified for, or remaining after, borrow material has been removed for placement onto a beach. In upland areas, the site frequently becomes a body of water. In marine areas, the site becomes a hole in a bay or nearshore area.

Carbonate platform - A large and thick accumulation of carbonate strata that it typically isolated from other land masses.

Carbonate sediments - Sediment formed by the organic or inorganic precipitation from aqueous solution of carbonates of calcium, magnesium, or iron.

Closure depth - The depth of water beyond which sediments are not normally affected by waves.

Coastal geology - Origin, structure, and characteristics of the sediments that make up the coastal region, from the uplands to the nearshore region. Sediments can vary from small particles of silt or sand to larger particles of gravel and cobble, to formations of consolidated sediments and rock.

Coastal plain - A broad, low relief region composed of horizontal or gently sloping strata of clastic materials fronting the coast, and generally representing a strip of sea bottom that has emerged from the sea in recent geologic time.

Coastal sediment budget - The identification of sediment sources and sinks, and the quantification of the amounts and rates of sediment transport, erosion, and deposition within a defined region.

Compatibility analysis - Methods used to evaluate the suitability of the sediments in a borrow area for beach nourishment purposes based on the characteristics of the native beach material and / or the profile shape of the constructed beach.

Continental shelf - The region of the oceanic bottom that extends outward from the shoreline with an average slope of less than 1:100, to a line where the gradient begins to exceed 1:40.

Cross-shore direction - Perpendicular to the shoreline.

Cross-shore transport - A wave and / or tide-generated movement of shallow-water coastal sediments toward or away from the shoreline.

Drowned barrier island - A long, narrow coastal sandy body, representing a broadened barrier beach that was above high tide and parallel to the shore in prior sea level conditions and is now underwater.

Dune - A ridge or mound of loose, wind-blown material, usually sand.

Ebb tidal delta - The bulge of sand formed at the seaward mouth of tidal inlets as a result of interaction between tidal currents and waves.

Equilibrium beach profile - The slightly concave slope of the floor of a sea or lake, taken in a vertical plane and extending away from and transverse to the shoreline, being steepest near the shore, and having a gradient such that the amount of sediment deposited by waves and currents is balanced by the amount removed by them; the transverse slope of a graded shoreline. The profile is easily disturbed by strong winds, large waves, and exceptional high tides.

Estuary - (1) A coastal embayment where there is freshwater input that is influenced by tides. (2) The part of a river that is affected by tides. (3) The region near a river mouth in which the fresh water of the river mixes with the salt water of the sea.

Flood tidal-delta - The bulge of sand formed at the landward mouth of tidal inlets as a result of flow expansion.

Gross sediment transport - The sum of the sediment transport magnitudes in the dominant and secondary directions. The gross sediment transport does not have a direction or sign.

Hot spot - Shoreline segment characterized by erosion rates that are significantly greater than adjacent shoreline segments.

Hydraulic sand placement - Sediment (sand) moved using water and centrifugal pumps mounted on a barge or large seagoing vessel (hydraulic dredging), usually moving sediment originating from an offshore site.

Hydrographic surveys - 1) The description and study of seas, lakes, rivers, and other waters. (2) The science of locating aids and dangers to navigation. (3) The description of physical properties of the waters of a region.

Inlet improvement - Modifications to an existing inlet, usually for purposes of navigation, which may include channel deepening and/or jetty construction. Other reasons for inlet improvement may include positional stabilization and improved flushing of the bay served by the inlet.

Inlet positional stability - A type of stability related to the orientation of the inlet's tidal jet.

Intertidal Zone - The zone between spring high tide and spring low tide.

Jet-probe - A long pipe into which water under high pressure is pumped in order to penetrate into unconsolidated sediment.

Littoral cell - A reach of the coast that is isolated sedimentologically from adjacent coastal reaches and that features its own sources and sinks. Isolation is typically caused by protruding headlands, submarine canyons, inlets, and some river mouths that prevent littoral sediment from one cell from passing into the next.

Littoral zone - In beach terminology, an indefinite zone extending seaward from the shoreline to just beyond the breaker zone.

Longshore bar - A sand bar that extends roughly parallel to the shoreline.

Longshore direction - Parallel to and near the shoreline, alongshore.

Longshore sand bars - A sand ridge or ridges, running roughly parallel to the shoreline and extending along the shore outside the trough, that may be exposed at low tide or may occur below the water level in the offshore.

Longshore transport - A wave- and/or tide-generated movement of shallow-water coastal sediments parallel to the shoreline.

Low energy environments - Coastlines where wave and tidal forces are typically relatively small due to the climate, the location of the site and / or due to nearshore submerged features that function to reduce incoming wave energy.

Magnetometer survey - A geophysical test to determine the ferrous returns for subsurface materials such as shipwrecks, debris and other anomalies located within a borrow site. Such materials must be located to avoid damage to dredge equipment or to determine the precise location of historic relics, shipwrecks, or other artifacts.

Marsh - An area of soft, wet, or periodically inundated land, generally treeless and characterized by grasses.

Miocene Epoch - The period of geologic time that extends from 24 million years to 5 million years before the present.

Moraine - An accumulation of earth, stones, etc. deposited by a glacier, usually in the form of a mound, ridge, or other prominence on the terrain.

Nearshore - In beach terminology, an indefinite zone extending seaward from the shoreline well beyond the breaker zone.

Nearshore zone - In beach terminology, the zone that extends seaward from the low tide line including the bar and trough topography that commonly extends well beyond the breaker zone.

Net sediment transport - The difference between the sediment transport magnitude in the dominant direction and the transport magnitude in the secondary direction. Sediment transport is usually considered to be positive to the right as an observer looks seaward. The net sediment transport can be positive, negative, or zero.

Oblique sand ridge - A generic name for any low ridge of sand formed at some distance from the shore, either submerged or emergent at an angle to the shoreline.

Planform - The outline or shape of a body of water as determined by the still-water line, that is, a map.

Planform evolution - The morphodynamic changes that take place over time on a particular geographic entity.

Profile eqnilibration - The process of adjustment of a beach profile from one shape to one which is in more of an equilibrium condition with the waves and tides. Occurs after placement of nourishment materials at a slope steeper than equilibrium.

Quartz sediment - Sediment formed by solid fragmental material that originates from the weathering of quartz rocks and comprises most sediment along the Atlantic Coast.

Reconnaissance level sand source investigations - Broad scale field investigation to provide sediment stratigraphy and particle size information to identify prospective candidate sand source and to provide information for the preparation of preliminary project design and cost estimates.

Regional sand management - Management of sediment resources based on broad geographic considerations.

Relict - Remnant left after decay, disintegration, or disappearance.

Sediment budget - The mass balance between inputs and outputs of sediment within a defined coastal environment.

Sediment characteristics - Physical attributes of a sediment sample measured by the statistical variations in particle size, chemical composition, density, moisture content, and color. Sediment is a solid fragmental material that originates from weathering of rocks and is transported or deposited by air, water, or ice, or that accumulates by other natural agents, such as chemical precipitation from solution or secretion by organisms (biological origin), and that forms in layers on the Earth's crust or surface at ordinary temperatures in a loose, unconsolidated form (for example, sand, gravel, silt, mud).

Sediment composites - A particle size distribution that represents the overall average of all sediment strata within a borrow site, usually based on multiple sediment grain size distributions weighted accordingly.

Sediment pathways - The routes along which sediment movement occurs.

Shore-parallel structures - Structures that are constructed onshore and parallel to the beach, including seawalls and revetments designed to protect the land and buildings located immediately landward. Shore-parallel structures also include breakwaters and submerged sills located in nearshore waters which act to intercept and reduce the energy of approaching waves.

Shore-perpendicular structures - Structures such as groins and jetties that are constructed perpendicular to the beach and extend out into the water. These types of structures are designed to retard or interrupt the longshore movement of sand and accumulate sand on the beach updrift of the structure.

Shoreline stabilizatiou - Measures to retard erosion to protect upland property. Recognized erosion control measures include seawalls, revetments, jetties, groins, breakwaters, and beach nourishment.

Siliciclastic sediment - Sediment that is composed primarily of fragments of silicate minerals or rock fragments, most commonly quartz.

Storm tide - A rise above normal water level on the open coast due to the action of wind stress on the water surface. Storm surge resulting from a hurricane also includes that rise in level due to atmospheric pressure reduction as well as that due to wind stress.

Tidal delta - An alluvial deposit, usually triangular or semi-circular, at the mouth of a tidal inlet that accumulates as the result of the combination of wave processes and tidal currents.

Tidal flat - Unvegetated sandy or muddy land area that is covered and uncovered by the rise and fall of the tide.

Tombolo - A bar or spit of sand that connects or "ties" an island to the mainland or to another island.

Trough sand accumulation - Where sand accumulates in a long and broad bathymetric low between adjacent sand bars or reefs.

Washover fan - Sediment deposited inland of a beach by overwash processes associated witb storms where elevated water level and large waves transport sediment across the beach.

Wetland - Land whose saturation with water is the dominant factor determining the nature of soil development and the types of plant and animal communities that live in the soil and on its surface.

NEW JERSEY
SHORE PROTECTION STUDY

US Army Corps
of Engineers
Philadelphia District

New Jersey Department
of Environmental
Protection

Hereford Inlet to Cape May Inlet

Volume - 2 Engineering and Technical Appendix

VOLUME 2: ENGINEERING TECHNICAL APPENDIX

Table of Contents

Section 1: General
Section 2: Hydrology and Hydraulics
Section 3: Surveying and Mapping Requirements
Section 4: Geotechnical Investigations
Section 5: Project Design
Section 6 Construction Procedure and Water Control Plan
Section 7: Initial Reservoir Filling and Surveillance Plan (na)
Section 8: Storm Emergency Plan
Section 9: Construction Materials
Section 10: Reservoir Clearing (na)
Section 11: Operation and Maintenance
Section 12: Access Roads
Section 13: Corrosion Mitigation (na)
Section 14: Project Security
Section 15: Cost Estimate
Section 16: Backpass Dredging Technology

Section 1

General

This Engineering and Technical Appendix was prepared in accordance with ER 1110-2-1150, Engineering and Design for Civil Works Projects. Information in this appendix supplements data in the Feasibility report to satisfy criteria in 1110-2-1150

Section 2

Hydrology and Hydraulics/Coastal Processes

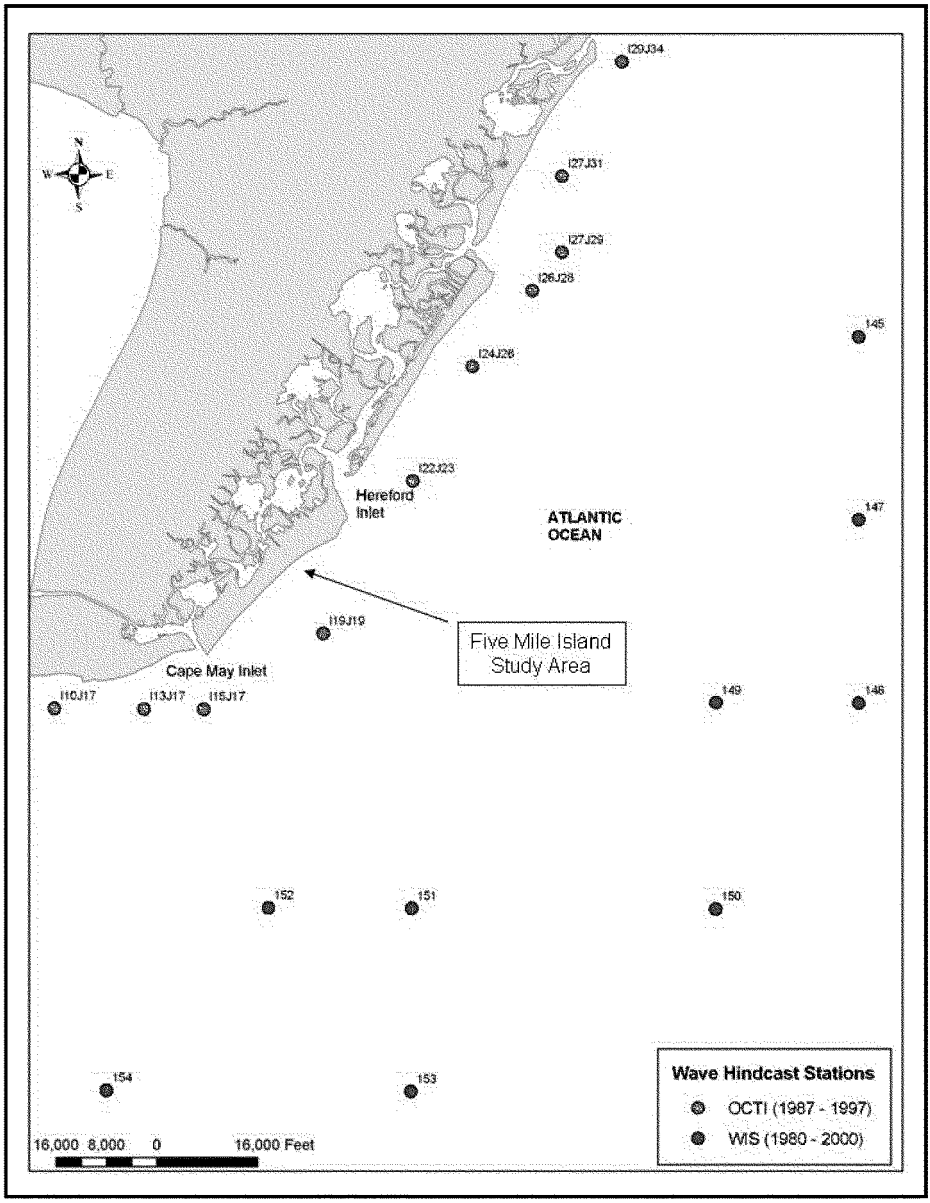


Figure 1. Wave Hindcast Stations

Table 1. Percent Occurrences of Wave Height by Month for WIS Station 147 (1980 – 2000)

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

Table 2. Percent Occurrences of Peak Period by Month for WIS Station 147 (1980 – 2000)

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

Table 3. Percent Occurrences of Mean Direction by Month for WIS Station 147 (1980 – 2000)

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

Table 4. Summary of Mean Hmo (feet) by Month and Year for WIS Station 147 (1980 – 2000)

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

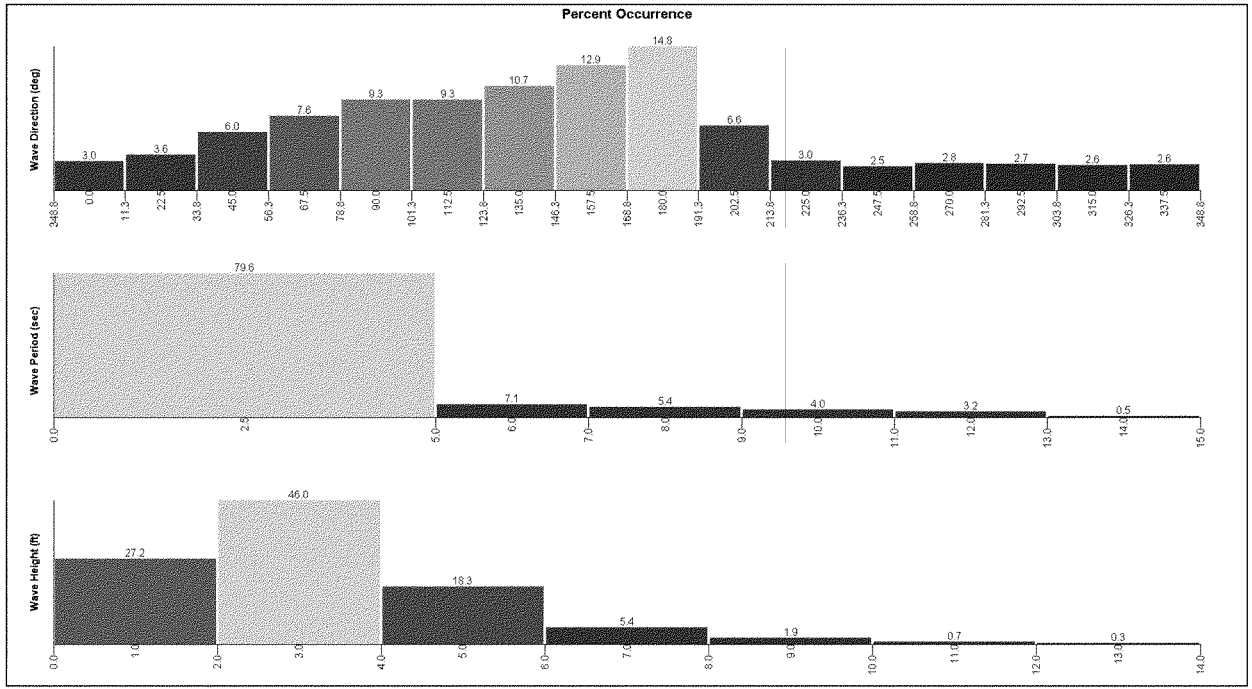
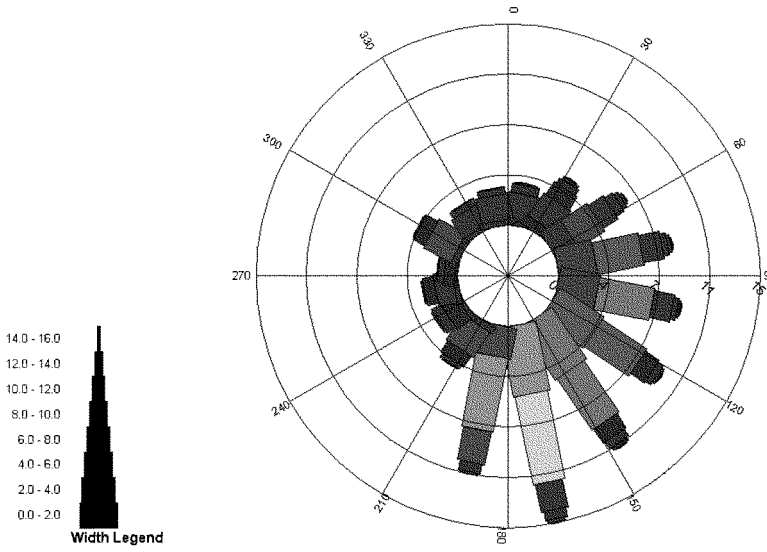
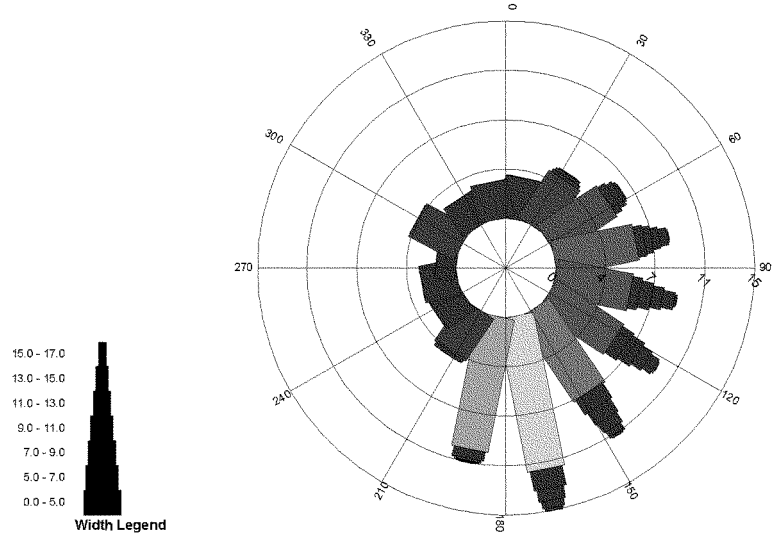


Figure 2. WIS Station 147 Percent Occurrence Wave Direction, Period, and Height Histograms (1980-2000)



(a) Percent Occurrence of Wave Direction vs. Wave Height (feet)



(b) Percent Occurrence of Wave Direction vs. Wave Period (sec)

Figure 3. Wave Roses of WIS Station 147 (1980-2000)

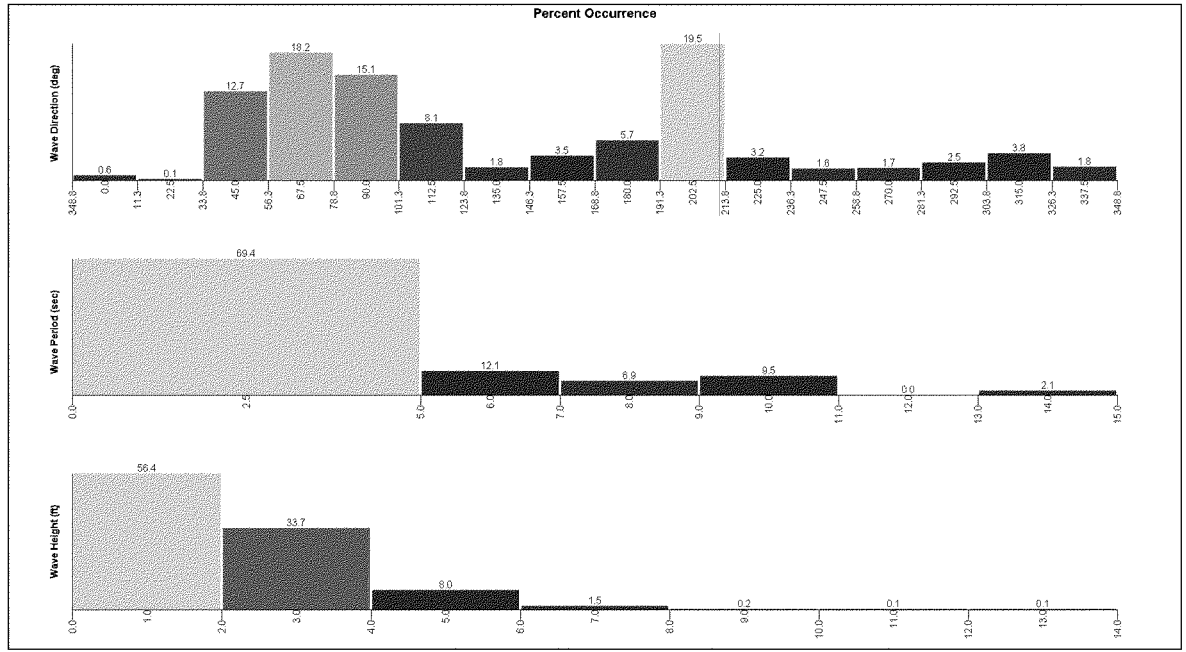
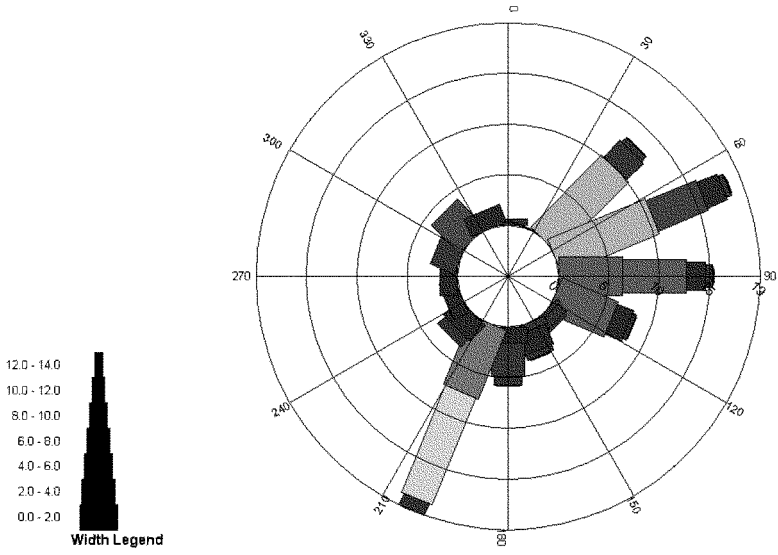
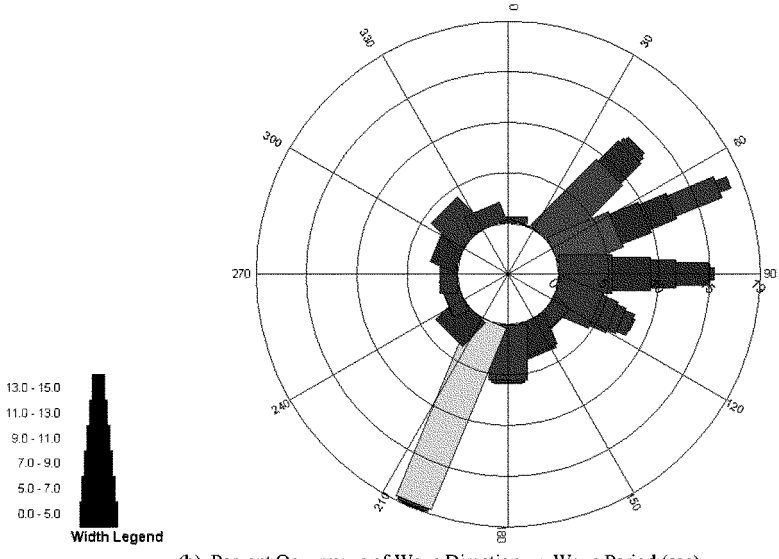


Figure 4. OCTI Station I19J19 Percent Occurrence Wave Direction, Period, and Height Histograms (1987-1997)



(a) Percent Occurrence of Wave Direction vs. Wave Height (feet)



(b) Percent Occurrence of Wave Direction vs. Wave Period (sec)

Figure 5. Wave Roses of OCTI Station I19J19 (1987-1997)

Table 5. Percent Occurrences of Wind Speed by Month for WIS Station 147 (1980 – 2000)

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

Table 6. Percent Occurrences of Wind Direction by Month for WIS Station 147 (1980 – 2000)

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

Table 7. Beach Profile Locations in Study Area

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

WW 18	Lower Township	Coast Guard Base	286+72	389,322.73	42,460.97	loc of LRP NP-120 prof

Table 7 (Continued). Beach Profile Locations in Study Area

Profile Line #	Municipality	Nearby Location Reference	Station (wrt Baseline)	Profile Origin (on Baseline)		Notes
				Easting NJSP NAD 83 (ft)	Northing NJSP NAD 83 (ft)	
CM 208	Lower Township	Coast Guard Base	287+09	389,950.36	41,936.55	
WW 19	Lower Township	Coast Guard Base	301+63	388,406.87	41,300.91	
WW 20	Lower Township	CM Inlet North Jetty	314+04	387,741.09	40,255.00	loc of LRP CS-1 prof

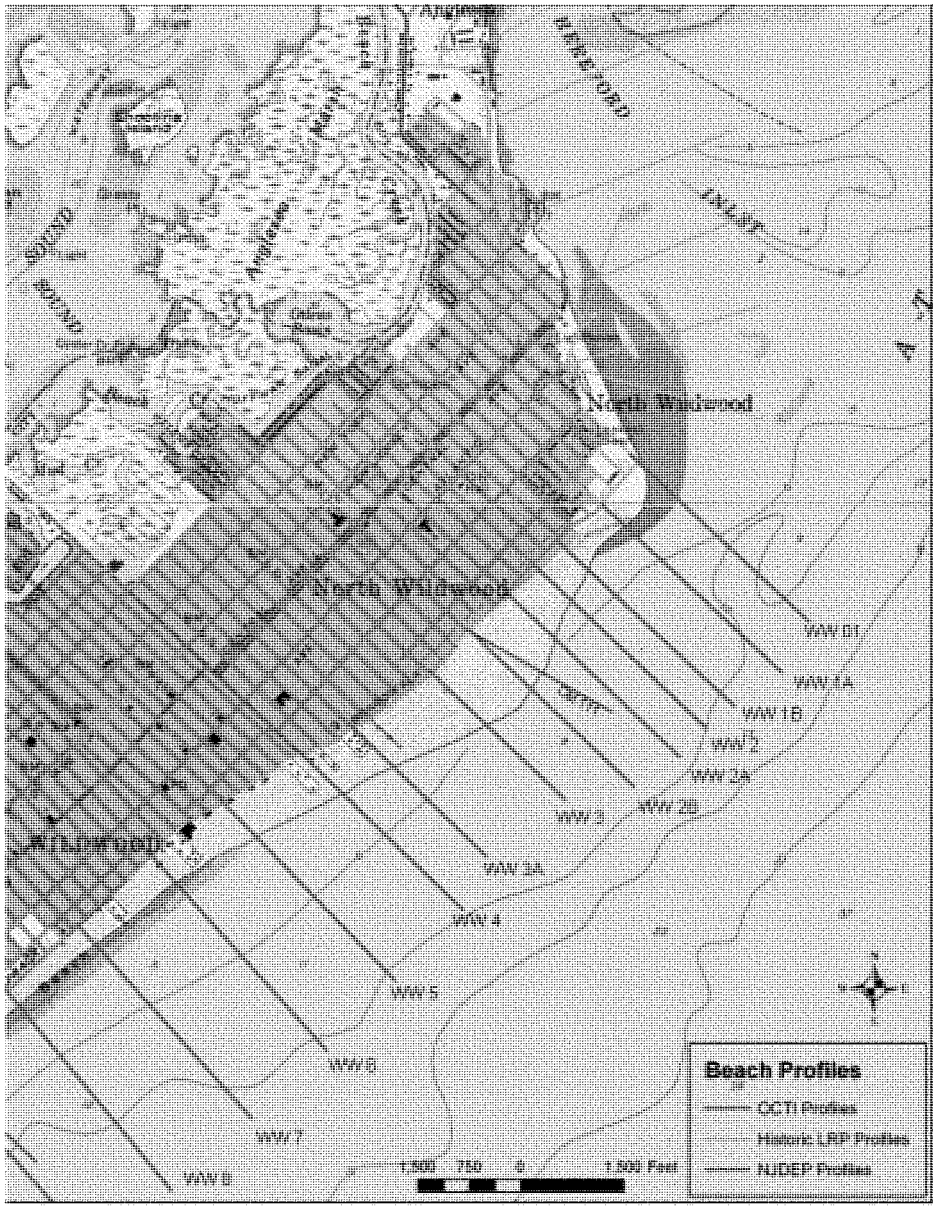


Figure 6. Beach Profile Locations Hereford Inlet to Wildwood

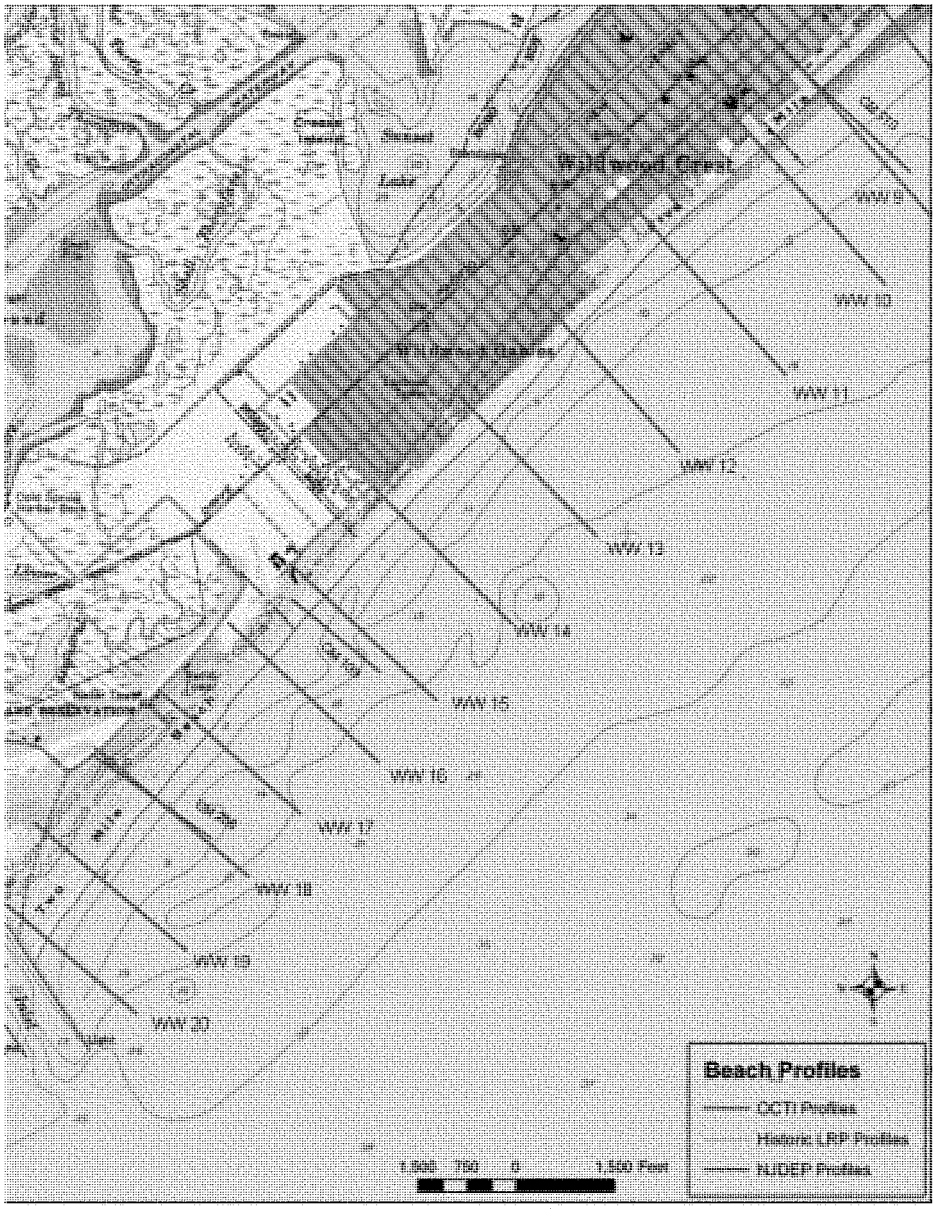


Figure 7. Beach Profile Locations from Wildwood to Cape May Inlet

Table 8. Elevation Parameters of the Beach Profiles Collected By OCTI in 2001 and 2003

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

Table 9. Contour Locations of the Beach Profiles Collected By OCTI in 2001 and 2003

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

Table 10. Shoreline Change Grid Compartments

Analysis Segment	Compartment Number	Compartment Start	Compartment End	Compartment Length (ft)
WW1	1	0	800	800
	2	800	1500	700
	3	1500	2250	750
	4	2250	3150	900
	5	3150	3850	700
	6	3850	4600	750
	7	4600	5400	800
	8	5400	6000	600
	9	6000	6840	840
WW2	1	0	1000	1000
	2	1000	1900	900
	3	1900	2500	600
	4	2500	3200	700
	5	3200	4200	1000
	6	4200	5200	1000
	7	5200	6200	1000
	8	6200	6830	630
WW3	1	0	1000	1000
	2	1000	2000	1000
	3	2000	3000	1000
	4	3000	4000	1000
	5	4000	5000	1000
	6	5000	6000	1000
	7	6000	7000	1000
	8	7000	7700	700
	9	7700	8700	1000
	10	8700	9630	930
WW4	1	0	800	800
	2	800	1600	800
	3	1600	2600	1000
	4	2600	3600	1000
	5	3600	4600	1000
	6	4600	5600	1000
	7	5600	6600	1000
	8	6600	7350	750
	9	7350	7850	500
	10	7850	8350	500
TOTALS	**37**			**31,650**

Table 11. Mean Shoreline Positions (feet) by Compartment

Segment	Comp	1899	1932	1943	1971	1977	1986	1994	1998	2003	Avg	Std Dev
1	1.00	1711.50	1859.10	2056.70		2178.70	2615.40		2321.30	2166.00	2129.81	325.04
	2.00	1845.90	1938.80	1938.70		2749.30	3294.90		2467.00	2180.80	2345.06	575.38
	3.00	1987.20	1996.50	1872.30		3442.80	3441.20		2590.90	2138.10	2495.57	731.47
	4.00	2063.00	2064.70	1879.30		3479.80	3471.30		2678.20	2218.20	2550.64	725.73
	5.00	2031.00	2076.20	1958.40		3355.40	3393.80		2777.50	2375.00	2566.76	669.63
	6.00	1835.50	2086.70	2049.60		3200.00	3294.40		2877.30	2488.90	2547.49	641.72
	7.00	1239.80	2103.40	2000.10		3048.70	3129.70		2936.10	2639.30	2442.44	752.87
	8.00	869.50	2050.40	1920.60		2901.10	2943.70		2909.90	2728.50	2331.96	823.80
	9.00	715.90	2026.10	1897.30		2755.90	2806.10		2864.10	2743.30	2258.39	829.31
2	1.00	632.40	1908.20	1855.30		2616.00	2710.00		2861.80	2802.10	2197.97	832.97
	2.00	672.90	1860.00	1921.60		2481.90	2595.10		2860.90	2866.80	2179.89	785.98
	3.00	743.00	1843.60	2001.20		2380.20	2486.50		2842.60	2896.40	2170.50	732.26
	4.00	768.60	1813.60	2012.50		2301.60	2454.60		2845.90	2920.10	2159.56	715.26
	5.00	774.90	1808.00	2023.80		2223.20	2373.10		2781.10	2917.60	2128.81	683.72
	6.00	831.30	1806.10	2066.70		2160.00	2347.90		2724.70	2894.20	2118.70	644.84
	7.00	946.40	1805.90	2063.60		2121.70	2355.00		2686.70	2862.10	2120.20	593.99
	8.00	1073.90	1797.30	2120.00	2031.10	2117.30	2342.90		2649.20	2851.20	2122.86	494.04
3	1.00	1134.60	1766.70	2099.60	2042.00	2091.90	2354.80		2604.90	2797.80	2111.54	467.97
	2.00	1146.70	1740.90	2076.20	2070.50	2066.70	2276.60		2516.40	2689.90	2072.99	438.19
	3.00	1177.90	1699.70	2012.90	2053.70	2025.60	2238.00		2420.60	2592.70	2027.64	404.88
	4.00	1188.50	1695.10	1897.00	2075.70	2033.20	2201.30		2354.90	2535.50	1997.65	385.47
	5.00	1151.70	1708.40	1889.30	2103.10	2088.10	2197.40		2340.00	2475.30	1994.16	398.11
	6.00	1080.80	1740.20	1892.00		2155.60	2241.60		2352.60	2459.90	1988.96	465.38
	7.00	942.60	1770.50	1891.90		2237.70	2289.40		2362.90	2481.60	1996.66	531.39
	8.00	620.00	1841.00	1931.70		2272.20	2325.30		2382.70	2475.40	1978.33	662.60
	9.00		1874.40	1944.90	2245.40	2292.20	2347.20		2394.50	2480.70	2225.61	218.83
	10.00		1961.50	1998.40	2277.00	2333.20	2404.90		2421.80	2476.50	2267.61	202.94

Table 11 (Continned). Mean Shoreline Positions (feet) by Compartment

Segment	Comp	1899	1932	1943	1971	1977	1986	1994	1998	2003	Avg	Std Dev
4	1.00		2036.60	2040.60	2290.70	2353.80	2472.10		2436.20	2496.30	2303.76	191.31
	2.00		2056.40	2050.60	2276.90	2340.90	2454.10	2386.60	2403.90	2485.40	2306.85	165.00
	3.00	1795.80	2069.80	2140.10	2272.20	2327.60	2396.30	2396.00	2404.10	2456.70	2250.96	213.45
	4.00	2203.50	2085.00	2167.60	2325.00	2358.00	2397.70	2411.70	2407.60	2455.70	2312.42	125.59
	5.00	2078.90	2074.20	2199.50	2376.10	2389.80	2410.80	2412.00	2408.60	2469.90	2313.31	151.25
	6.00	1644.30	2119.90	2248.70	2399.60	2430.10	2480.40	2437.10	2437.80	2492.50	2298.93	282.10
	7.00	1122.50	2203.70	2347.90	2439.20	2469.70	2546.00	2483.30	2508.80	2554.80	2297.32	474.23
	8.00	775.90	2296.30	2478.30	2519.90	2515.40	2589.20	2544.40	2553.80	2621.50	2321.63	615.89
	9.00	504.10	2362.30	2538.90	2606.10	2587.30	2682.20	2604.40	2608.70	2678.00	2352.44	736.34
	10.00		2364.50	2612.30	2687.30	2663.60	2783.60	2648.20	2666.40	2709.80	2641.96	129.38

Table 12. Shoreline Change Rates (feet/year) by Epochs

Segment	Comp #	Length	1899-1932	1932-1943	1943-1971	1943-1977	1977-1986	1986-1994	1994-1998	1986-1998	1998-2003
1	1	800	4.47	17.96		3.59	48.52			-23.85	-30.57
	2	700	2.82	-0.01		23.84	60.62			-67.15	-56.34
	3	750	0.28	-11.29		46.19	-0.18			-68.96	-89.13
	4	900	0.05	-16.85		47.07	-0.94			-64.32	-90.55
	5	700	1.37	-10.71		41.09	4.27			-49.98	-79.23
	6	750	7.61	-3.37		33.84	10.49			-33.83	-76.46
	7	800	26.17	-9.39		30.84	9.00			-15.70	-58.43
	8	600	35.78	-11.80		28.84	4.73			-2.74	-35.71
	9	840	39.70	-11.71		25.25	5.58			4.70	-23.78
2	1	1000	38.66	-4.81		22.37	10.40			12.65	-11.75
	2	900	35.97	5.60		16.48	12.58			21.56	1.16
	3	600	33.35	14.33		11.15	11.81			28.88	10.59
	4	700	31.67	18.08		8.50	17.00			31.74	14.61
	5	1000	31.31	19.62		5.86	16.66			33.09	26.87
	6	1000	29.54	23.69		2.74	20.88			30.56	33.37
	7	1000	26.05	23.43		1.71	25.92			26.90	34.53
	8	630	21.92	29.34		-0.08	25.07			24.84	39.76
3	1	1000	19.15	30.26	-2.07	8.33	29.21			20.28	37.97
	2	1000	18.01	30.48	-0.20	-0.63	23.32			19.45	34.15
	3	1000	15.81	28.47	1.46	-4.68	23.60			14.81	33.88
	4	1000	15.35	18.35	6.38	-7.08	18.68			12.46	35.55
	5	1000	16.87	16.45	7.64	-2.50	12.14			11.57	26.63
	6	1000	19.98	13.80			9.56			9.00	21.12
	7	1000	25.09	11.04			5.74			5.96	23.37
	8	700	37.00	8.25			5.90			4.66	18.25
	9	1000		6.41	10.73	7.80	6.11			3.84	16.97
	10	930		3.35	9.95	9.37	7.97			1.37	10.77

Table 12 (Continued). Shoreline Change Rates (feet/year) by Epochs

Segment	Comp #	Length	1899-1932	1932-1943	1943-1971	1943-1977	1977-1986	1986-1994	1994-1998	1986-1998	1998-2003
4	1	800		0.36	8.93	10.52	13.14			-2.91	11.83
	2	800		-0.53	8.08	10.67	12.58	-7.95	4.51	-4.07	16.04
	3	1000	8.30	6.39	4.72	9.23	7.63	-0.04	2.11	0.63	10.35
	4	1000	-3.59	7.51	5.62	5.50	4.41	1.65	-1.07	0.80	9.47
	5	1000	-0.14	11.39	6.31	2.28	2.33	0.14	-0.89	-0.18	12.07
	6	1000	14.41	11.71	5.39	5.08	5.59	-5.10	0.18	-3.45	10.77
	7	1000	32.76	13.11	3.26	5.08	8.48	-7.39	6.64	-3.02	9.06
	8	750	46.07	16.55	1.49	-0.75	8.20	-5.28	2.45	-2.87	13.33
	9	500	56.31	16.05	2.40	-3.13	10.54	-9.16	1.12	-5.96	13.64
	10	500		22.53	2.68	-3.95	13.33	-15.95	4.74	-9.51	8.54

Table 13. Shoreline Change Rates (feet/year) Relative to 2003

Segment	Comp #	Length	1899-2003	1932-2003	1943-2003	1971-2003	1977-2003	1986-2003	1998-2003
1	1	800	6.26	5.92	3.83		-3.27	-25.45	-30.57
	2	700	8.59	9.41	7.22		-27.52	-64.58	-56.34
	3	750	9.31	10.77	7.75		-51.40	-73.75	-89.13
	4	900	9.37	11.25	9.02		-49.25	-70.55	-90.55
	5	700	10.09	11.92	10.01		-38.06	-56.93	-79.23
	6	750	11.63	12.12	10.41		-26.80	-43.95	-76.46
	7	800	16.11	13.08	13.10		-14.53	-25.85	-58.43
	8	600	18.65	13.94	15.03		-5.29	-10.57	-35.71
	9	840	19.17	13.64	15.25		0.84	-2.06	-23.78
2	1	1000	19.89	14.84	16.43		8.36	5.29	-11.75
	2	900	19.55	15.04	16.13		15.93	16.71	1.16
	3	600	18.56	14.34	14.93		21.15	24.54	10.59
	4	700	18.94	15.27	13.80		24.86	27.67	14.61
	5	1000	17.72	13.84	14.39		27.29	31.61	26.87
	6	1000	16.74	12.95	13.11		28.08	31.23	33.37
	7	1000	15.60	12.51	12.66		27.72	28.71	34.53
	8	630	15.00	14.18	12.10	25.20	27.07	28.39	39.76
3	1	1000	13.68	11.69	10.90	23.32	25.51	24.49	37.97
	2	1000	12.57	10.65	10.08	19.69	22.73	22.94	34.15
	3	1000	11.68	10.08	9.36	17.15	20.19	19.34	33.88
	4	1000	11.33	10.03	9.88	14.43	17.66	17.94	35.55
	5	1000	11.33	9.47	9.11	11.59	13.92	15.14	26.63
	6	1000	11.89	9.31	8.97		10.92	11.88	21.12
	7	1000	13.15	9.44	9.18		8.42	10.10	23.37
	8	700	15.29	8.70	8.60		7.00	7.88	18.25
	9	1000		8.45	8.36	6.50	6.42	6.96	16.97
	10	930		7.59	7.69	5.50	4.70	3.60	10.77
4	1	800		7.03	7.44	5.46	4.01	0.59	11.83
	2	800		6.45	6.95	5.25	3.80	0.71	16.04
	3	1000	6.07	5.32	5.16	5.00	4.13	2.94	10.35
	4	1000	3.16	5.00	4.53	3.49	3.13	2.86	9.47
	5	1000	4.20	5.04	3.99	2.27	2.34	2.73	12.07
	6	1000	7.46	4.83	3.73	2.04	1.30	-0.08	10.77
	7	1000	11.44	4.42	3.35	2.95	2.16	-0.15	9.06
	8	750	13.98	3.52	2.10	2.65	2.77	0.98	13.33
	9	500	16.39	3.50	1.99	1.73	1.80	-1.30	13.64
	10	500		3.87	1.50	0.35	-0.09	-5.22	8.54

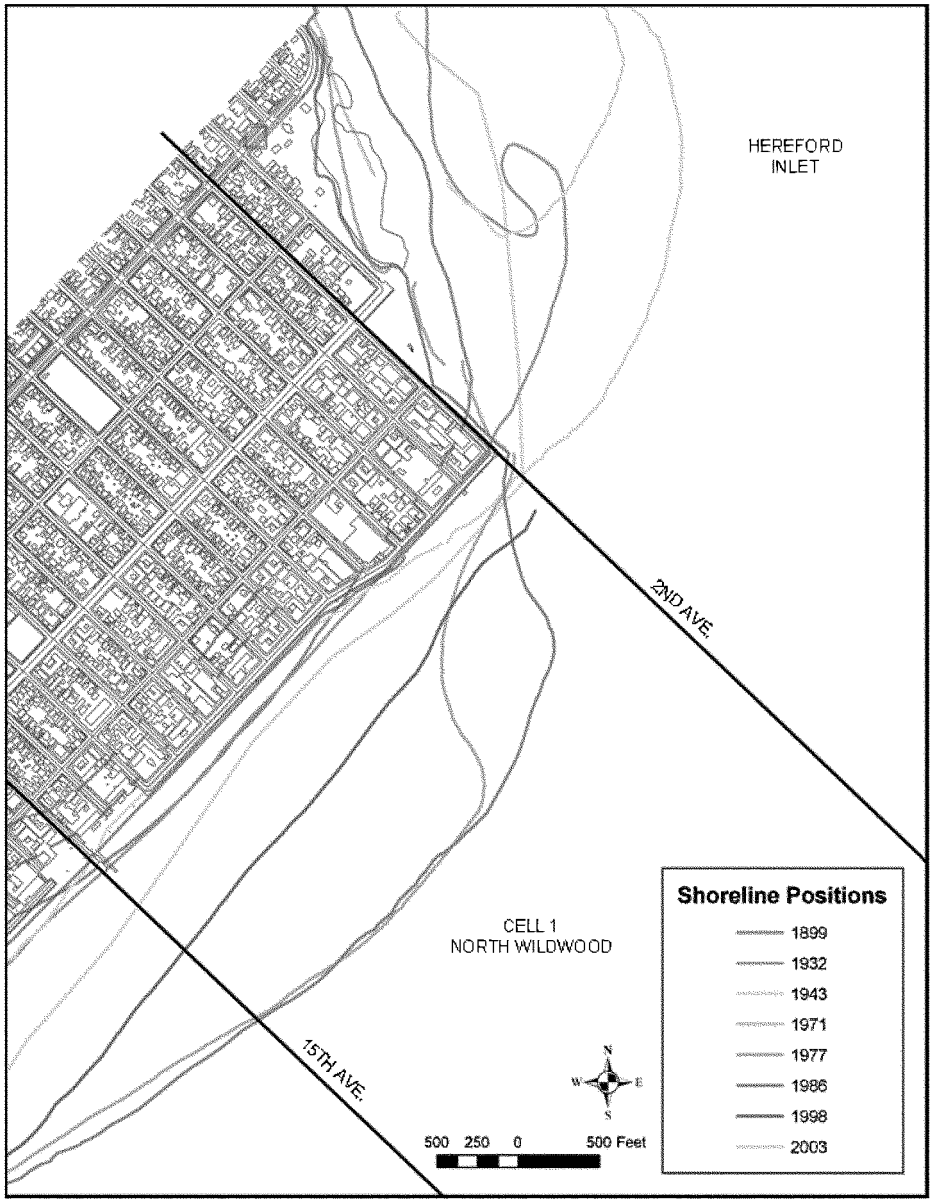


Figure 8. North Wildwood Shoreline Positions

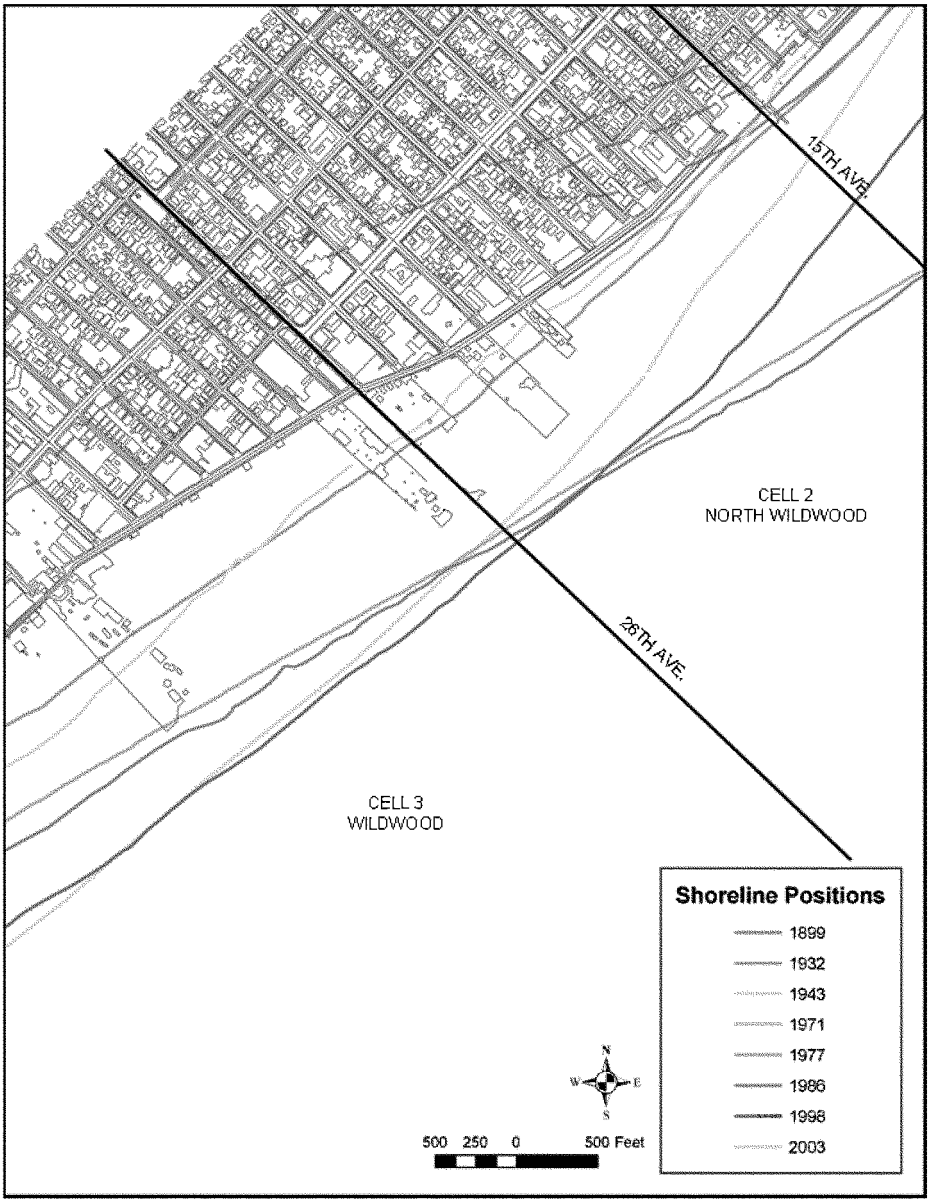


Figure 9. North Wildwood and Wildwood Shoreline Positions

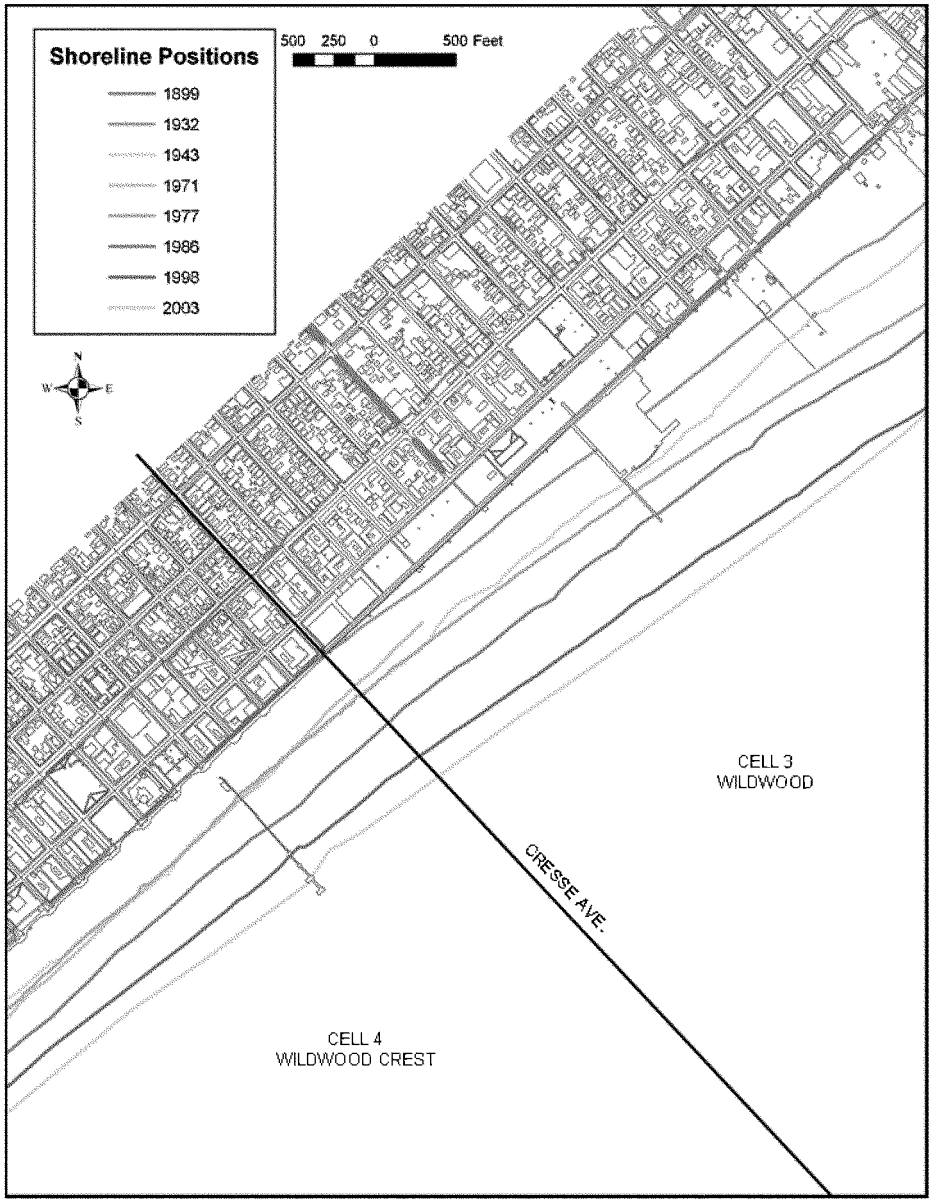


Figure 10. Wildwood and Wildwood Crest Shoreline Positions

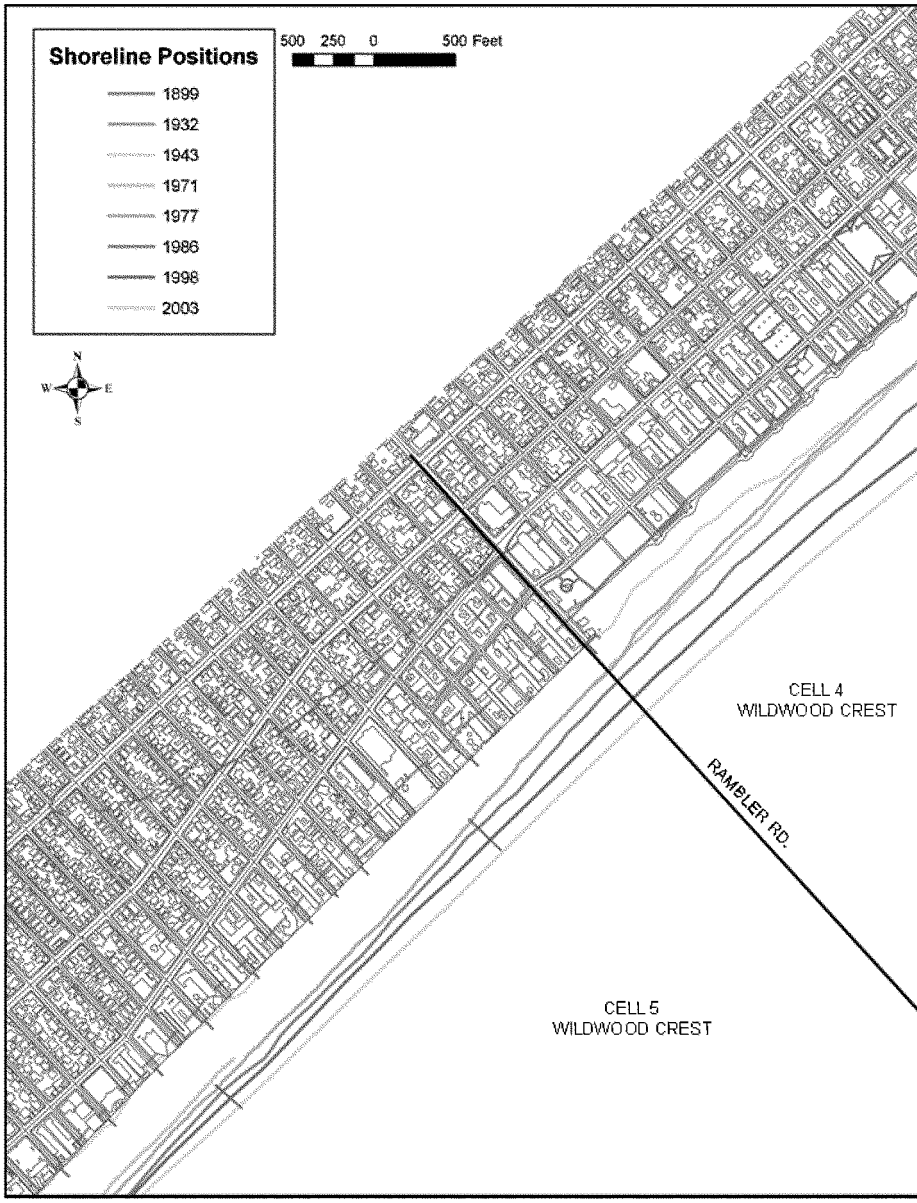


Figure 11. Wildwood Crest Shoreline Positions

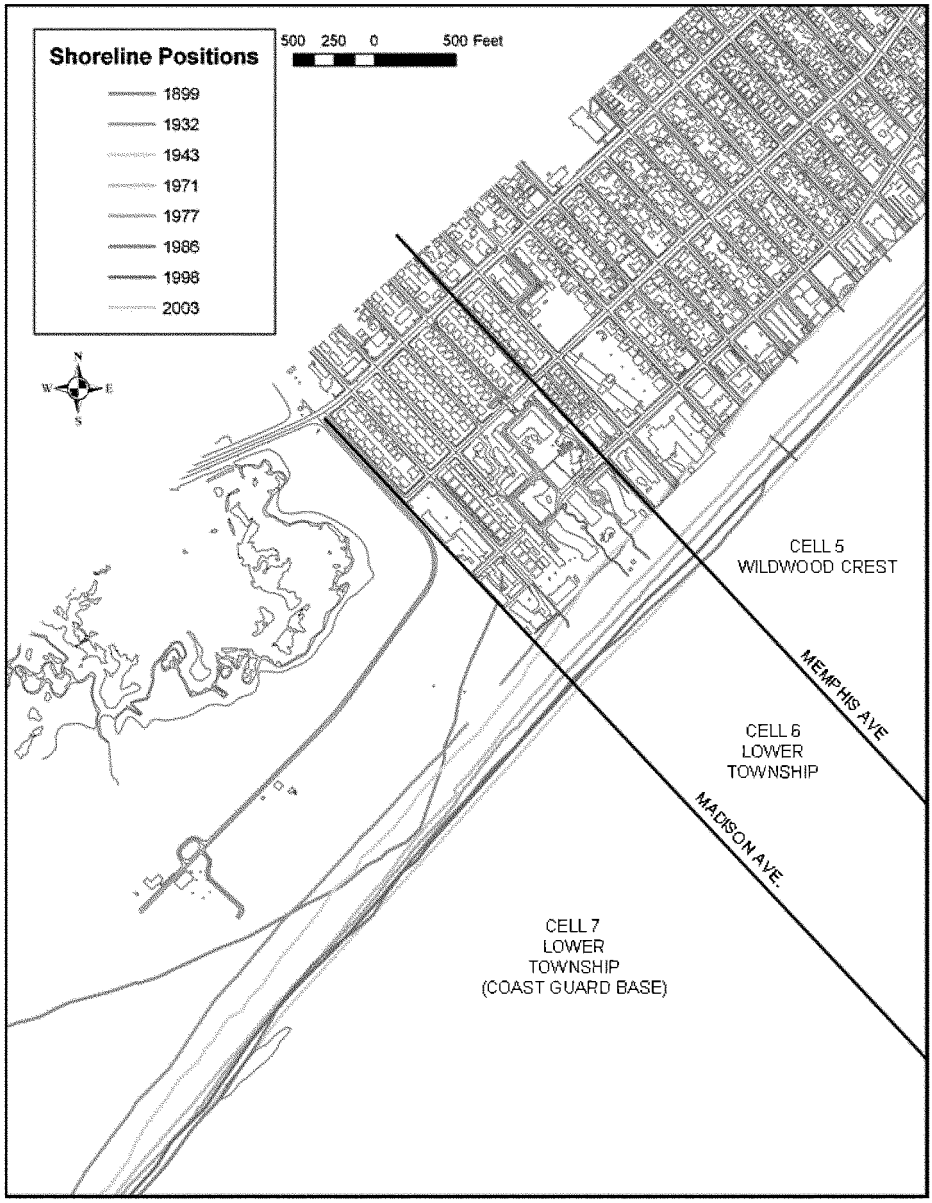


Figure 12. Lower Township Shoreline Positions

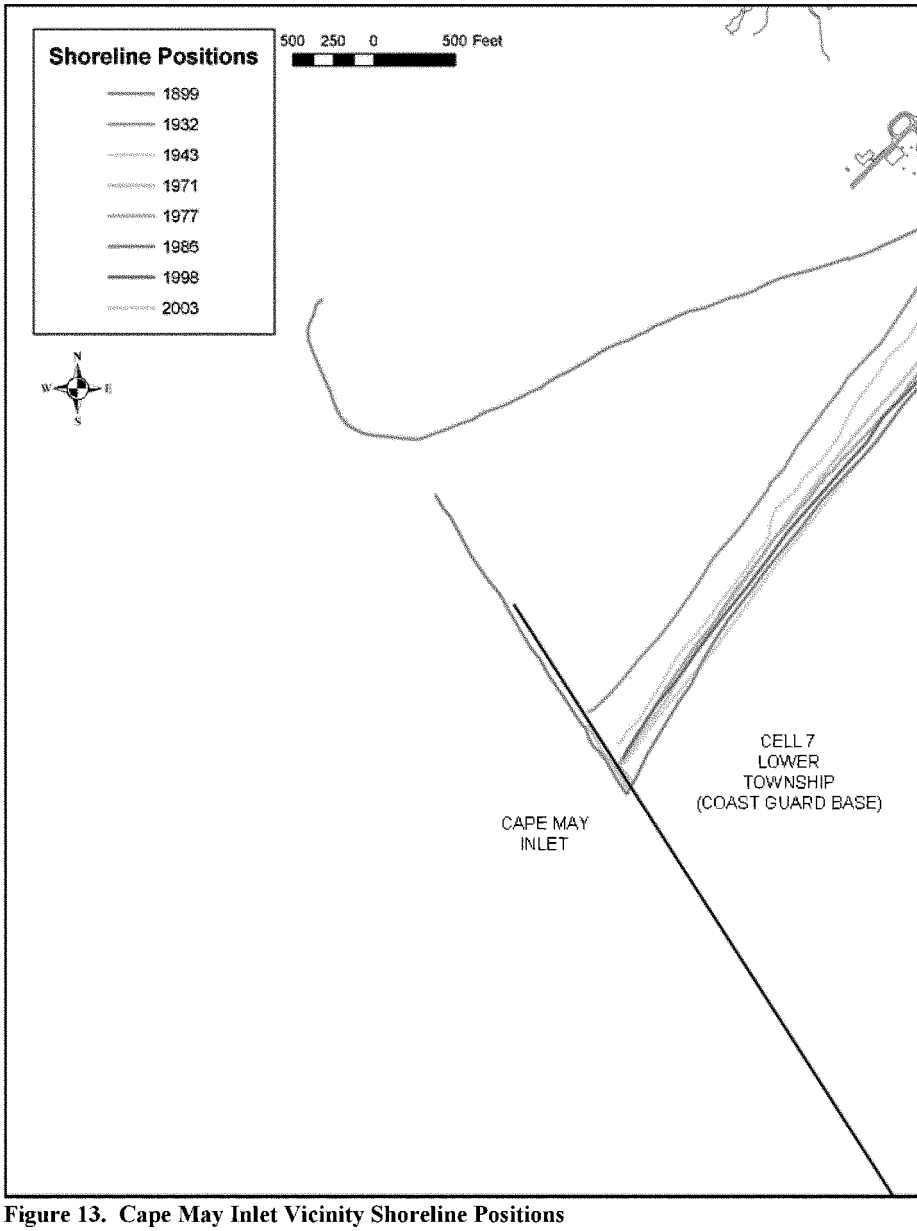


Figure 13. Cape May Inlet Vicinity Shoreline Positions

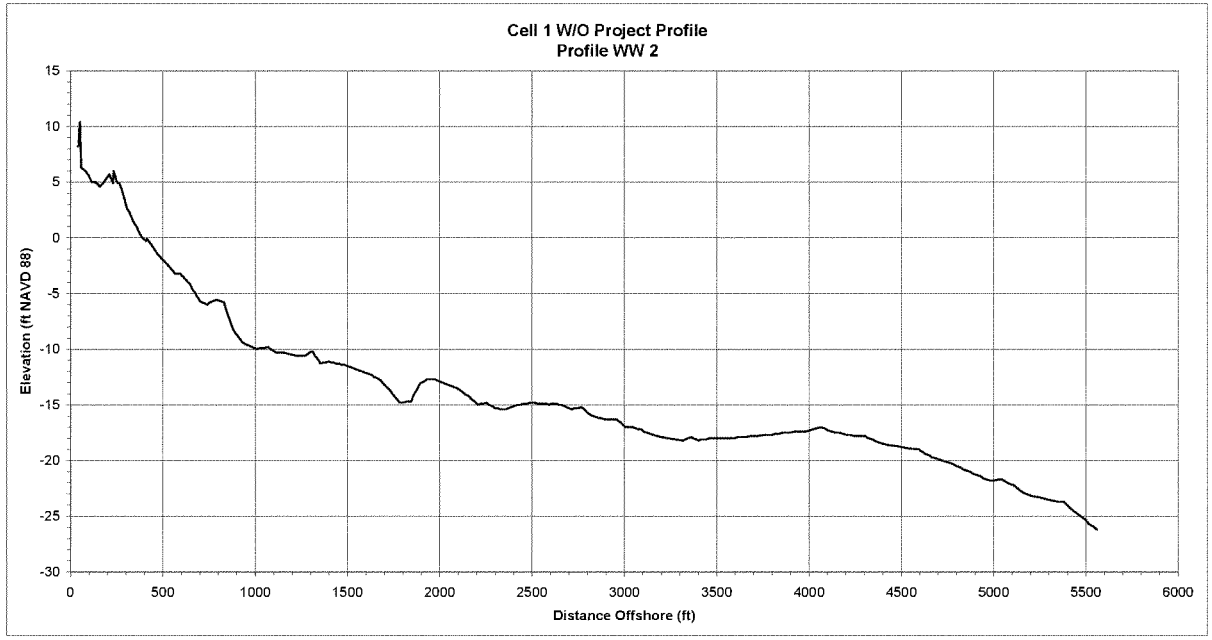


Figure 14. W/O Project Conditions Profile for Cell 1

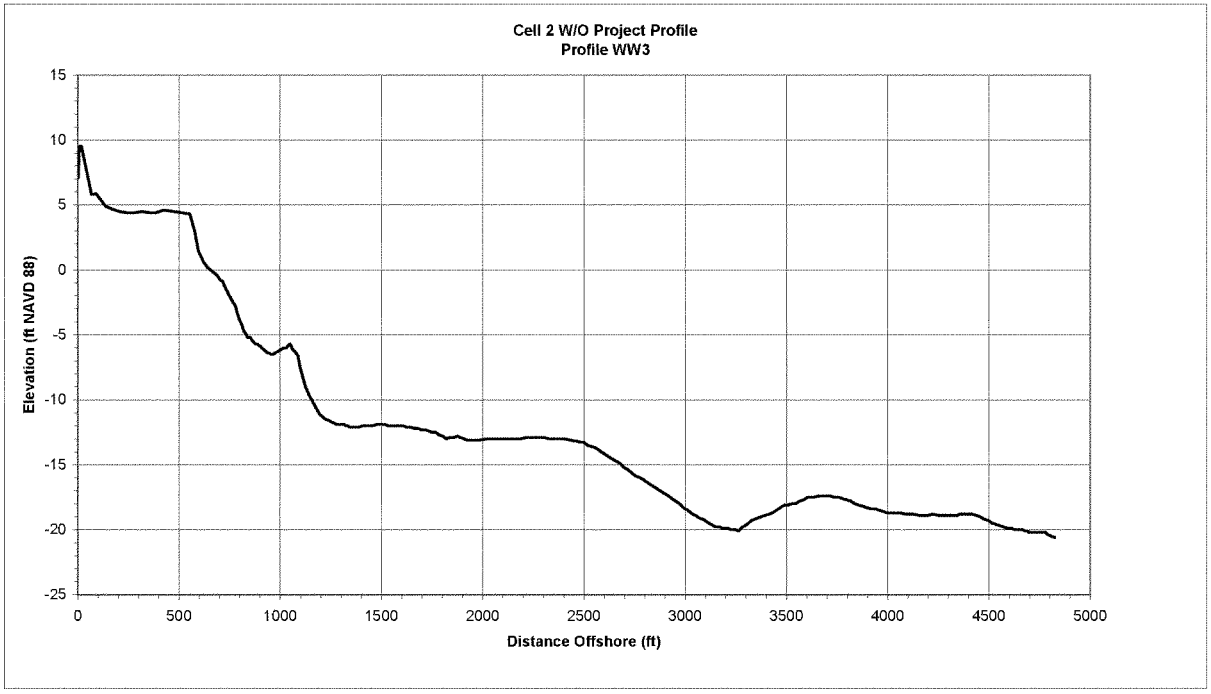


Figure 15. W/O Project Conditions Profile for Cell 2

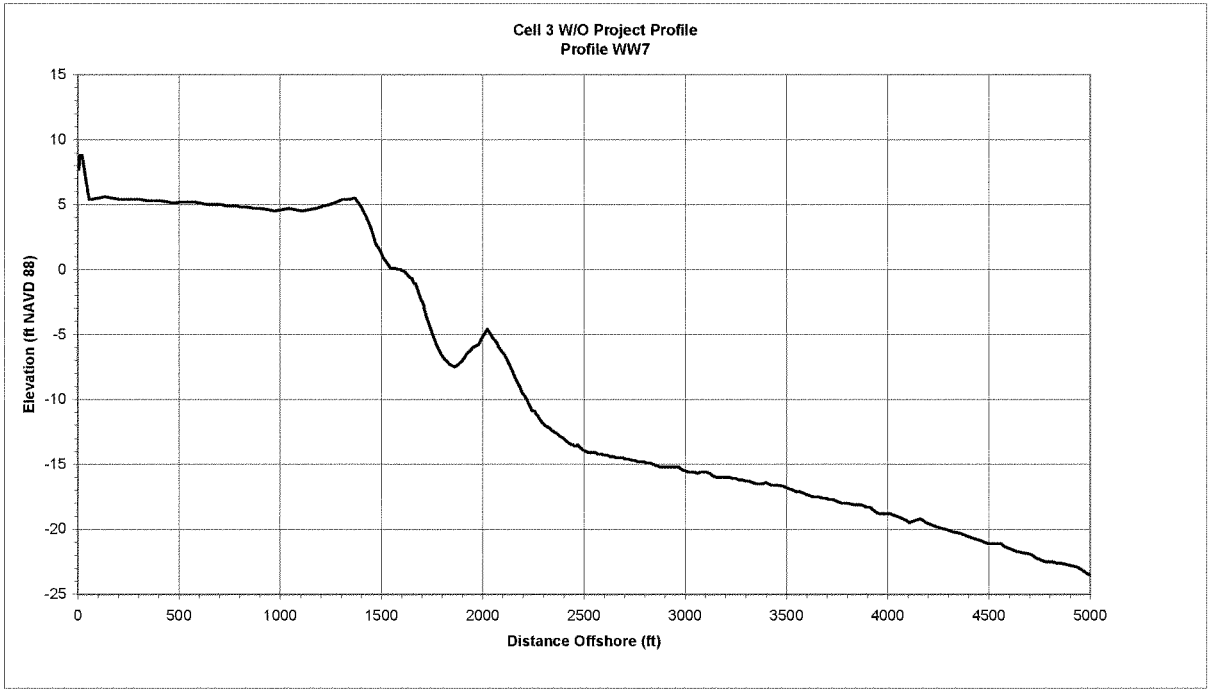


Figure 16. W/O Project Conditions Profile for Cell 3

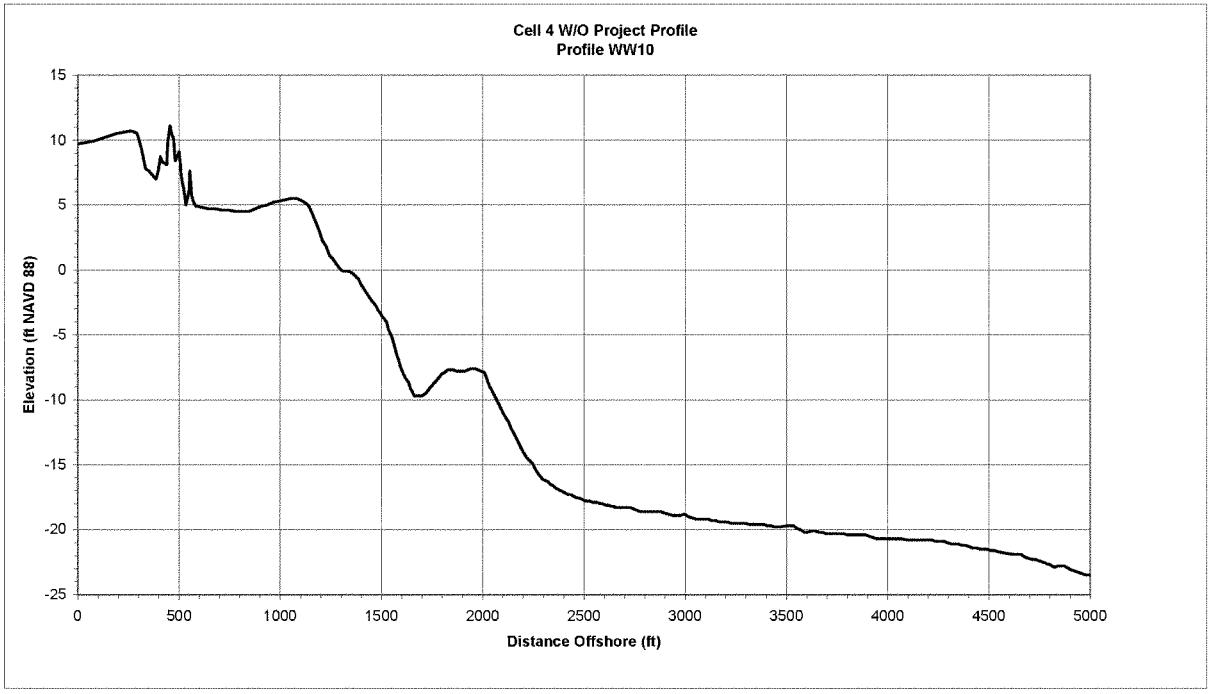


Figure 17. W/O Project Conditions Profile for Cell 4

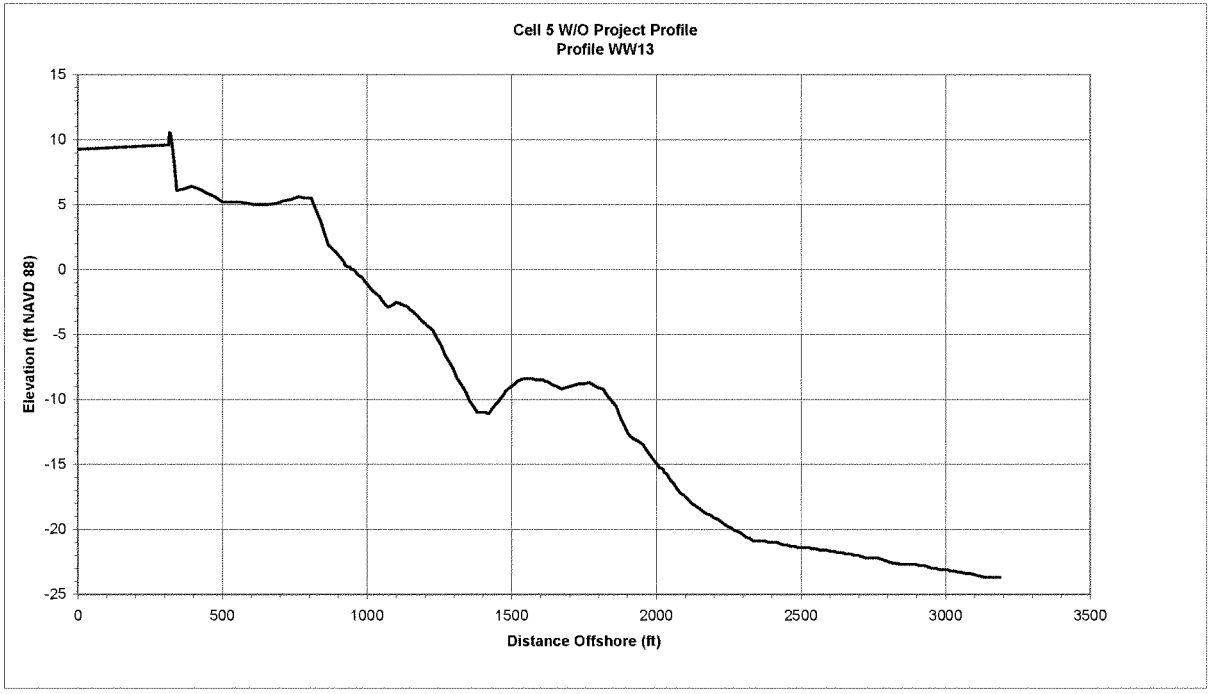


Figure 18. W/O Project Conditions Profile for Cell 5

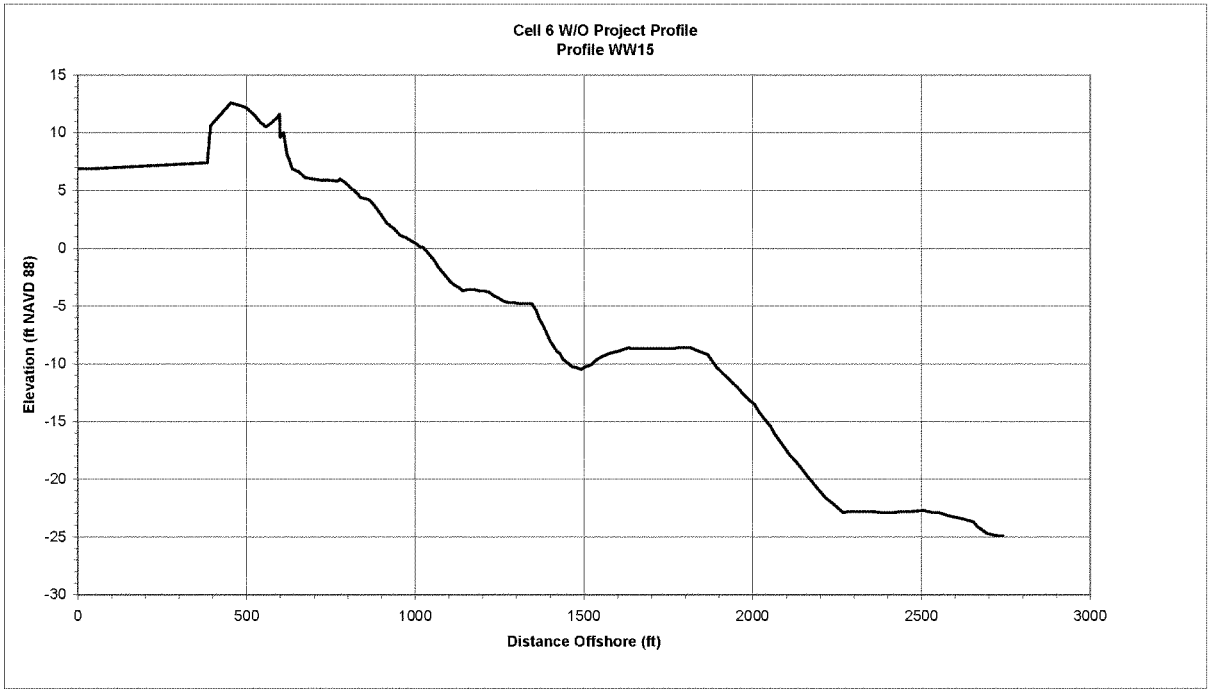


Figure 19. W/O Project Conditions Profile for Cell 6

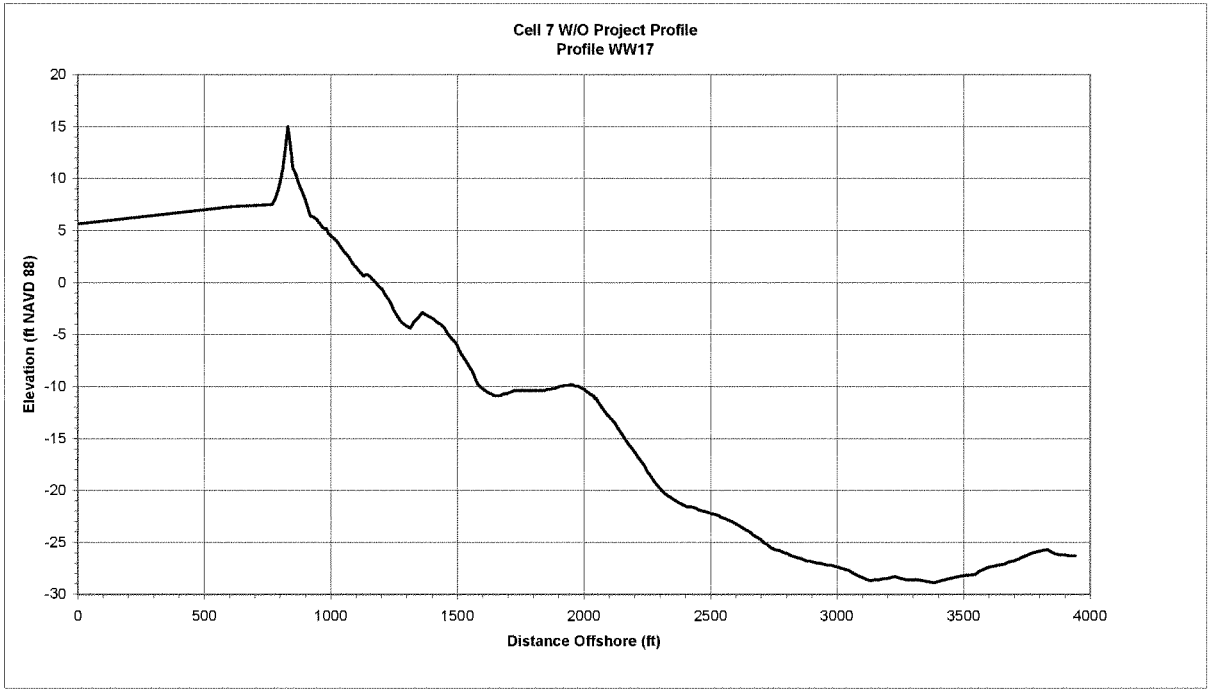


Figure 20. W/O Project Conditions Profile for Cell 7

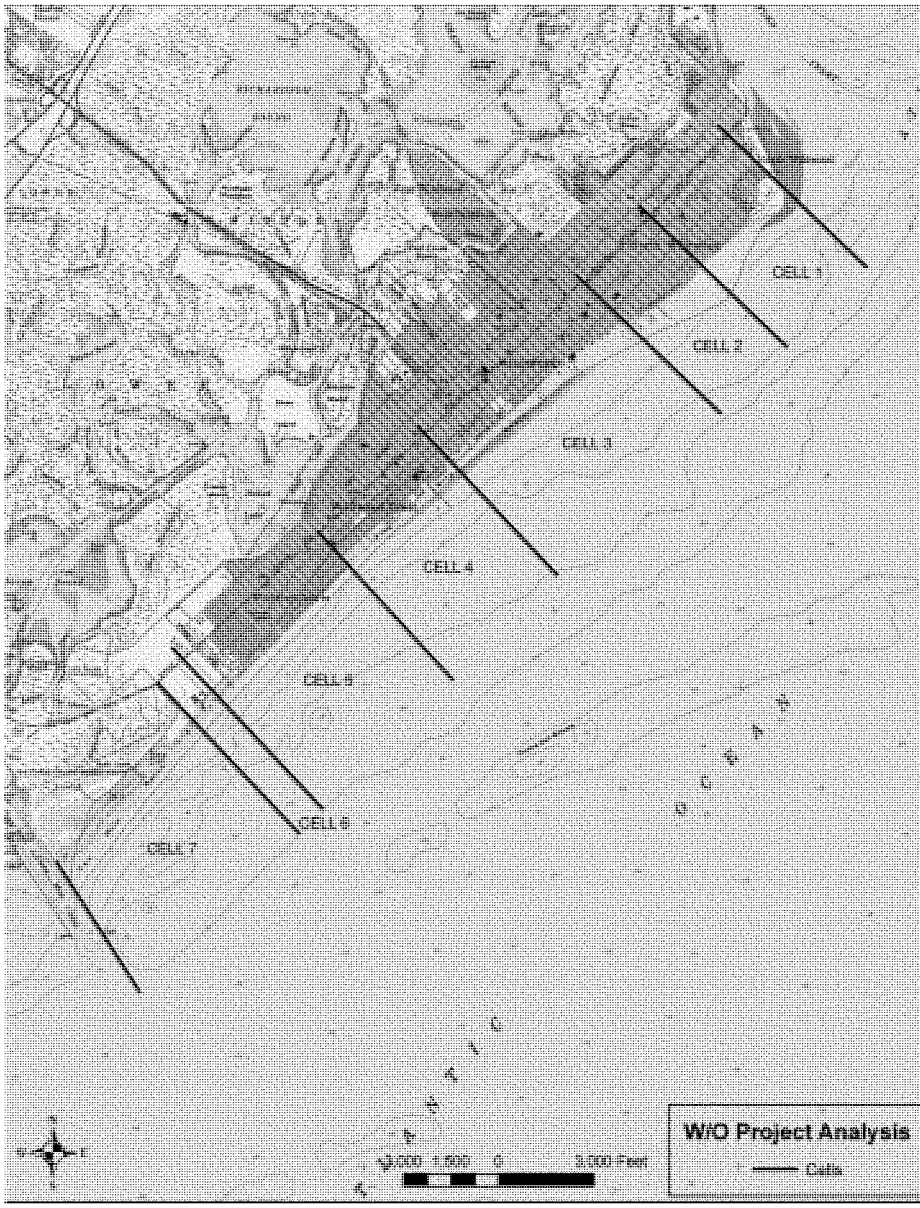


Figure 21. Cell Limits

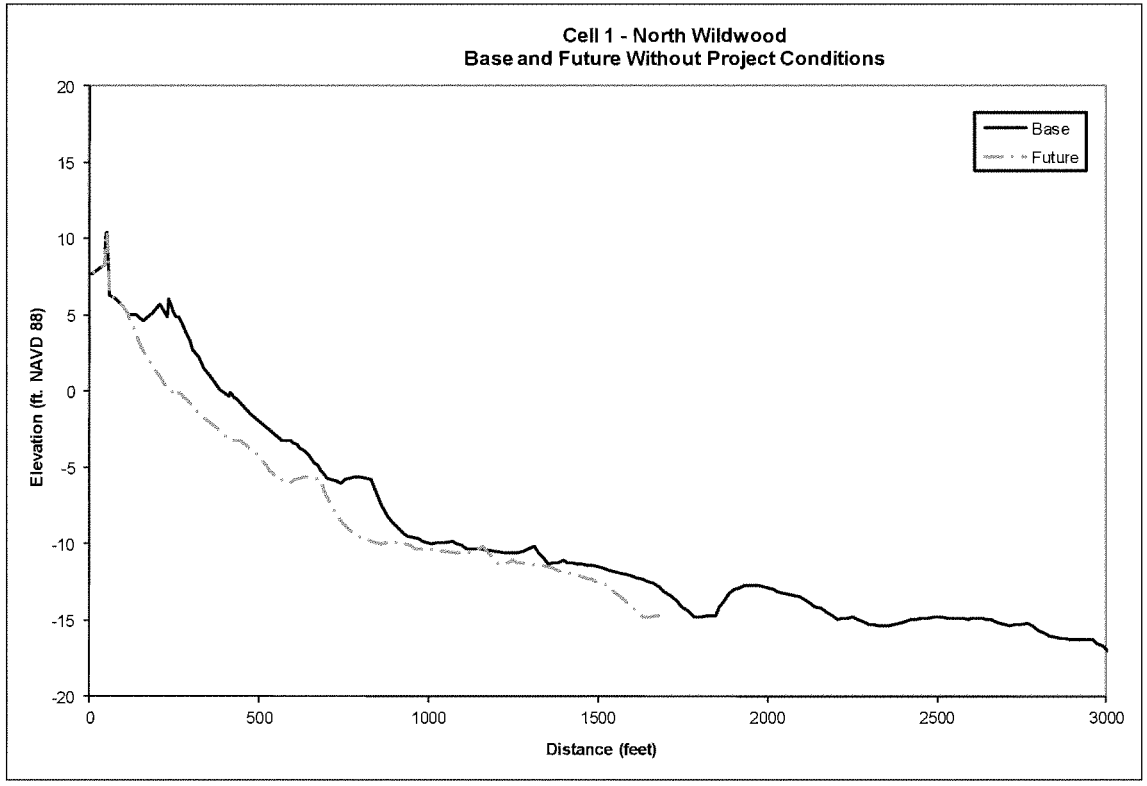


Figure 22. Base and Future Without Project Conditions for Cell 1

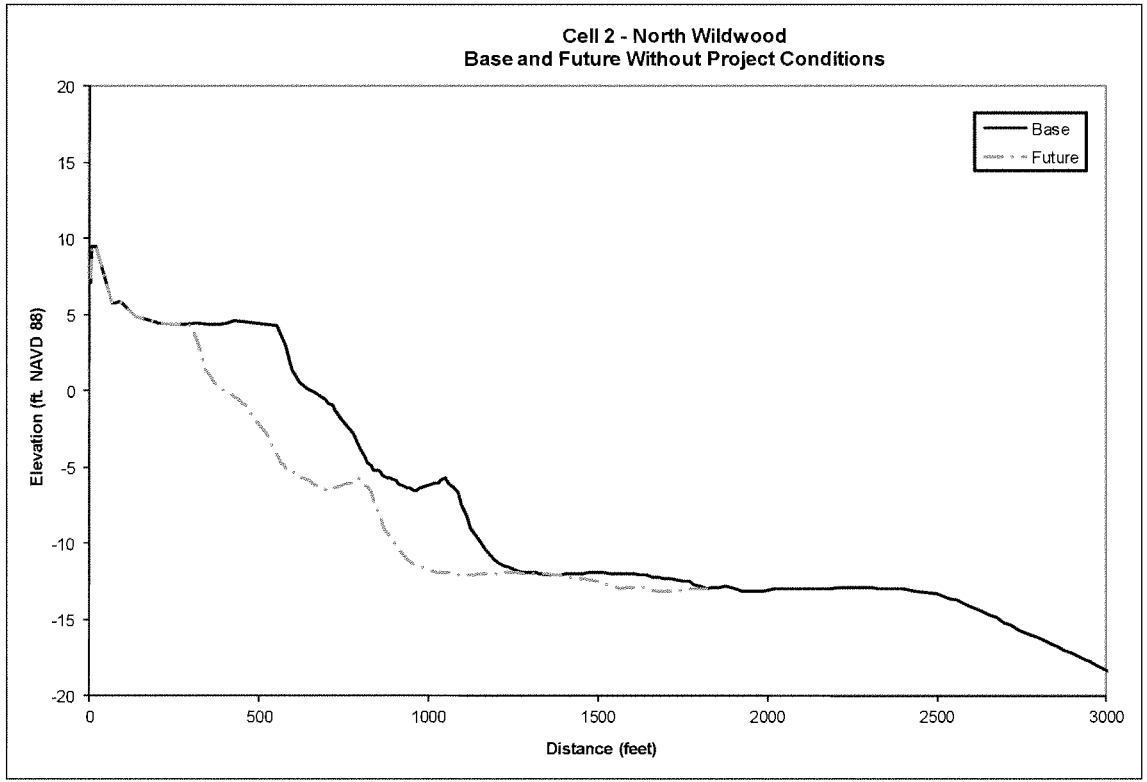


Figure 23. Base and Future Without Project Conditions for Cell 2

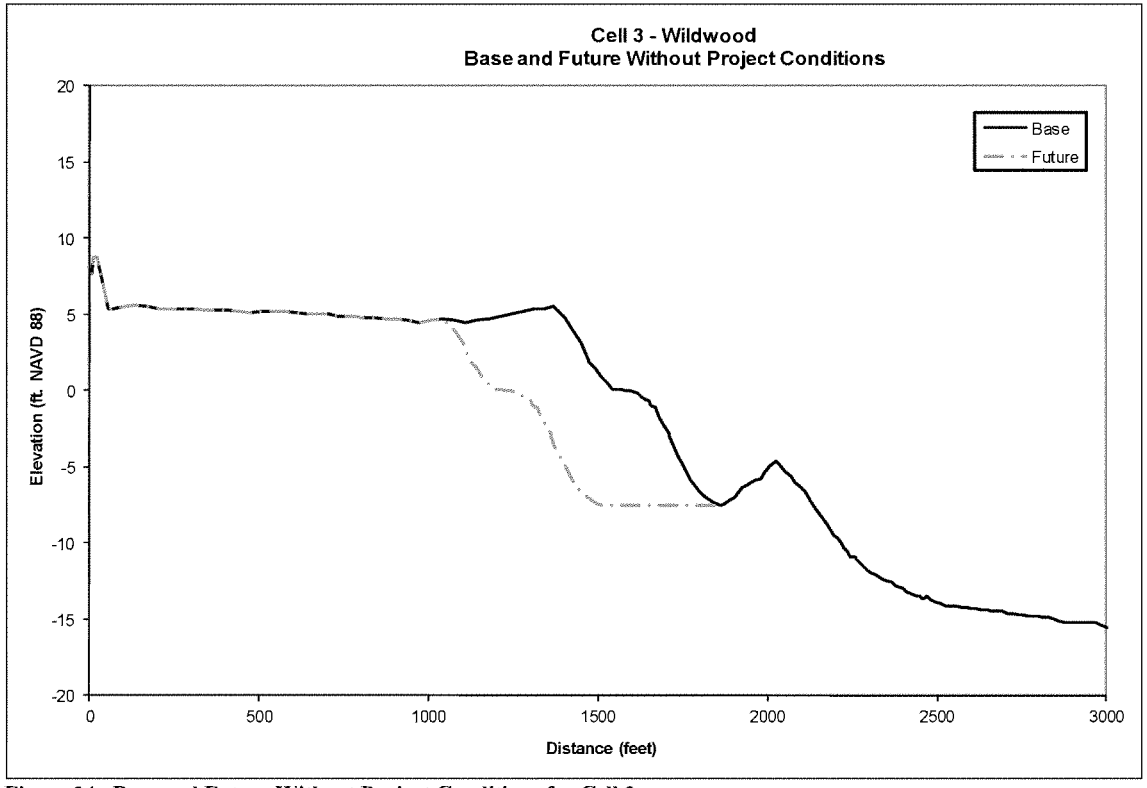


Figure 24. Base and Future Without Project Conditions for Cell 3

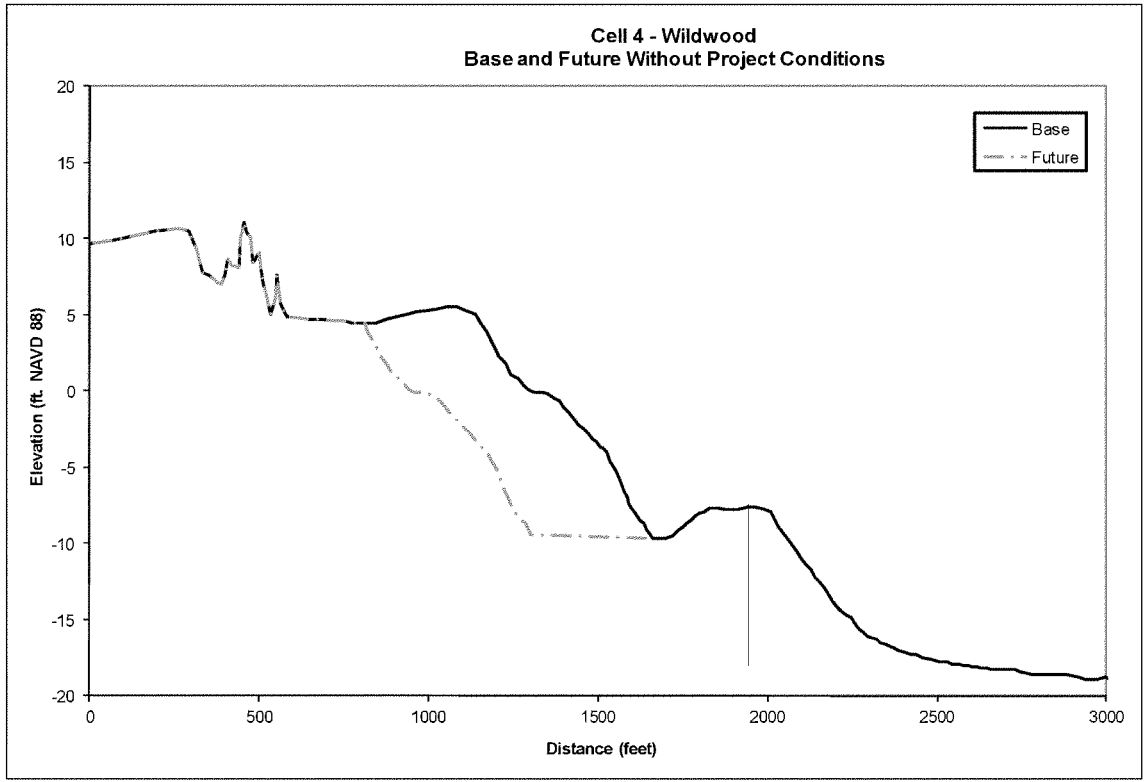


Figure 25. Base and Future Without Project Conditions for Cell 4

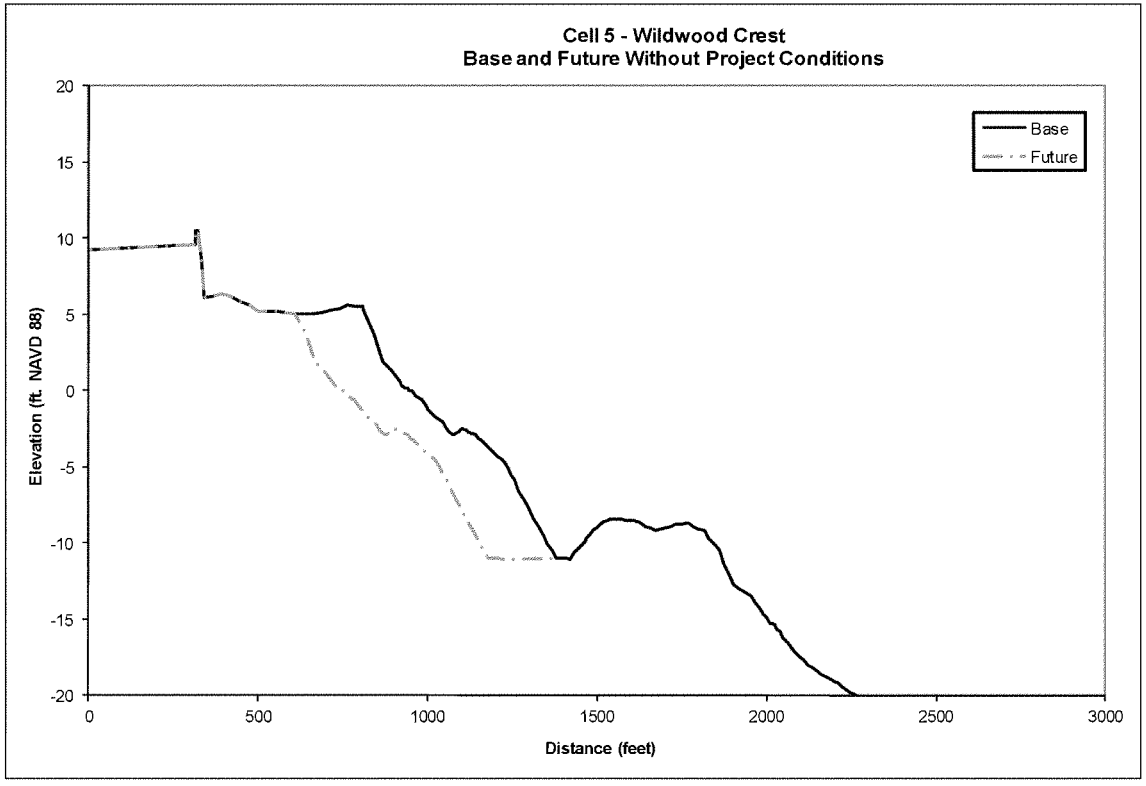


Figure 26. Base and Future Without Project Conditions for Cell 5

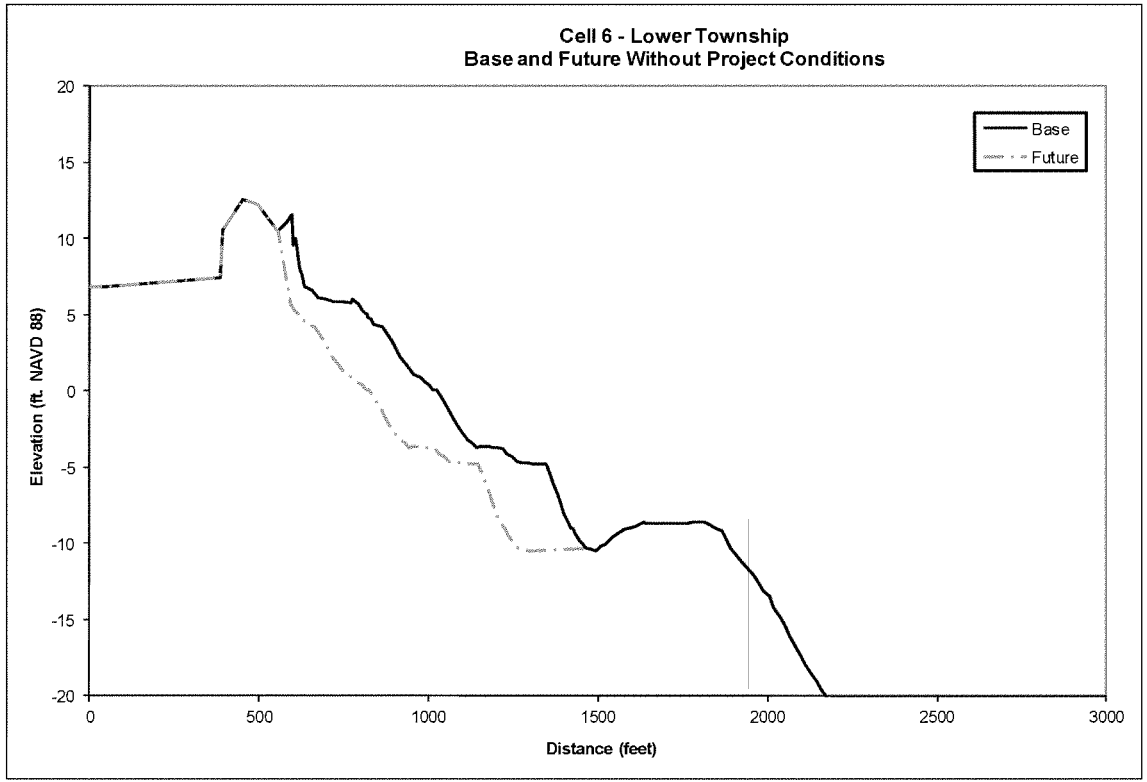


Figure 27. Base and Future Without Project Conditions for Cell 6

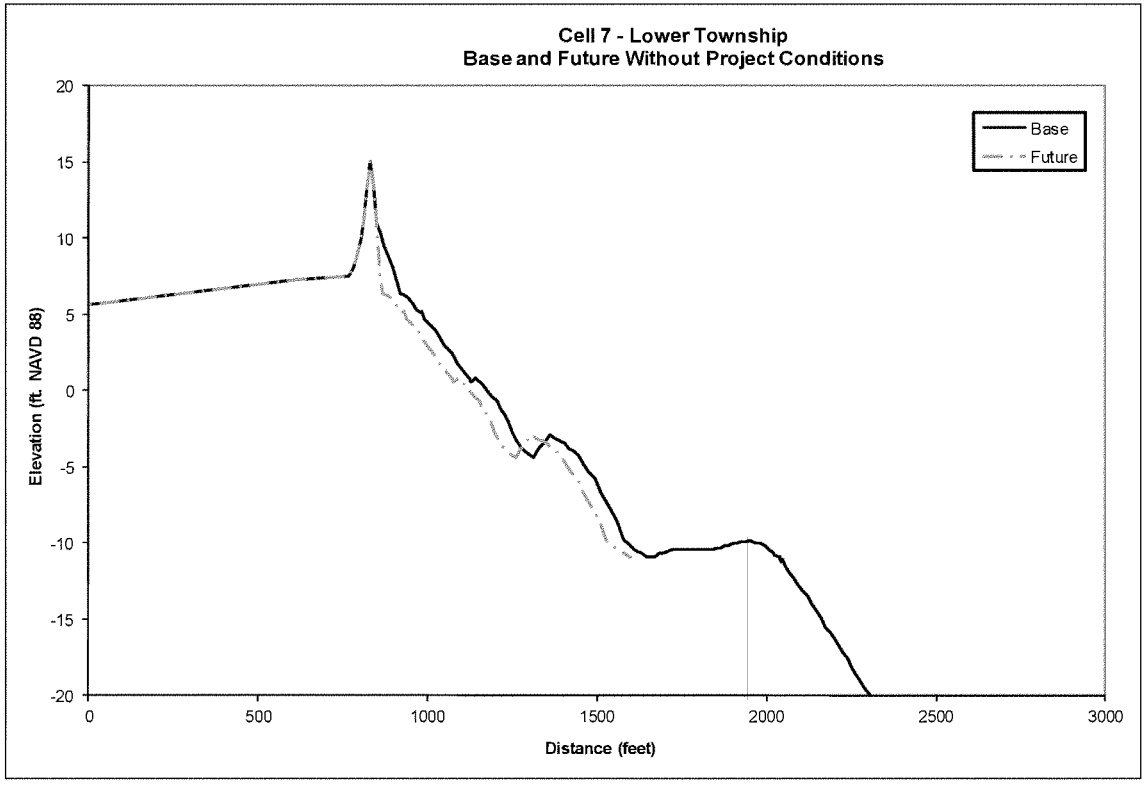


Figure 28. Base and Future Without Project Conditions for Cell 7

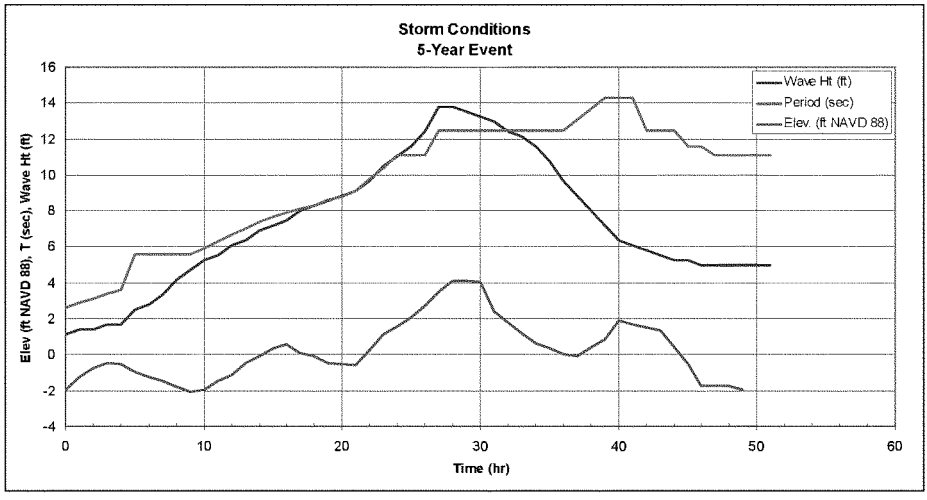


Figure 29. "5-yr" Storm Conditions used in Storm Damage Analysis

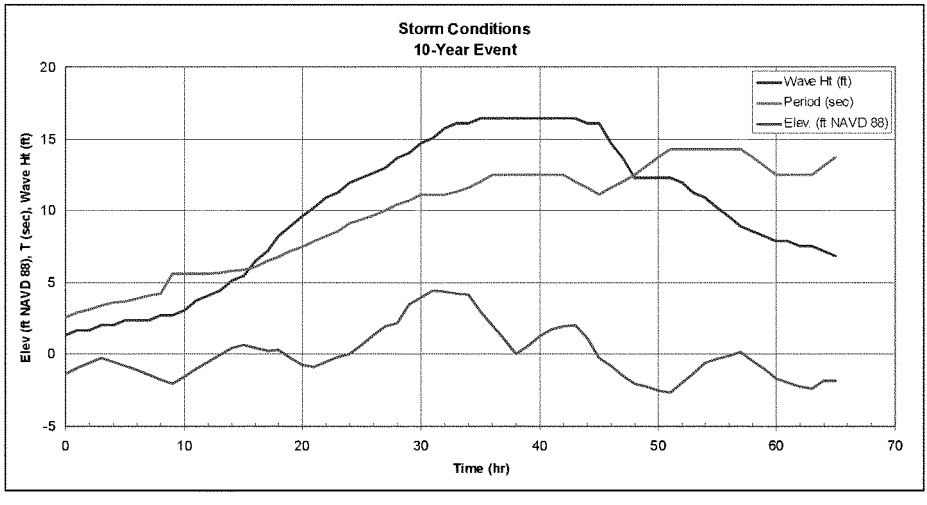


Figure 30. "10-yr" Storm Conditions used in Storm Damage Analysis

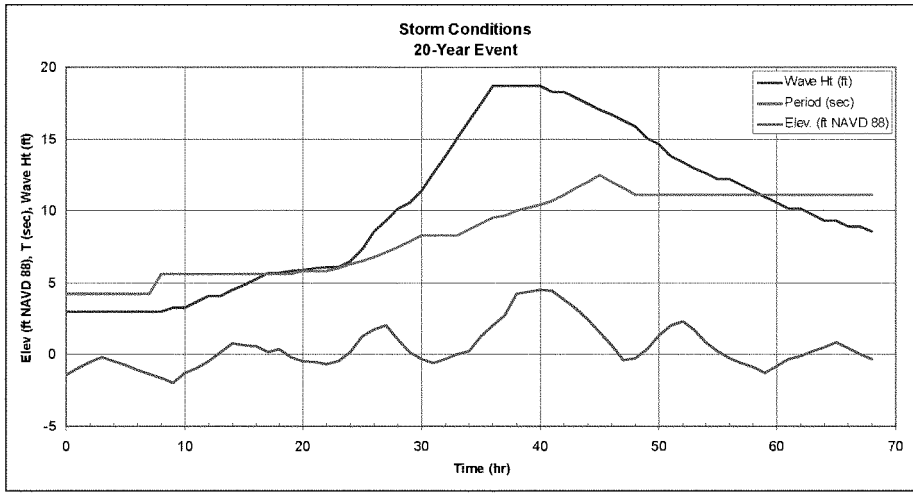


Figure 31. "20-yr" Storm Conditions used in Storm Damage Analysis

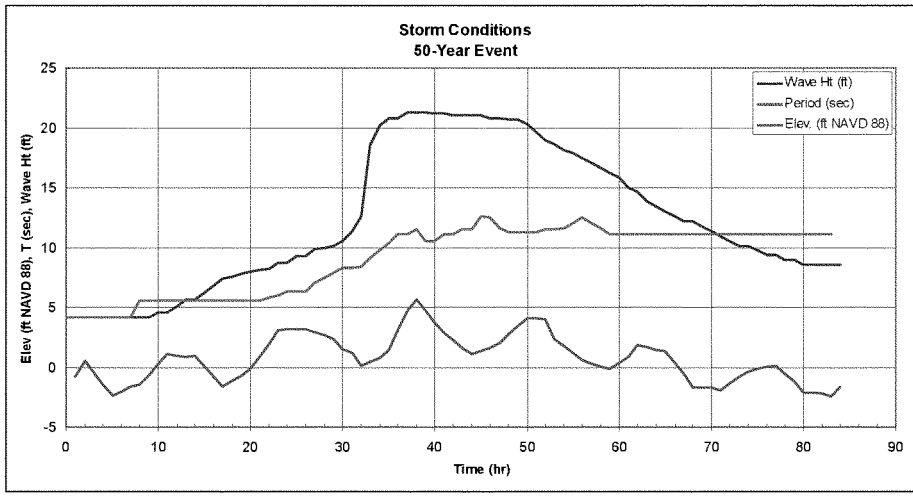


Figure 32. "50-yr" Storm Conditions used in Storm Damage Analysis

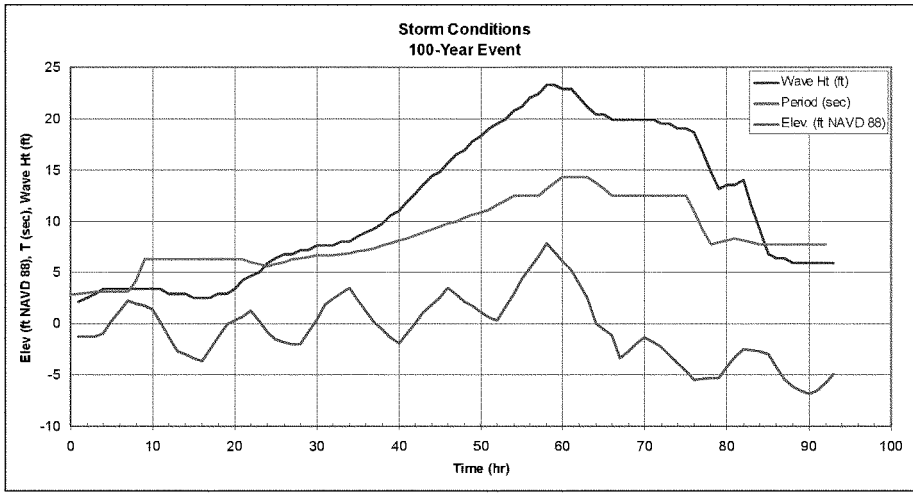


Figure 33. "100-yr" Storm Conditions used in Storm Damage Analysis

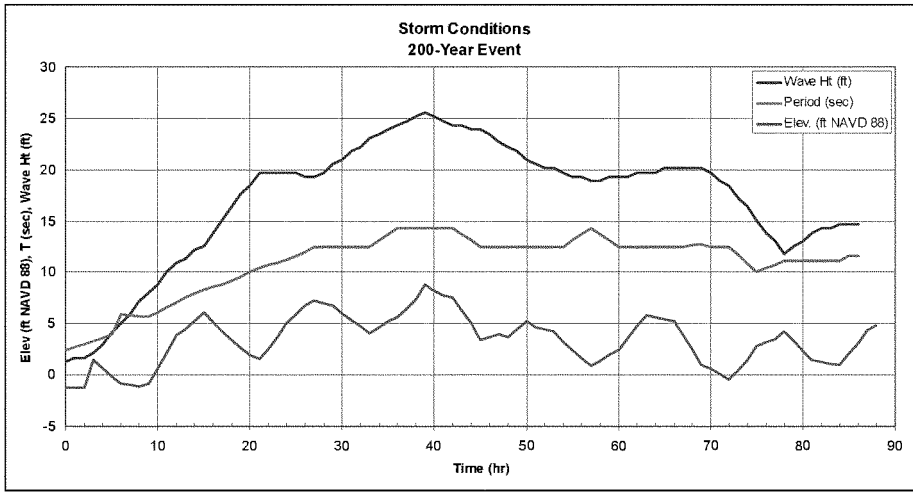


Figure 34. "200-yr" Storm Conditions used in Storm Damage Analysis

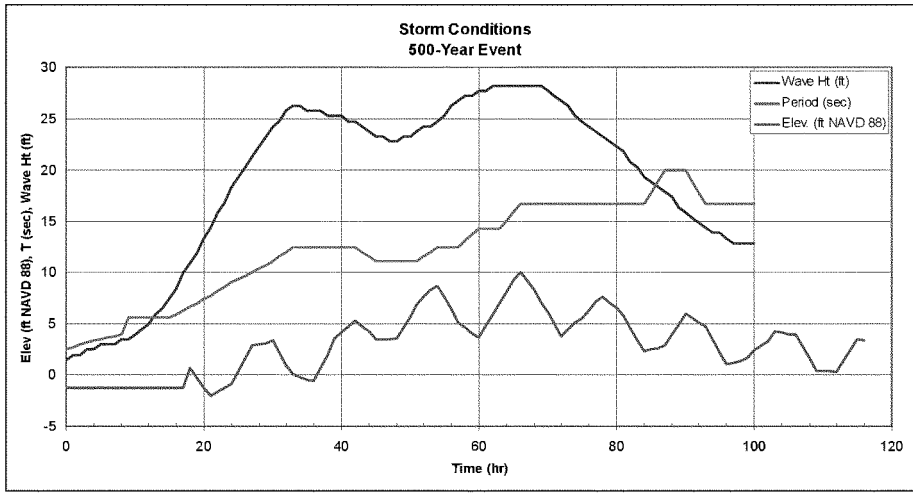


Figure 35. "500-yr" Storm Conditions used in Storm Damage Analysis

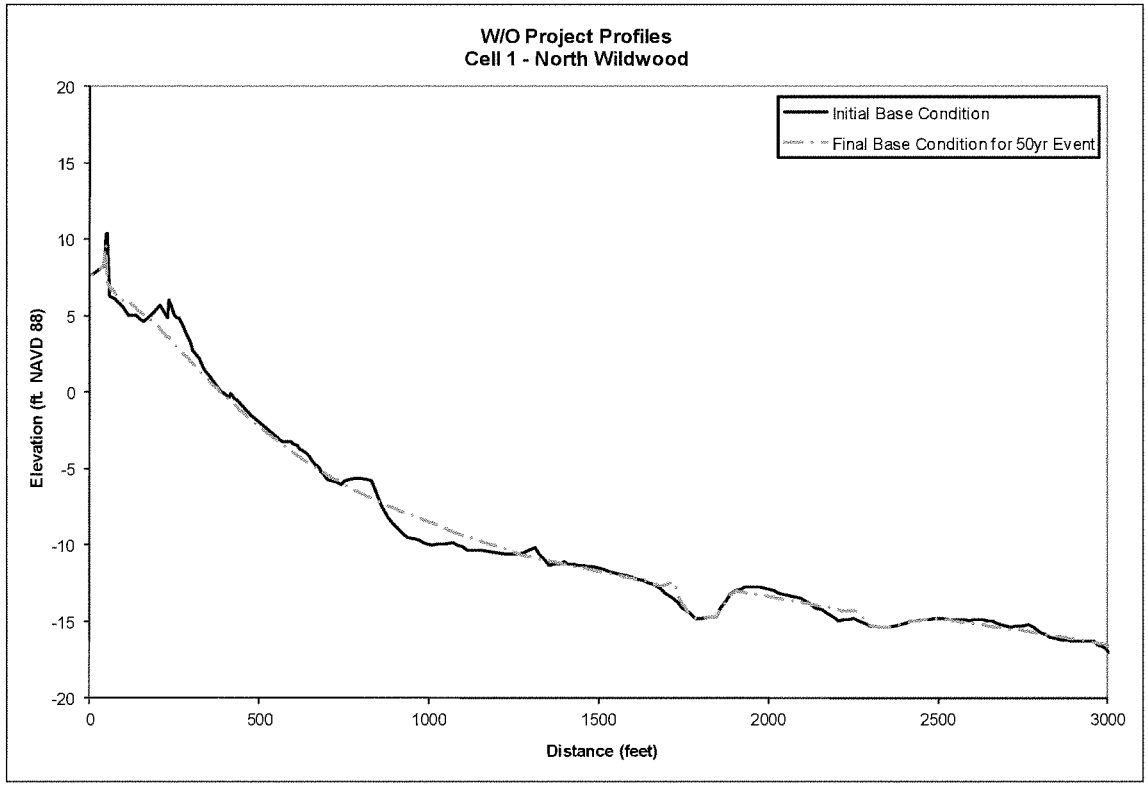


Figure 36. Pre- and Post "50-yr" Storm Beach Profiles for Without Base Conditions in Cell 1

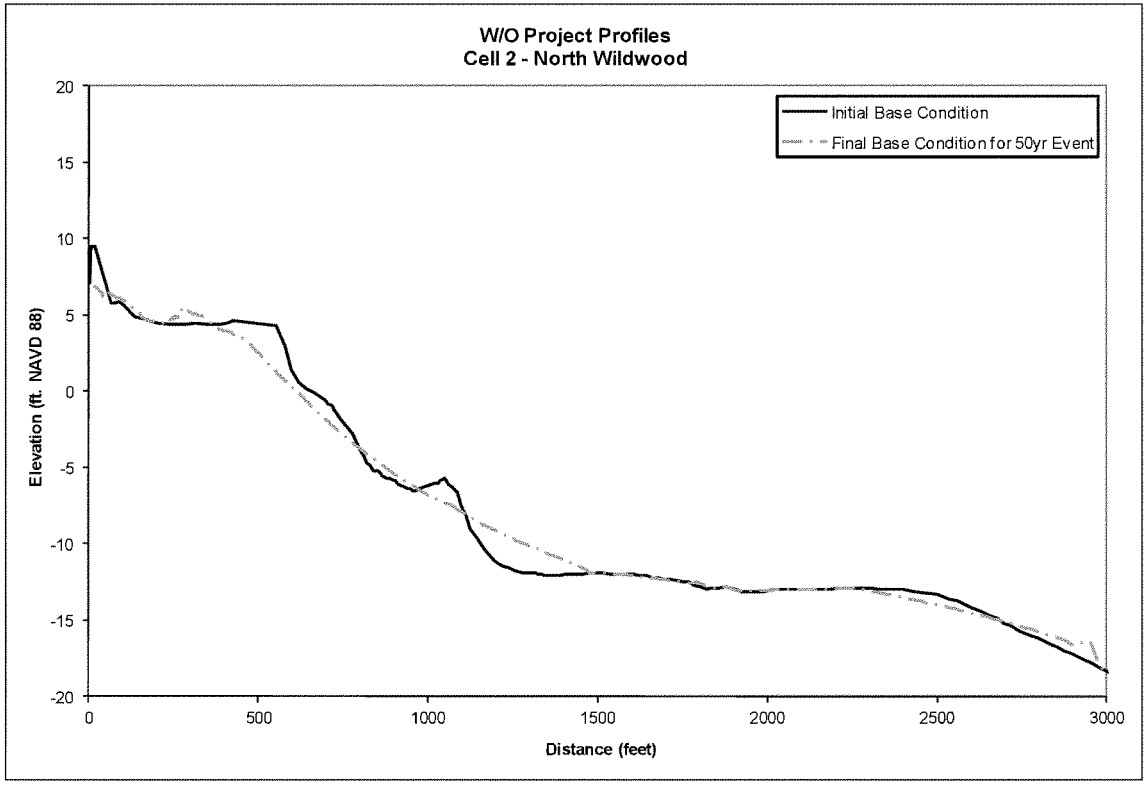


Figure 37. Pre- and Post "50-yr" Storm Beach Profiles for Without Base Conditions in Cell 2

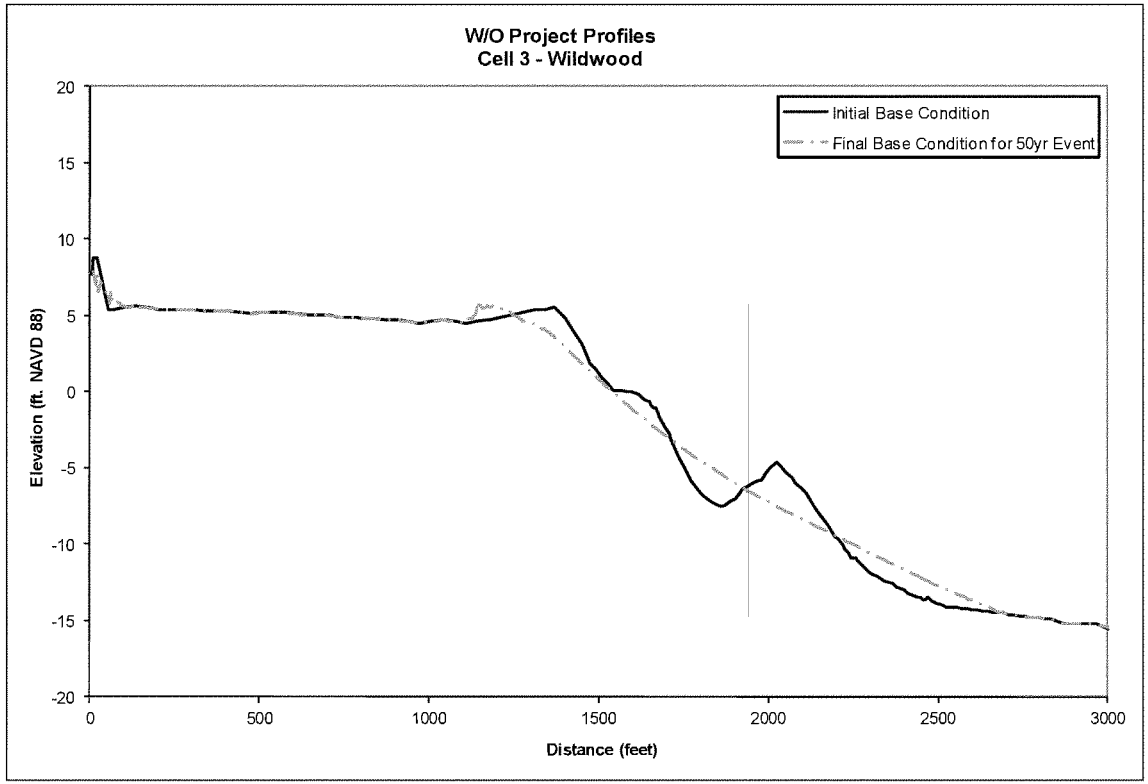


Figure 38. Pre- and Post "50-yr" Storm Beach Profiles for Without Base Conditions in Cell 3

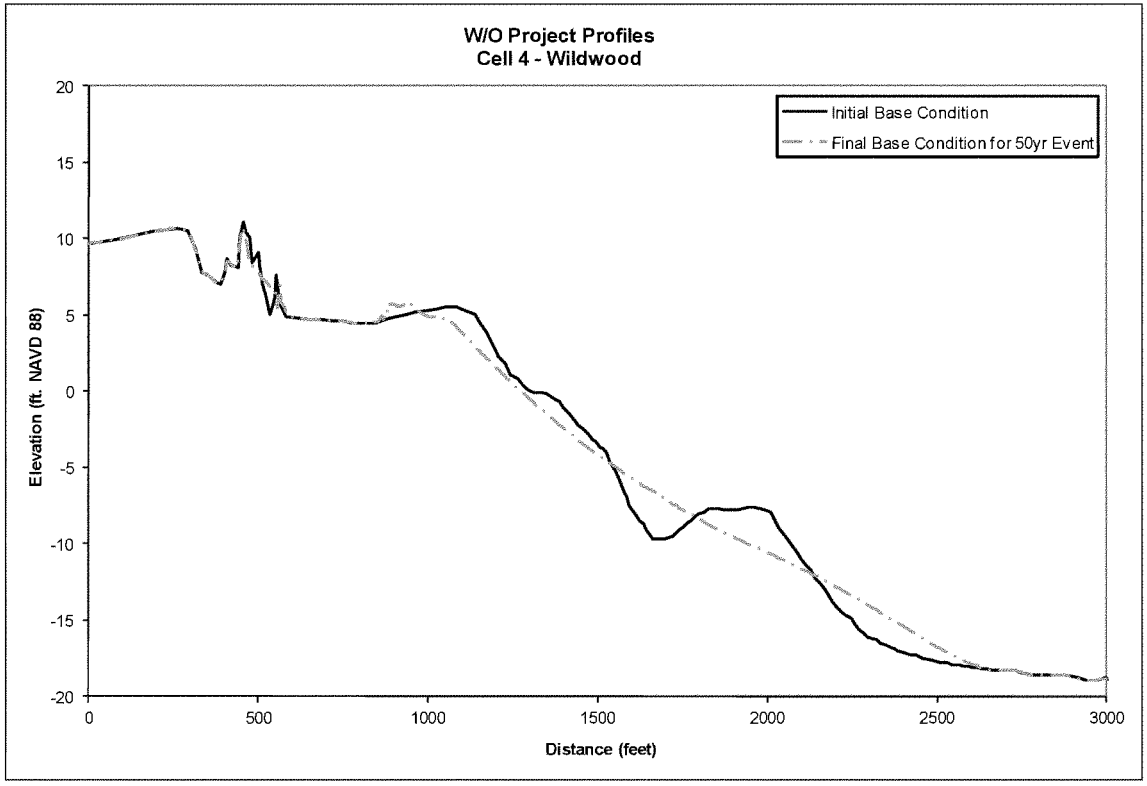


Figure 39. Pre- and Post "50-yr" Storm Beach Profiles for Without Base Conditions in Cell 4

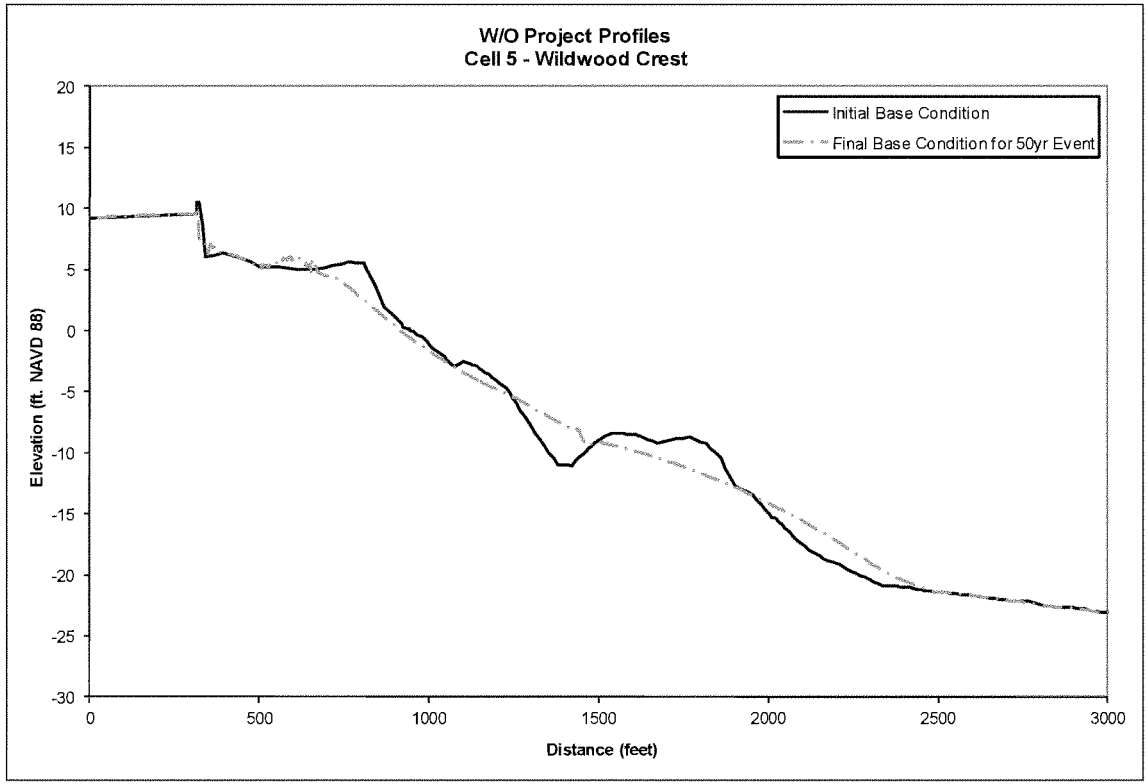


Figure 40. Pre- and Post "50-yr" Storm Beach Profiles for Without Base Conditions in Cell 6

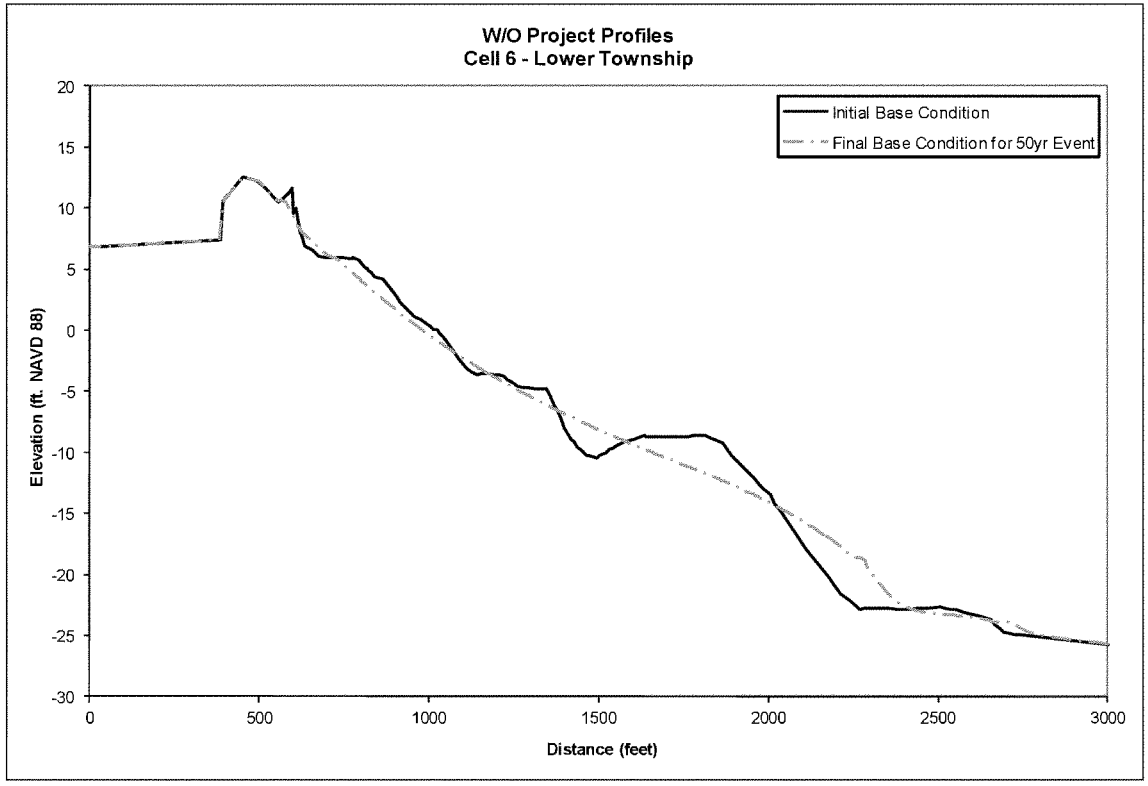


Figure 41. Pre- and Post "50-yr" Storm Beach Profiles for Without Base Conditions in Cell 6

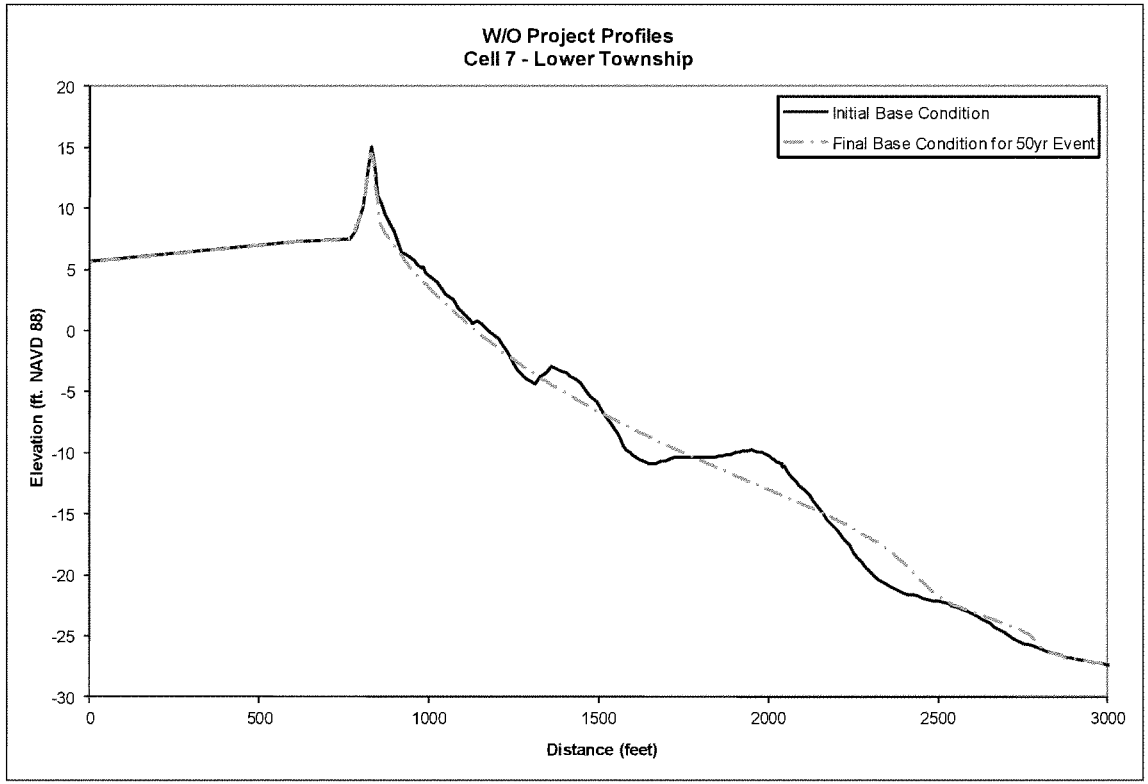


Figure 42. Pre- and Post "50-yr" Storm Beach Profiles for Without Base Conditions in Cell 7

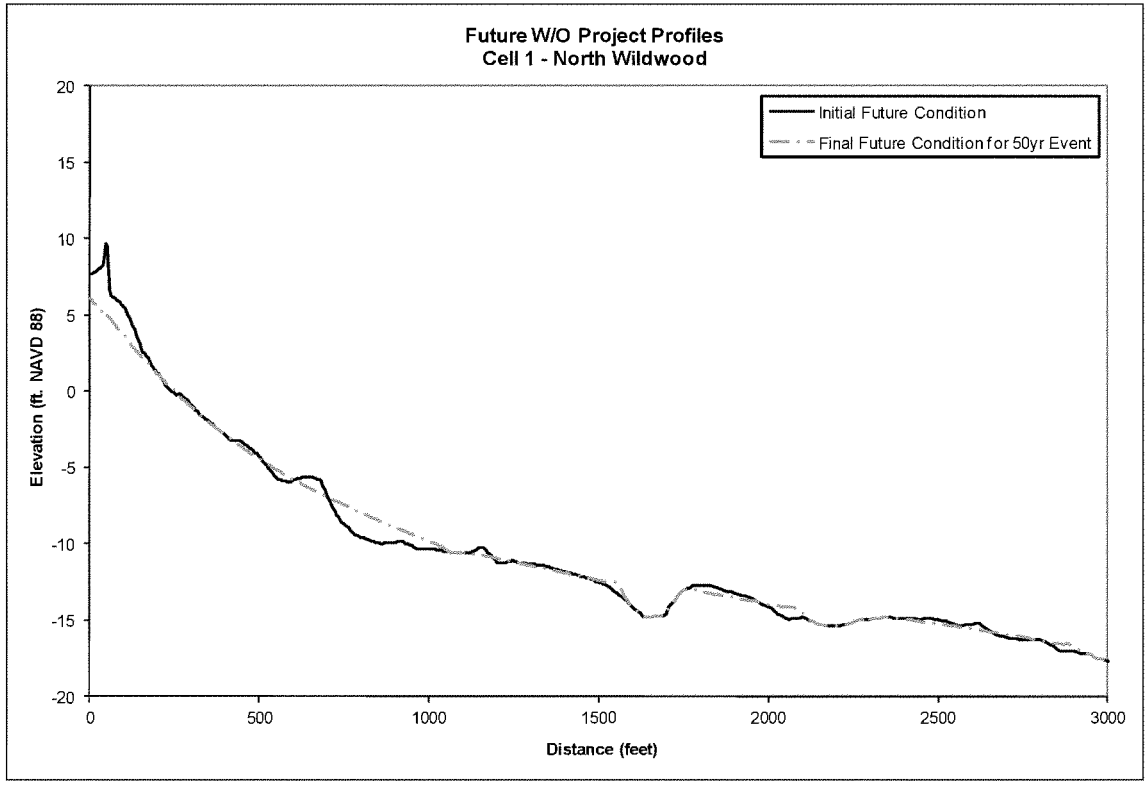


Figure 43. Pre- and Post "50-yr" Storm Beach Profiles for Without Future Conditions in Cell 1

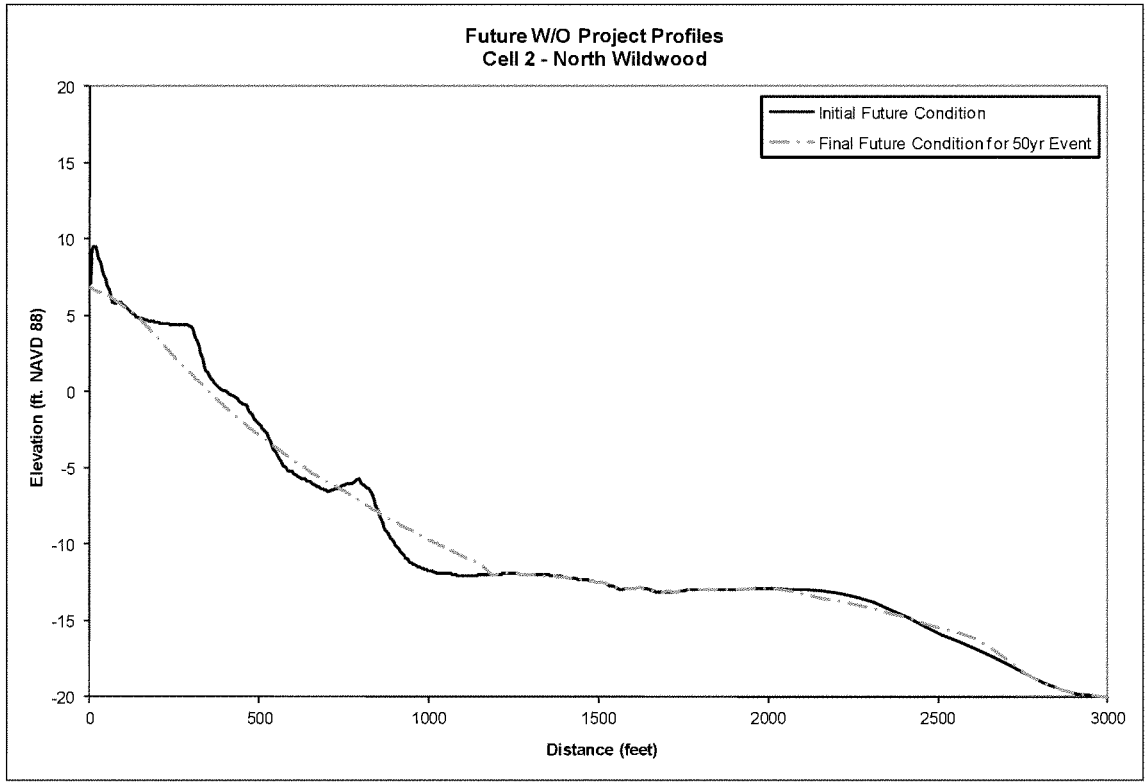


Figure 44. Pre- and Post "50-yr" Storm Beach Profiles for Without Future Conditions in Cell 2

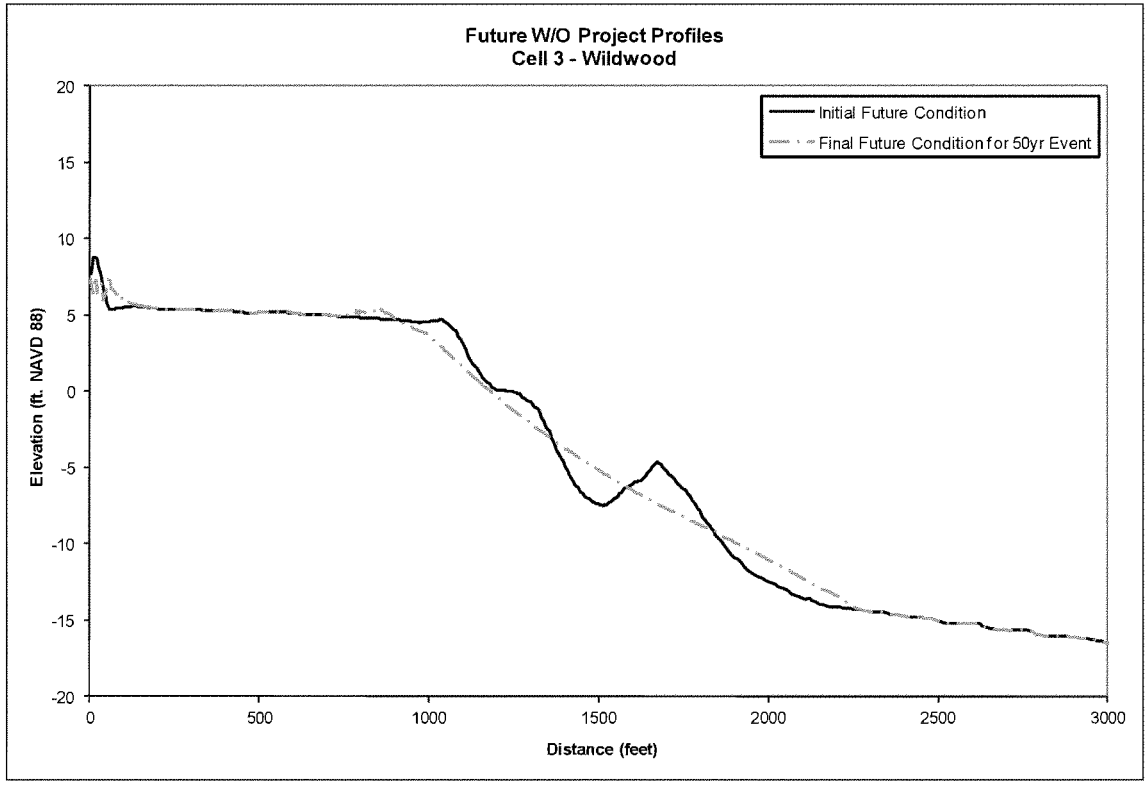


Figure 45. Pre- and Post "50-yr" Storm Beach Profiles for Without Future Conditions in Cell 3

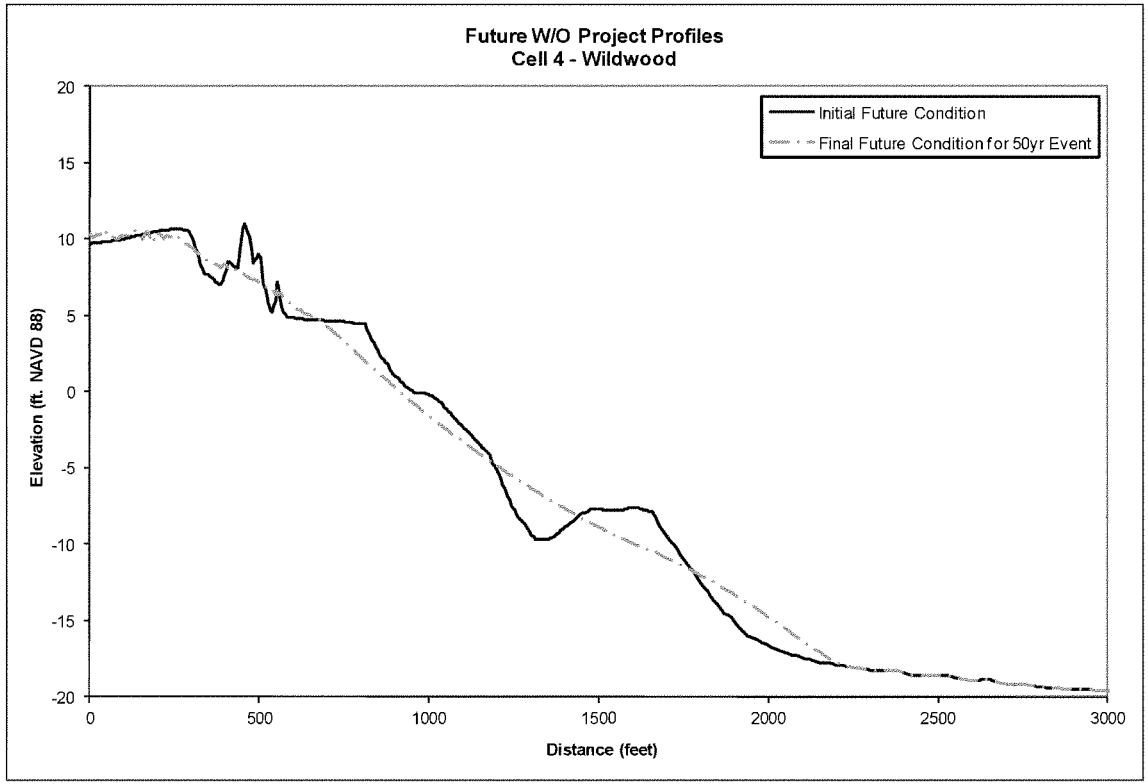


Figure 46. Pre- and Post "50-yr" Storm Beach Profiles for Without Future Conditions in Cell 4

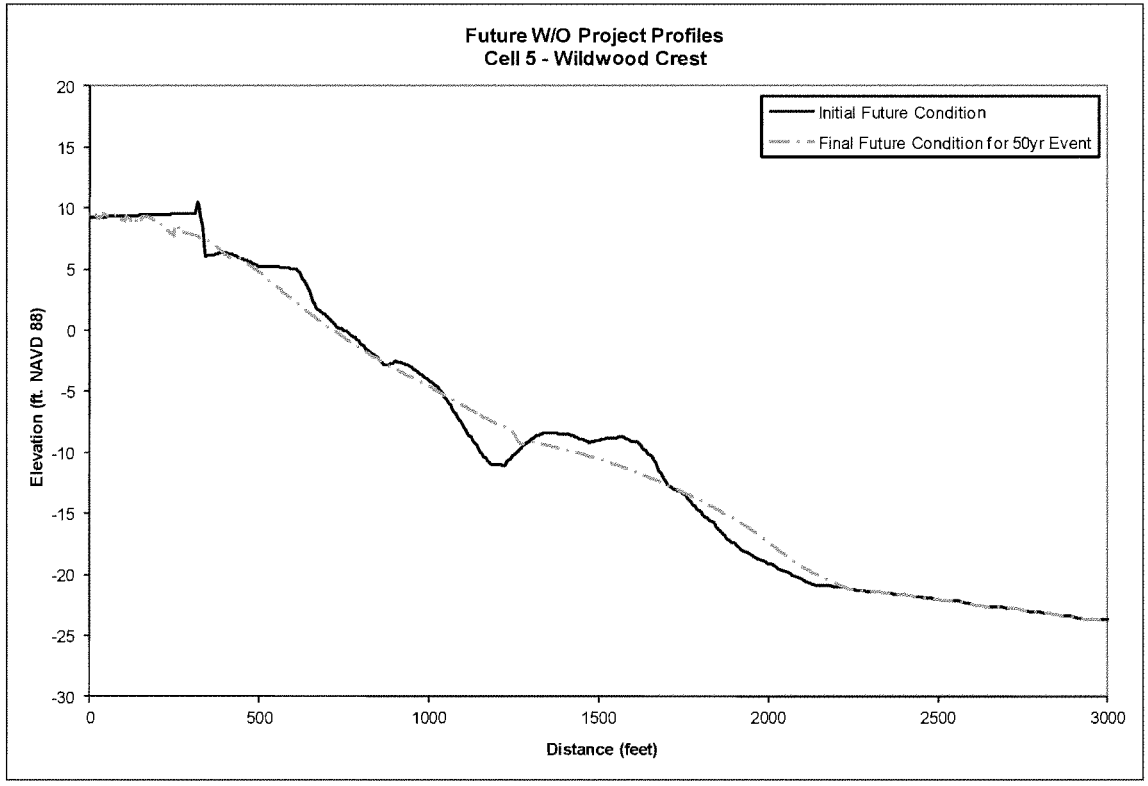


Figure 47. Pre- and Post "50-yr" Storm Beach Profiles for Without Future Conditions in Cell 5

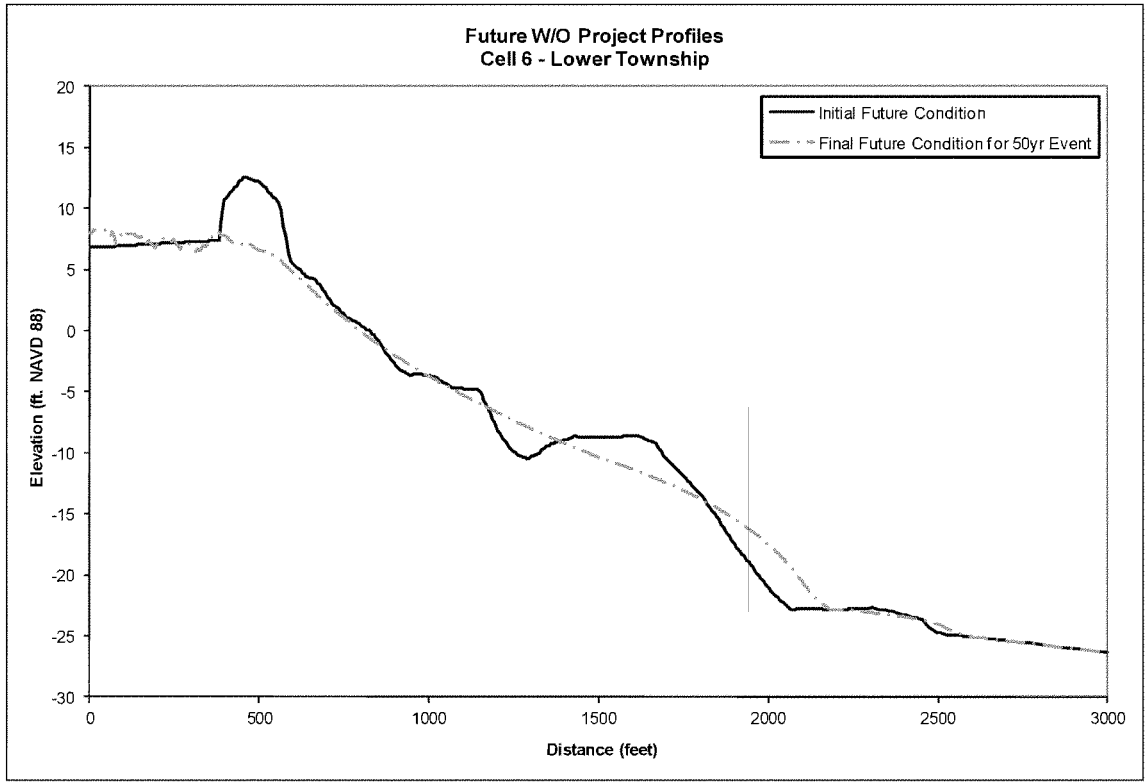


Figure 48. Pre- and Post "50-yr" Storm Beach Profiles for Without Future Conditions in Cell 6

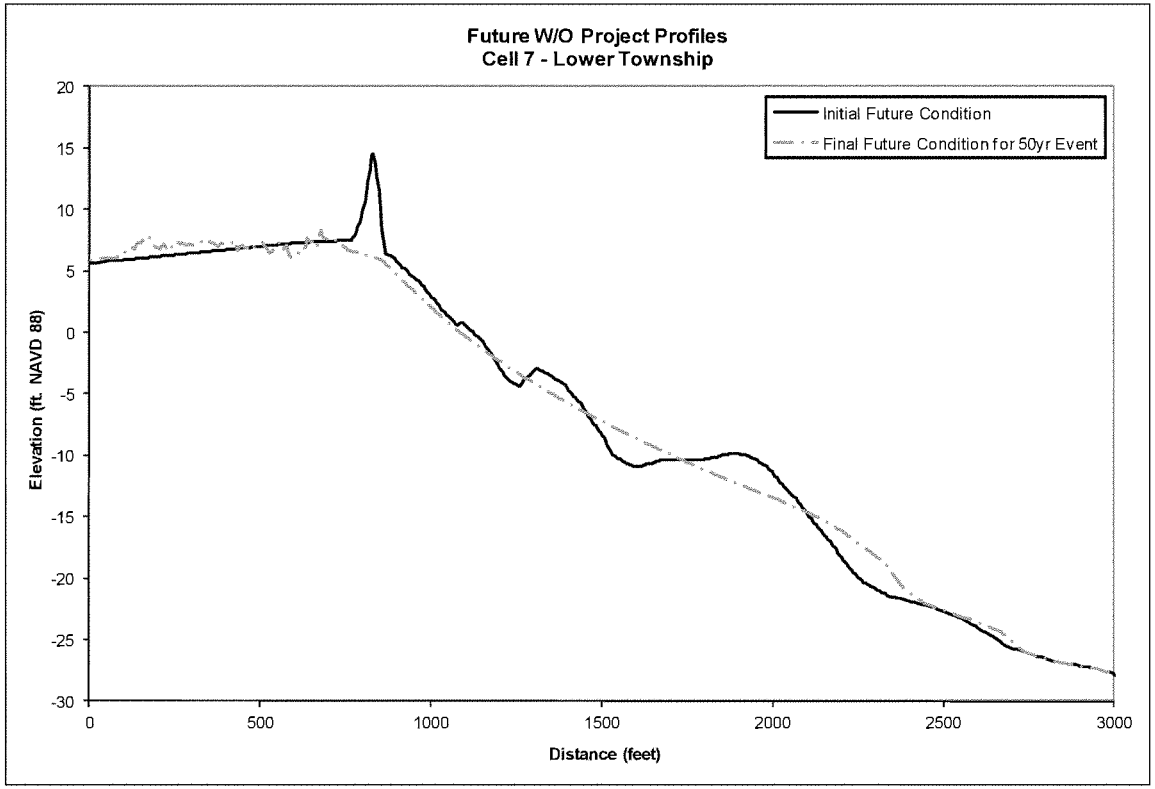


Figure 49. Pre- and Post "50-yr" Storm Beach Profiles for Without Future Conditions in Cell 7

Costdam file explanation.

Location of the 0.5 ft erosion depth for the 5-yr through 500-yr storm events

Location of the 3 foot wave impact zone for the 5-yr through 500-yr storm events

Inundation profiles shown as distance, elevation pairs for the 5-yr through 500-yr storm events

```
REACH LENGTH                                    ME
1000.,0.0
DISTANCE SHORELINE TO REF                       EROSION RATE
0.0        0.0
DEFAULT PERSONAL PROPERTY
0.25
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
5yr    0.0      .0      0.0     0.    0000.
10yr   0.0      .0      0.0     0.    0000.
20yr   0.0      .0      0.0     0.    0000.
50yr   0.0      .0      0.0     0.    0000.
100yr 45.0    955.0     0.0     0.    0000.
200yr 60.0    940.0     0.0     0.    0000.
500yr 65.0    935.0     0.0    00.    0000.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          7
 INUNDATION PROFILE:  DISTANCE FROM BASELINE AND TOTAL
WATERLEVEL
```

5yr	-200.0	10.7	-60.0	10.7	0.0	5.0	500.0	5.0
	700.0	5.0	800.0	5.0	1000.0	5.0		
10yr	-200.0	12.1	-30.0	11.8	0.0	5.5	500.0	5.5
	700.0	5.5	800.0	5.5	1000.0	5.5		
20yr	-200.0	12.4	-30.0	11.8	0.0	6.1	150.0	6.1
	250.0	6.1	500.0	6.1	1000.0	6.1		
50yr	-200.0	15.2	-5.0	13.5	45.0	8.9	150.0	8.0
	250.0	7.5	500.0	7.1	1000.0	7.1		
100yr	-200.0	16.9	-30.0	15.5	45.0	15.5	295.0	15.2
	545.0	14.2	795.0	11.1	1000.0	7.9		
200yr	-200.0	19.8	-20.0	17.8	60.0	17.8	310.0	17.3
	560.0	16.3	810.0	12.6	1000.0	8.9		
500yr	-200.0	22.6	-30.0	20.5	65.0	20.5	315.0	19.9
	565.0	18.9	780.0	14.4	1000.0	10.0		

Table 14. Without Project Conditions COSTDAM File for Cell 1

```
REACH LENGTH AND X-SECTION VOLUME
  3549,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
   1080.00        0.00        0.0      0.       0.
   1180.00        0.00        0.0      0.       0.
   1235.00        0.00        0.0      0.       0.
   1285.00        0.00        0.0      0.       0.
   1345.00      285.00        0.0      0.       0.
   1450.00     2190.00        0.0      0.       0.
   1535.00     2105.00        0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00     9.20  650.00     9.20 1302.00     9.20 1307.00     0.00 1700.00     0.00
 2100.00     0.00 2500.00     0.00 2800.00     0.00 3200.00     0.00 3640.00     0.00
    0.00     9.40  650.00     9.40 1302.00     9.40 1307.00     0.00 1700.00     0.00
 2100.00     0.00 2500.00     0.00 2800.00     0.00 3200.00     0.00 3640.00     0.00
    0.00     9.70  650.00     9.70 1302.00     9.70 1307.00     0.00 1700.00     0.00
 2100.00     0.00 2500.00     0.00 2800.00     0.00 3200.00     0.00 3640.00     0.00
    0.00    11.50 1302.00    11.50 1352.00     8.70 1680.00     8.60 2008.00     8.60
 2336.00     8.30 2664.00     8.00 2992.00     7.10 3320.00     7.10 3640.00     7.10
    0.00    13.60  650.00    13.60 1302.00    13.60 1320.00    13.60 1335.00    13.60
 1352.00    13.60 1845.00    11.70 2339.00     9.80 2832.00     7.90 3640.00     7.90
    0.00    15.00  700.00    15.00 1420.00    15.00 1450.00    15.00 1470.00    15.00
 1492.00    15.00 1998.00    13.00 2505.00    10.90 3012.00     8.90 3640.00     8.90
    0.00    17.10  750.00    17.10 1490.00    17.10 1520.00    17.10 1550.00    17.10
 1583.00    17.10 2170.00    14.70 2758.00    12.40 3346.00    10.00 3640.00    10.00
```

Table 15. Without Project Conditions COSTDAM File for Cell 2

```
REACH LENGTH AND X-SECTION VOLUME
  2959,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
```

```
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
   1040.00       0.00       0.0     0.      0.
   1100.00       0.00       0.0     0.      0.
   1170.00       0.00       0.0     0.      0.
   1265.00       0.00       0.0     0.      0.
   1330.00     145.00       0.0     0.      0.
   1385.00    2170.00       0.0     0.      0.
   1440.00    2115.00       0.0     0.      0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00    8.60  650.00    8.60 1333.00    8.60 1338.00    0.00 1700.00    0.00
 2100.00    0.00 2500.00    0.00 2800.00    0.00 3200.00    0.00 3555.00    0.00
    0.00    8.90  650.00    8.90 1333.00    8.90 1338.00    0.00 1700.00    0.00
 2100.00    0.00 2500.00    0.00 2800.00    0.00 3200.00    0.00 3555.00    0.00
    0.00    9.30  650.00    9.30 1343.00    9.30 1348.00    0.00 1700.00    0.00
 2100.00    0.00 2500.00    0.00 2800.00    0.00 3200.00    0.00 3555.00    0.00
    0.00   10.80  650.00   10.80 1337.00   10.80 1580.00    9.80 1823.00    8.80
 2006.00    8.00 2316.00    7.80 2626.00    7.60 3250.00    7.10 3555.00    7.10
    0.00   14.20  650.00   14.20 1480.00   14.20 1500.00   14.20 1520.00   14.20
 1538.00   14.20 2051.00   12.10 2564.00   10.00 3077.00    7.90 3555.00    7.90
    0.00   15.90  650.00   15.90 1480.00   15.90 1500.00   15.90 1520.00   15.90
 1556.00   15.90 2128.00   13.60 2700.00   11.20 3272.00    8.90 3555.00    8.90
    0.00   18.10  650.00   18.10 1480.00   18.10 1500.00   18.10 1520.00   18.10
 1560.00   18.10 2072.00   16.10 2566.00   14.10 3061.00   12.10 3555.00   10.10
```

Table 16. Without Project Conditions COSTDAM File for Cell 3

```
REACH LENGTH AND X-SECTION VOLUME
  6965,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0      0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
     85.00       0.00       0.0     0.      0.
    250.00       0.00       0.0     0.      0.
    415.00       0.00       0.0     0.      0.
    665.00       0.00       0.0     0.      0.
    875.00       0.00       0.0     0.      0.
   1075.00    2245.00       0.0     0.      0.
   1375.00    1945.00       0.0     0.      0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
```

```
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00     7.90  650.00     7.90 1338.00     7.90 1343.00     0.00 1700.00     0.00
 2100.00     0.00 2500.00     0.00 2800.00     0.00 3200.00     0.00 3320.00     0.00
    0.00     8.30  650.00     8.30 1338.00     8.30 1343.00     0.00 1700.00     0.00
 2100.00     0.00 2500.00     0.00 2800.00     0.00 3200.00     0.00 3320.00     0.00
    0.00     8.60  650.00     8.60 1338.00     8.60 1343.00     0.00 1700.00     0.00
 2100.00     0.00 2500.00     0.00 2800.00     0.00 3200.00     0.00 3320.00     0.00
    0.00     9.30  650.00     9.30 1338.00     9.30 1343.00     0.00 1700.00     0.00
 2100.00     0.00 2500.00     0.00 2800.00     0.00 3200.00     0.00 3320.00     0.00
    0.00    13.60  650.00    13.60  900.00    13.60 1200.00    13.60 1300.00    13.60
 1388.00    13.60 1891.00    11.50 2399.00     9.50 2800.00     7.90 3320.00     7.90
    0.00    15.20  650.00    15.20  900.00    15.20 1200.00    15.20 1300.00    15.20
 1473.00    15.20 2040.00    12.90 2608.00    10.70 3050.00     8.90 3320.00     8.90
    0.00    17.20  650.00    17.20  900.00    17.20 1200.00    17.20 1300.00    17.20
 1528.00    17.20 1976.00    15.40 2400.00    13.60 3150.00    10.70 3320.00    10.00
```

Table 17. Without Project Conditions COSTDAM File for Cell 4

```
REACH LENGTH AND X-SECTION VOLUME
  4585,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
    325.00        0.00        0.0      0.       0.
    485.00        0.00        0.0      0.       0.
    655.00        0.00        0.0      0.       0.
    875.00        0.00        0.0      0.       0.
   1045.00        0.00        0.0      0.       0.
   1200.00     1915.00        0.0      0.       0.
   1415.00     1700.00        0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00     8.00  650.00     8.00  893.00     8.00  898.00     0.00 1200.00     0.00
 1600.00     0.00 2000.00     0.00 2400.00     0.00 2800.00     0.00 3115.00     0.00
    0.00     8.60  650.00     8.60  893.00     8.60  898.00     0.00 1200.00     0.00
 1600.00     0.00 2000.00     0.00 2400.00     0.00 2800.00     0.00 3115.00     0.00
    0.00     9.20  650.00     9.20  893.00     9.20  898.00     0.00 1200.00     0.00
 1600.00     0.00 2000.00     0.00 2400.00     0.00 2800.00     0.00 3115.00     0.00
    0.00    10.20  650.00    10.20  898.00    10.20  903.00    10.70 1200.00     0.00
 1600.00     0.00 2000.00     0.00 2400.00     0.00 2800.00     0.00 3115.00     0.00
    0.00    12.30  650.00    12.30  900.00    12.30  920.00    12.30  940.00    12.30
```

```
  948.00   12.30 1368.00   10.80 1789.00    9.40 2210.00    7.90 3115.00    7.90
    0.00   14.60  650.00   14.60  900.00   14.60  920.00   14.60  940.00   14.60
 1168.00   14.60 1644.00   12.70 2120.00   10.80 2596.00    8.90 3115.00    8.90
    0.00   16.80  650.00   16.80  900.00   16.80  920.00   16.80  940.00   16.80
 1210.00   16.80 1783.00   14.50 2355.00   12.30 2928.00   10.00 3115.00   10.50
```

Table 18. Without Project Conditions COSTDAM File for Cell 5

```
REACH LENGTH AND X-SECTION VOLUME
  5835,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
    655.00       0.00       0.0      0.       0.
    715.00       0.00       0.0      0.       0.
    775.00       0.00       0.0      0.       0.
    870.00       0.00       0.0      0.       0.
   1275.00       0.00       0.0      0.       0.
   1400.00       0.00       0.0      0.       0.
   1475.00      45.00       0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00    8.30  650.00    8.30 1029.00    8.30 1034.00    0.00 1400.00    0.00
 1800.00    0.00 2200.00    0.00 2600.00    0.00 3000.00    0.00 3315.00    0.00
    0.00    9.00  650.00    9.00 1034.00    9.00 1039.00    0.00 1400.00    0.00
 1800.00    0.00 2200.00    0.00 2600.00    0.00 3000.00    0.00 3315.00    0.00
    0.00    9.50  650.00    9.50 1034.00    9.50 1039.00    0.00 1400.00    0.00
 1800.00    0.00 2200.00    0.00 2600.00    0.00 3000.00    0.00 3315.00    0.00
    0.00   11.20 1034.00   11.20 1084.00   10.60 1402.00   10.20 1721.00    9.80
 2040.00    9.40 2359.00    9.10 2677.00    8.50 2996.00    8.10 3315.00    7.70
    0.00   13.10  650.00   13.10 1000.00   13.10 1020.00   13.10 1040.00   13.10
 1084.00   13.10 1545.00   11.70 2006.00   10.30 2467.00    8.90 3315.00    7.90
    0.00   14.70  650.00   14.70 1000.00   14.70 1020.00   14.70 1040.00   14.70
 1226.00   14.70 1697.00   12.80 2168.00   10.80 2640.00    8.90 3315.00    8.90
    0.00   17.40  650.00   17.40 1000.00   17.40 1200.00   17.40 1220.00   17.40
 1246.00   17.40 1871.00   14.90 2497.00   12.50 3123.00   10.00 3315.00   10.00
```

Table 19. Without Project Conditions COSTDAM File for Cell 6

```
REACH LENGTH AND X-SECTION VOLUME
  1090,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0      0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
    525.00       0.00       0.0      0.       0.
    575.00       0.00       0.0      0.       0.
    645.00       0.00       0.0      0.       0.
    730.00       0.00       0.0      0.       0.
    830.00       0.00       0.0      0.       0.
    970.00       0.00       0.0      0.       0.
   1145.00       0.00       0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
           10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00     9.90  650.00     9.90  893.00     9.90  898.00     0.00 1200.00     0.00
 1600.00     0.00 2000.00     0.00 2400.00     0.00 2800.00     0.00 3150.00     0.00
    0.00    10.20  650.00    10.20  893.00    10.20  898.00     0.00 1200.00     0.00
 1600.00     0.00 2000.00     0.00 2400.00     0.00 2800.00     0.00 3150.00     0.00
    0.00    10.40  650.00    10.40  893.00    10.40  898.00     0.00 1200.00     0.00
 1600.00     0.00 2000.00     0.00 2400.00     0.00 2800.00     0.00 3150.00     0.00
    0.00    12.40  650.00    12.40  893.00    12.40  898.00     0.00 1200.00     0.00
 1600.00     0.00 2000.00     0.00 2400.00     0.00 2800.00     0.00 3150.00     0.00
    0.00    13.40  650.00    13.40  893.00    13.40  909.00    13.10  926.00    12.90
  943.00    12.60 1320.00    11.00 1698.00     9.50 2075.00     7.90 3150.00     7.90
    0.00    15.10  650.00    15.10  903.00    15.10  919.00    15.00  936.00    14.90
  953.00    14.70 1468.00    12.80 1983.00    10.90 2498.00     8.90 3150.00     8.90
    0.00    17.10  650.00    17.10 1000.00    17.10 1020.00    17.10 1040.00    17.10
 1088.00    17.10 1727.00    14.80 2367.00    12.40 3007.00    10.00 3150.00    10.00
```

Table 20. Without Project Conditions COSTDAM File for Cell 7

```
REACH LENGTH AND X-SECTION VOLUME
  6267,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
    110.00       0.00       0.0      0.       0.
    215.00       0.00       0.0      0.       0.
    310.00       0.00       0.0      0.       0.
    435.00       0.00       0.0      0.       0.
    535.00       0.00       0.0      0.       0.
    685.00       0.00       0.0      0.       0.
    925.00     630.00       0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
           10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00     9.60  200.00     9.60  518.00     9.60  523.00     0.00  800.00     0.00
 1000.00     0.00 1100.00     0.00 1200.00     0.00 1400.00     0.00 1650.00     0.00
    0.00     9.90  200.00     9.90  518.00     9.90  523.00     0.00  800.00     0.00
 1000.00     0.00 1100.00     0.00 1200.00     0.00 1400.00     0.00 1650.00     0.00
    0.00    10.80  200.00    10.80  518.00    10.80  523.00     0.00  800.00     0.00
 1000.00     0.00 1100.00     0.00 1200.00     0.00 1400.00     0.00 1650.00     0.00
    0.00    12.80  200.00    12.80  518.00    12.80  523.00     0.00  800.00     0.00
 1000.00     0.00 1100.00     0.00 1200.00     0.00 1400.00     0.00 1650.00     0.00
    0.00    13.60  200.00    13.60  518.00    13.60  534.00    13.30  551.00    12.90
  568.00    12.60  838.00    11.50 1109.00    10.40 1379.00     9.30 1650.00     8.20
    0.00    15.30  200.00    15.30  300.00    15.30  400.00    15.30  500.00    15.30
  603.50    15.30  864.00    14.20 1126.00    13.20 1388.00    12.20 1650.00    11.20
    0.00    17.90  200.00    17.90  300.00    17.90  400.00    17.90  500.00    17.90
  683.00    17.90  924.00    17.20 1166.00    16.50 1408.00    15.90 1650.00    15.20
```

Table 21. Future Low Risk Without Project Conditions COSTDAM File for Cell 1

```
REACH LENGTH AND X-SECTION VOLUME
```

```
  3549,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0      0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
   1045.00       0.00       0.0      0.       0.
   1141.00       0.00       0.0      0.       0.
   1188.00       0.00       0.0      0.       0.
   1226.00       0.00       0.0      0.       0.
   1262.00      58.00       0.0      0.       0.
   1310.00     341.00       0.0      0.       0.
   1371.00    1250.00       0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00    8.00  650.75    8.00 1301.50    8.00 1306.50    0.00 1695.42    0.00
 2084.33    0.00 2473.25    0.00 2862.17    0.00 3251.08    0.00 3640.00    0.00
    0.00    8.80  650.75    8.80 1301.50    8.80 1306.50    0.00 2062.67    0.00
 2818.83    0.00 3575.00    0.00 1350.00    0.00 2495.00    0.00 3640.00    0.00
    0.00    9.60  650.75    9.60 1301.50    9.60 1306.50    0.00 1969.33    0.00
 2632.17    0.00 3295.00    0.00 1350.00    0.00 2495.00    0.00 3640.00    0.00
    0.00   10.10  650.75   10.10 1301.50   10.10 1306.50    0.00 1769.33    0.00
 2232.17    0.00 2695.00    0.00 1350.00    0.00 2495.00    0.00 3640.00    0.00
    0.00   11.74 1302.00   11.74 1352.00    8.90 1680.00    8.80 2008.00    8.80
 2336.00    8.50 2664.00    8.20 2992.00    7.90 3320.00    7.90 3640.00    7.90
    0.00   12.70  680.25   12.70 1360.50   12.70 1377.17   12.70 1393.83   12.70
 1410.50   12.70 1725.90   11.44 2041.30   10.17 2356.70    8.90 3640.00    8.90
    0.00   14.18  702.85   14.18 1405.70   14.18 1430.47   14.18 1455.23   14.18
 1480.00   14.18 1828.00   12.78 2176.00   11.39 2524.00   10.00 3640.00   10.00
```

Table 22. Future Low Risk Without Project Conditions COSTDAM File for Cell 2

```
REACH LENGTH AND X-SECTION VOLUME
  2959,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0      0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
   1002.00       0.00       0.0      0.       0.
   1059.00       0.00       0.0      0.       0.
   1121.00       0.00       0.0      0.       0.
   1208.00       0.00       0.0      0.       0.
   1256.00       0.00       0.0      0.       0.
```

```
   1297.00      55.00       0.0     0.      0.
   1329.00     340.00       0.0     0.      0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00     8.00  666.25     8.00 1332.50     8.00 1337.50     0.00 1707.08     0.00
 2076.67     0.00 2446.25     0.00 2815.83     0.00 3185.42     0.00 3555.00     0.00
    0.00     8.20  666.25     8.20 1332.50     8.20 1337.50     0.00 1707.08     0.00
 2076.67     0.00 2446.25     0.00 2815.83     0.00 3185.42     0.00 3555.00     0.00
    0.00     8.50  666.25     8.50 1332.50     8.50 1337.50     0.00 1821.67     0.00
 2305.83     0.00 2790.00     0.00 1350.00     0.00 2452.50     0.00 3555.00     0.00
    0.00    10.10  666.25    10.10 1337.00    10.10 1580.00     9.10 1823.00     8.00
 1920.00     7.60 2200.00     7.40 2400.00     7.30 2700.00     7.10 3555.00     7.10
    0.00    12.06  721.85    12.06 1443.70    12.06 1460.37    12.06 1477.03    12.06
 1493.70    12.06 1826.80    10.67 2159.90     9.29 2493.00     7.90 3555.00     7.90
    0.00    12.82  727.00    12.82 1454.00    12.82 1470.67    12.82 1487.33    12.82
 1504.00    12.82 1815.90    11.51 2127.80    10.21 2439.70     8.90 3555.00     8.90
    0.00    15.20  730.35    15.20 1460.70    15.20 1477.37    15.20 1494.03    15.20
 1510.70    15.20 1930.63    13.47 2350.57    11.73 2770.50    10.00 3555.00    10.00
```

Table 23. Future Low Risk Without Project Conditions COSTDAM File for Cell 3

```
REACH LENGTH AND X-SECTION VOLUME
  6965,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
      0.00       0.00       0.0     0.      0.
     70.00       0.00       0.0     0.      0.
    205.00       0.00       0.0     0.      0.
    424.00       0.00       0.0     0.      0.
    508.00       0.00       0.0     0.      0.
    590.00     838.00       0.0     0.      0.
    842.00     956.00       0.0     0.      0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00     6.70  668.75     6.70 1337.50     6.70 1342.50     0.00 1672.08     0.00
 2001.67     0.00 2331.25     0.00 2660.83     0.00 2990.42     0.00 3320.00     0.00
    0.00     7.00  668.75     7.00 1337.50     7.00 1342.50     0.00 1672.08     0.00
 2001.67     0.00 2331.25     0.00 2660.83     0.00 2990.42     0.00 3320.00     0.00
    0.00     7.10  668.75     7.10 1337.50     7.10 1342.50     0.00 1672.08     0.00
 2001.67     0.00 2331.25     0.00 2660.83     0.00 2990.42     0.00 3320.00     0.00
```

```
    0.00     8.40  668.75     8.40 1337.50     8.40 1342.50     0.00 1846.67     0.00
 2350.83     0.00 2855.00     0.00 1350.00     0.00 2335.00     0.00 3320.00     0.00
    0.00    12.00  668.75    12.00 1337.50    12.00 1354.17    12.00 1370.83    12.00
 1387.50    12.00 1712.50    10.63 2037.50     9.27 2362.50     7.90 3320.00     7.90
    0.00    13.12  668.75    13.12 1337.50    13.12 1364.17    13.12 1390.83    13.12
 1417.50    13.12 1768.83    11.71 2120.17    10.31 2471.50     8.90 3320.00     8.90
    0.00    14.69  708.75    14.69 1417.50    14.69 1434.17    14.69 1450.83    14.69
 1467.50    14.69 1856.50    13.13 2245.50    11.56 2634.50    10.00 3320.00    10.00
```

Table 24. Future Low Risk Without Project Conditions COSTDAM File for Cell 4

```
REACH LENGTH AND X-SECTION VOLUME
  4585,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
    247.00        0.00        0.0      0.       0.
    349.00        0.00        0.0      0.       0.
    455.00        0.00        0.0      0.       0.
    593.00        0.00        0.0      0.       0.
    691.00        0.00        0.0      0.       0.
    791.00        0.00        0.0      0.       0.
    909.00     2206.00        0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00     7.60  432.25     7.60  864.50     7.60  869.50     0.00 1243.75     0.00
 1618.00     0.00 1992.25     0.00 2366.50     0.00 2740.75     0.00 3115.00     0.00
    0.00     8.00  432.25     8.00  864.50     8.00  869.50     0.00 1243.75     0.00
 1618.00     0.00 1992.25     0.00 2366.50     0.00 2740.75     0.00 3115.00     0.00
    0.00     8.50  432.25     8.50  864.50     8.50  869.50     0.00 1243.75     0.00
 1618.00     0.00 1992.25     0.00 2366.50     0.00 2740.75     0.00 3115.00     0.00
    0.00     9.90  434.25     9.90  868.50     9.90  873.50     0.00 1545.67     0.00
 2217.83     0.00 2890.00     0.00 1350.00     0.00 2232.50     0.00 3115.00     0.00
    0.00    10.50  528.75    10.50 1057.50    10.50 1062.50     0.00 1425.00     0.00
 1787.50     0.00 2150.00     0.00 1350.00     0.00 2232.50     0.00 3115.00     0.00
    0.00    12.52  528.75    12.52 1057.50    12.52 1074.17    12.52 1090.83    12.52
 1107.50    12.52 1399.33    11.31 1691.17    10.11 1983.00     8.90 3115.00     8.90
    0.00    14.70  539.00    14.70 1078.00    14.70 1094.67    14.70 1111.33    14.70
 1128.00    14.70 1517.00    13.14 1906.00    11.57 2295.00    10.00 3115.00    10.00
```

Table 25. Future Low Risk Without Project Conditions COSTDAM File for Cell 5

```
REACH LENGTH AND X-SECTION VOLUME
  5835,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
    355.00       0.00       0.0      0.       0.
    450.00       0.00       0.0      0.       0.
    495.00       0.00       0.0      0.       0.
    550.00       0.00       0.0      0.       0.
   1010.00       0.00       0.0      0.       0.
   1175.00       0.00       0.0      0.       0.
   1290.00       0.00       0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00     7.60  514.25     7.60 1028.50     7.60 1033.50     0.00 1413.75     0.00
 1794.00     0.00 2174.25     0.00 2554.50     0.00 2934.75     0.00 3315.00     0.00
    0.00     8.30  514.25     8.30 1033.50     8.30 1038.50     0.00 1061.83     0.00
 1078.50     0.00 1521.83     0.00 1965.17     0.00 2408.50     0.00 3315.00     0.00
    0.00     8.60  516.75     8.60 1033.50     8.60 1038.50     0.00 1066.83     0.00
 1083.50     0.00 1516.83     0.00 1950.17     0.00 2383.50     0.00 3315.00     0.00
    0.00    10.10 1038.50    10.10 1043.50     0.00 1402.00     0.00 1721.00     0.00
 2040.00     0.00 2359.00     0.00 2677.00     0.00 2996.00     0.00 3315.00     0.00
    0.00    12.20  592.50    12.20  700.00    12.20  800.67    12.20 1000.33    12.20
 1084.00    12.20 1545.00    10.80 2006.00     9.60 2820.00     7.90 3315.00     7.90
    0.00    13.30  657.50    13.30 1015.00    13.30 1131.67    13.30 1248.33    13.30
 1250.00    13.30 1650.00    11.90 2480.00     8.90 2640.00     8.90 3315.00     8.90
    0.00    15.80  667.50    15.80 1335.00    15.80 1368.33    15.80 1401.67    15.80
 1435.00    15.80 1871.00    13.40 2720.00    10.00 3123.00    10.00 3315.00    10.00
```

Table 26. Future Low Risk Without Project Conditions COSTDAM File for Cell 6

```
REACH LENGTH AND X-SECTION VOLUME
  1090,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0      0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
    468.00       0.00       0.0      0.       0.
    509.00       0.00       0.0      0.       0.
    567.00       0.00       0.0      0.       0.
    621.00       0.00       0.0      0.       0.
    697.00       0.00       0.0      0.       0.
    803.00       0.00       0.0      0.       0.
    949.00       0.00       0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00     9.30  437.25     9.30  874.50     9.30  879.50     0.00 1257.92     0.00
 1636.33     0.00 2014.75     0.00 2393.17     0.00 2771.58     0.00 3150.00     0.00
    0.00     9.60  437.25     9.60  874.50     9.60  879.50     0.00 1594.67     0.00
 2309.83     0.00 3025.00     0.00 1350.00     5.50 2250.00     5.50 3150.00     5.50
    0.00     9.80  437.25     9.80  874.50     9.80  879.50     0.00 1528.00     0.00
 2176.50     0.00 2825.00     0.00 1350.00     6.10 2250.00     6.10 3150.00     6.10
    0.00    11.50  437.25    11.50  874.50    11.50  879.50     0.00 1228.00     0.00
 1576.50     0.00 1925.00     0.00 1350.00     7.10 2250.00     7.10 3150.00     7.10
    0.00    12.30  440.25    12.30  880.50    12.30  885.50     0.00 1096.17     0.00
 1306.83     0.00 1517.50     0.00 1350.00     7.90 2250.00     7.90 3150.00     7.90
    0.00    13.70  440.25    13.70  880.50    13.70  897.17    13.17  913.83    12.64
  930.50    12.11 1219.17    11.04 1507.83     9.97 1796.50     8.90 3150.00     8.90
    0.00    14.52  497.25    14.52  994.50    14.52 1011.17    14.52 1027.83    14.52
 1044.50    14.52 1454.50    13.01 1864.50    11.51 2274.50    10.00 3150.00    10.00
```

Table 27. Future Low Risk Without Project Conditions COSTDAM File for Cell 7

```
REACH LENGTH AND X-SECTION VOLUME
  6267,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
     78.00        0.00        0.0      0.       0.
    146.00        0.00        0.0      0.       0.
    237.00        0.00        0.0      0.       0.
    332.00        0.00        0.0      0.       0.
    399.00        0.00        0.0      0.       0.
    506.00        0.00        0.0      0.       0.
    716.00        0.00        0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
         10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00    9.10  258.75    9.10  517.50    9.10  522.50    0.00  710.42    0.00
  898.33    0.00 1086.25    0.00 1274.17    0.00 1462.08    0.00 1650.00    0.00
    0.00    9.30  258.75    9.30  517.50    9.30  522.50    0.00  830.00    0.00
 1137.50    0.00 1445.00    0.00 1350.00    0.00 1500.00    0.00 1650.00    0.00
    0.00   10.10  258.75   10.10  517.50   10.10  522.50    0.00  776.67    0.00
 1030.83    0.00 1285.00    0.00 1350.00    0.00 1500.00    0.00 1650.00    0.00
    0.00   11.90  258.75   11.90  517.50   11.90  522.50    0.00  750.83    0.00
  979.17    0.00 1207.50    0.00 1350.00    0.00 1500.00    0.00 1650.00    0.00
    0.00   12.50  200.00   12.50  300.00   12.50  350.00   12.50  375.00   12.50
  553.50   12.50  838.00   11.17 1109.00   10.10 1600.00    7.90 1650.00    7.90
    0.00   13.41  262.25   13.41  524.50   13.41  541.17   13.41  557.83   13.41
  574.50   13.41  843.38   12.34 1112.25   11.28 1381.13   10.21 1650.00    9.14
    0.00   15.13  291.75   15.13  583.50   15.13  600.17   15.13  616.83   15.13
  633.50   15.13  887.63   14.40 1141.75   13.67 1395.88   12.93 1650.00   12.20
```

Table 28. Future High Risk Without Project Conditions COSTDAM File for Cell 1

```
REACH LENGTH AND X-SECTION VOLUME
  3549,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
   1175.00        0.00        0.0      0.       0.
   1255.00        0.00        0.0      0.       0.
```

```
   1330.00        0.00        0.0      0.       0.
   1435.00       95.00        0.0      0.       0.
   1555.00     1050.00        0.0      0.       0.
   1645.00     1995.00        0.0      0.       0.
   1690.00     1950.00        0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00     9.50  650.75     9.50 1301.50     9.50 1306.50     0.00 1695.42     0.00
 2084.33     0.00 2473.25     0.00 2862.17     0.00 3251.08     0.00 3640.00     0.00
    0.00    10.87  650.75    10.87 1301.50    10.87 1318.17    10.87 1334.83    10.87
 1351.50    10.87 1782.43     9.08 2213.37     7.29 2644.30     5.50 3640.00     5.50
    0.00    11.60  650.75    11.60 1301.50    11.60 1318.17    11.58 1334.83    11.56
 1351.50    11.54 1788.17     9.73 2224.83     7.91 2661.50     6.10 3640.00     6.10
    0.00    14.52  650.75    14.52 1301.50    14.52 1386.00    14.52 1470.50    14.52
 1555.00    14.52 2173.06    12.04 2791.11     9.57 3409.17     7.10 3640.00     7.10
    0.00    16.37  777.50    16.37 1555.00    16.37 1585.00    16.37 1615.00    16.37
 1645.00    16.37 2143.75    14.38 2642.50    12.38 3141.25    10.39 3640.00     8.39
    0.00    17.98  822.50    17.98 1645.00    17.98 1668.33    17.98 1691.67    17.98
 1715.00    17.98 2196.25    16.06 2677.50    14.13 3158.75    12.21 3640.00    10.28
    0.00    20.38  857.50    20.38 1715.00    20.38 1741.67    20.38 1768.33    20.38
 1795.00    20.38 2256.25    18.53 2717.50    16.69 3178.75    14.84 3640.00    13.00
```

Table 29. Future High Risk Without Project Conditions COSTDAM File for Cell 2

```
REACH LENGTH AND X-SECTION VOLUME
  2959,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0      0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
   1150.00        0.00        0.0      0.       0.
   1235.00        0.00        0.0      0.       0.
   1315.00        0.00        0.0      0.       0.
   1392.00        0.00        0.0      0.       0.
   1448.00      802.00        0.0      0.       0.
   1502.00     2053.00        0.0      0.       0.
   1578.00     1977.00        0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00    11.27  857.50    11.27 1000.00    11.27 1200.00    11.27 1400.00    11.27
 1455.00    11.27 1955.00     9.18 2480.00     7.09 2995.83     5.00 3555.00     5.00
    0.00    11.85  713.75    11.85 1427.50    11.85 1444.17    11.85 1460.83    11.85
```

```
 1477.50   11.85 2002.78    9.74 2528.06    7.62 3053.33    5.50 3555.00    5.50
    0.00   12.57  732.50   12.57 1465.00   12.57 1481.67   12.57 1498.33   12.57
 1515.00   12.57 2048.06   10.41 2581.11    8.26 3114.17    6.10 3555.00    6.10
    0.00   14.77  748.75   14.77 1497.50   14.77 1520.83   14.77 1544.17   14.77
 1567.50   14.77 2206.94   12.22 2846.39    9.66 3485.83    7.10 3555.00    7.10
    0.00   16.81  783.75   16.81 1567.50   16.81 1584.17   16.81 1600.83   16.81
 1617.50   16.81 2101.88   14.85 2586.25   12.89 3070.63   10.93 3555.00    8.97
    0.00   18.43  797.75   18.43 1595.50   18.43 1612.17   18.43 1628.83   18.43
 1645.50   18.43 2122.88   16.50 2600.25   14.58 3077.63   12.66 3555.00   10.74
    0.00   20.86  816.25   20.86 1632.50   20.86 1649.17   20.86 1665.83   20.86
 1682.50   20.86 2150.63   18.98 2618.75   17.09 3086.88   15.21 3555.00   13.33
```

Table 30. Future High Risk Without Project Conditions COSTDAM File for Cell 3

```
REACH LENGTH AND X-SECTION VOLUME
  6965,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
    258.00        0.00        0.0      0.       0.
    430.00        0.00        0.0      0.       0.
    625.00        0.00        0.0      0.       0.
    906.00        0.00        0.0      0.       0.
   1095.00     1466.00        0.0      0.       0.
   1245.00     1760.00        0.0      0.       0.
   1500.00     2190.00        0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
         10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00   11.38  816.25   11.38 1349.00   11.38 1365.00   11.38 1382.00   11.38
 1399.00   11.38 1905.00    9.25 2445.00    7.13 2943.50    5.00 3320.00    5.00
    0.00   11.99  674.25   11.99 1348.50   11.99 1365.17   11.99 1381.83   11.99
 1398.50   11.99 1922.50    9.83 2446.50    7.66 2970.50    5.50 3320.00    5.50
    0.00   12.75  674.25   12.75 1348.50   12.75 1365.17   12.75 1381.83   12.75
 1398.50   12.75 1935.83   10.53 2473.17    8.32 3010.50    6.10 3320.00    6.10
    0.00   14.74  674.25   14.74 1348.50   14.74 1365.17   14.74 1381.83   14.74
 1398.50   14.74 2018.43   12.19 2638.37    9.65 3258.30    7.10 3320.00    7.10
    0.00   16.76  674.25   16.76 1348.50   16.76 1365.17   16.76 1381.83   16.76
 1398.50   16.76 1878.88   14.79 2359.25   12.82 2839.63   10.85 3320.00    8.87
    0.00   18.34  674.25   18.34 1348.50   18.34 1397.33   18.34 1446.17   18.34
 1495.00   18.34 1951.25   16.52 2407.50   14.69 2863.75   12.86 3320.00   11.04
    0.00   21.42  747.50   21.42 1495.00   21.42 1515.00   21.42 1535.00   21.42
 1555.00   21.42 1996.25   19.65 2437.50   17.89 2878.75   16.13 3320.00   14.36
```

Table 31. Future High Risk Without Project Conditions COSTDAM File for Cell 4

```
REACH LENGTH AND X-SECTION VOLUME
  4585,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0      0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
    450.00       0.00       0.0     0.      0.
    674.00       0.00       0.0     0.      0.
    903.00       0.00       0.0     0.      0.
   1228.00     890.00       0.0     0.      0.
   1428.00    1687.00       0.0     0.      0.
   1642.00    1473.00       0.0     0.      0.
   1921.00    1194.00       0.0     0.      0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00   10.50  502.25   10.50 1004.50   10.50 1009.50    0.00 1360.42    0.00
 1711.33    0.00 2062.25    0.00 2413.17    0.00 2764.08    0.00 3115.00    0.00
    0.00   11.50  502.25   11.50 1004.50   11.50 1021.17   11.40 1037.83   11.30
 1054.50   11.20 1512.83    9.30 1971.17    7.40 2429.50    5.50 3115.00    5.50
    0.00   12.10  502.25   12.10 1004.50   12.10 1021.17   11.94 1037.83   11.77
 1054.50   11.61 1497.00    9.77 1939.50    7.94 2382.00    6.10 3115.00    6.10
    0.00   13.99  502.25   13.99 1004.50   13.99 1021.17   13.99 1037.83   13.99
 1054.50   13.99 1685.50   11.69 2316.50    9.40 2947.50    7.10 3115.00    7.10
    0.00   16.02  612.50   16.02 1225.00   16.02 1241.67   16.02 1258.33   16.02
 1275.00   16.02 1735.00   14.16 2195.00   12.31 2655.00   10.46 3115.00    8.60
    0.00   17.83  630.00   17.83 1260.00   17.83 1276.67   17.83 1293.33   17.83
 1310.00   17.83 1761.25   16.01 2212.50   14.19 2663.75   12.37 3115.00   10.55
    0.00   19.59  647.50   19.59 1295.00   19.59 1311.67   19.59 1328.33   19.59
 1345.00   19.59 1787.50   17.81 2230.00   16.03 2672.50   14.25 3115.00   12.47
```

Table 32. Future High Risk Without Project Conditions COSTDAM File for Cell 5

```
REACH LENGTH AND X-SECTION VOLUME
  5835,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
   1028.00       0.00       0.0      0.       0.
   1125.00       0.00       0.0      0.       0.
   1225.00       0.00       0.0      0.       0.
   1430.00       0.00       0.0      0.       0.
   1758.00       0.00       0.0      0.       0.
   1845.00      45.00       0.0      0.       0.
   1925.00    1390.00       0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00   10.80  647.50   10.80 1028.00   10.80 1206.17   10.00 1344.00    9.40
 1400.00    9.10 1500.03    8.77 1971.57    6.89 2443.10    5.00 3315.00    5.00
    0.00   11.40  514.25   11.40 1028.50   11.40 1045.17   11.28 1061.83   11.16
 1078.50   11.04 1525.17    9.19 1971.83    7.35 2418.50    5.50 3315.00    5.50
    0.00   12.00  516.75   12.00 1033.50   12.00 1050.17   11.83 1066.83   11.66
 1083.50   11.49 1516.00    9.69 1948.50    7.90 2381.00    6.10 3315.00    6.10
    0.00   14.39  516.75   14.39 1033.50   14.39 1050.17   14.39 1066.83   14.39
 1083.50   14.39 1724.39   11.96 2365.28    9.53 3006.17    7.10 3315.00    7.10
    0.00   15.87  592.25   15.87 1184.50   15.87 1201.17   15.87 1217.83   15.87
 1234.50   15.87 1925.50   13.21 2616.50   10.56 3307.50    7.90 3315.00    7.90
    0.00   17.59  657.50   17.59 1315.00   17.59 1331.67   17.59 1348.33   17.59
 1365.00   17.59 1852.50   15.61 2340.00   13.63 2827.50   11.65 3315.00    9.67
    0.00   19.72  667.50   19.72 1335.00   19.72 1368.33   19.72 1401.67   19.72
 1435.00   19.72 1905.00   17.84 2375.00   15.96 2845.00   14.08 3315.00   12.20
```

Table 33. Future High Risk Without Project Conditions COSTDAM File for Cell 6

```
REACH LENGTH AND X-SECTION VOLUME
  1090,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0      0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
    715.00       0.00       0.0     0.      0.
    774.00       0.00       0.0     0.      0.
    872.00       0.00       0.0     0.      0.
   1005.00       0.00       0.0     0.      0.
   1135.00       0.00       0.0     0.      0.
   1312.00       0.00       0.0     0.      0.
   1540.00       0.00       0.0     0.      0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00   12.30  456.25   12.30  912.50   12.30  917.50    0.00 1289.58    0.00
 1661.67    0.00 2033.75    0.00 2405.83    0.00 2777.92    0.00 3150.00    0.00
    0.00   12.60  913.00   12.60  918.00    0.00 1287.86    0.00 1598.21    0.00
 1908.57    0.00 2218.93    0.00 2529.29    0.00 2839.64    0.00 3150.00    0.00
    0.00   13.60  938.00   13.60  988.00    8.37 1296.86    7.91 1605.71    7.81
 1914.57    7.72 2223.43    7.64 2532.29    7.55 2841.14    7.13 3150.00    6.20
    0.00   15.10  469.00   15.10  938.00   15.10  954.67   14.97  971.33   14.83
  988.00   14.70 1607.00   12.17 2226.00    9.64 2845.00    7.11 3150.00    7.10
    0.00   16.24  472.50   16.24  945.00   16.24  961.67   16.24  978.33   16.24
  995.00   16.24 1686.67   13.46 2378.33   10.68 3070.00    7.90 3150.00    7.90
    0.00   18.07  492.50   18.07  985.00   18.07 1001.67   18.07 1018.33   18.07
 1035.00   18.07 1563.75   16.03 2092.50   13.98 2621.25   11.94 3150.00    9.89
    0.00   20.69  552.50   20.69 1105.00   20.69 1121.67   20.69 1138.33   20.69
 1155.00   20.69 1653.75   18.86 2152.50   17.03 2651.25   15.20 3150.00   13.36
```

Table 34. Future High Risk Without Project Conditions COSTDAM File for Cell 7

```
REACH LENGTH AND X-SECTION VOLUME
  6267,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0      0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
```

```
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
    315.00        0.00        0.0      0.       0.
    438.00        0.00        0.0      0.       0.
    548.00        0.00        0.0      0.       0.
    715.00        0.00        0.0      0.       0.
    873.00       69.00        0.0      0.       0.
    983.00      668.00        0.0      0.       0.
   1182.00      618.00        0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
           10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00   11.70  322.25   11.70  644.50   11.70  649.50    0.00  816.25    0.00
  983.00    0.00 1149.75    0.00 1316.50    0.00 1483.25    0.00 1650.00    0.00
    0.00   12.30  329.75   12.30  659.50   12.30  664.50    0.00  924.67    0.00
 1184.83    0.00 1445.00    0.00 1350.00    0.00 1500.00    0.00 1650.00    0.00
    0.00   12.60  329.75   12.60  659.50   12.60  676.17   12.50  692.83   12.40
  709.50   12.30  944.63   11.33 1179.75   10.35 1414.88    9.38 1650.00    8.40
    0.00   14.66  337.25   14.66  674.50   14.66  691.17   14.66  707.83   14.66
  724.50   14.66  955.88   13.70 1187.25   12.75 1418.63   11.79 1650.00   10.83
    0.00   16.50  347.25   16.50  694.50   16.50  711.17   16.50  727.83   16.50
  744.50   16.50  970.88   15.65 1197.25   14.80 1423.63   13.95 1650.00   13.10
    0.00   18.15  400.00   18.15  800.00   18.15  816.67   18.15  833.33   18.15
  850.00   18.15 1050.00   17.43 1250.00   16.70 1450.00   15.98 1650.00   15.25
    0.00   20.35  462.50   20.35  925.00   20.35  941.67   20.35  958.33   20.35
  975.00   20.35 1143.75   19.79 1312.50   19.22 1481.25   18.66 1650.00   18.09
```

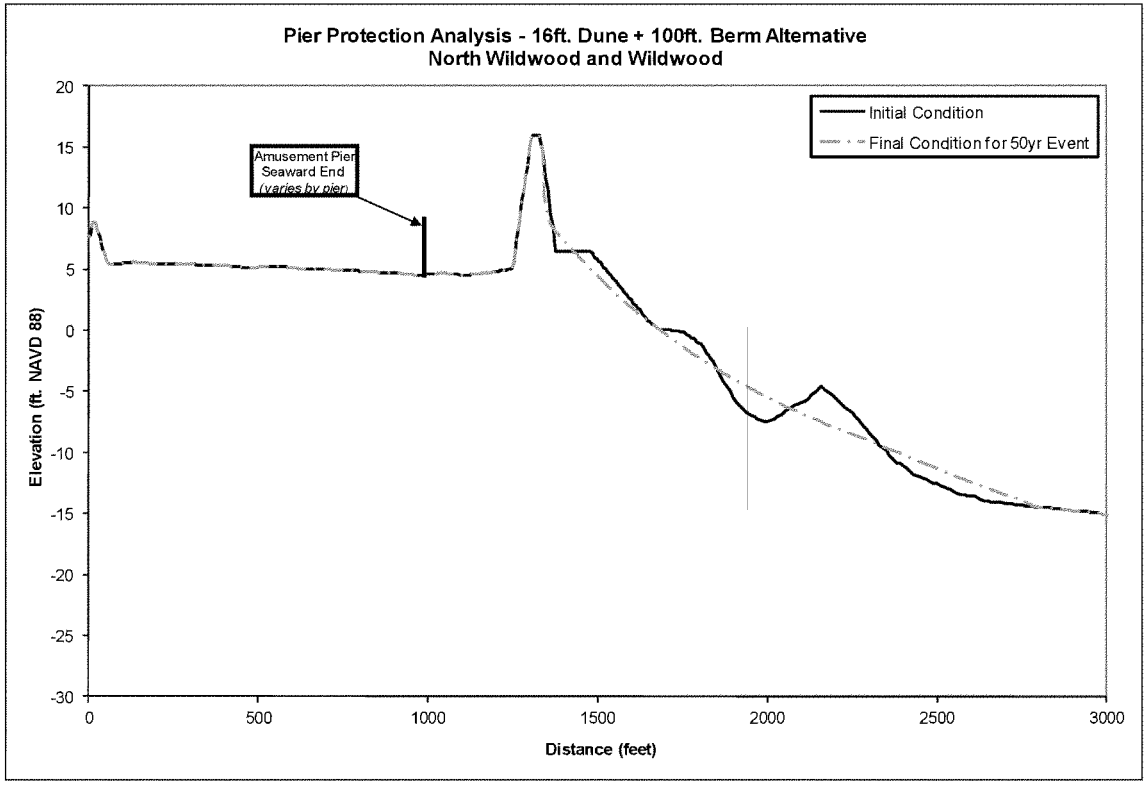


Figure 50. Pre- and Post "50-yr" Storm Beach Profiles for 16 ft. Dune & 100 ft. Berm Pier Protection Alternative

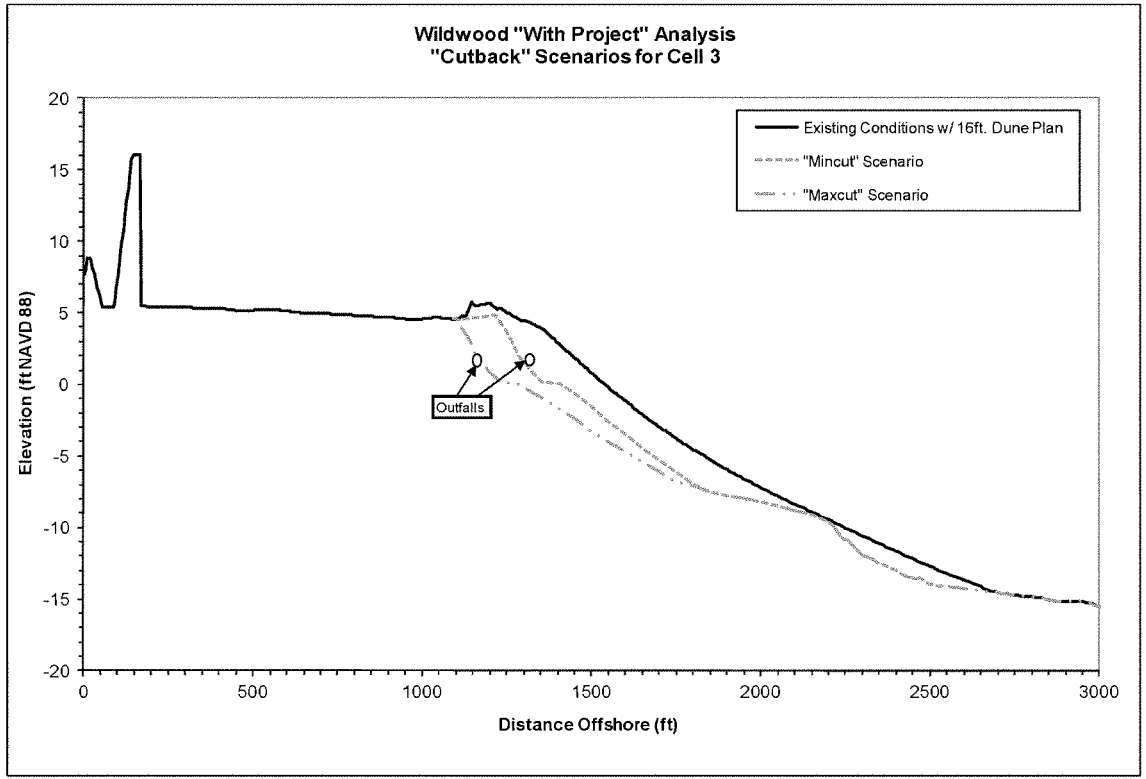


Figure 51. Berm Cntback Alternatives Examined for With Project Analysis in Cell 3

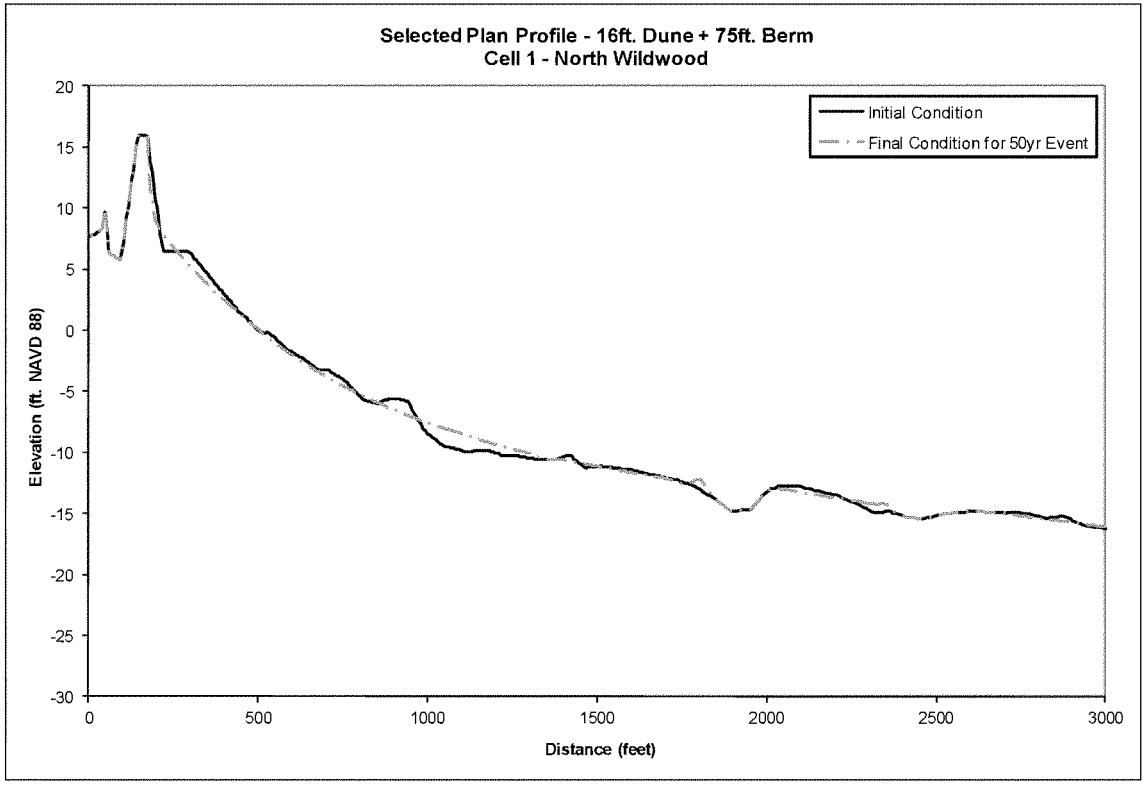


Figure 52. Pre- and Post "50-yr" Storm Beach Profiles for Selected Plan in Cell 1

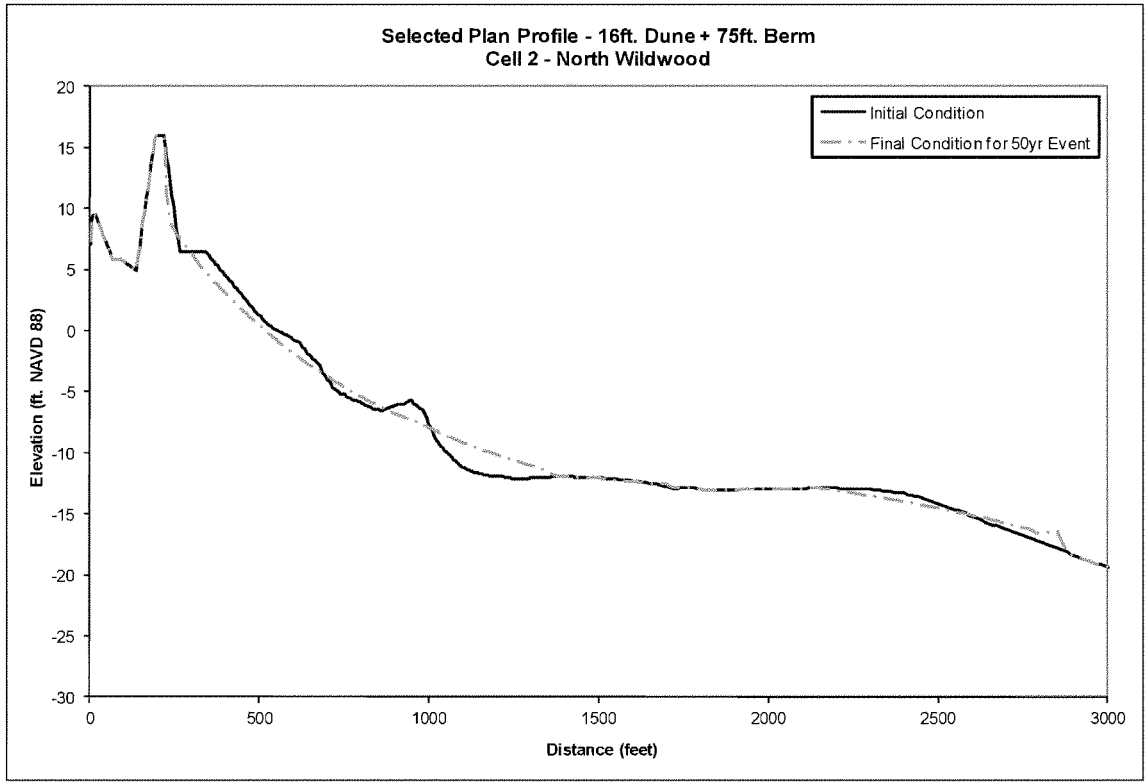


Figure 53. Pre- and Post "50-yr" Storm Beach Profiles for Selected Plan in Cell 2

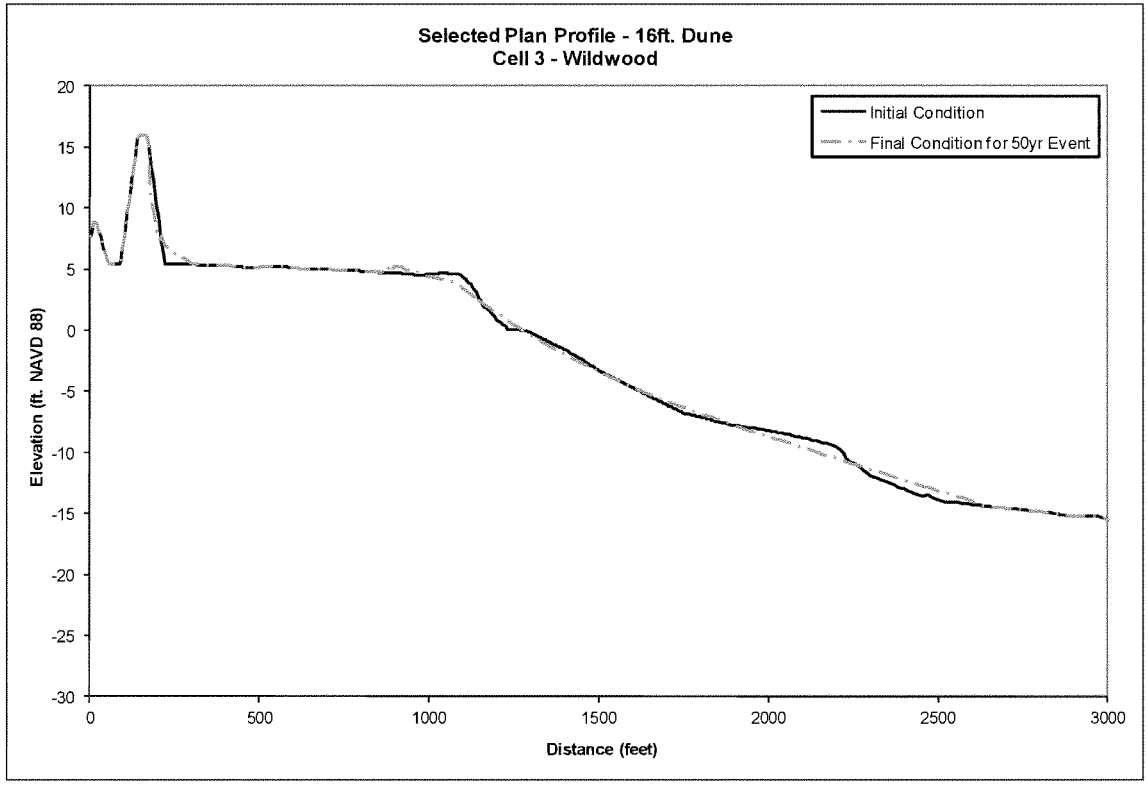


Figure 54. Pre- and Post "50-yr" Storm Beach Profiles for Selected Plan in Cell 3

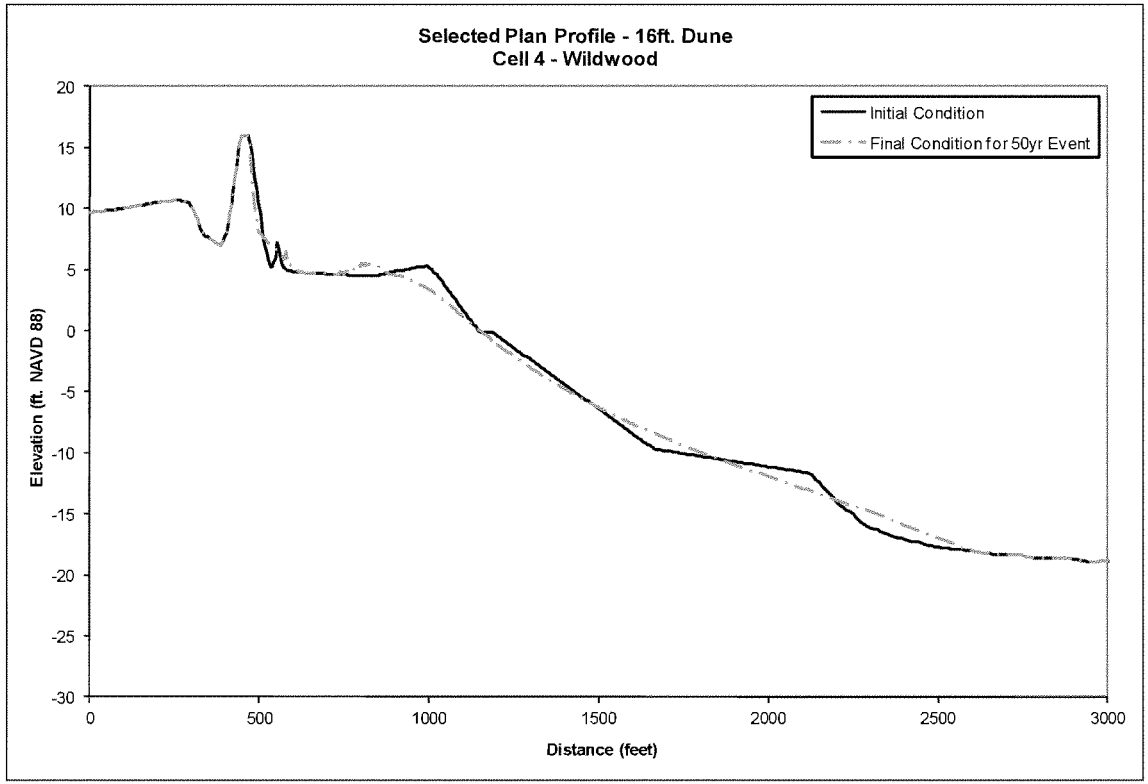


Figure 55. Pre- and Post "50-yr" Storm Beach Profiles for Selected Plan in Cell 4

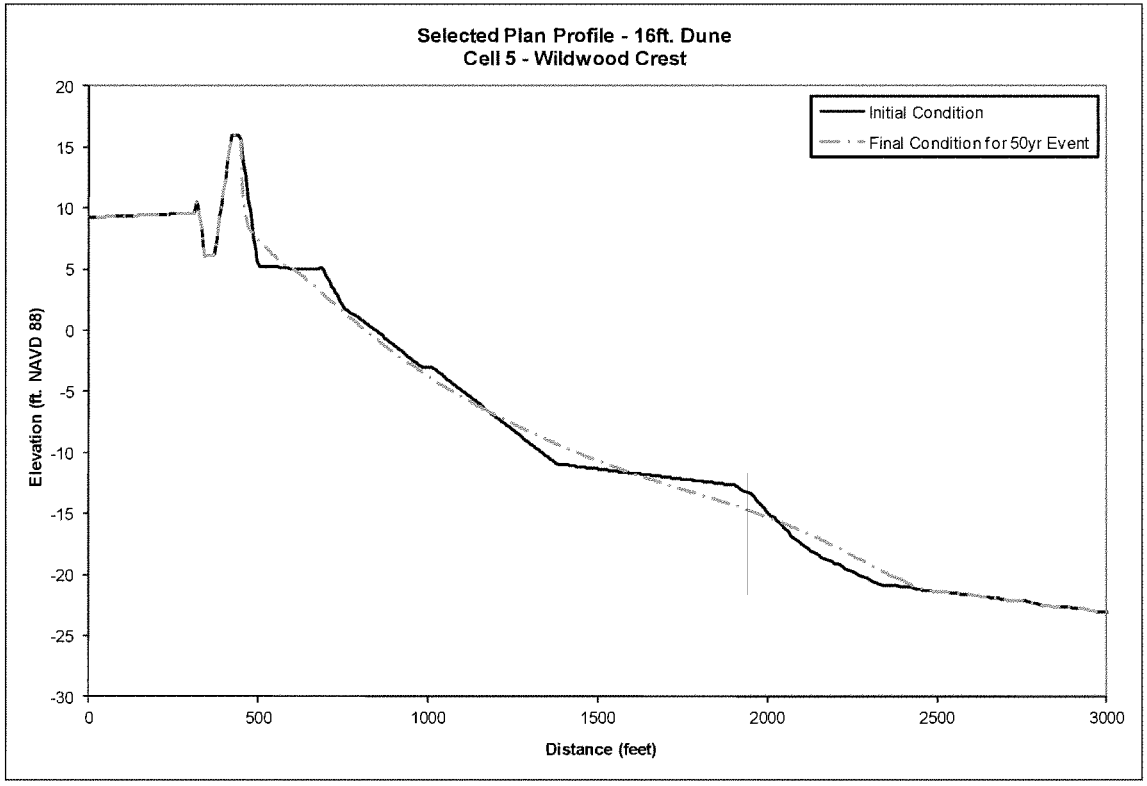


Figure 56. Pre- and Post "50-yr" Storm Beach Profiles for Selected Plan in Cell 5

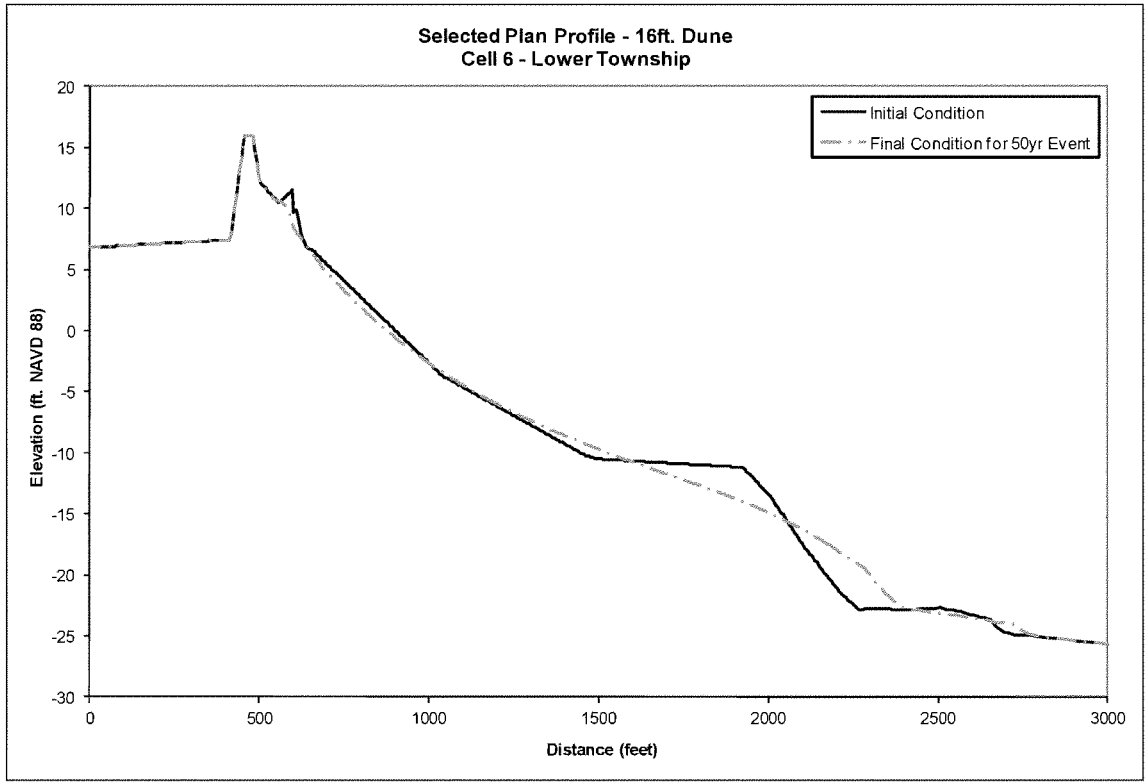


Figure 57. Pre- and Post "50-yr" Storm Beach Profiles for Selected Plan in Cell 6

Table 35. Selected Plan of 16 ft. Dune + 75 ft. Berm COSTDAM File for Cell 1

```
REACH LENGTH AND X-SECTION VOLUME
  3549,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
   1065.00        0.00        0.0      0.       0.
   1155.00        0.00        0.0      0.       0.
   1160.00        0.00        0.0      0.       0.
   1175.00        0.00        0.0      0.       0.
   1185.00        0.00        0.0      0.       0.
   1215.00        0.00        0.0      0.       0.
   1250.00     2390.00        0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00     8.80  600.00     8.80 1182.00     8.80 1187.00     0.00 1300.00     0.00
 1500.00     0.00 1900.00     0.00 2300.00     0.00 2900.00     0.00 3640.00     0.00
    0.00     9.00  600.00     9.00 1182.00     9.00 1187.00     0.00 1300.00     0.00
 1500.00     0.00 1900.00     0.00 2300.00     0.00 2900.00     0.00 3640.00     0.00
    0.00     9.40  600.00     9.40 1182.00     9.40 1187.00     0.00 1300.00     0.00
 1500.00     0.00 1900.00     0.00 2300.00     0.00 2900.00     0.00 3640.00     0.00
    0.00    11.20  600.00    11.20 1182.00    11.20 1187.00     0.00 1300.00     0.00
 1500.00     0.00 1900.00     0.00 2300.00     0.00 2900.00     0.00 3640.00     0.00
    0.00    13.20  600.00    13.20 1187.00    13.20 1192.00     0.00 1300.00     0.00
 1500.00     0.00 1900.00     0.00 2300.00     0.00 2900.00     0.00 3640.00     0.00
    0.00    14.90  600.00    14.90 1187.00    14.90 1204.00    14.90 1221.00    14.90
 1238.00    14.70 1749.00    12.80 2260.00    10.80 2771.00     8.90 3640.00     8.90
    0.00    16.90  600.00    16.90 1313.00    16.90 1329.00    16.90 1346.00    16.90
 1363.00    16.90 1954.00    14.90 2546.00    12.50 3175.00    10.00 3640.00    10.00
```

Table 36. Selected Plan of 16 ft. Dune + 75 ft. Berm COSTDAM File for Cell 2

```
REACH LENGTH AND X-SECTION VOLUME
  2959,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
```

```
   1045.00        0.00        0.0      0.       0.
   1110.00        0.00        0.0      0.       0.
   1160.00        0.00        0.0      0.       0.
   1200.00        0.00        0.0      0.       0.
   1260.00        0.00        0.0      0.       0.
   1305.00        0.00        0.0      0.       0.
   1380.00      335.00        0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
         10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00     9.40  600.00     9.40 1132.00     9.40 1137.00     0.00 1200.00     0.00
 1400.00     0.00 2000.00     0.00 2500.00     0.00 3000.00     0.00 3555.00     0.00
    0.00     9.80  600.00     9.80 1132.00     9.80 1137.00     0.00 1200.00     0.00
 1400.00     0.00 2000.00     0.00 2500.00     0.00 3000.00     0.00 3555.00     0.00
    0.00    10.00  600.00    10.00 1132.00    10.00 1137.00     0.00 1200.00     0.00
 1400.00     0.00 2000.00     0.00 2500.00     0.00 3000.00     0.00 3555.00     0.00
    0.00    12.00  600.00    12.00 1132.00    12.00 1137.00     0.00 1200.00     0.00
 1400.00     0.00 2000.00     0.00 2500.00     0.00 3000.00     0.00 3555.00     0.00
    0.00    13.00  600.00    13.00 1142.00    13.00 1147.00     0.00 1200.00     0.00
 1400.00     0.00 2000.00     0.00 2500.00     0.00 3000.00     0.00 3555.00     0.00
    0.00    14.50  600.00    14.50 1142.00    14.50 1159.00    14.50 1176.00    14.50
 1193.00    14.50 1723.00    12.80 2252.00    10.70 2765.00     8.90 3555.00     8.90
    0.00    17.40  600.00    17.40 1200.00    17.40 1220.00    17.40 1230.00    17.40
 1240.00    17.40 2014.00    14.50 2703.00    11.70 3150.00    10.00 3555.00    10.00
```

Table 37. Selected Plan of 16 ft. Dune COSTDAM File for Cell 3

```
REACH LENGTH AND X-SECTION VOLUME
  6965,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0      0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
     85.00        0.00        0.0      0.       0.
    250.00        0.00        0.0      0.       0.
    420.00        0.00        0.0      0.       0.
    675.00        0.00        0.0      0.       0.
    885.00        0.00        0.0      0.       0.
    995.00      845.00        0.0      0.       0.
   1275.00     2045.00        0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
         10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00     7.90  650.00     7.90 1182.00     7.90 1187.00     0.00 1700.00     0.00
```

```
 2100.00    0.00 2500.00    0.00 2800.00    0.00 3200.00    0.00 3320.00    0.00
    0.00    8.30  650.00    8.30 1182.00    8.30 1187.00    0.00 1700.00    0.00
 2100.00    0.00 2500.00    0.00 2800.00    0.00 3200.00    0.00 3320.00    0.00
    0.00    8.60  650.00    8.60 1182.00    8.60 1187.00    0.00 1700.00    0.00
 2100.00    0.00 2500.00    0.00 2800.00    0.00 3200.00    0.00 3320.00    0.00
    0.00    9.30  650.00    9.30 1182.00    9.30 1187.00    0.00 1700.00    0.00
 2100.00    0.00 2500.00    0.00 2800.00    0.00 3200.00    0.00 3320.00    0.00
    0.00   13.60  650.00   13.60 1187.00   13.60 1192.00    0.00 1251.00    0.00
 1268.00    0.00 1571.00    0.00 1874.00    0.00 2178.00    0.00 3320.00    0.00
    0.00   15.80  650.00   15.80 1200.00   15.80 1250.00   15.80 1255.00   15.80
 1258.00   15.80 1589.00   14.40 1920.00   13.00 2252.00    8.90 3320.00    8.90
    0.00   17.90  650.00   17.90 1200.00   17.90 1250.00   17.90 1260.00   17.90
 1300.00   17.90 1385.00   17.90 1895.00   15.80 2518.00   13.30 3320.00   10.10
```

Table 38. Selected Plan of 16 ft. Dune COSTDAM File for Cell 4

```
REACH LENGTH AND X-SECTION VOLUME
  4585,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0      0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
    330.00       0.00       0.0      0.       0.
    490.00       0.00       0.0      0.       0.
    665.00       0.00       0.0      0.       0.
    805.00       0.00       0.0      0.       0.
    955.00       0.00       0.0      0.       0.
   1145.00     855.00       0.0      0.       0.
   1425.00    1690.00       0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00    8.00  650.00    8.00  877.00    8.00  882.00    0.00 1200.00    0.00
 1600.00    0.00 2000.00    0.00 2400.00    0.00 2800.00    0.00 3115.00    0.00
    0.00    8.60  650.00    8.60  877.00    8.60  882.00    0.00 1200.00    0.00
 1600.00    0.00 2000.00    0.00 2400.00    0.00 2800.00    0.00 3115.00    0.00
    0.00    9.20  650.00    9.20  882.00    9.20  887.00    0.00 1200.00    0.00
 1600.00    0.00 2000.00    0.00 2400.00    0.00 2800.00    0.00 3115.00    0.00
    0.00   10.50  650.00   10.50  887.00   10.50  892.00    0.00 1200.00    0.00
 1600.00    0.00 2000.00    0.00 2400.00    0.00 2800.00    0.00 3115.00    0.00
    0.00   12.80  650.00   12.80  902.00   12.80  907.00    0.00  930.00    0.00
  947.00    0.00 1294.00    0.00 1640.00    0.00 2120.00    0.00 3115.00    0.00
    0.00   14.90  650.00   14.90  900.00   14.90  915.00   14.90  930.00   14.90
 1050.00   14.90 1343.00   13.70 1734.00   12.10 2540.00    8.90 3115.00    8.90
```

```
    0.00   17.00  650.00   17.00  900.00   17.00  915.00   17.00 1063.00   17.00
 1200.00   17.00 1680.00   14.90 2309.00   12.40 2939.00   10.00 3115.00   10.00
```

Table 39. Selected Plan of 16 ft. Dune COSTDAM File for Cell 5

```
REACH LENGTH AND X-SECTION VOLUME
  5835,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0      0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
    655.00       0.00       0.0     0.      0.
    715.00       0.00       0.0     0.      0.
    775.00       0.00       0.0     0.      0.
    870.00       0.00       0.0     0.      0.
   1035.00       0.00       0.0     0.      0.
   1195.00       0.00       0.0     0.      0.
   1315.00       0.00       0.0     0.      0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00    8.30  650.00    8.30  917.00    8.30  922.00    0.00 1400.00    0.00
 1800.00    0.00 2200.00    0.00 2600.00    0.00 3000.00    0.00 3315.00    0.00
    0.00    9.00  650.00    9.00  922.00    9.00  927.00    0.00 1400.00    0.00
 1800.00    0.00 2200.00    0.00 2600.00    0.00 3000.00    0.00 3315.00    0.00
    0.00    9.50  650.00    9.50  932.00    9.50  937.00    0.00 1400.00    0.00
 1800.00    0.00 2200.00    0.00 2600.00    0.00 3000.00    0.00 3315.00    0.00
    0.00   11.40  650.00   11.40  932.00   11.40  937.00    0.00 1721.00    0.00
 2040.00    0.00 2359.00    0.00 2677.00    0.00 2996.00    0.00 3315.00    0.00
    0.00   13.40  650.00   13.40  932.00   13.40  937.00    0.00  976.00    0.00
  993.00    0.00 1348.00    0.00 1703.00    0.00 2058.00    0.00 3315.00    0.00
    0.00   14.90  650.00   14.90  700.00   14.90  800.00   14.90 1000.00   14.90
 1020.00   14.90 1492.00   13.00 1963.00   11.00 2474.00    8.90 3315.00    8.90
    0.00   17.50  650.00   17.50  900.00   17.50 1000.00   17.50 1100.00   17.50
 1150.00   17.50 1711.00   15.40 2273.00   13.10 3064.00   10.00 3315.00   10.00
```

Table 40. Selected Plan of 16 ft. Dune COSTDAM File for Cell 6

```
REACH LENGTH AND X-SECTION VOLUME
  1090,0.0
DISTANCE SHORELINE TO REF LINE / LONG TERM EROSION RATE
     0.0       0.0
DEFAULT PERSONAL PROPERTY PERCENTAGE
0.35
STORM EROSION,WAVE IMPACT,WAVE DAMAGE ELEVATION, ZONES 1 & 2
    525.00        0.00        0.0      0.       0.
    575.00        0.00        0.0      0.       0.
    645.00        0.00        0.0      0.       0.
    730.00        0.00        0.0      0.       0.
    830.00        0.00        0.0      0.       0.
    920.00        0.00        0.0      0.       0.
   1120.00        0.00        0.0      0.       0.
NUMBER OF POINTS IN WATER ELEVATION PROFILE
          10
INUNDATION PROFILE.  DISTANCE FROM BASELINE AND TOTAL WATERLEVEL
    0.00   10.30  650.00   10.30  893.00   10.30  898.00    0.00 1200.00    0.00
 1600.00    0.00 2000.00    0.00 2400.00    0.00 2800.00    0.00 3150.00    0.00
    0.00   10.60  650.00   10.60  893.00   10.60  898.00    0.00 1200.00    0.00
 1600.00    0.00 2000.00    0.00 2400.00    0.00 2800.00    0.00 3150.00    0.00
    0.00   10.90  650.00   10.90  893.00   10.90  898.00    0.00 1200.00    0.00
 1600.00    0.00 2000.00    0.00 2400.00    0.00 2800.00    0.00 3150.00    0.00
    0.00   12.70  650.00   12.70  893.00   12.70  898.00    0.00 1200.00    0.00
 1600.00    0.00 2000.00    0.00 2400.00    0.00 2800.00    0.00 3150.00    0.00
    0.00   13.70  650.00   13.70  893.00   13.70  898.00    0.00 1200.00    0.00
 1600.00    0.00 2000.00    0.00 2400.00    0.00 2800.00    0.00 3150.00    0.00
    0.00   15.50  650.00   15.50  903.00   15.50  919.00   15.40  936.00   15.30
  953.00   15.10 1468.00   13.00 1983.00   10.90 2435.00    8.90 3150.00    8.90
    0.00   17.60  650.00   17.60 1000.00   17.60 1020.00   17.60 1040.00   17.60
 1088.00   17.60 1727.00   15.20 2367.00   12.70 3100.00   10.00 3150.00   10.00
```

Section 3.

Surveying and Mapping Requirements

Profile data was developed from offshore and onshore survey lines collected in 1955, 1965, 2001, 2003 and 2012. These profiles were used to perform storm damage and volume calculations. A total of 25 survey lines were occupied in North Wildwood, Wildwood, Wildwood Crest and Lower Township. These profiles consisted of surveys from the back dune, over the berm to the offshore area and to the depth of closure. Profiles from the Richard Stockton Coastal Research Center were also used for this analysis.

Data collection for the study mapping effort including surveys, historic aerial photography from 1920, 1933, 1944, 1962, 1970, 2003, and 2006. Planimetric data was also collected from the 2003 survey data. Auto CAD and Arcmap were used to store and interpret the survey data. Mapping for the Feasibility study is sufficient for the plans and specifications phase, but new survey data will be acquired. Beach profile surveys every 200 feet from the dune/bulkhead line to the depth of closure will be required to accurately determine the quantities in developing the plans and specifications. These profiles will also include shore protection structures and groins in the study area.

Section 4

Geotechnical Appendix

GEOTECHNICAL APPENDIX

03/6/14 Version

INTRODUCTION

The geotechnical appendix provides detailed information and records of the data and procedures utilized in the preparation of the Geotechnical Analysis presented in this report. The information and data presented in the following sections which include the following:

Section 1 – Summary of Boring and Vibracore Utilized
Section 2 – Design Value Computations and Tables
Section 3 – Description of the Design Methodology
Section 4 – Investigation Reports (DVD)
Section 5 – Bibliography of Referenced Documents

GEOTECHNICAL APPENDIX

SECTION 1
Summary of Boring and Vibracore Utilized

This section presents the boring and vibracore logs and gradation curves utilized in the geotechnical analysis presented in this report. It is noted that there are additional beach, vibracore and SPT sampling locations along the beach and near the proposed borrow areas that are not included in the analysis because they were either outside the area under consideration, or they represent material that was examined and found to be unsatisfactory for the proposed North Wildwood beach replenishment. In some cases, potential borrow areas had been dedicated to other beach replenishment projects and were therefore not considered in this analysis. The additional geotechnical information is available in the geotechnical investigation reports included for reference in Section 4, on the attached DVD. The following presents a summary of the borings and vibracores used for the geotechnical analysis.

Boring ID	Boring Type	Sample Area	Report
NVB-1, NVB-2 & NVB-3	Borings	Native Beach Material - North Wildwood	Geotechnical Data Report Wildwood Beach Investigation (4-17-2007)
WW-1, WW-2 & WW-2B	Beach Samples		Atlantic Coast of New Jersey Beach Profile Data Collection (12-17-2003)
		Hereford Inlet Borrow Area	
NJV-745, NJV-452 & NJV-799	Vibracore	H-1	Geotechnical Data Report – Vibrational Coring – Wildwood to Hereford Inlet (06-30-2006) and Geotechnical Investigation Vibrocoring along the New Jersey Coast – Townsend/Hereford Inlet Study Area (12/1998)
NJV-185 & NJV-746		H-2	
NJV-747 & NJV-797		H-3	
NJV-187 & NJV-800		H-4	
NVB-5, 7, 9 & 11	Borings	WW/WWC Borrow Area	Geotechnical Data Report Wildwood Beach Investigation (4-17-2007)
WW-4, WW-7, WW-10, WW-2B, WW-13 & WW-15	Beach Samples		Atlantic Coast of New Jersey Beach Profile Data Collection (12-17-2003)
NJGS-158 & 159	Vibracore	Offshore #1	Logs provided by NJGS
NJGS-147 & 148	Vibracore	Offshore #2	
NJV-34, 45, 48, 49 & 51	Vibracore	Offshore #3	No report was available, information taken from grain size analysis curves

GEOTECHNICAL APPENDIX

SECTION 2
Design Value Computations, Plots and Tables

This section presents the computations utilized in the geotechnical analysis, including the millimeter to phi conversion and design value computations, cumulative grain size distribution (GSD) plots and composite distribution plot, for the borrow areas, and tables utilized to tabulate and calculate the overfill factors and re-nourishment factors for each of the borrow areas.

NORTH WILDWOOD BEACH RESTORATION PROJECT

CURRENT SUMMARY SHEETS

North Wildwood Native Beach parameters established using composite of surface and SPT samples values - See Table 2.5

A. Native Beach Material Parameters

From Beach Lines - WW-1, WW-2 and WW-2B, surface samples for total line - BC+200 to El.-18, and 0 to 4' SPT samples for NJB -1, 2 and 3

(See **Table 2.5** for additional information and details)

$M_{\Phi n}$ (Average) = 2.34 Subscript "n" indicates native beach material property.

$\sigma_{\Phi n}$ (Average) = 0.46 Subscript "b" indicates borrow material property.

B. Individual Borrow Area Summaries

Table 2.1A Hereford Inlet Borrow Areas (Considering only depth of borrow and compositing)

Borrow Area & Comments	Vibracores	Mean Median Dia. in Phi Units $M_{\Phi b}$	Mean Standard Deviation in Phi units $\sigma_{\Phi b}$	Est. Borrow Depth D	$M_{\Phi b}$*D	D*$\sigma_{\Phi b}$	Avg. $M_{\Phi b}$	Avg. $\sigma_{\Phi b}$	$\sigma_{\Phi b}/\sigma_{\Phi n}$	$\frac{(M_{\Phi b}-M_{\Phi n})}{\sigma_{\Phi n}}$	Overfill Factor & Quadrant (R_a)	Renourish-ment Factor (R_j)
H-1	NJV- 745	2.41	0.36	12.5	30.10	4.46			0.78	0.15		
	NJV- 799	2.22	0.66	14	31.14	9.26			1.44	-0.25		
	NJV- 452	2.61	0.39	12	31.34	4.63			0.84	0.59		
H-1 Totals	NJV-745,799&452	7.24	1.40	38.5	92.58	18.35						
H-1 Average	NJV-745,799&452						2.40	0.48	1.04	0.14	1.25/Q1	1.2/1
H-1 Average*							2.41	0.47	1.02	0.16	1.25/Q1	1.2/1
H-2	NJV-185	2.25	0.65	14	31.50	9.03			1.40	-0.20		
	NJV-746	2.51	0.33	17	42.74	5.61			0.72	0.38		
H-2 Totals	NJV-185&746	4.76	0.98	31	74.24	14.64						
H-2 Average	NJV-185&746						2.39	0.47	1.03	0.12	1.2/1	1.2/1
H-2 Average*							2.38	0.49	1.06	0.09	1.15/Q1	1/1
H-3	NJV-747	2.38	0.41	16	38.02	6.62			0.90	0.08		
	NJV-797	2.57	0.43	11	28.27	4.71			0.93	0.50		
H-3 Totals	NJV-747&797	4.95	0.84	27	66.29	11.33						
H-3 Average	NJV-747&797						2.46	0.42	0.91	0.25	1.6/Q4	1.4/1
H-3 Average*							2.47	0.42	0.92	0.29	1.75/Q4	1.5/1
H-4	NJV-187	2.43	0.67	16	38.85	10.69			1.45	0.19		
	NJV-800	2.42	0.66	12	28.98	7.86			1.42	0.16		
H-4 Totals	NJV-187&800	4.84	1.32	28	67.83	18.55						
H-4 Average	NJV-187&800						2.42	0.66	1.44	0.18	1.3/Q1	0.7/1
H-4 Average*							2.42	0.66	1.44	0.18	1.3/Q1	0.9/1
Average H-1 to H-4 (Weighted by depth)							2.42	0.51	1.10	0.17	1.25/Q1	1.2/1
Average H-1 to H-4*(No weighting)							2.42	0.51	1.11	0.18	1.25/Q1	1.2/1

Notes:
1 - Overfill (R_a) and Renourishment (R_j)Factors calculated using isolines for adjusted overfill and renourishment, (Shore Protection Manual, 1984).
2 - Overfill (R_a) and Renourishment (R_j) Factors calculated using "Beach Nourishment Overfill Ratio and Volume" equations contained in Coastal Engineering Manual, 2004.

Overfill/Renourishment Factors[2]	
R_a	1.17
R_j	1.06

NORTH WILDWOOD BEACH RESTORATION PROJECT

CURRENT SUMMARY SHEETS

North Wildwood Native Beach parameters established using composite of surface and SPT samples values - See Table 2.5

A. Native Beach Material Parameters

From Beach Lines - WW-1, WW-2 and WW-2B, surface samples for total line - BC+200 to El.-18, and 0 to 4' SPT samples for NJB -1, 2 and 3

(See **Table 2.5** for additional information and details)

$M_{\Phi n}$ (Average) = 2.34 Subscript "n" indicates native beach material property.

$\sigma_{\Phi n}$ (Average) = 0.46 Subscript "b" indicates borrow material property.

B. Individual Borrow Area Summaries

Table 2.1B Hereford Inlet Borrow Areas (Considering compositing by volume using depth based M_Φ & σ_Φ values)

Borrow Area & Comments	Vibracores	Mean Median Diameter in Phi units (weighted) $M_{\Phi b}$ Mean Median	Mean Standard Deviation in Phi units (weighted) $\sigma_{\Phi b}$	Est. Area ($SF*10^6$)	Est. Borrow Depth D	Estimated Volume (V)	$V*M_{\Phi b}$	$V*\sigma_{\Phi b}$	$\sigma_{\Phi b}/\sigma_{\Phi n}$	$\frac{(M_{\Phi b}-M_{\Phi n})}{\sigma_{\Phi n}}$	Overfill Factor & Quadrant (R_a)	Renourish-ment Factor (R_j)
H-1	NJV-745, 452 & 799	2.40	0.48	2.55	15	1415000	3396000	674955	1.04	0.13	1.25/Q1	1.2/1
H-2	NJV-185 & 746	2.39	0.47	4.25	16	2516741	6015010	1187902	1.03	0.11	1.2/Q1	1.2/1
H-3	NJV-747 & 797	2.46	0.42	1.80	14	932296	2293449	391564	0.91	0.26	1.6/Q4	1.4/1
H-4	NJV-187 & 800	2.42	0.66	1.71	14	884074	2139459	586141	1.44	0.17	1.25/Q1	0.7/1
			ΣVolumetric Values		59	5748111	13843919	2840562				
						Avg M_Φ =	$\Sigma V*M_\Phi/\Sigma V$ =	2.41				
						Avg σ_Φ =	$\Sigma V*\Phi_\sigma/\Sigma V$=	0.49	1.07	0.15	1.2/Q1	1.2/1

Notes:
1 - Overfill (R_a) and Renourishment (R_j)Factors calculated using isolines for adjusted overfill and renourishment, (Shore Protection Manual, 1984).
2 - Overfill (R_a) and Renourishment (R_j) Factors calculated using "Beach Nourishment Overfill Ratio and Volume" equations contained in Coastal Engineering Manual, 2004.

Overfill/Renourishment Factors[2]	
R_a	1.16
R_j	1.09

NORTH WILDWOOD BEACH RESTORATION PROJECT

CURRENT SUMMARY SHEETS

North Wildwood Native Beach parameters established using composite of surface and SPT samples values - See Table 2.5

A. Native Beach Material Parameters

From Beach Lines - WW-1, WW-2 and WW-2B, surface samples for total line - BC+200 to El.-18, and 0 to 4' SPT samples for NJB -1, 2 and 3 (See **Table 2.5** for additional information and details)

$M_{\Phi n}$ (Average) 2.34 — Subscript "n" indicates native beach material property.

$\sigma_{\Phi n}$ (Average) 0.46 — Subscript "b" indicates borrow material property.

B. Individual Borrow Area Summaries

Table 2.1C Hereford Inlet Borrow Areas (Considering compositing by volume with no weighting by depth)

Borrow Area & Comments	Vibracores	Mean Median Diameter in Phi units (weighted) $M_{\Phi b}$	Mean Standard Deviation in Phi units (weighted) $\sigma_{\Phi b}$	Est. Area ($SF*10^6$)	Est. Borrow Depth D	Estimated Volume (V)	$V*M_{\Phi b}$	$V*\sigma_{\Phi b}$	$\sigma_{\Phi b}/\sigma_{\Phi n}$	$\frac{(M_{\Phi b}-M_{\Phi n})}{\sigma_{\Phi n}}$	Overfill Factor & Quadrant (Ra)	Renourish-ment Factor (Rj)
H-1	NJV-745, 452 & 799	2.41	0.47	2.55	15	1415000	3416753	662126	1.02	0.16	1.25/Q1	1.3/1
H-2	NJV-185 & 746	2.38	0.49	4.25	16	2516741	5994876	1226911	1.06	0.09	1.2/Q1	1.2/1
H-3	NJV-747 & 797	2.47	0.42	1.80	14	932296	2305569	392497	0.92	0.29	1.75/Q4	1.5/1
H-4	NJV-187 & 800	2.42	0.66	1.71	14	884074	2140785	584948	1.44	0.18	1.3/Q1	0.8/1
		ΣVolumetric Values		10.30	59	5748111	13857984	2866481				
						Avg $M_{\Phi b} = \Sigma V*M_{\Phi b}/\Sigma V =$		2.41				
						Avg $\sigma_{\Phi b} = \Sigma V*\sigma_{\Phi b}/\Sigma V =$		0.50	1.08	0.15	1.2/Q1	1.2/1

Notes:
1 - Overfill (R_a) and Renourishment (R_j)Factors calculated using isolines for adjusted overfill and renourishment, (Shore Protection Manual, 1984).
2 - Overfill (R_a) and Renourishment (R_j) Factors calculated using "Beach Nourishment Overfill Ratio and Volume" equations contained in Coastal Engineering Manual, 2004.

Overfill/Renourishment Factors[2]	
R_a	1.15
R_j	1.06

Table 2.1D - Summary - Total values for Tables 2.1A, 2.1B and 2.1C

Description	Avg. $M_{\Phi b}$	Avg. $\sigma_{\Phi b}$	$\sigma_{\Phi b}/\sigma_{\Phi n}$	$\frac{(M_{\Phi b}-M_{\Phi n})}{\sigma_{\Phi n}}$	Overfill Factor & Quadrant (Ra)	Renourish-ment Factor (Rj)
H-1 thru H-4 Values by method of Note 1	2.42	0.51	1.10	0.17	1.25/Q1	1.2/1
H-1 thru H-4 Values by method of Note 2	2.42	0.51	1.11	0.18	1.25/Q1	1.2/1
H-1 thru H-4 Values by volumetric method with weighted (Note 1) values for individual areas	2.41	0.49	1.07	0.15	1.2/Q1	1.2/1
H-1 thru H-4 Values by volumetric method with unweighted (Note 2) values for individual areas	2.41	0.50	1.08	0.15	1.2/Q1	1.2/1

NOTES:

1 In **Table 2.1A** shows results which employed the weighted values by height to determine the average values of M_Φ & σ_Φ.

2 In **Table 2.1A** shows results which employed the unweighted values by height to determine the average values of M_Φ & σ_Φ.

TABLE 2.2 OFFSHORE BORROW AREA - OS#1

Summary Sheet for Borrow Area Characteristics

Vibracore Designation	Mean Median Diameter in Phi Units (weighted $M_{\Phi b}$)	Mean Standard Deviation in Phi Units (wgt'd $\sigma_{\Phi b}$)	Depth of Suitable Material (feet)	Assumed Borrow Depth	$M_{\Phi b}$*D	D*$\sigma_{\Phi b}$	($M_{\Phi b}$*D)/D	(D*$\sigma_{\Phi b}$)/D	$\sigma_{\Phi b}/\sigma_{\Phi n}$	$\frac{(M_{\Phi b}-M_{\Phi n})}{\sigma_{\Phi n}}$	Overfill Factor & Quadrant (Ra)	Renourish-ment Factor (Rj)
NJGS-158	2.15	1.35	10	10	21.5	13.50	2.15	1.35	2.93	-0.41	----	----
NJGS-159	2.36	0.61	10	10	23.6	6.10	2.36	0.61	1.33	0.04	----	----
	Totals -Borrow Area OS#1			20	45.1	19.60						
	Wtd. Average-Borrow Area OS#1						2.26	0.98	2.13	-0.18	1.35/Q2	1/10
	Check - using individual weighted averages for each vibrocore						2.26	0.98	2.13	-0.18	1.35/Q2	1/10

Overfill/Renourishment Factors[2]	
R_a	1.03
R_j	0.14

TABLE 2.3 OFFSHORE BORROW AREA - OS#2

Summary Sheet for Borrow Area Characteristics

Vibracore Designation	Mean Median Diameter in Phi Units (weighted $M_{\Phi b}$)	Mean Standard Deviation in Phi Units (wgt'd $\sigma_{\Phi b}$)	Depth of Suitable Material (feet)	Assumed Borrow Depth	$M_{\Phi b}$*D	D*$\sigma_{\Phi b}$	($M_{\Phi b}$*D)/D	(D*$\sigma_{\Phi b}$)/D	$\sigma_{\Phi b}/\sigma_{\Phi n}$	$\frac{(M_{\Phi b}-M_{\Phi n})}{\sigma_{\Phi n}}$	Overfill Factor & Quadrant (Ra)	Renourish-ment Factor (Rj)
NJGS-147	1.64	1.07	10	10	16.36	10.72	1.64	1.07	2.33	-1.53	----	----
NJGS-148	1.42	1.43	10	10	14.20	14.34	1.42	1.43	3.12	-2.00	----	----
	Totals -Borrow Area OS#2			20	30.56	25.06						
	Wtd. Average-Borrow Area OS#2						1.53	1.25	2.72	-1.77	1.22/Q2	Stable
	Check - using individual weighted averages for each vibrocore						1.53	1.25	2.72	-1.77	1.22/Q2	Stable

Overfill/Renourishment Factors[2]	
R_a	1.12
R_j	0.007

TABLE 2.4 OFFSHORE BORROW AREA - OS#3

Summary Sheet for Borrow Area Characteristics

Vibracore Designation	Mean Median Diameter in Phi Units (weighted $M_{\Phi b}$)	Mean Standard Deviation in Phi Units (wgt'd $\sigma_{\Phi b}$)	Depth of Suitable Material (feet)	Assumed Borrow Depth	$M_{\Phi b}$*D	D*$\sigma_{\Phi b}$	($M_{\Phi b}$*D)/D	(D*$\sigma_{\Phi b}$)/D	$\sigma_{\Phi b}/\sigma_{\Phi n}$	$\frac{(M_{\Phi b}-M_{\Phi n})}{\sigma_{\Phi n}}$	Overfill Factor & Quadrant (Ra)	Renourish-ment Factor (Rj)
NJV-34	1.29	0.54	9	9	11.59	4.89	1.29	0.54	1.18	-2.29	----	----
NJV-45	2.08	1.78	9	9	18.75	16.05	2.08	1.78	3.88	-0.56	----	----
NJV-48	1.28	0.26	12.2	10	12.79	2.57	1.28	0.26	0.56	-2.31	----	----
NJV-49	1.64	0.59	14	10	16.42	5.93	1.64	0.59	1.29	-1.52	----	----
NJV-51	1.19	0.87	14	10	11.92	8.74	1.19	0.87	1.90	-2.50	----	----
	Totals -Borrow Area OS#3			48	71.47	38.19						
	Wtd. Average-Borrow Area OS#3						1.49	0.80	1.73	-1.85	1.02/Q2	1/18
	Check - using individual weighted averages for each vibracore						1.50	0.81	1.76	-1.83	1.02/Q2	1/18

Overfill/Renourishment Factors[2]	
R_a	1.01
R_j	0.06

Notes:
1 - Overfill (R_a) and Renourishment (R_j)Factors calculated using isolines for adjusted overfill and renourishment, (Shore Protection Manual, 1984).
2 - Overfill (R_a) and Renourishment (R_j) Factors calculated using "Beach Nourishment Overfill Ratio and Volume" equations contained in Coastal Engineering Manual, 2004.

STANDARD PENETRATION TEST (SRT) BORING TO BEACH SAMPLE DESIGN VALUE COMPARISON AND DETERMINATION OF COMPOSITE DESIGN VALUES FOR NORTH WILDWOOD BEACH RESTORATION PROJECT

Table 2.5 - NATIVE BEACH DESIGN ANALYSIS FOR NORTH WILDWOOD

Beach Sampling Line	Average Value BC + 200 to EL -18		SPT Boring Number	Depth (Feet)	Average Value SPT Sample Depth Range		Remarks	Depth (Feet)	Composite Value	
	Geometric Mean (M_Φ)	Inclusive Graphic Deviation (σ_Φ)			Geometric Mean (M_Φ)	Inclusive Graphic Deviation (σ_Φ)			M_Φ	σ_Φ
WW-1	2.36	0.46	NVB-1	0-4	2.38	0.40	Combine NVB-1 values with WW-1 values	0-4	2.37	0.43
				0-8	2.47	0.40		0-8	2.41	0.40
				0-12	2.54	0.41		0-12	2.45	0.41
WW-2	2.24	0.49	NVB-2	0-4	2.37	0.40	Combine NVB-2 values with WW-2 values	0-4	2.30	0.44
				0-8	2.60	0.48		0-8	2.42	0.48
				0-12	2.54	0.52		0-12	2.39	0.52
WW-2B	2.23	0.48	NVB-3	0-4	2.46	0.52	Combine NVB-3 values with WW-2B values	0-4	2.35	0.50
				0-8	2.57	0.53		0-8	2.40	0.53
				0-12	2.70	0.51		0-12	2.46	0.51
Average Values	2.27	0.47			**North Wildwood - Native Beach - Overall Composite using WW-1 to WW-2B Surface Samples & NVB-1, NV-2 & NVB-3 (0-4')**				2.34	0.46

Table 2.6 - BORROW AREA DESIGN ANALYSIS (AREA WW/WC)

Beach Sampling Line	Average Value BC + 200 to EL -18		SPT Boring	Depth (feet)	Average Value SPT Sample Depth Range		Remarks	Depth (feet)	Composite Value	
	Geometric Mean (M_Φ)	Inclusive Graphic Deviation (σ_Φ)			Geometric Mean (M_Φ)	Inclusive Graphic Deviation (σ_Φ)			M_Φ	σ_Φ
WW-15	2.38	0.53	NVB-11	0-4	2.53	0.36	Combine NVB-11 values with avg. for WW-15 & WW-13	0-4	2.44	0.43
AVG. WW-15 & -13	2.35	0.51		0-8	2.56	0.38		0-8	2.45	0.45
WW-13	2.33	0.48		0-12	2.56	0.47		0-12	2.45	0.49
				0-16	2.46	0.47		0-16	2.41	0.49
WW-13	2.33	0.48	NVB-9	0-4	2.46	0.45	Combine NVB-9 values with avg. for WW-13 & WW-10	0-4	2.40	0.47
AVG. WW-13 & -10	2.34	0.48		0-8	2.46	0.44		0-8	2.40	0.46
WW-10	2.36	0.48		0-12	2.44	0.50		0-12	2.39	0.49
				0-16	2.48	0.48		0-16	2.41	0.48
WW-10	2.36	0.48	NVB-7	0-4	2.40	0.41	Combine NVB-7 values with avg. for WW-10 & WW-07	0-4	2.37	0.44
AVG. WW-10 & -07	2.33	0.48		0-8	2.46	0.36		0-8	2.40	0.42
WW-07	2.30	0.47		0-12	2.44	0.38		0-12	2.39	0.43
				0-16	2.45	0.39		0-16	2.39	0.43
WW-07	2.30	0.47	NVB-5	0-4	2.47	0.32	Combine NVB-5 values with avg. for WW-07 & WW-04	0-4	2.37	0.41
AVG. WW-07 & -04	2.28	0.50		0-8	2.47	0.37		0-8	2.37	0.42
WW-04	2.27	0.52		0-12	2.48	0.34		0-12	2.38	0.41
				0-16	2.63	0.39		0-16	2.45	0.43
WW/WC Overall Composite using Only Beach Samples Calculations & M_Φ=2.34 & σ_Φ=0.46			**Composite using only SPT Samples**				**Composite using WW-15 to WW-4 Surface Samples and NVB-11 to NVB-5 SPT Samples**			
	2.33	0.49		0-4	2.46	0.38		0-4	2.40	0.44
	2.33	0.50		0-8	2.48	0.39		0-8	2.41	0.44
				0-12	2.48	0.42		0-12	2.40	0.45
	$(M_{\Phi b}-M_{\Phi n})/\sigma_{\Phi n}$ =	-0.03	@12' Excavation	$(M_{\Phi b}-M_{\Phi n})/\sigma_{\Phi n}$ =	0.30	Ra=1.7	@12' Excavation	$(M_{\Phi b}-M_{\Phi n})/\sigma_{\Phi n}$ =	0.14	Ra=1.25
	$\sigma_{\Phi b}/\sigma_{\Phi n}$ =	1.07		$\sigma_{\Phi b}/\sigma_{\Phi n}$ =	0.92	Rj=1.5/1		$\sigma_{\Phi b}/\sigma_{\Phi n}$ =	0.99	Rj=1.2/1
		Ra=1.05		0-16	2.51	0.43		0-16	2.42	0.47
WW/WC Beach Sample Composite & Using only Beach Samples to compute Avg. σ_Φ& M_Φ for Native beach		Rj=1/1	@16' excavation	$(M_{\Phi b}-M_{\Phi n})/\sigma_{\Phi n}$ =	0.36	Ra=1.9	@16' excavation	$(M_{\Phi b}-M_{\Phi n})/\sigma_{\Phi n}$ =	0.17	Ra=1.25
				$\sigma_{\Phi b}/\sigma_{\Phi n}$ =	0.93	Rj=1.7/1		$\sigma_{\Phi b}/\sigma_{\Phi n}$ =	1.02	Rj=1.25/1
	$(M_{\Phi b}-M_{\Phi n})/\sigma_{\Phi n}$ = 0.11		Overfill/ Renourishment Factors[2]	0-12'	R_a	1.61	Overfill/ Renourishment Factors[2]	0-12'	R_a	1.18
	$\sigma\varphi b/\sigma\varphi n$= 1.05				R_j	1.47			Rj	1.16
		Ra=1.17		0-16'	R_a	1.76		0-16'	R_a	1.21
		Rj=1.1/1			R_j	1.54			R_j	1.16

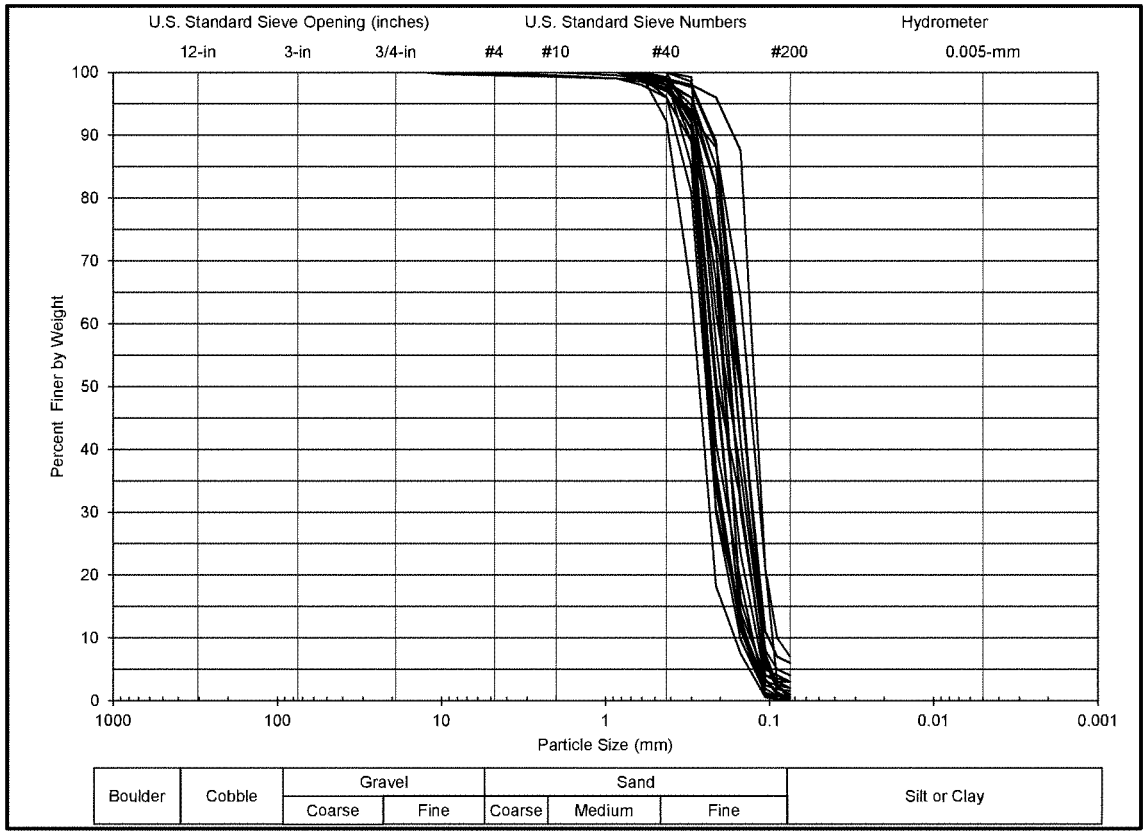
Notes:
1 - Overfill (R_a) and Renourishment (R_j)Factors calculated using isolines for adjusted overfill and renourishment, (Shore Protection Manual, 1984).
2 - Overfill (R_a) and Renourishment (R_j) Factors calculated using "Beach Nourishment Overfill Ratio and Volume" equations contained in Coastal Engineering Manual, 2004.

Statistical Analysis of Gradation Data

Native Beach - North Wildwood

Boring ID	Sample No. Sample Depth	Gravel (%)	Sand (%) Coarse	Sand (%) Medium	Sand (%) Fine	Fines (%)	c_u	Soil Description
WW-1	S1	0.0	0.0	0.0	99.8	0.2		SP
WW1	S3	0.0	0.0	2.5	97.5	0.1		SP
WW1	S4	0.0	0.0	2.1	97.9	0.0		SP
WW1	S5	0.0	0.0	2.0	98.0	0.0		SP
WW2	S6	0.0	0.0	1.1	98.3	0.6		SP
WW2	S7	0.0	0.0	0.8	99.0	0.3		SP
WW2	S9	0.0	0.0	0.8	99.1	0.1		SP
WW2	S10	0.0	0.0	1.5	98.4	0.2		SP
WW2	S11	0.0	0.0	3.9	96.0	0.1		SP
WW2B	S12	0.0	0.0	1.4	98.6	0.0		SP
WW2B	S13	0.0	0.0	0.0	99.6	0.4		SP
WW2B	S15	0.0	0.0	0.0	98.5	1.5		SP
WW2B	S16	0.0	0.0	1.2	98.3	0.5		SP
WW2B	S17	0.0	0.0	7.8	91.9	0.3		SP
WW2B	S18	0.0	0.0	2.7	97.0	0.3		SP
NVB-1	0-4	0.0	0.0	2.0	96.0	2.0		SP
NVB-1	4-8	0.0	0.0	2.0	95.0	3.0		SP
NVB-1	8-12	0.0	0.0	1.0	95.0	4.0		SP
NVB-2	0-4	0.5	0.2	1.8	94.5	3.0		SP
NVB-2	4-8	0.5	0.2	2.3	94.0	3.0		SP
NVB-2	8-12	0.3	0.2	2.0	96.5	1.0		SP
NVB-3	0-4	0.0	0.5	3.5	94.0	2.0		SP
NVB-3	4-8	0.0	0.5	1.0	92.5	6.0		SP-SC
NVB-3	8-12	0.0	0.5	1.0	91.5	7.0		SP-SC
Minimum		0.0	0.0	0.0	91.5	0.0		
Maximum		0.5	0.5	7.8	99.8	7.0		
Median		0.0	0.0	1.6	97.2	0.5		
Mean		0.1	0.1	1.8	96.5	1.5		
Standard Deviation		0.2	0.2	1.6	2.5	2.0		
Variance		0.0	0.0	2.6	6.1	3.8		

Cummulative Grain Size Distribution (GSD) Plot
North Wildwood Beach - Native Beach

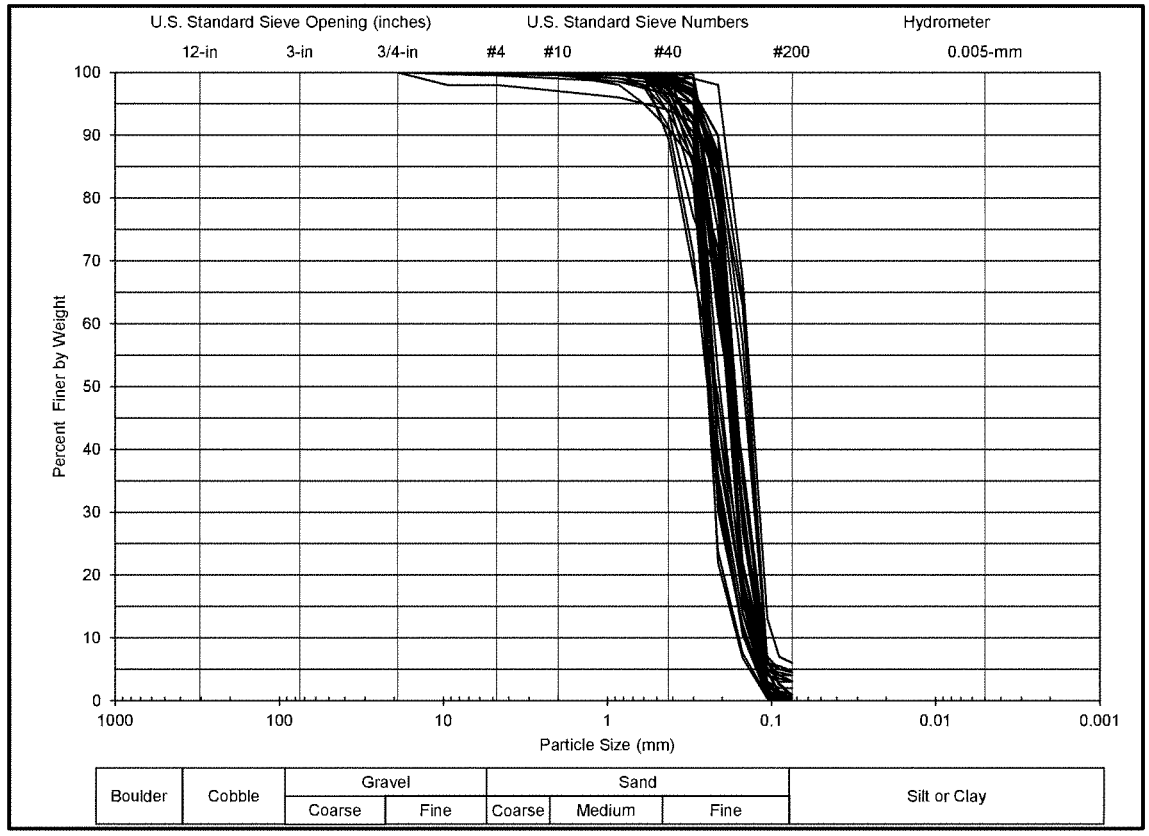


Statistical Analysis of Gradation Data

Borrow Area - Wilwood/Wildwood Crest

Boring ID	Sample No./ Sample Depth	Gravel (%)	Sand (%) Coarse	Sand (%) Medium	Sand (%) Fine	Fines (%)	c_u	Soil Description
WW-4	S19	0.0	0.0	0.5	99.0	0.5		SP
WW-4	S21	0.0	0.0	0.8	99.1	0.1		SP
WW-4	S22	0.0	0.0	2.1	97.8	0.1		SP
WW-4	S23	0.0	0.0	8.5	91.3	0.2		SP
WW-4	S24	0.0	0.0	1.8	98.1	0.2		SP
WW-7	S25	0.0	0.0	0.0	99.8	0.2		SP
WW-7	S27	0.0	0.0	6.5	92.8	0.7		SP
WW-7	S28	0.0	0.0	4.4	95.3	0.4		SP
WW-7	S29	0.0	0.0	10.7	89.0	0.3		SP
WW-7	S30	0.0	0.0	1.8	97.4	0.8		SP
WW-10	S31	0.0	0.0	0.0	99.9	0.2		SP
WW-10	S33	0.0	0.0	0.0	99.8	0.2		SP
WW-10	S34	0.0	0.0	2.1	97.7	0.2		SP
WW-10	S35	0.0	0.0	4.9	94.7	0.4		SP
WW-10	S36	0.0	0.0	3.5	95.5	1.0		SP
WW-13	S37	0.0	0.0	0.2	99.8	0.0		SP
WW-13	S39	0.0	0.0	3.0	96.8	0.2		SP
WW-13	S40	0.0	0.0	4.1	95.7	0.2		SP
WW-13	S41	0.0	0.0	2.5	97.4	0.1		SP
WW-13	S42	0.0	0.0	1.4	98.2	0.4		SP
WW-15	S43	0.0	0.0	0.2	99.6	0.2		SP
WW-15	S45	0.0	0.0	1.3	98.5	0.1		SP
WW-15	S46	0.0	0.0	2.3	97.5	0.1		SP
WW-15	S47	0.0	0.0	1.0	98.7	0.3		SP
NVB-05	0-4	0.0	0.2	0.8	97.0	2.0		SP
NVB-05	4-8	2.0	1.0	3.0	92.0	2.0		SP
NVB-05	8-12	0.5	0.5	1.5	94.5	3.0		SP
NVB-05	12-16	0.0	0.2	0.6	93.2	6.0		SP-SC
NVB-07	0-4	0.0	0.0	1.0	96.0	3.0		SP
NVB-07	4-8	0.0	0.3	1.7	97.0	1.0		SP
NVB-07	8-12	0.0	0.5	2.0	93.5	4.0		SP
NVB-07	12-16	0.0	0.0	1.5	95.5	3.0		SP
NVB-09	0-4	0.0	0.0	0.2	95.3	4.5		SP
NVB-09	4-8	0.0	0.2	1.1	95.7	3.0		SP
NVB-09	8-12	0.0	0.3	8.7	87.0	4.0		SP
NVB-09	12-16	0.3	0.2	3.0	92.0	4.5		SP
NVB-11	0-4	0.0	0.0	0.0	96.9	3.1		SP
NVB-11	4-8	0.0	0.0	1.0	96.0	3.0		SP
NVB-11	8-12	0.0	0.1	0.7	94.7	4.5		SP
NVB-11	12-16	0.0	0.0	6.4	88.9	4.7		SP
Minimum		0.0	0.0	0.0	87.0	0.0		
Maximum		2.0	1.0	10.7	99.9	6.0		
Median		0.0	0.0	1.6	96.4	0.5		
Mean		0.1	0.1	2.4	95.9	1.6		
Standard Deviation		0.3	0.2	2.6	3.2	1.8		
Variance		0.1	0.0	6.7	10.1	3.1		

Cummulative Grain Size Distribution (GSD) Plot
Wildwood/Wildwood Crest Borrow Area

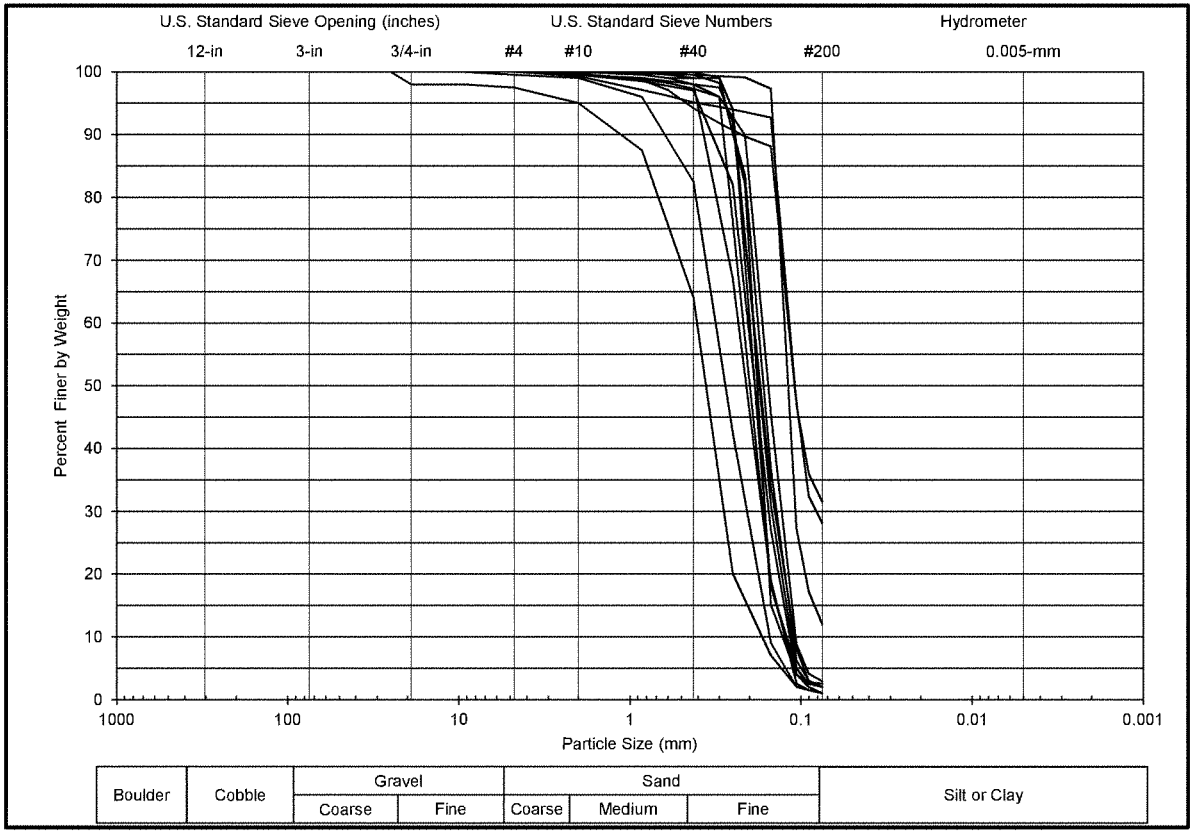


Statistical Analysis of Gradation Data

Borrow Area - Hereford Inlet - H-1

Boring ID	Sample No.	Gravel (%)	Sand (%)			Fines (%)	c_u	Soil Description
			Coarse	Medium	Fine			
NJV-799	0-5	0.0	0.5	2.5	96.0	1.0		SP
NJV-799	5-10	0.5	0.5	16.5	81.5	1.0		SP
NJV-799	10-15	0.0	0.5	1.5	97.0	1.0		SP
NJV-799	15-20	2.5	2.5	31.0	63.0	1.0		SP
NJV-745	0-5	0.0	0.5	1.5	96.0	2.0		SP
NJV-745	5-10	0.0	0.0	2.0	96.0	2.0		SP
NJV-745	10-15	0.0	0.0	1.0	98.0	1.0		SP
NJV-745	15-20	0.0	0.0	1.0	97.0	2.0		SP
NJV-452	0-5	0.0	0.3	2.4	94.4	2.9		SP
NJV-452	5-10	0.0	0.0	0.1	97.4	2.5		SP
NJV-452	10-11.3	0.0	0.0	0.5	97.5	2.0		SP
NJV-452	11.3-14.1	0.0	0.1	0.4	87.5	12.0		SC
NJV-452	15-16.8	0.0	0.7	4.2	67.0	28.1		SC
NJV-452	16.8-18.6	0.0	0.3	5.5	62.7	31.5		SC
Minimum		0.0	0.0	0.1	62.7	1.0		
Maximum		2.5	2.5	31.0	98.0	31.5		
Median		0.0	0.3	1.8	96.0	2.0		
Mean		0.2	0.4	5.0	87.9	6.4		
Standard Deviation		0.7	0.6	8.6	13.6	10.3		
Variance		0.5	0.4	73.3	186.3	106.4		

Cummulative Grain Size Distrubtion (GSD) Plot
Hereford Inlet - H-1

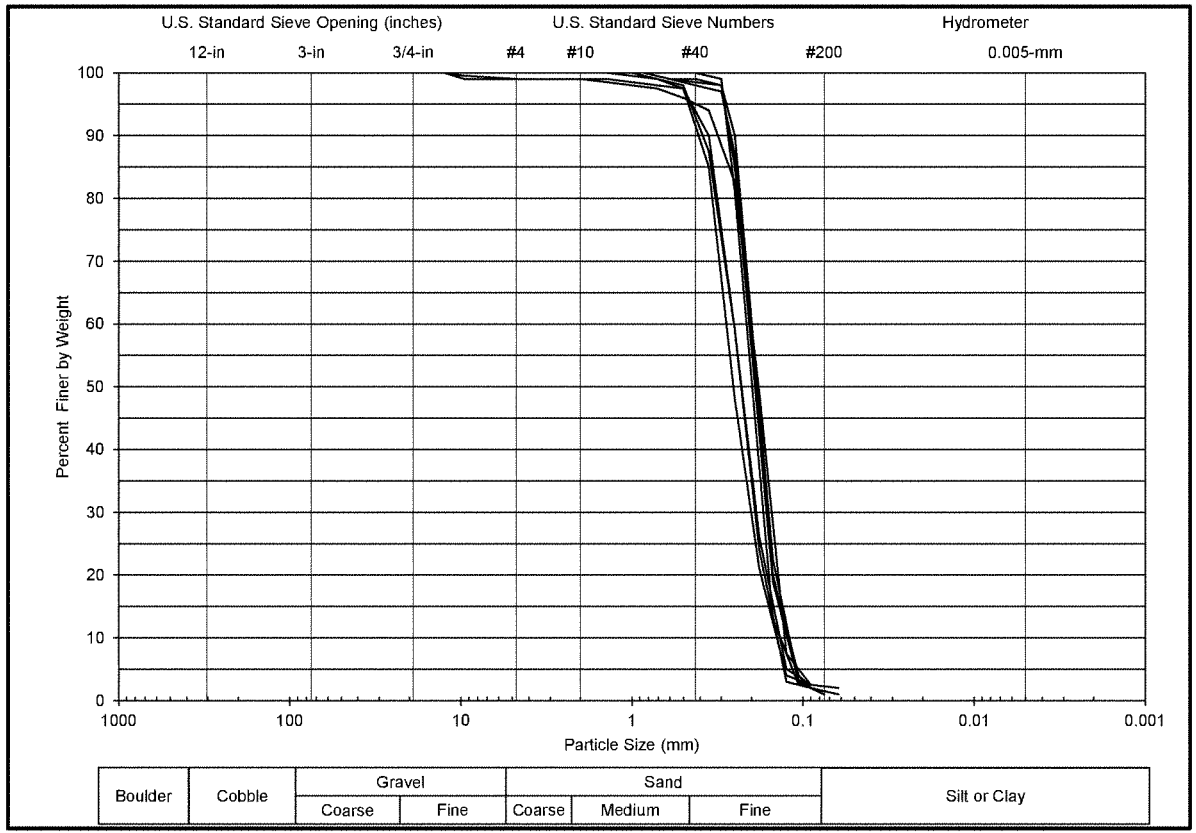


Statistical Analysis of Gradation Data

Borrow Area - Hereford Inlet - H-2

Boring ID	Sample Depth	Gravel (%)	Sand (%)			Fines (%)	c_u	Soil Description
			Coarse	Medium	Fine			
NJV-185	2.8-3.3	0.0	0.0	5.6	92.9	1.5		SP
NJV-185	6.3-6.5	0.0	0.0	7.0	91.5	1.5		SP
NJV-185	7.8-8.3	0.0	0.0	8.4	89.3	2.3		SP
NJV-185	10.6-10.9	1.0	0.0	5.1	91.7	2.3		SP
NJV-185	13.1-13.7	1.0	0.0	3.9	92.8	2.3		SP
NJV-746	0-5	0.0	0.0	2.0	97.0	1.0		SP
NJV-746	5-10	0.0	0.0	0.0	99.0	1.0		SP
NJV-746	10-15	0.0	0.0	1.5	97.5	1.0		SP
NJV-746	15-20	0.0	0.0	1.0	98.0	1.0		SP
Minimum		0.0	0.0	0.0	89.3	1.0		
Maximum		1.0	0.0	8.4	99.0	2.3		
Median		0.0	0.0	3.9	92.9	1.5		
Mean		0.2	0.0	3.8	94.4	1.5		
Standard Deviation		0.4	0.0	2.9	3.5	0.6		
Variance		0.2	0.0	8.4	12.1	0.3		

Cummulative Grain Size Distrubtion (GSD) Plot
Hereford Inlet - H-2

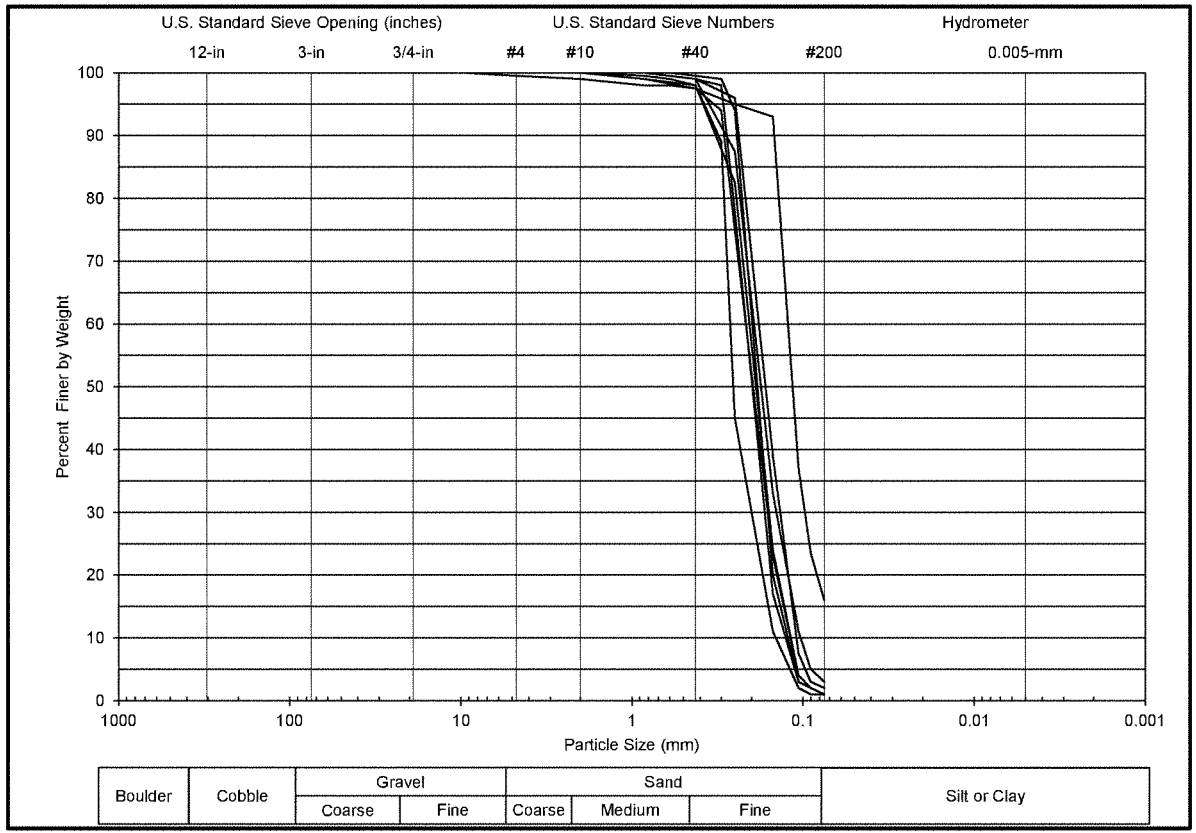


Statistical Analysis of Gradation Data

Borrow Area - Hereford Inlet - H-3

Boring ID	Sample Depth	Gravel (%)	Sand (%)			Fines (%)	C_u	Soil Description
			Coarse	Medium	Fine			
NJV-797	0-5	0.0	0.0	2.0	97.0	1.0		SP
NJV-797	5-10	0.0	0.0	1.0	97.0	2.0		SP
NJV-797	10-15	0.0	0.0	1.0	96.0	3.0		SP
NJV-797	15-20	0.0	0.0	2.5	81.5	16.0		SC
NJV-747	0-5	0.5	0.5	1.5	96.5	1.0		SP
NJV-747	5-10	0.0	0.0	2.0	97.0	1.0		SP
NJV-747	10-15	0.0	0.0	1.0	98.0	1.0		SP
NJV-747	15-20	0.0	0.0	0.5	98.5	1.0		SP
Minimum		0.0	0.0	0.5	81.5	1.0		
Maximum		0.5	0.5	2.5	98.5	16.0		
Median		0.0	0.0	1.3	97.0	1.0		
Mean		0.1	0.1	1.4	95.2	3.3		
Standard Deviation		0.2	0.2	0.7	5.6	5.2		
Variance		0.0	0.0	0.5	31.2	27.1		

Cummulative Grain Size Distrubtion (GSD) Plot
Hereford Inlet - H-3

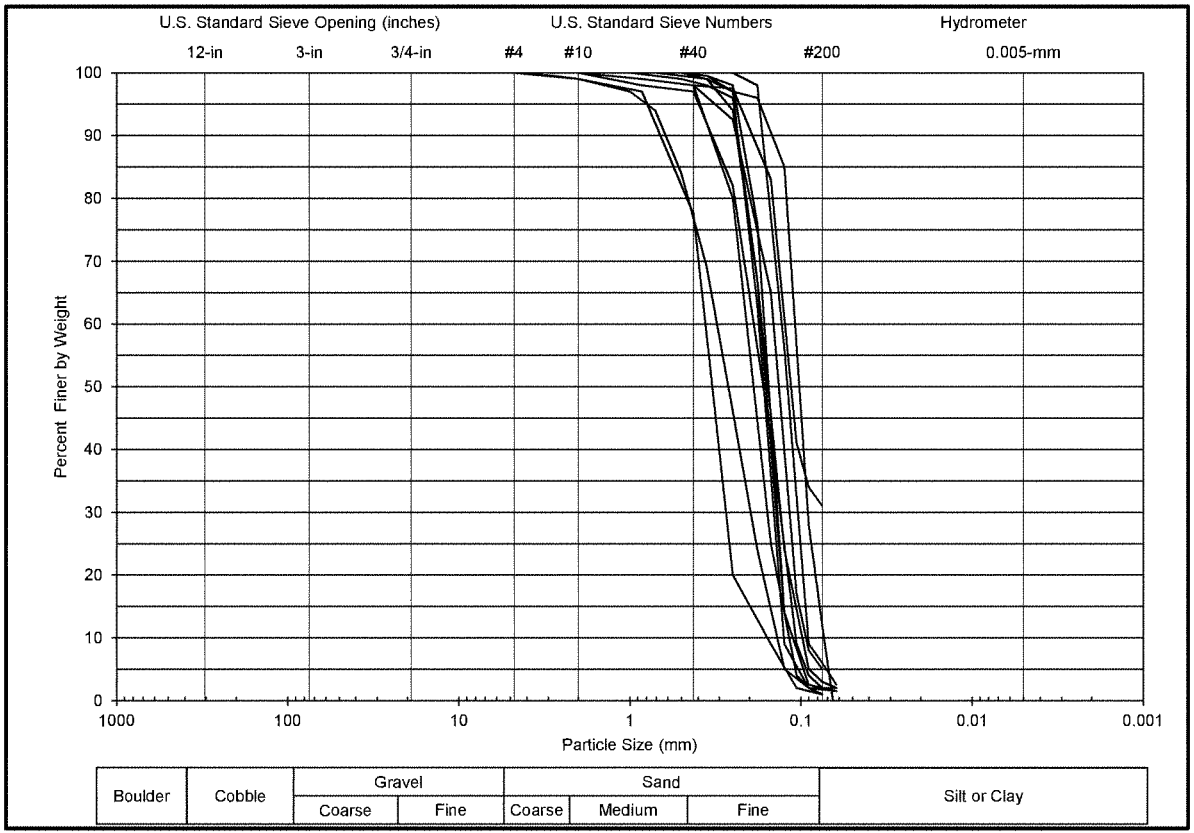


Statistical Analysis of Gradation Data

Borrow Area - Hereford Inlet (H-4)

Boring ID	Sample Depth.	Gravel (%)	Sand (%)			Fines (%)	c_u	Soil Description
			Coarse	Medium	Fine			
NJV-187	2-2.5	0.0	0.0	0.7	87.3	12.0		SP-SC
NJV-187	4.5-4.8	0.0	0.0	1.5	95.5	3.0		SP
NJV-187	8-8.5	0.0	0.0	0.2	98.0	1.8		SP
NJV-187	10.2-10.5	0.0	0.0	0.2	97.8	2.0		SP
NJV-187	13.2-13.7	0.0	0.0	0.5	97.5	2.0		SP
NJV-187	15-15.3	0.0	1.0	22.1	74.9	2.0		SP
NJV-187	18.2-18.7	0.0	0.0	0.0	94.0	6.0		SP-SC
NJV-800	0-5	0.0	0.0	2.0	97.0	1.0		SP
NJV-800	5-7.5	0.0	0.0	3.0	95.0	2.0		SP
NJV-800	7.5-10	0.0	1.0	21.5	76.5	1.0		SP
NJV-800	10-15	0.0	0.0	2.0	93.0	5.0		SP-SC
NJV-800	15-20	0.0	0.0	2.0	67.0	31.0		SC
Minimum		0.0	0.0	0.0	67.0	1.0		
Maximum		0.0	1.0	22.1	98.0	31.0		
Median		0.0	0.0	1.7	94.5	2.0		
Mean		0.0	0.2	4.6	89.5	5.7		
Standard Deviation		0.0	0.4	8.1	10.7	8.5		
Variance		0.0	0.2	65.1	114.0	72.9		

Cummulative Grain Size Distrubtion (GSD) Plot
Hereford Inlet - H-4

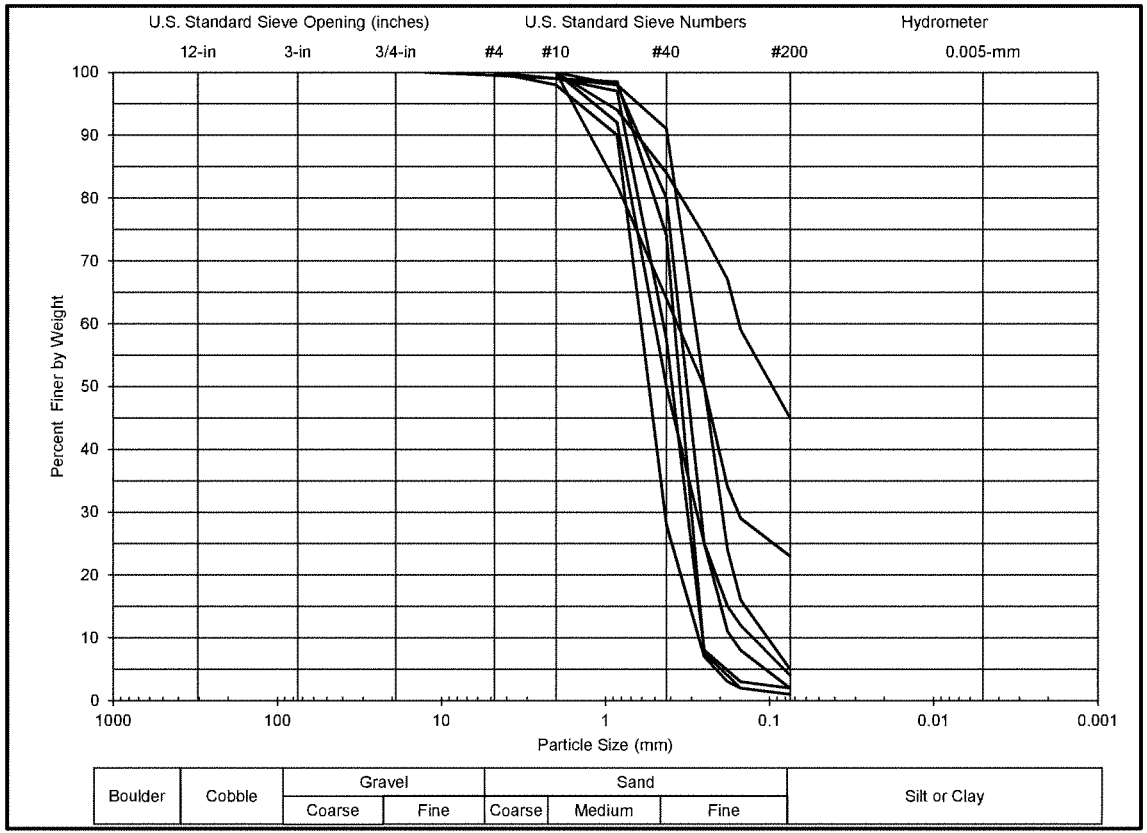


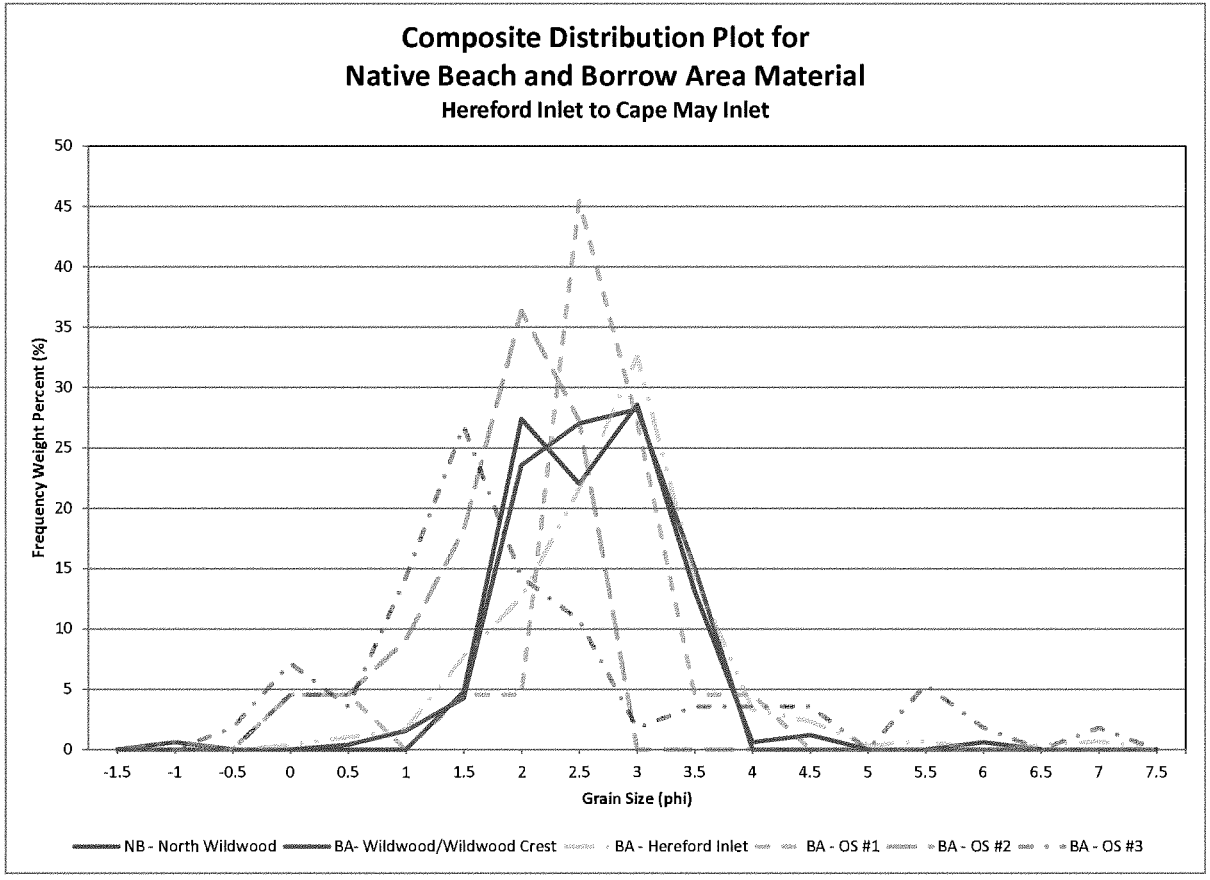
Statistical Analysis of Gradation Data

Off Shore Borrow Area - OS #3

Boring ID	Sample No.	Gravel (%)	Sand (%)			Fines (%)	c_u	Soil Description
			Coarse	Medium	Fine			
NJV-34	S-1	0.5	0.5	41.5	55.5	2.0		SP
NJV-48	S-1	0.0	1.0	25.0	73.0	1.0		SP
NJV-45	S-1	0.0	0.0	36.0	41.0	23.0		SC-SM
NJV-45	S-2	0.0	0.0	9.0	86.0	5.0		SP-SC
NJV-45	S-3	0.0	0.0	16.0	39.0	45.0		SC
NJV-51	S-1	0.0	0.0	50.0	46.0	4.0		SP
NJV-51	S-2	0.0	2.0	70.0	27.0	1.0		SP
NJV-49	S-1	0.0	1.0	19.0	78.0	2.0		SP
Minimum		0.0	0.0	9.0	27.0	1.0		
Maximum		0.5	2.0	70.0	86.0	45.0		
Median		0.0	0.3	30.5	50.8	3.0		
Mean		0.1	0.6	33.3	55.7	10.4		
Standard Deviation		0.2	0.7	20.2	21.1	15.8		
Variance		0.0	0.5	409.1	446.8	249.1		

Cummulative Grain Size Distribution (GSD) Plot
Off-Shore Borrow Area #3




Composite Distribution Plot for
Native Beach and Borrow Area Material
Hereford Inlet to Cape May Inlet
Frequency Weight Percent (%)
50
45
40
35
30
25
20
15
10
5
0
-1.5
-1
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
5.5
6
6.5
7
7.5
Grain Size (phi)
NB - North Wildwood
BA- Wildwood/Wildwood Crest
BA - Hereford Inlet
BA - OS #1
BA - OS #2
BA - OS #3

GEOTECHNICAL APPENDIX

SECTION 3

Description of the Design Methodology

This section presents additional information and details on the method developed by the Philadelphia District to convert available gradation data to design values for comparison of native beach and borrow materials.

Method for Determining Median Grain Size (M_Φ) and Mean Standard Deviation (σ_φ)

The method described herein was developed by the Geotechnical Section of the Philadelphia District of the U.S. Army Corps of Engineers (NAP-EC-EG) during the period 2005 to 2006. At the time, NAP-EC-EG was tasked to perform a borrow area investigation for the proposed beach restoration in North Wildwood, New Jersey.

A limited amount of geotechnical data was available from past investigations of the North Wildwood, Wildwood, Wildwood Crest and Lower Township beaches and borrows areas located offshore and in Hereford Inlet adjacent to the North Wildwood beach. Additional investigations were preformed to obtain supplemental information required for the geotechnical analysis of the target site and potential source areas. Recovered soil samples were subjected to visual identification and laboratory gradation analyses to determine the type of soil material present and grain size distribution of the recovered samples.

The data evaluated was primarily in the form of gradation curves plotted on 5 Cycle semi-log paper (ENG FORM 2087). The gradation curves were available for beach samples which had been taken along selected lines and that had been obtained in a number of potential borrow areas considered for the North Wildwood beach restoration site. As the study progressed it was determined that additional sampling was required to accurately determine the native beach and borrow area material design parameters. These investigations consisted of several additional vibracores taken in the Hereford Inlet borrow area and 12 Standard Penetration Test (SPT) borings drilled along the beach between North Wildwood and Lower Township.

The available data was converted to phi grain size designations in order to develop design parameters for the native beach and borrow area materials. This was accomplished using the following procedure:

1. The grain size in millimeters (mm) for the 95, 84, 75, 50, 25, 16, and 5 percentages coarser by weight of each sample (D_{95}, D_{84}, D_{75}, etc.) were determined from the individual grain size curve.

2. These values were converted to phi sizes using the relationship: $\varphi = -\log_2 D$.

3. The mean grain size and standard deviation for each sample were then computed as follows:

a. The mean grain size (M_φ) of each sample was determined using the relationship:

$M_\varphi = (\varphi_{16}+\varphi_{50}+\varphi_{84})/3$ where φ_{16}, φ_{50} and φ_{84} are the 16%, 50% and 84% coarser by weight phi sizes, respectively.

b. The standard deviation for each sample was determined using the relationship:

$\sigma_\varphi = (\varphi_{84}-\varphi_{16})/4 + (\varphi_{95}+\varphi_{5})/6$.

4. The mean grain size and standard deviation for each group of samples can then be determined by averaging the values of each test, i.e. $M_{\varphi 1to4} = (M_\varphi 1+ M_\varphi 2+ M_\varphi 3+ M_\varphi 4)/4$ and σ_1 to $\sigma_4 = (\sigma_1+\sigma_2+\sigma_3+\sigma_4)/4$. The weighted averages of these values can also be determined by using the height or volume of the sample portion represented by the individual result as a multiplier of that result then summing and averaging to obtain the weighted value for a given sample or area. The following example shows this methodology for an individual vibracore with varying heights of samples:

Weighted $M_{\varphi 1to4} = (h_1 * M_{\varphi 1}+h_2 * M_{\varphi 2}+ h_3 * M_{\varphi 3}+ h_4 * M_{\varphi 4})/ (h_1 +h_2 + h_3 + h_4)$.

The EXCEL program developed to accomplish these calculations is illustrated on **Tables 3.1** and **3.2**. **Table 3.1** provides typical output from the program for Vibracore NJV-454. **Table 3.2** provides the input for the individual cells for the same vibracore. It is noted that the program, once set up for an individual sample, can be copied and pasted in subsequent sections of the worksheet for new samples with minimal effort. However, care must be taken in entering new data and spot checking of computed values is required to assure valid results.

The method employed to determine the overall median grain sizes and standard deviations for complete sampling lines, vibracores, STP boring borings, native beach area and complete borrow sources are obtained in a similar manner as was shown on the **Table 3.1**.

Once the values were obtained for the native beach material and each individual borrow area investigated, the values for the overfill (R_a) and renourishment (R_j) factors were determined using the nomograph method of the 2008 Edition of the Coastal Engineering Manual and 1984 Edition of the Shore Protection Manual. A further refinement in determining the R_a and R_j factors consisted of using the applicable portion of the Automated Coastal Engineering System (ACES) methodology with inputs of the M_Φ and σ_Φ values for the native beach and borrow areas to obtain the values of R_a and R_j for each individual borrow area. These values were then checked against those obtained using the nomograph method. Agreement between the two methods is not exact, but is considered adequate for the scope of this study. It is noted that the higher values of the renourishment factors (those obtained by the nomograph method) were used to determine the beachfill costs for the cost analysis.

Table 3.1

Calculated Values of Φ, MΦ, σΦ and Wtd. Values of same from mm grain size Values

Vibrocore Number	Sample and Number	Depth	Grain Size	D - % Coarser	Phi Diameter	Geometric Mean (phi16+phi50+phi84)/3 (M_Φ)	Inclusive Graphic Deviation (phi84-phi16)/4+phi95-phi05)/6 (σ_Φ)	Depth represented by sample - D (ft)	Wtd, GM GM*D $D*M_\Phi$	Wtd. IGD IGD*D $D*\sigma_\Phi$
NJV - 455	S -1	0.0 - 5.0.	0.12	95	3.059					
			0.13	84	2.943					
			0.15	75	2.737					
			0.17	50	2.556	2.540	0.392	5	12.700	1.958
			0.2	25	2.322					
			0.23	16	2.120					
			0.26	5	1.943					
NJV - 455	S - 2	5.5 - 10.0	0.13	95	2.943					
			0.16	84	2.644					
			0.17	75	2.556					
			0.21	50	2.252	2.211	0.485	5	11.054	2.423
			0.26	25	1.943					
			0.3	16	1.737					
			0.38	5	1.396					
NJV - 455	S - 3	10.0 - 15.0	0.13	95	2.943					
			0.15	84	2.737					
			0.17	75	2.556					
			0.24	50	2.059	2.077	0.737	5	10.384	3.686
			0.35	25	1.515					
			0.37	16	1.434					
			0.72	5	0.474					
NJV - 455	S - 4	15.0 - 19.1	0.14	95	2.837					
			0.19	84	2.396					
			0.22	75	2.184					
			0.27	50	1.889	1.906	0.505	5	9.532	2.523
			0.33	25	1.599					
			0.37	16	1.434					
			0.42	5	1.252					
				SUM		8.734	2.118			
				Average		2.184	0.530			
								SUM	20	43.670	10.590
								WTD. AVG.		2.184	0.530

Table 3.2

Formulas used to determine Values of Φ, MΦ, σΦ and Weighted Values of same from mm grain size data

Vibrocore Number	Sample and	Number Depth	Grain Size	D - % Coarser	Phi Diameter	Geometric Mean $\varphi16+\varphi50+\varphi84)/3$ (M_Φ)	Inclusive Graphic Deviation $(\varphi_{84}-\varphi_{16})/4+(\varphi_{95}-\varphi_{05})/6$ (σ_Φ)	Depth represented by sample D (ft)	Wtd, GM GM*D $D*M_\Phi$	Wtd. IGD IGD*D $D*\sigma_\Phi$
NJV - 455	S -1	0.0 - 5.0.	0.12	95	=-LOG(D4,2)					
			0.13	84	=-LOG(D5,2)					
			0.15	75	=-LOG(D6,2)					
			0.17	50	=-LOG(D7,2)	=AVERAGE(F9,F7,F5)	=(F5-F9)/4+(F4-F10)/6	5	=PRODUCT(G7,I7)	=PRODUCT(H7,I7)
			0.2	25	=-LOG(D8,2)					
			0.23	16	=-LOG(D9,2)					
			0.26	5	=-LOG(D10,2)					
NJV - 455	S - 2	5.5 - 10.0	0.13	95	=-LOG(D12,2)					
			0.16	84	=-LOG(D13,2)					
			0.17	75	=-LOG(D14,2)					
			0.21	50	=-LOG(D15,2)	=AVERAGE(F17,F15,F13)	=(F13-F17)/4+(F12-F18)/6	5	=PRODUCT(G15,I15)	=PRODUCT(H15,I15)
			0.26	25	=-LOG(D16,2)					
			0.3	16	=-LOG(D17,2)					
			0.38	5	=-LOG(D18,2)					
NJV - 455	S - 3	10.0 - 15.0	0.13	95	=-LOG(D20,2)					
			0.15	84	=-LOG(D21,2)					
			0.17	75	=-LOG(D22,2)					
			0.24	50	=-LOG(D23,2)	=AVERAGE(F25,F23,F21)	=(F21-F25)/4+(F20-F26)/6	5	=PRODUCT(G23,I23)	=PRODUCT(H23,I23)
			0.35	25	=-LOG(D24,2)					
			0.37	16	=-LOG(D25,2)					
			0.72	5	=-LOG(D26,2)					
NJV - 455	S - 4	15.0 - 19.1	0.14	95	=-LOG(D28,2)					
			0.19	84	=-LOG(D29,2)					
			0.22	75	=-LOG(D30,2)					
			0.27	50	=-LOG(D31,2)	=AVERAGE(F33,F31,F29)	=(F29-F33)/4+(F28-F34)/6	5	=PRODUCT(G31,I31)	=PRODUCT(H31,I31)
			0.33	25	=-LOG(D32,2)					
			0.37	16	=-LOG(D33,2)					
			0.42	5	=-LOG(D34,2)					
				SUM		=SUM(G4:G35)	=SUM(H4:H35)			
				Average		=AVERAGE(G4:G35)	=AVERAGE(H4:H35)			
								SUM =SUM(I7:I31)	=SUM(J6:J34)	=SUM(K6:K34)
								WTD. AVG.	=(J38/I38)	=(K38/I38)

GEOTECHNICAL APPENDIX

SECTION 4

Investigation Reports (DVD)

Electronic versions of the investigation reports and data utilized in the calculations are included for additional reference in the DVD attached to this report. The following is a list of the reports and information contained on the DVD:

Previous Investigation Reports

- Geotechnical Data Report Vibrational Coring Cape May Fillet Area Study Cape May County, New Jersey. May 16, 2006
- Geotechnical Data Report Vibrational Coring Cape May, New Jersey. October 12, 2007
- Geotechnical Data Report Vibrational Coring Townsends & Hereford Inlets Cape May County, New Jersey. October 12, 2007
- Geotechnical Data Report Vibrational Coring Wildwood to Hereford Inlet Cape May County, New Jersey. June 30, 2006
- Geotechnical Data Report Wildwood Beach Investigation Cape May County, New Jersey. April 17, 2007
- Geotechnical Investigation Vibrocoring along the New Jersey Coast – Townsend/Hereford Inlet Study Area. December 1998
- Nearshore Ridges and Underlying Upper Pleistocene Sediments on the Inner Continental Shelf of New Jersey. October 1996
- Atlantic Coast of New Jersey Beach Profile Data Collection: September 2003. Wildwood, New Jersey. Project Summary Report. December 17, 2003

Geotechnical Data

- USACE – Grain Size Analysis, October 1978, January 1979, March, 1995
- NJGS – Boring Logs and Grain Size Analysis, March 2009

GEOTECHNICAL APPENDIX

SECTION 5

Bibliography of Referenced Documents

The following documents and reports were utilized in the preparation of the report.

Atlantic Coast of New Jersey Beach Profile Data Collection: September 2003. Wildwood, New Jersey. Project Summary Report. Offshore & Coastal Technologies, Incorporated. December 17, 2003.

Automated Coastal Engineering System (ACES), Veritech, 2014

Cape May Inlet to Lower Township, New Jersey. Phase I General Design Memorandum. USACE, August 1980.

Characterization of Sediments in Federal Waters Offshore of New Jersey as Potential Sources of Beach Replenishment Sand. Phase II, Year 2 Final Report. NJGS, Rutgers University, NJDEP.

Coastal Engineering Manual – Appendix A – Glossary of Coastal Terminology. USACE. July 31, 2003.

Coastal Engineering Manual. EM-1110-2-1100, USACE. August 1, 2008.

Draft Feasibility Report and Draft Environmental Impact Statement, Volume 1. New Jersey Shore Protection Study, Townsends Inlet to Cape May Inlet. USACE, July 1996.

Geoacoustic Study of New Jersey Coast from Townsends Inlet to Hereford Inlet. Technical Report HL-96-3. WES, July 1996.

Geotechnical Data Report Vibrational Coring Cape May Fillet Area Study Cape May County, New Jersey. Schnabel Engineering. May 16, 2006.

Geotechnical Data Report Vibrational Coring Cape May, New Jersey. Schnabel Engineering. October 12, 2007.

Geotechnical Data Report Vibrational Coring Townsends & Hereford Inlets Cape May County, New Jersey. Schnabel Engineering. October 12, 2007.

Geotechnical Data Report Vibrational Coring Wildwood to Hereford Inlet Cape May County, New Jersey. Schnabel Engineering. June 30, 2006.

Geotechnical Data Report Wildwood Beach Investigation Cape May County, New Jersey. Schnabel Engineering. April 17, 2007.

Geotechnical Investigation Vibrocoring along the New Jersey Coast – Townsend/Hereford Inlet Study Area. Duffield Associates, December 1998

Land Use Management. New Jersey Geological Survey. New Jersey Department of Environmental Protection (NJDEP). April 12, 2006.

Nearshore Ridges and Underlying Upper Pleistocene Sediments on the Inner Continental Shelf of New Jersey. Rutgers University. October 1996.

Shore Protection Manual. Coastal Engineering Research Center. USACE, 1984.

The Geology and Landscapes of New Jersey. 1977.

Townsends Inlet to Cape May Inlet Feasibility Report and Environmental Impact Statement. Volume 2. Appendix D. 1996.

Section 5

Project Design

The following section contains the infrastructure damages from Hereford Inlet to Cape May Inlet feasibility study by cell (1-7) for each storm event (5, 10, 20, 50, 100, 200, 500 year).

Infrastructure damages include damages to gas lines, water lines electric utilities, light poles, boardwalk etc, from erosion, wave damage and inundation.

The selected plan layout and cross sections are contained at the end of the section.

CELL	1	500 yr	200 yr	100 yr	50 yr	20 yr	10 yr	5 yr				
	Utility Pole (EA)	67	67	29	1	0	0	0		Assume all electric is 120V/240V		
	Transformer (EA)	9	0	0	0	0	0	0				
	Street Light (EA)	66	66	31	1	0	0	0		PIPE TRENCH		5
	Electric (LF)	1101	410	136	39	0	0	0		Pipe Size		4
	Lateral Elec (LF)	540	315	30	0	0	0	0		Excavation		
	Telephone (LF)	1101	410	136	39	0	0	0			A=	7.111111
	Lateral Tel (LF)	540	315	30	0	0	0	0			V=	0.263374
	Cable TV (LF)	1101	410	136	39	0	0	0				
	Lateral Cable TV (LF)	540	315	30	0	0	0	0		Bedding		4
2	Gas (LF)	225	0	0	0	0	0	0			V=	0.016461
	Excavation (CY)	59.3	0	0	0	0	0	0				
	Bedding 4" (CY)	3.7	0	0	0	0	0	0		Backfill	V=	0.243681
	Backfill (CY)	54.8	0	0	0	0	0	0				
1.5	Lateral Gas (LF)	540	0	0	0	0	0	0				
	Excavation (CY)	142.2	0	0	0	0	0	0		Excavation Each Manhole		
	Bedding 4" (CY)	8.9	0	0	0	0	0	0		6" Bedding Each Manhole		
	Backfill (CY)	131.6	0	0	0	0	0	0		Backfill Each Manhole		
	Man Hole (EA)	12	12	0	0	0	0	0		Concrete Each Manhole		
	Excavation (CY)	1154.39	1154.39	0	0	0	0	0				
	Bedding 6" (CY)	8.91	8.91	0	0	0	0	0				
	Backfill (CY)	1056.11	1056.11	0	0	0	0	0		Outfall pipe lengths shown in rec		
	Concrete (CY)	44.68	44.68	0	0	0	0	0		See attached outfall pipe support		
8" to 15"	Sanitary Sewer (LF)	1860	755	0	0	0	0	0		taken from the Lower Cape May		
	Excavation (CY)	1112.3	451.5	0	0	0	0	0		Assume excavation and backfill f		
	Bedding 4" (CY)	63.1	25.6	0	0	0	0	0				
	Backfill (CY)	964.6	391.5	0	0	0	0	0				
16" to 21"	Sanitary Sewer (LF)	0	0	0	0	0	0	0				
	Excavation (CY)	0	0	0	0	0	0	0				
	Bedding 6" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	0	0	0	0	0	0	0				
24" to 30"	Sanitary Sewer (LF)	0	0	0	0	0	0	0				
	Excavation (CY)	0	0	0	0	0	0	0				
	Bedding 6" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	0	0	0	0	0	0	0				
33" to 42"	Sanitary Sewer (LF)	0	0	0	0	0	0	0				
	Excavation (CY)	0	0	0	0	0	0	0				
	Bedding 6" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	0	0	0	0	0	0	0				
6	Lateral San Sew (LF)	540	315	0	0	0	0	0				
	Excavation (CY)	1020	595	0	0	0	0	0				
	Bedding 6" (CY)	30	17.5	0	0	0	0	0				
	Backfill (CY)	797.6	465.3	0	0	0	0	0				
	Man Hole SD (EA)	13	13	11	0	0	0	0				
	Excavation (CY)	1250.58	1250.58	1058.19	0	0	0	0				
	Bedding 6" (CY)	9.66	9.66	8.17	0	0	0	0				
	Backfill (CY)	1144.12	1144.12	968.1	0	0	0	0				

	Concrete (CY)	48.41	48.41	40.96	0	0	0	0				
	Catch Basin (EA)	0	0	0	0	0	0	0				
	Excavation (CY)	0	0	0	0	0	0	0				
	Bedding 6" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	0	0	0	0	0	0	0				
	Concrete (CY)	0	0	0	0	0	0	0				
6" to 15"	Storm Drain (LF)	0	0	0	0	0	0	0				
	Excavation (CY)	0	0	0	0	0	0	0				
	Bedding 4" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	0	0	0	0	0	0	0				
16" to 21"	Storm Drain (LF)	210	125	0	0	0	0	0				
	Excavation (CY)	179.4	106.8	0	0	0	0	0				
	Bedding 6" (CY)	8.4	5	0	0	0	0	0				
	Backfill (CY)	152.2	90.6	0	0	0	0	0				
24" to 30"	Storm Drain (LF)	1064	1064	1064	0	0	0	0				
	Excavation (CY)	1330	1330	1330	0	0	0	0				
	Bedding 6" (CY)	49.3	49.3	0	0	0	0	0				
	Backfill (CY)	1087.3	1087.3	1087.3	0	0	0	0				
33" to 48"	Storm Drain (LF)	2479	2271	2137	603	547	485	373				
	Excavation (CY)	4682.6	4289.7	4036.6	1139	1033.2	916.1	704.6				
	Bedding 6" (CY)	137.7	126.2	0	0	0	0	0				
	Backfill (CY)	3661.5	3354.3	3156.3	890.6	807.9	716.3	550.9				
6	Water (LF)	5058	3250	0	0	0	0	0				
	Excavation (CY)	3024.7	1943.5	0	0	0	0	0				
	Bedding 6" (CY)	171.7	110.3	0	0	0	0	0				
	Backfill (CY)	2623	1685.4	0	0	0	0	0				
1	Lateral Water (LF)	540	315	0	0	0	0	0				
	Excavation (CY)	1020	595	0	0	0	0	0				
	Bedding 4" (CY)	30	17.5	0	0	0	0	0				
	Backfill (CY)	797.6	465.3	0	0	0	0	0				
	Pavement (SF)	152459	108477	79133	0	0	0	0				
	6 ft Sidewalk (SF)	63437	42295	0	0	0	0	0				
	Curb (LF)	12800	7617	3050	0	0	0	0				
	Number of Buildings (N	36	21	0	0	0	0	0				
	Number of FH (F)	4	0	0	0	0	0	0				
	Typical Lateral (Ft)	15	15	15	15	15	15	15				
	Typical Road Width (W	30	30	30	30	30	30	30				
	Number of pipe support	356	356	356	67	61	54	41				

CELL	2	500 yr	200 yr	100 yr	50 yr	20 yr	10 yr	5 yr
	Utility Pole (EA)	114	71	39	16			
	Transformer (EA)	11	3	0	0	0	0	0
	Street Light (EA)	114	71	39	16			
	Electric (LF)	4002	3433	3328	3128	0	0	0
	Lateral Elec (LF)	210	150	150	0	0	0	0
	Telephone (LF)	874	305	200	16	0	0	0
	Lateral Tel (LF)	210	150	150	0	0	0	0
	Cable TV (LF)	874	305	200	0	0	0	0
	Lateral Cable TV (LF)	210	150	150	0	0	0	0
2	Gas (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 4" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
1.5	Lateral Gas (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 4" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
	Man Hole (EA)	11	10	0	0	0	0	0
	Excavation (CY)	1058.19	961.99	0	0	0	0	0
	Bedding 6" (CY)	8.17	7.43	0	0	0	0	0
	Backfill (CY)	968.1	880.09	0	0	0	0	0
	Concrete (CY)	40.96	37.24	0	0	0	0	0
6" to 15"	Sanitary Sewer (LF)	750	0	0	0	0	0	0
	Excavation (CY)	448.5	0	0	0	0	0	0
	Bedding 4" (CY)	25.5	0	0	0	0	0	0
	Backfill (CY)	388.9	0	0	0	0	0	0
16" to 21"	Sanitary Sewer (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 6" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
24" to 30"	Sanitary Sewer (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 6" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
33" to 42"	Sanitary Sewer (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 6" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
6	Lateral San Sew (LF)	210	150	0	0	0	0	0
	Excavation (CY)	396.7	283.3	0	0	0	0	0
	Bedding 6" (CY)	11.7	8.3	0	0	0	0	0
	Backfill (CY)	310.2	221.5	0	0	0	0	0
	Man Hole SD (EA)	15	10	10	0	0	0	0
	Excavation (CY)	1442.98	961.99	961.99	0	0	0	0

	Bedding 6" (CY)	11.14	7.43	7.43	0	0	0	0				
	Backfill (CY)	1320.14	880.09	880.09	0	0	0	0				
	Concrete (CY)	55.85	37.24	37.24	0	0	0	0				
	Catch Basin (EA)	0	0	0	0	0	0	0				
	Excavation (CY)	0	0	0	0	0	0	0				
	Bedding 6" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	0	0	0	0	0	0	0				
	Concrete (CY)	0	0	0	0	0	0	0				
6" to 15"	Storm Drain (LF)	924	420	0	0	0	0	0				
	Excavation (CY)	552.5	251.2	0	0	0	0	0				
	Bedding 4" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	479.2	217.8	0	0	0	0	0				
16" to 21"	Storm Drain (LF)	770	0	0	0	0	0	0				
	Excavation (CY)	657.7	0	0	0	0	0	0				
	Bedding 6" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	558.2	0	0	0	0	0	0				
24" to 30"	Storm Drain (LF)	0	1821	1701	0	0	0	0				
	Excavation (CY)	0	2276.3	2126.3	0	0	0	0				
	Bedding 6" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	0	1860.9	1738.2	0	0	0	0				
33" to 42"	Storm Drain (LF)	0	0	0	0	0	0	0				
	Excavation (CY)	0	0	0	0	0	0	0				
	Bedding 6" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	0	0	0	0	0	0	0				
6"	Water (LF)	1314	896	0	0	0	0	0				
	Excavation (CY)	785.8	535.8	0	0	0	0	0				
	Bedding 6" (CY)	44.6	30.4	0	0	0	0	0				
	Backfill (CY)	681.4	464.7	0	0	0	0	0				
1	Lateral Water (LF)	210	150	0	0	0	0	0				
	Excavation (CY)	396.7	283.3	0	0	0	0	0				
	Bedding 4" (CY)	11.7	8.3	0	0	0	0	0				
	Backfill (CY)	310.2	221.5	0	0	0	0	0				
	Pavement (SF)	51312	28392	6504	0	0	0	0				
	6 ft Sidewalk (SF)	12888	8320	6600	0	0	0	0				
	Curb (LF)	2200	968	0	0	0	0	0				
	Number of Buildings (N	14	10	10	0	0	0	0				
	Number of FH (F)	2	0	0	0	0	0	0				
	Typical Lateral (Ft)	15	15	15	15	15	15	15				
	Typical Road Width (W	30	30	30	30	30	30	30				
	Number of pipe suppor	626	249	189	0	0	0	0				

CELL	3	500 yr	200 yr	100 yr	50 yr	20 yr	10 yr	5 yr
	Utility Pole (EA)	62	9	6	5	0	0	0
	Transformer (EA)	14	6	0	0	0	0	0
	Street Light (EA)	62	9	6	5	0	0	0
	Electric (LF)	3983	1288	1087	876	0	0	0
	Lateral Elec (LF)	465	75	30	0	0	0	0
	Telephone (LF)	3983	1288	1087	876	0	0	0
	Lateral Tel (LF)	465	75	30	0	0	0	0
	Cable TV (LF)	3983	1288	1087	876	0	0	0
	Lateral Cable TV (LF)	465	75	30	0	0	0	0
2	Gas (LF)	586	233	0	0	0	0	0
	Excavation (CY)	154.3	61.4	0	0	0	0	0
	Bedding 4" (CY)	9.6	3.8	0	0	0	0	0
	Backfill (CY)	142.8	56.8	0	0	0	0	0
1	Lateral Gas (LF)	465	0	0	0	0	0	0
	Excavation (CY)	122.5	0	0	0	0	0	0
	Bedding 4" (CY)	7.7	0	0	0	0	0	0
	Backfill (CY)	113.3	0	0	0	0	0	0
	Man Hole (EA)	30	0	0	0	0	0	0
	Excavation (CY)	2885.96	0	0	0	0	0	0
	Bedding 6" (CY)	22.28	0	0	0	0	0	0
	Backfill (CY)	2640.28	0	0	0	0	0	0
	Concrete (CY)	111.71	0	0	0	0	0	0
6" to 15"	Sanitary Sewer (LF)	5185	0	0	0	0	0	0
	Excavation (CY)	3100.6	0	0	0	0	0	0
	Bedding 4" (CY)	176	0	0	0	0	0	0
	Backfill (CY)	2688.9	0	0	0	0	0	0
16" to 21"	Sanitary Sewer (LF)	1280	0	0	0	0	0	0
	Excavation (CY)	1093.3	0	0	0	0	0	0
	Bedding 6" (CY)	51.4	0	0	0	0	0	0
	Backfill (CY)	927.9	0	0	0	0	0	0
24" to 30"	Sanitary Sewer (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 6" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
33" to 42"	Sanitary Sewer (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 6" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
6	Lateral San Sew (LF)	465	0	0	0	0	0	0
	Excavation (CY)	878.3	0	0	0	0	0	0
	Bedding 6" (CY)	25.8	0	0	0	0	0	0
	Backfill (CY)	686.8	0	0	0	0	0	0
	Man Hole SD (EA)	30	7	5	1	0	0	
	Excavation (CY)	2885.96	673.39	480.99	96.2	0	0	
	Bedding 6" (CY)	22.28	5.2	3.71	0.74	0	0	
	Backfill (CY)	2640.28	616.07	440.05	88.01	0	0	
	Concrete (CY)	111.71	26.07	18.62	3.72	0	0	

	Catch Basin (EA)	11	0	0	0	0	0					
	Excavation (CY)	1058.19	0	0	0	0	0					
	Bedding 6" (CY)	8.17	0	0	0	0	0					
	Backfill (CY)	968.1	0	0	0	0	0					
	Concrete (CY)	40.96	0	0	0	0	0					
6" to 15"	Storm Drain (LF)	2372	1790	1570	1340	1066	885	705				
	Excavation (CY)	1418.4	1070.4	938.9	801.3	637.5	529.2	421.6				
	Bedding 4" (CY)	80.5	0	0	0	0	0	0				
	Backfill (CY)	1230.1	928.3	814.2	694.9	552.8	459	365.6				
16" to 21"	Storm Drain (LF)	7553	4626	3826	2986	2037	1541	1046				
	Excavation (CY)	6451.5	3951.4	3268	2550.5	1739.9	1316.3	893.5				
	Bedding 6" (CY)	303.1	0	0	0	0	0	0				
	Backfill (CY)	5475.6	3353.7	2773.7	2164.7	1476.7	1117.2	758.3				
24" to 30"	Storm Drain (LF)	7947	4025	3423	2790	2037	1540	1042				
	Excavation (CY)	9933.8	5031.3	4278.8	3487.5	2546.3	1925	1302.5				
	Bedding 6" (CY)	367.9	0	0	0	0	0	0				
	Backfill (CY)	8121	4113.1	3498	2851.1	2081.6	1573.7	1064.8				
33" to 42"	Storm Drain (LF)	0	0	0	0	0	0					
	Excavation (CY)	0	0	0	0	0	0	0				
	Bedding 6" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	0	0	0	0	0	0	0				
6"	Water (LF)	5880	0	0	0	0	0	0				
	Excavation (CY)	3516.2	0	0	0	0	0	0				
	Bedding 6" (CY)	199.6	0	0	0	0	0	0				
	Backfill (CY)	3049.3	0	0	0	0	0	0				
1"	Lateral Water (LF)	465	0	0	0	0	0	0				
	Excavation (CY)	878.3	0	0	0	0	0	0				
	Bedding 4" (CY)	25.8	0	0	0	0	0	0				
	Backfill (CY)	686.8	0	0	0	0	0	0				
	Pavement (SF)	364619	340185	0	0	0	0	0				
	6 ft Sidewalk (SF)	56160	0	0	0	0	0	0				
	Curb (LF)	4160	0	0	0	0	0	0				
	Number of Buildings (N	31	0	0	0	0	0	0				
	Number of FH (F)	9	0	0	0	0	0	0				
	Typical Lateral (Ft)	15	15	15	15	15	15	15				
	Typical Road Width (W	30	30	30	30	30	30	30				
	Number of pipe support	1160	1160	980	791	571	441	310				

CELL	4	500 yr	200 yr	100 yr	50 yr	20 yr	10 yr	5 yr
	Utility Pole (EA)	81	22	2	0	0	0	0
	Transformer (EA)	20	7	1	0	0	0	0
	Street Light (EA)	81	22	2	0	0	0	0
	Electric (LF)	6674	2298	460	0	0	0	0
	Lateral Elec (LF)	615	225	30	0	0	0	0
	Telephone (LF)	6674	2298	460	0	0	0	0
	Lateral Tel (LF)	615	225	30	0	0	0	0
	Cable TV (LF)	6674	2298	460	0	0	0	0
	Lateral Cable TV (LF)	615	225	30	0	0	0	0
2	Gas (LF)	1039	0	0	0	0	0	0
	Excavation (CY)	273.6	0	0	0	0	0	0
	Bedding 4" (CY)	17.1	0	0	0	0	0	0
	Backfill (CY)	253.2	0	0	0	0	0	0
1.5	Lateral Gas (LF)	615	0	0	0	0	0	0
	Excavation (CY)	162	0	0	0	0	0	0
	Bedding 4" (CY)	10.1	0	0	0	0	0	0
	Backfill (CY)	149.9	0	0	0	0	0	0
	Man Hole (EA)	38	9	1	0	0	0	0
	Excavation (CY)	3655.55	865.79	96.2	0	0	0	0
	Bedding 6" (CY)	28.23	6.69	0.74	0	0	0	0
	Backfill (CY)	3344.35	792.08	88.01	0	0	0	0
	Concrete (CY)	141.5	33.51	3.72	0	0	0	0
6" to 15"	Sanitary Sewer (LF)	3200	730	150	0	0	0	0
	Excavation (CY)	1913.6	436.5	89.7	0	0	0	0
	Bedding 4" (CY)	108.6	24.8	5.1	0	0	0	0
	Backfill (CY)	1659.5	378.6	77.8	0	0	0	0
16" to 21"	Sanitary Sewer (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 6" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
24" to 30"	Sanitary Sewer (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 6" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
33" to 42"	Sanitary Sewer (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 6" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
6	Lateral San Sew (LF)	615	225	0	0	0	0	0
	Excavation (CY)	1161.7	425	0	0	0	0	0
	Bedding 6" (CY)	34.2	12.5	0	0	0	0	0
	Backfill (CY)	908.4	332.3	0	0	0	0	0
	Man Hole SD (EA)	0	0	0	0	0	0	
	Excavation (CY)	0	0	0	0	0	0	
	Bedding 6" (CY)	0	0	0	0	0	0	
	Backfill (CY)	0	0	0	0	0	0	
	Concrete (CY)	0	0	0	0	0	0	

	Catch Basin (EA)	0	0	0	0	0	0					
	Excavation (CY)	0	0	0	0	0	0					
	Bedding 6" (CY)	0	0	0	0	0	0					
	Backfill (CY)	0	0	0	0	0	0					
	Concrete (CY)	0	0	0	0	0	0					
6" to 15"	Storm Drain (LF)	0	0	0	0	0	0	0				
	Excavation (CY)	0	0	0	0	0	0	0				
	Bedding 4" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	0	0	0	0	0	0	0				
16" to 21"	Storm Drain (LF)	5760	4616	3967	3317	2435	1757	1148				
	Excavation (CY)	4920	3942.8	3388.5	2833.3	2079.9	1500.8	980.6				
	Bedding 6" (CY)	231.1	185.2	159.2	0	0	0	0				
	Backfill (CY)	4175.8	3346.4	2875.9	2404.7	1765.3	1273.8	832.3				
24" to 30"	Storm Drain (LF)	2456	2025	1715	1375	934	636	475				
	Excavation (CY)	3070	2531.3	2143.8	1718.8	1167.5	795	593.8				
	Bedding 6" (CY)	113.7	93.8	79.4	0	0	0	0				
	Backfill (CY)	2509.8	2069.3	1752.6	1405.1	954.5	649.9	485.4				
33" to 42"	Storm Drain (LF)	0	0	0	0	0	0					
	Excavation (CY)	0	0	0	0	0	0	0				
	Bedding 6" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	0	0	0	0	0	0	0				
6"	Water (LF)	1489	0	0	0	0	0	0				
	Excavation (CY)	890.4	0	0	0	0	0	0				
	Bedding 6" (CY)	50.6	0	0	0	0	0	0				
	Backfill (CY)	772.2	0	0	0	0	0	0				
1	Lateral Water (LF)	615	0	0	0	0	0	0				
	Excavation (CY)	1161.7	0	0	0	0	0	0				
	Bedding 4" (CY)	34.2	0	0	0	0	0	0				
	Backfill (CY)	908.4	0	0	0	0	0	0				
	Pavement (SF)	346669	108783	0	0	0	0	0				
	6 ft Sidewalk (SF)	227970	135024	0	0	0	0	0				
	Curb (LF)	21258	7200	0	0	0	0	0				
	Number of Buildings (N	41	15	0	0	0	0	0				
	Number of FH (F)	5	0	0	0	0	0	0				
	Typical Lateral (Ft)	15	15	15	15	15	15	15				
	Typical Road Width (W	30	30	30	30	30	30	30				
	Number of pipe support	521	521	521	521	374	266	180				

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CELL	5	500 yr	200 yr	100 yr	50 yr	20 yr	10 yr	5 yr
	Utility Pole (EA)	119	102	68	0	0	0	0
	Transformer (EA)	85	68	51	0	0	0	0
	Street Light (EA)	119	102	68	0	0	0	0
	Electric (LF)	16286	13702	10319	0	0	0	0
	Lateral Elec (LF)	1815	1260	960	0	0	0	0
	Telephone (LF)	16286	13702	10319	0	0	0	0
	Lateral Tel (LF)	1815	1260	960	0	0	0	0
	Cable TV (LF)	16286	13702	10319	0	0	0	0
	Lateral Cable TV (LF)	1815	1260	960	0	0	0	0
2	Gas (LF)	864	658	152	0	0	0	0
	Excavation (CY)	227.6	173.3	40	0	0	0	0
	Bedding 4" (CY)	14.2	10.8	2.5	0	0	0	0
	Backfill (CY)	210.5	160.3	37	0	0	0	0
1.5	Lateral Gas (LF)	1815	1260	960	0	0	0	0
	Excavation (CY)	478	331.9	252.8	0	0	0	0
	Bedding 4" (CY)	29.9	20.7	15.8	0	0	0	0
	Backfill (CY)	442.3	307	233.9	0	0	0	0
	Man Hole (EA)	46	42	27	0	0	0	0
	Excavation (CY)	4425.14	4040.35	2597.37	0	0	0	0
	Bedding 6" (CY)	34.17	31.2	20.06	0	0	0	0
	Backfill (CY)	4048.43	3696.39	2376.25	0	0	0	0
	Concrete (CY)	171.29	156.39	100.54	0	0	0	0
6" to 15"	Sanitary Sewer (LF)	9385	7585	4710	0	0	0	0
	Excavation (CY)	5612.2	4535.8	2816.6	0	0	0	0
	Bedding 4" (CY)	318.6	257.5	159.9	0	0	0	0
	Backfill (CY)	4867	3933.5	2442.6	0	0	0	0
16" to 21"	Sanitary Sewer (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 6" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
24" to 30"	Sanitary Sewer (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 6" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
33" to 42"	Sanitary Sewer (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 6" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
6	Lateral San Sew (LF)	1815	1260	960	0	0	0	0
	Excavation (CY)	3428.3	2380	1813.3	0	0	0	0
	Bedding 6" (CY)	100.8	70	53.3	0	0	0	0
	Backfill (CY)	2680.7	1861	1417.9	0	0	0	0
	Man Hole SD (EA)	1	1	0	0	0	0	0
	Excavation (CY)	96.2	96.2	0	0	0	0	0
	Bedding 6" (CY)	0.74	0.74	0	0	0	0	0
	Backfill (CY)	88.01	88.01	0	0	0	0	0

	Concrete (CY)	3.72	3.72	0	0	0	0	0				
	Catch Basin (EA)	5	2	0	0	0	0	0				
	Excavation (CY)	480.99	192.4	0	0	0	0	0				
	Bedding 6" (CY)	3.71	1.49	0	0	0	0	0				
	Backfill (CY)	440.05	176.02	0	0	0	0	0				
	Concrete (CY)	18.62	7.45	0	0	0	0	0				
6" to 15"	Storm Drain (LF)	0	0	0	0	0	0	0				
	Excavation (CY)	0	0	0	0	0	0	0				
	Bedding 4" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	0	0	0	0	0	0	0				
16" to 21"	Storm Drain (LF)	2029	1729	1337	531	341	221	101				
	Excavation (CY)	1733.1	1476.9	1142	453.6	291.3	188.8	86.3				
	Bedding 6" (CY)	81.4	69.4	53.6	0	0	0	0				
	Backfill (CY)	1470.9	1253.5	969.3	385	247.2	160.2	73.2				
24" to 30"	Storm Drain (LF)	882	807	686	283	188	128	68				
	Excavation (CY)	1102.5	1008.8	857.5	353.8	235	160	85				
	Bedding 6" (CY)	40.8	37.4	31.8	0	0	0	0				
	Backfill (CY)	901.3	824.7	701	289.2	192.1	130.8	69.5				
33" to 42"	Storm Drain (LF)	0	0	0	0	0	0	0				
	Excavation (CY)	0	0	0	0	0	0	0				
	Bedding 6" (CY)	0	0	0	0	0	0	0				
	Backfill (CY)	0	0	0	0	0	0	0				
12"	Water (LF)	2178	0	0	0	0	0	0				
	Excavation (CY)	1302.4	0	0	0	0	0	0				
	Bedding 6" (CY)	73.9	0	0	0	0	0	0				
	Backfill (CY)	1129.5	0	0	0	0	0	0				
8"	Water (LF)	2326	0	0	0	0	0	0				
	Excavation (CY)	1390.9	0	0	0	0	0	0				
	Bedding 6" (CY)	79	0	0	0	0	0	0				
	Backfill (CY)	1206.2	0	0	0	0	0	0				
6"	Water (LF)	6500	4575	2500	0	0	0	0				
	Excavation (CY)	3887	2735.8	1495	0	0	0	0				
	Bedding 6" (CY)	220.7	155.3	84.9	0	0	0	0				
	Backfill (CY)	3370.8	2372.6	1296.5	0	0	0	0				
1"	Lateral Water (LF)	1815	1260	960	0	0	0	0				
	Excavation (CY)	3428.3	2380	1813.3	0	0	0	0				
	Bedding 4" (CY)	100.8	70	53.3	0	0	0	0				
	Backfill (CY)	2680.7	1861	1417.9	0	0	0	0				
	Pavement (SF)	377975	322300	198750	0	0	0	0				
	6 ft Sidewalk (SF)	150060	127560	79500	0	0	0	0				
	Curb (LF)	3680	3200	2880	0	0	0	0				
	Number of Buildings (N	121	84	64	0	0	0	0				
	Number of FH (F)	18	15	10	0	0	0	0				
	Typical Lateral (Ft)	15	15	15	15	15	15	15				
	Typical Road Width (W	30	30	30	30	30	30	30				
	Number of pipe support	31	31	31	31	21	14	8				

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3 lines

= assumed depth of trench							W
15	21	30	42	48		DIA	MAX
						6" to 15"	8
16.14583	23.0625	33.75	51	63	SF	16" to 21"	10
0.597994	0.854167	1.25	1.888889	2.333333	CY/LF	24" to 30"	12
						33" to 42"	15
6	6	6	6	6		48" & grea	18
0.033951	0.040123	0.046296	0.055556	0.064815	CY/LF		
0.518592	0.724958	1.021898	1.476994	1.803096	CY/LF		

96.1988	cy
0.7428	cy
88.0093	cy
3.7236	cy

are pipes suported on timber piles and cribbing.
drawing,
Meadows Beachfill
or these portions involves beach sand only.

CELL	6	500 yr	200 yr	100 yr	50 yr	20 yr	10 yr	5 yr
	Utility Pole (EA)	52	50	46	46	45	37	35
	Transformer (EA)	0	0	0	0	0	0	0
	Street Light (EA)	44	44	44	44	44	43	43
	Electric (LF)	0	0	0	0	0	0	0
	Lateral Elec (LF)	1275	1230	1215	1185	1170	1155	1110
	Telephone (LF)	0	0	0	0	0	0	0
	Lateral Tel (LF)	1275	1230	1215	1185	1170	1155	1110
	Cable TV (LF)	0	0	0	0	0	0	0
	Lateral Cable TV (LF)	1275	1230	1215	1185	1170	17325	16650
2	Gas (LF)	577.6	530.9	520.6	515.4	510.3	505	500
	Excavation (CY)	152.1	139.8	137.1	135.7	134.4	133	131.7
	Bedding 4" (CY)	9.5	8.7	8.6	8.5	8.4	8.3	8.2
	Backfill (CY)	140.8	129.4	126.9	125.6	124.4	123.1	121.8
1.5	Lateral Gas (LF)	1275	1230	1215	1185	1170	48786	47670
	Excavation (CY)	335.8	324	320	312.1	308.1	12849	12555.1
	Bedding 4" (CY)	21	20.2	20	19.5	19.3	803.1	784.7
	Backfill (CY)	310.7	299.7	296.1	288.8	285.1	11888.2	11616.3
	Man Hole (EA)	27	26	26	26	25	25	20
	Excavation (CY)	2597.37	2501.17	2501.17	2501.17	2404.97	2404.97	1923.98
	Bedding 6" (CY)	20.06	19.31	19.31	19.31	18.57	18.57	14.86
	Backfill (CY)	2376.25	2288.24	2288.24	2288.24	2200.23	2200.23	1760.19
	Concrete (CY)	100.54	96.81	96.81	96.81	93.09	93.09	74.47
6" to 15"	Sanitary Sewer (LF)	2746.9	2375.6	2173.3	2072.1	1976.1	1633.5	1145.1
	Excavation (CY)	1642.6	1420.6	1299.6	1239.1	1181.7	976.8	684.8
	Bedding 4" (CY)	93.3	80.7	73.8	70.3	67.1	55.5	38.9
	Backfill (CY)	1424.5	1232	1127.1	1074.6	1024.8	847.1	593.8
16" to 21"	Sanitary Sewer (LF)	4324.7	4324.7	4324.7	4324.7	4324.7	4324.7	4324.7
	Excavation (CY)	3694	3694	3694	3694	3694	3694	3694
	Bedding 6" (CY)	173.5	173.5	173.5	173.5	173.5	173.5	173.5
	Backfill (CY)	3135.2	3135.2	3135.2	3135.2	3135.2	3135.2	3135.2
24" to 30"	Sanitary Sewer (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 6" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
33" to 42"	Sanitary Sewer (LF)	0	0	0	0	0	0	0

	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 6" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
6	Lateral San Sew (LF)	1275	1230	1215	1185	1170	1155	1110
	Excavation (CY)	2408.3	2323.3	2295	2238.3	2210	2181.7	2096.7
	Bedding 6" (CY)	70.8	68.3	67.5	65.8	65	64.2	61.7
	Backfill (CY)	1883.2	1816.7	1794.5	1750.2	1728.1	1705.9	1639.5
	Man Hole SD (EA)	37	36	35	35	35	34	34
	Excavation (CY)	3559.36	3463.16	3366.96	3366.96	3366.96	3270.76	3270.76
	Bedding 6" (CY)	27.48	26.74	26	26	26	25.26	25.26
	Backfill (CY)	3256.34	3168.33	3080.33	3080.33	3080.33	2992.32	2992.32
	Concrete (CY)	137.77	134.05	130.33	130.33	130.33	126.6	126.6
	Catch Basin (EA)	15	11	7	7	7	7	7
	Excavation (CY)	1442.98	1058.19	673.39	673.39	673.39	673.39	673.39
	Bedding 6" (CY)	11.14	8.17	5.2	5.2	5.2	5.2	5.2
	Backfill (CY)	1320.14	968.1	616.07	616.07	616.07	616.07	616.07
	Concrete (CY)	55.85	40.96	26.07	26.07	26.07	26.07	26.07
6" to 15"	Storm Drain (LF)	1681.3	1651.5	1630.2	1619.6	1609	1598.3	1587.7
	Excavation (CY)	1005.4	987.6	974.8	968.5	962.2	955.8	949.4
	Bedding 4" (CY)	57.1	56.1	55.3	55	54.6	54.3	53.9
	Backfill (CY)	871.9	856.5	845.4	839.9	834.4	828.9	823.4
16" to 21"	Storm Drain (LF)	9568.2	9497.3	9447.3	9422.3	9397.2	9372.2	9347.2
	Excavation (CY)	8172.8	8112.3	8069.6	8048.2	8026.8	8005.4	7984.1
	Bedding 6" (CY)	383.9	381.1	379.1	378.1	377	376	375
	Backfill (CY)	6936.5	6885.1	6848.9	6830.8	6812.6	6794.5	6776.3
24" to 30"	Storm Drain (LF)	5921.3	5851.1	5801.1	5776.1	5751.1	5726.1	5701.1
	Excavation (CY)	7401.6	7313.9	7251.4	7220.1	7188.9	7157.6	7126.4
	Bedding 6" (CY)	274.1	270.9	268.6	267.4	266.3	265.1	263.9
	Backfill (CY)	6051	5979.2	5928.1	5902.6	5877	5851.5	5825.9
33" to 42"	Storm Drain (LF)	0	0	0	0	0	0	0
	Excavation (CY)	0	0	0	0	0	0	0
	Bedding 6" (CY)	0	0	0	0	0	0	0
	Backfill (CY)	0	0	0	0	0	0	0
8	Water (LF)	5534.9	4416.7	4067.4	3666.8	3334.2	3252.4	3178
	Excavation (CY)	3309.8	2641.2	2432.3	2192.7	1993.8	1944.9	1900.4
	Bedding 6" (CY)	187.9	149.9	138.1	124.5	113.2	110.4	107.9
	Backfill (CY)	2870.4	2290.5	2109.3	1901.6	1729.1	1686.7	1648.1

1	Lateral Water (LF)	1275	1230	1215	1185	1170	1155	1110
	Excavation (CY)	2408.3	2323.3	2295	2238.3	2210	2181.7	2096.7
	Bedding 4" (CY)	70.8	68.3	67.5	65.8	65	64.2	61.7
	Backfill (CY)	1883.2	1816.7	1794.5	1750.2	1728.1	1705.9	1639.5
	Pavement (SF)	132480	96000	86400	81600	76800	72000	67200
	4 ft Sidewalk (SF)	7360	6400	5760	5440	5120	4800	4480
	Curb (LF)	3680	3200	2880	2720	2560	2400	2240
	Number of Buildings (N)	85	82	81	79	78	77	74
	Number of FH (F)	9	9	9	9	9	9	9
	Typical Lateral (Ft)	15	15	15	15	15	15	15
	Typical Road Width (W)	36	30	30	30	30	30	30

Hereford Inlet to Cape May Inlet			
Without Project Boardwalk Damages			
Cell 2	Damages occur at 100 year event		
	Item	**Quantity**	**Comments**
	2x6 decking	103700 sf	new decking is ipe lumber
	3x6 joists	130677 ft	new joists are southern yellow pine, grade No.1, 2.5pcf CCA preservative
	2x6 bridging	15250 ft	new bridging is southern yellow pine, grade No.1, 0.25pcf CCA preservative
	deck screws 3" long	399,000	screws are weather guard coated steel
	1/2" x 6" L. SS bolts	5,085	include nuts&washers
	twist straps	5085	straps are stainless steel
	light poles	20	poles are tubular aluminum 20' long
	electric cable @220 v	1800 ft	
	public telephone	20	
	telephone cable	1000 ft	
	1.5" dia. SS pipe	8105 ft	actual pipe length needed to fabricate railing, not railing distance
	for handrail (see sketch)		
	3/8" dia. X 6" L SS bolts	1010	for attaching handrail posts to outside joist
	(for handrail)		
	concrete walkway	600 cy	for tramcars-4000 psi concrete
	WWF	48800 sf	W2 x W2 galvanized
	plywood 1" thick	54900 sf	base for concrete walkway
	shotcrete	61000 sf	under concrete walkway
	8x10	12200 ft	support beam for concrete walkway- new lumber is southern yellow pine, grade No.1, 2.5pcf CCA preservative
Cell 3	Damages occur at 100 year event		
	Item	**Quantity**	**Materials**
	2x6 decking	239360 sf	new decking is ipe lumber
	3x6 joists	301312 ft	new joists are southern yellow pine, grade No.1, 2.5pcf CCA preservative
	2x6 bridging	35200 ft	new bridging is southern yellow pine, grade No.1, 0.25pcf CCA preservative
	deck screws 3" long	920,830	screws are weather guard coated steel
	1/2" x 6" L. SS bolts	23,470	include nuts&washers
	twist straps	23470	straps are stainless steel
	light poles	47	poles are tubular aluminum 20' long
	electric cable @220 v	4000 ft	
	public telephone	26	
	telephone cable	1300 ft	
	1.5" dia. SS pipe	18775 ft	actual pipe length needed to fabricate railing, not railing distance
	for handrail (see sketch)		
	3/8" dia. X 6" L SS bolts	2350	for attaching handrail posts to outside joist
	(for handrail)		
	concrete walkway	1390 cy	for tramcars-4000 psi concrete
	WWF	112640 sf	W2 x W2 galvanized
	plywood 1" thick	126720 sf	base for concrete walkway

	shotcrete		140800 sf		under concrete walkway
	8x10		28160 ft		support beam for concrete walkway- new lumber is southern yellow pine, grade No.1, 2.5pcf CCA preservative
Based on total water level and wave setup in vicinity of boardwalk decking. Damage is assumed to occur if waves are impacting the deck form underneath or on top.					

Wildwood/ North Wildwood
Pier damages

Surfside Pier Cell 2 (located at approx.Station 65+00 - Refer to attached retaining wall cross section

Retaining Wall (located at seaward end of pier
Damages occur at 10 year event

Description	Quantity
Shoreguard Series 300 Vinyl Sheetpile, 12' L	1143 lf
6x6 wale .40 CCA	1143 lf
5/8" tie rod 12' L A307, HD Galvanized	190
4x12 1.0 CCA	1143 lf
4x4x4'L posts 1.0 CCA	95
3" Ogee Washer	380
Concrete sidewalk 3000 psi	116,600 sf
2x2 welded wire mesh	116,600 sf
Backfill clean well draining sandy fill	17274 cy

Utility Damages (lineal feet)

	Event	**5**	**10**	**20**	**50**	**100***	**200***	**500***
distance to each amusement/ building (lf)		2763	3177	3598	4113	4113	4113	4113
**2" dia. pvc gas		2763	3177	3598	4113	4113	4113	4113
**4" pvc san. sewer		2763	3177	3598	4113	4113	4113	4113
**4" pvc water		2763	3177	3598	4113	4113	4113	4113
# of pipe hangar supports (for all pvc pipe)								
2" dia. pvc gas		277	318	360	412	412	412	412
4" pvc san. sewer		277	318	360	412	412	412	412
4" pvc water		277	318	360	412	412	412	412

* following 50 year event erosion lines are landward of pier and include boardwalk

** Utility lines are not located underground in trenches
but are suspended from pier deck substructure with clamps and pipe hangars (see attached).
~Assume installation of utility lines will require 2 carpenters and 2 electricians.
~Assume utility lines can be installed at the rate of 100' per day.
~Use 20% of the cost of the electrical cables to account for mounting hardware costs.

Wildwood/ North Wildwood
Pier damages

Mariner's Landing Cell 3 (located at approx.Station 88+00-refer to attached retaining wall cross section)

Retaining Wall (located at seaward end of pier)
Damages occur at 10 year event

Description	Quantity
Shoreguard Series 300 Vinyl Sheetpile, 12' L	350 lf
6x6 wale .40 CCA	350 lf
5/8" tie rod 12' L A307, HD Galvanized	58
4x12 1.0 CCA	350 lf
4x4x4'L posts 1.0 CCA	29
3" Ogee Washer	116
Concrete sidewalk 3000 psi	13260 sf
2x2 welded wire mesh	13260 sf
Backfill clean well draining sandy fill	1719 cy

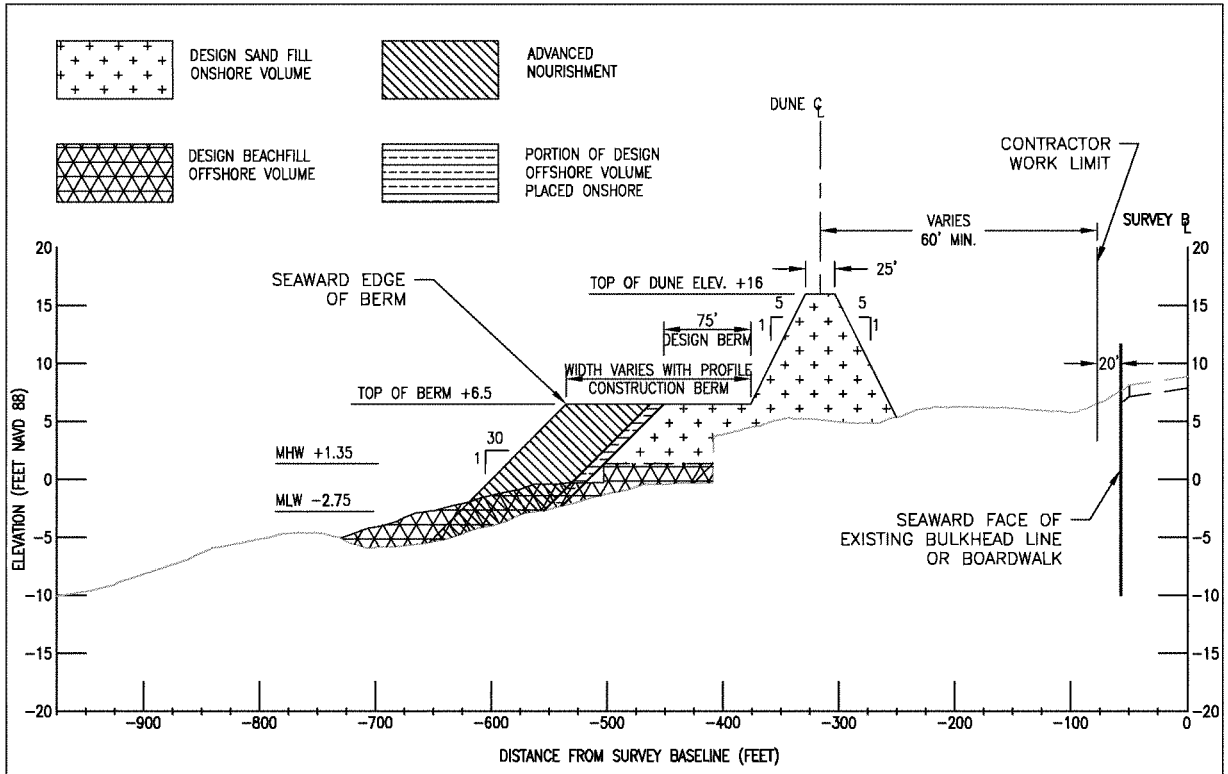
Utility Damages (lineal feet)

	Event	5	10	20	50	100*	200*	500*
distance to each amusement/ building (lf)		0	105	1397	2942	3948	5129	6609
2" dia. pvc gas		0	105	1397	2942	3948	5129	6609
4" pvc san. sewer		0	105	1397	2942	3948	5129	6609
4" pvc water		0	105	1397	2942	3948	5129	6609
	Event	**5**	**10**	**20**	**50**	**100***	**200***	**500***
# of pipe hangar supports (for all pvc pipe)								
2" dia. pvc gas		0	10	140	295	395	513	661
4" pvc san. sewer		0	10	140	295	395	513	661
4" pvc water		0	10	140	295	395	513	661

* following 50 year event erosion lines are landward of pier and include boardwalk

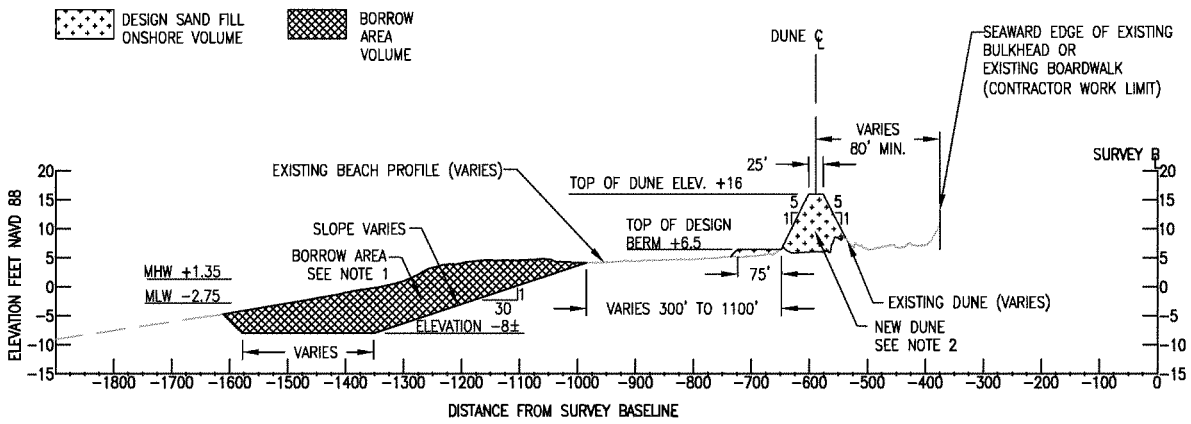
** Utility lines are not located underground in trenches
but are suspended from pier deck substructure with clamps and pipe hangars (see attached).
~Assume installation of utility lines will require 2 carpenters and 2 electricians.
~Assume utility lines can be installed at the rate of 100' per day.

~Use 20% of the cost of the electrical cables to account for mounting hardware costs.



HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY

TYPICAL BEACHFILL DESIGN AND CONSTRUCTION CROSS SECTION
STATION 0+00 TO 85+00
ELEVATION +6.5 BERM +16' DUNE ELEVATION
SCALE AS SHOWN IN FEET

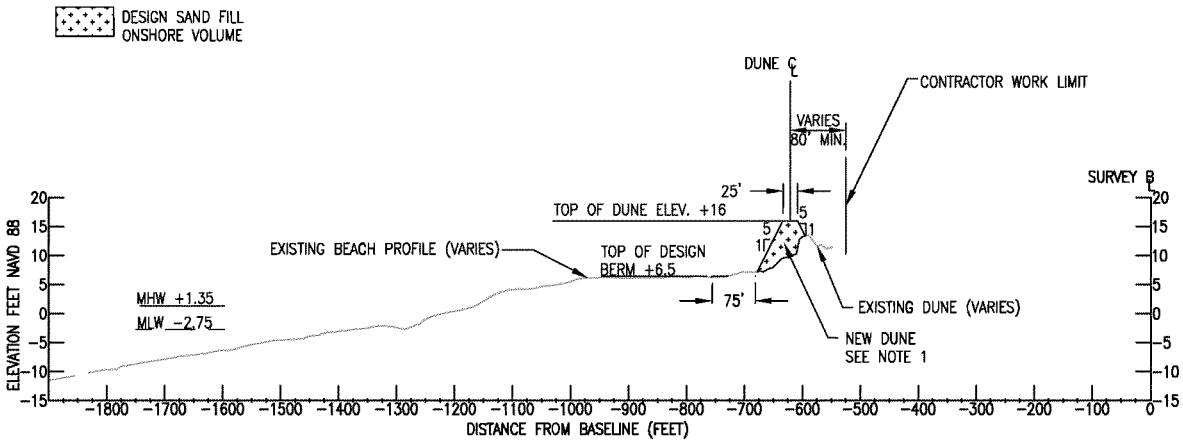


NOTES:
1. EXACT LIMITS OF BORROW AREA MAY VARY FROM THAT SHOWN HERE, BASED ON EXISTING BEACH CONDITIONS AND DREDGING EQUIPMENT SELECTED AT TIME OF CONSTRUCTION.
2. CENTERLINE OF NEW DUNE IS LOCATED ALONG THE SEAWARD EDGE OF THE EXISTING DUNES IN ORDER TO MINIMIZE SAND VOLUME REQUIRED
3. NEW DUNE VEGETATION IS NOT SHOWN.

HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY

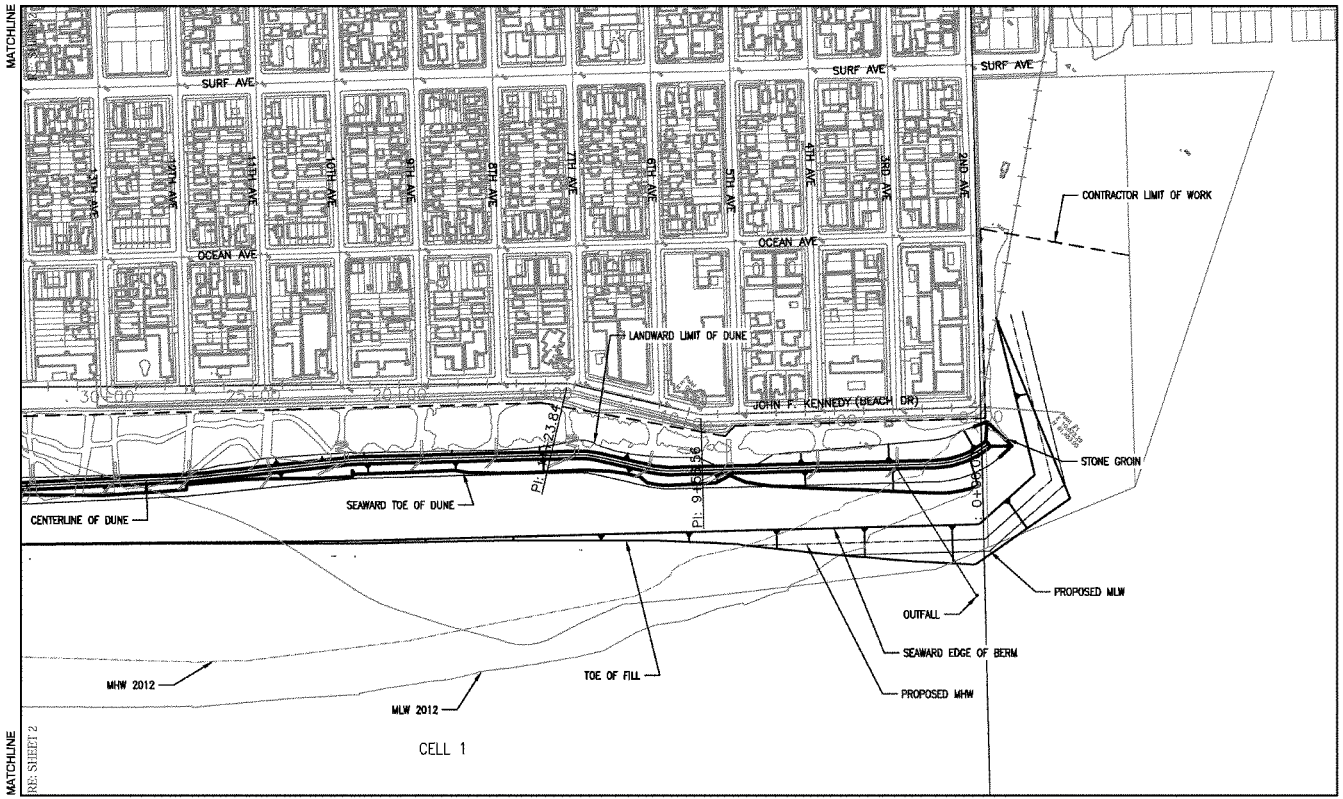
TYPICAL DESIGN CROSS SECTION STATION 85+00 TO 240+00
BEACH BORROW AREA WITH ELEVATION +16 DUNE

SCALE AS SHOWN IN FEET



NOTES:
1. CENTERLINE OF NEW DUNE IS LOCATED ALONG THE SEAWARD EDGE OF THE EXISTING DUNES IN ORDER TO MINIMIZE SAND VOLUME REQUIRED.
2. NEW DUNE VEGETATION IS NOT SHOWN.

HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY
TYPICAL DESIGN CROSS SECTION
STATION 240+00 TO 314+03
ELEVATION +16 DUNE
SCALE AS SHOWN IN FEET



BORROW AREA

NOTES:
1. ALL EXISTING DUNE CROSSOVERS AND BEACH ACCESS POINTS WILL BE EXTENDED OVER THE PROPOSED DUNE. SPREAD SHEET AVAILABLE OF LOCATIONS AND CROSSING TYPE.
2. SAND WILL BE PLACED ON THE SEAWARD SIDE OF ESTABLISHED DUNES. IN ORDER TO REACH PROPOSED HEIGHT.

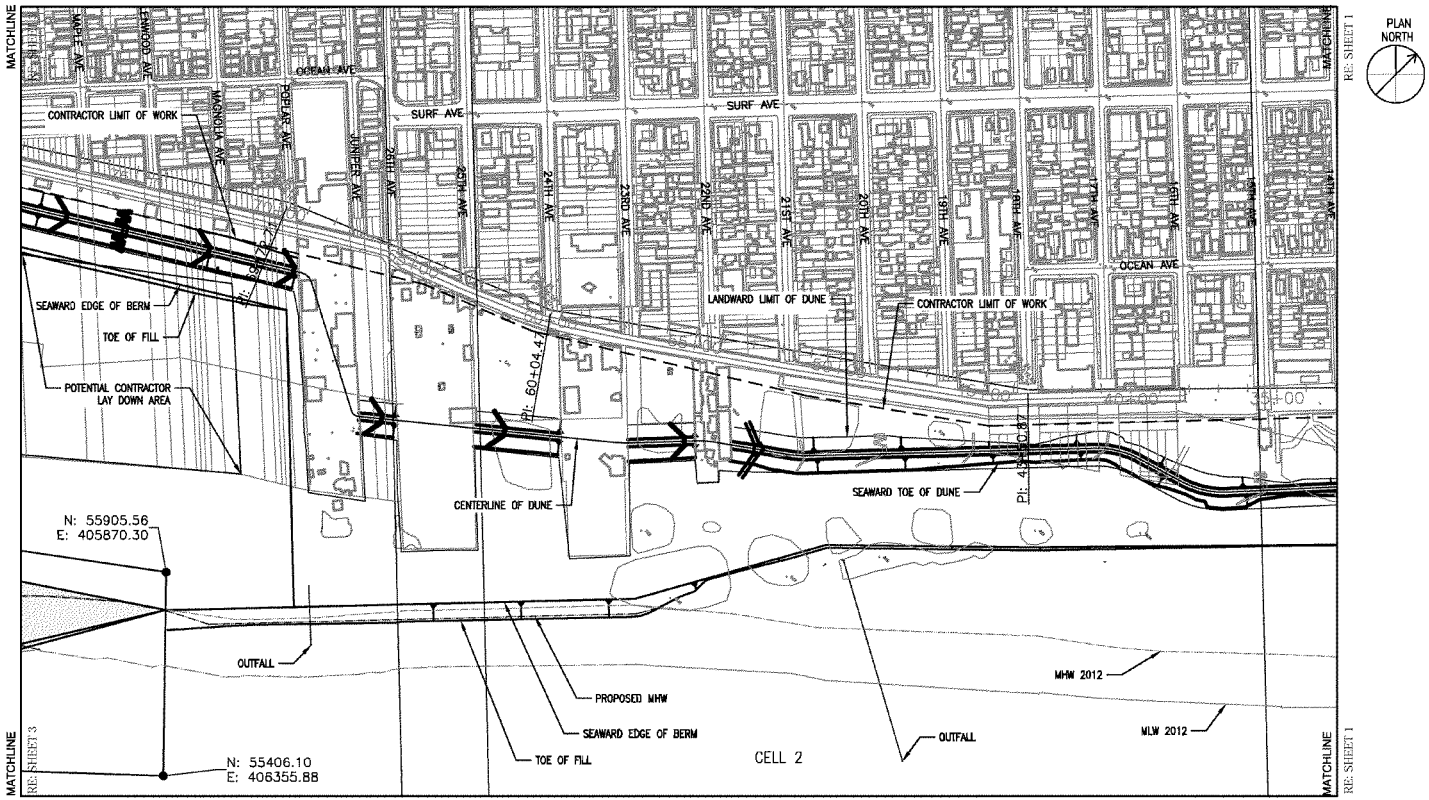
GRAPHIC SCALE
300 0 150 300 600 900
(IN FEET)
1 inch = 300 ft.

HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY

PLAN – BEACH FILL AND BORROW AREA

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SHEET 1 OF 6



PLAN NORTH

BORROW AREA

NOTES:
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2. SAND WILL BE PLACED ON THE SEAWARD SIDE OF ESTABLISHED DUNES. IN ORDER TO REACH PROPOSED HEIGHT.

GRAPHIC SCALE
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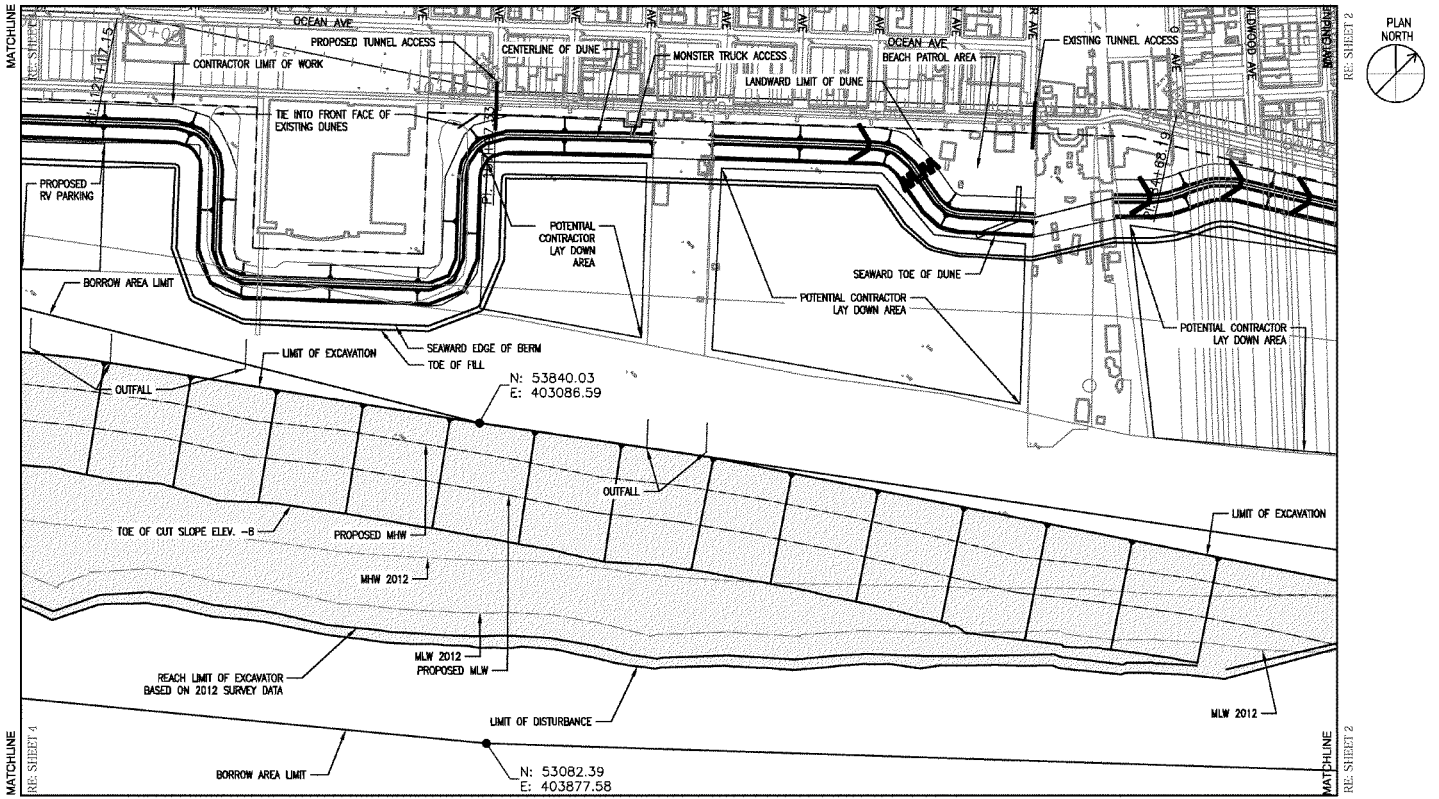
(IN FEET)
1 inch = 300 ft.

HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY
PLAN – BEACH FILL AND BORROW AREA
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SHEET 2 OF 6



BORROW AREA

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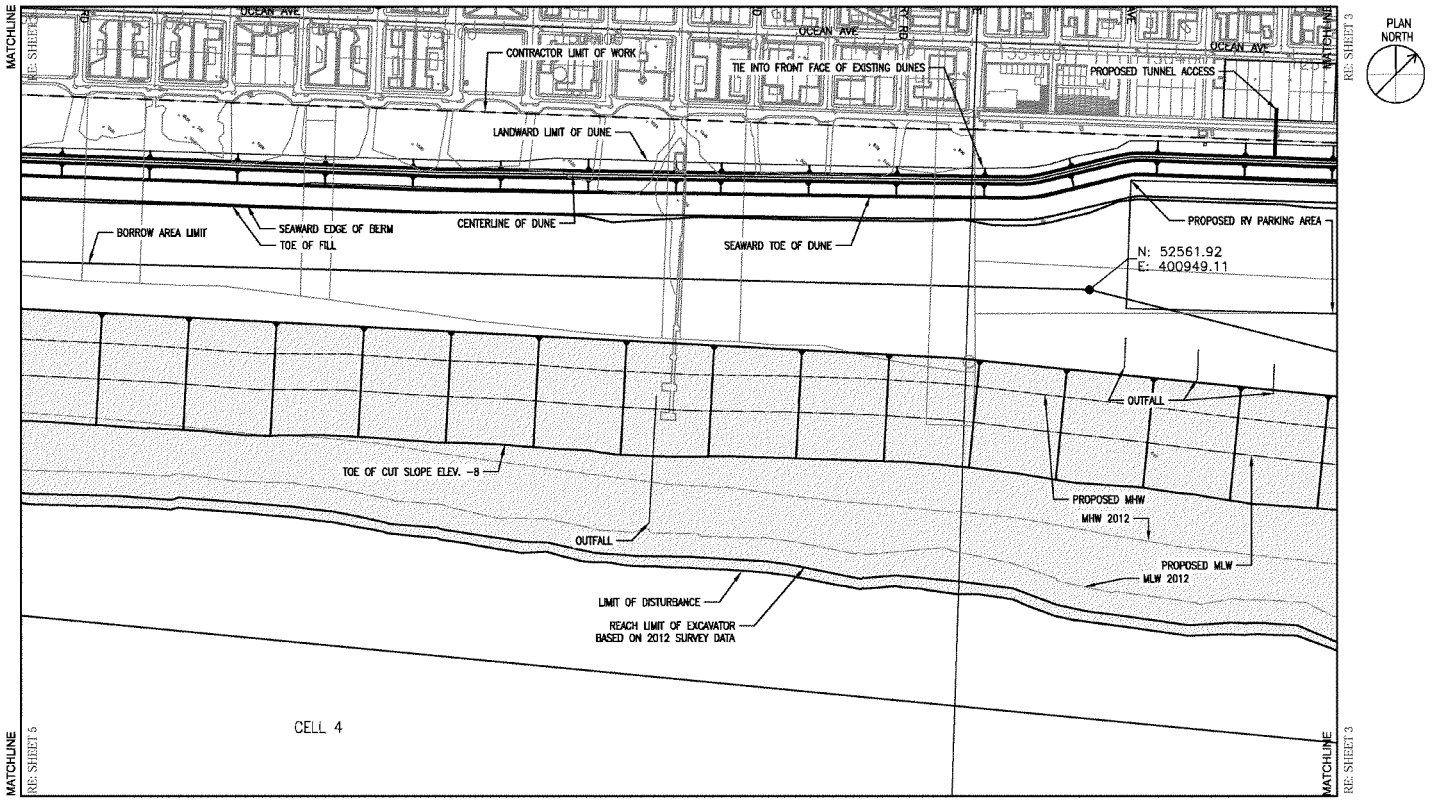
(IN FEET)
1 inch = 300 ft.

HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY

PLAN – BEACH FILL AND BORROW AREA

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SHEET 3 OF 6



BORROW AREA

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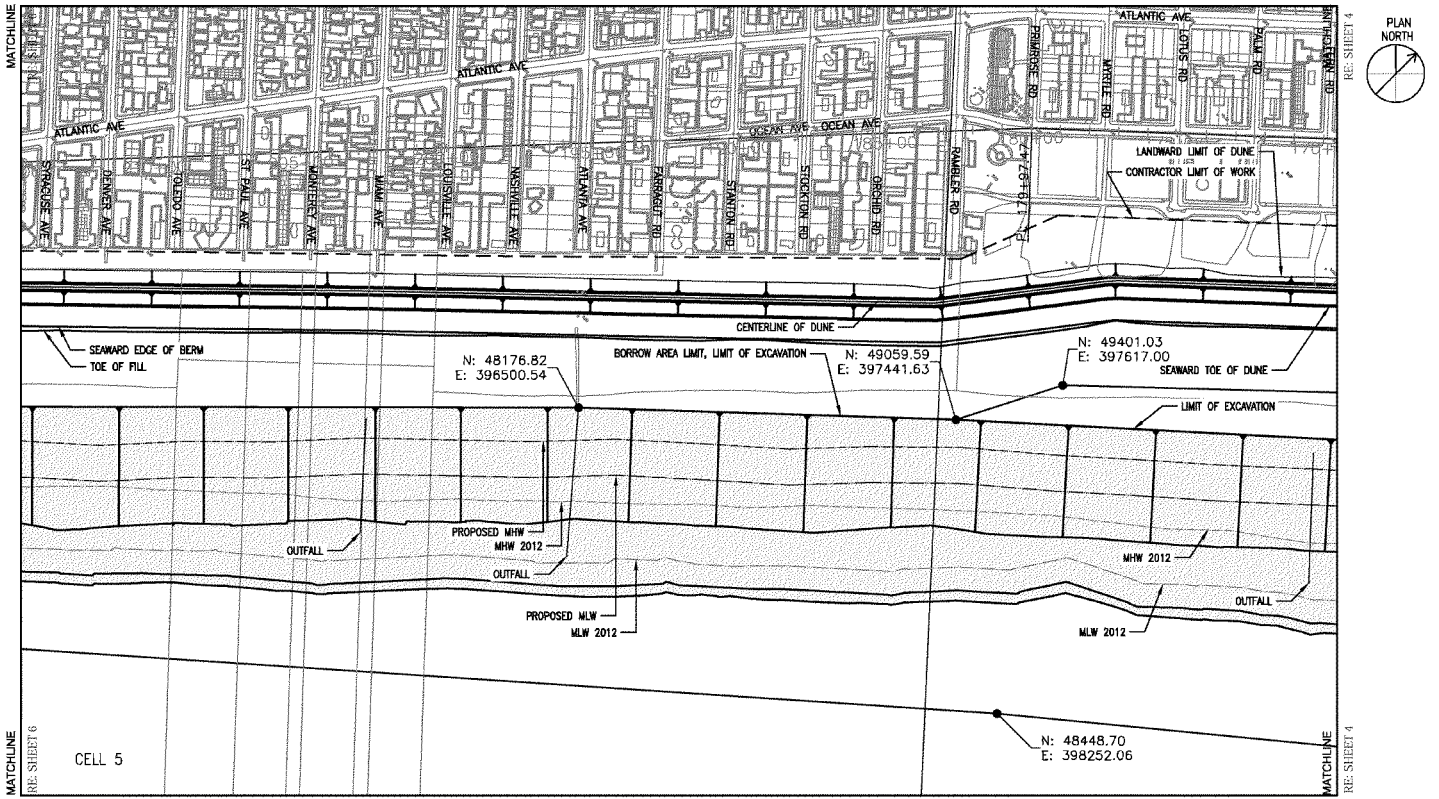
(IN FEET)
1 inch = 300 ft.

HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY
PLAN – BEACH FILL AND BORROW AREA
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SHEET 4 OF 6



BORROW AREA

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GRAPHIC SCALE
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(IN FEET)
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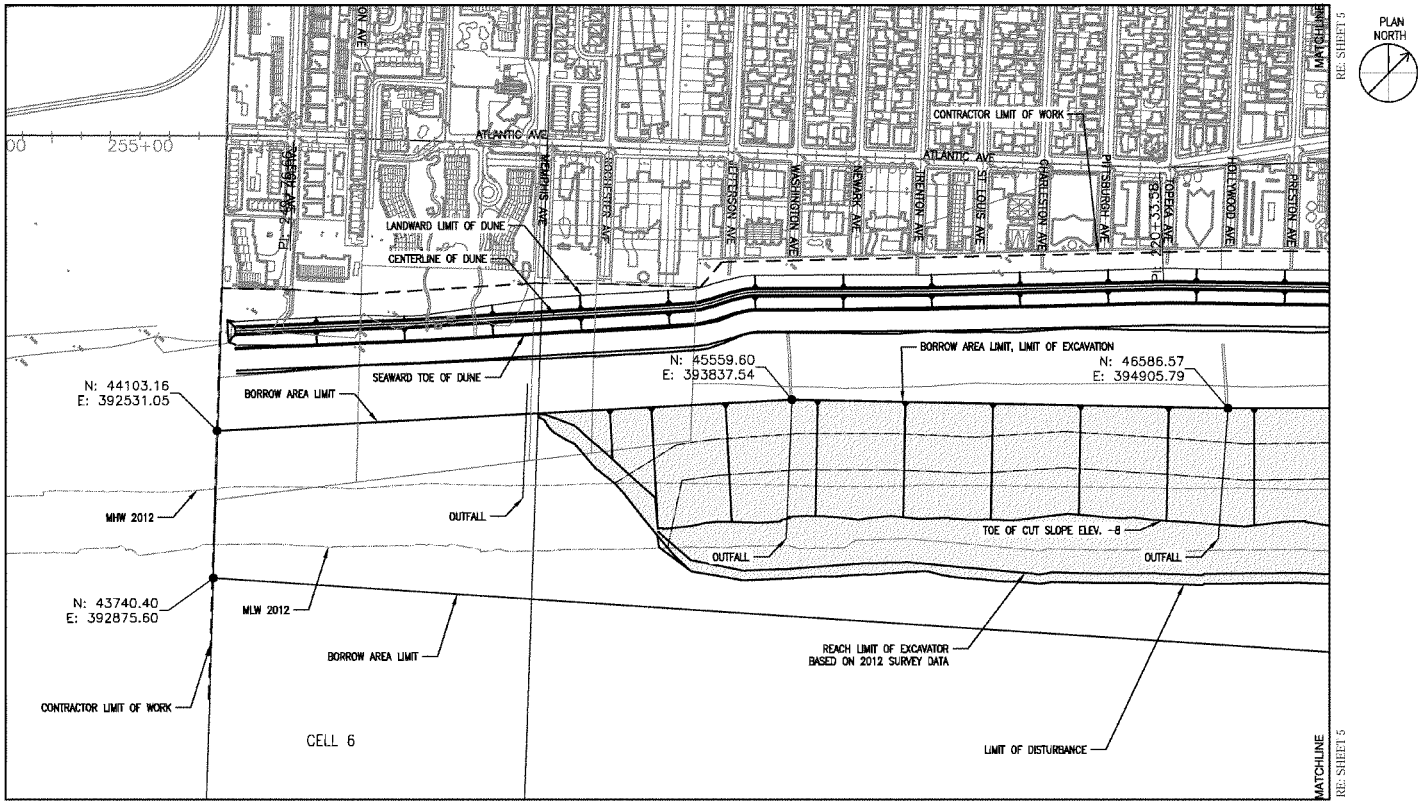
HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY

PLAN – BEACH FILL AND BORROW AREA

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS

SHEET 5 OF 6



BORROW AREA

NOTES:
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HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY
PLAN – BEACH FILL AND BORROW AREA
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
SHEET 6 OF 6

Section 6

Construction Procednres and Water Control Plan

The specific method of construction to be used by the contractor is not specified beforehand in the contract specification. The contractor will be instructed to back-pass the sand hydraulically from the borrow area to the placement area, but may chose other method to mobilize the material from the borrow area. However, based on the information provide in the feasibility study, the contractor will likely use a mobile crane with an educator or centrifugal pump to mobilize the sand, and series of booster pumps to transport the sand to the placement site. this pipeline will run north south along the beach, likely above the mean high water line on the beach/berm.

The contractor will likely use excavators, bulldozers, and frontend loaders to maneuver the sand around the placement site to get the dune to the design specifications. The discharge pipe will be smaller than traditional 30" pipe used in other projects, and likely be 8" hgh density polyethylene pipe (HDPE) that will be maneuvered by front end loaders with grapple arms. Miscellaneous equipment to be stored on the beach will include a light tower, fuel tank with containment, welding machine, a temporary shelter for construction personal and a site trailer. Upland staging areas will be provided for construction field offices, temporary storage during construction.

Water quality monitoring is described in the environmental section of the main report.

Section 7

Initial Reservoir Filling and Surveillance Plan

N/A

Section 8

Storm Emergency Plan

An emergency plan, New Jersey Hurricane Evacuation Study, was created in 2007 for the Federal Emergency Management Association, the Department of Homeland Security, and the Philadelphia District of the Army Corp of Engineers. A copy of the report can be found at the website below. http://www.state.nj.us/njoem/plan/pdf/maps/hurrevacution_study.pdf

Section 9

Construction Materials

The beachfill material is from an onshore beach borrow source and is fully compatible with the existing beach sand. The dredged material is clean beach sand and chemical contamination is not an issue with this type of material . Vehicular crossovers and pedestrian crossovers will be constructed with pressure treated pine lumber and I-5 type gravel will likely be used as a base material for their construction. This base material will be trucked in from an outside source.

Section 10

Reservoir Clearing

N/A

Section 11

Operation and Maintenance

Operation, Maintenance, repair, replacement and Rehabilitation (OMRR&R) of the completed initial beachfill project is a non Federal Responsibility. The non-Federal sponsor will be furnished with an OMRR&R manual to assist them I carrying out their obligations under ER 1110-2-2902. Some items considered as the non Federal sponsor's responsibility include dune grass and sand fence, dune crossovers, and some of the project monitoring. Periodic nourishment of the project is expected to occur every 4 years subsequent to the completion of the intial construction and as part of continuing construction, will be a Federal non-Federal cost share responsibility.

Section 12

Access Roads

Most of the work in conjunction with this project will be done in the nearshore. The required equipment will be transported to the project site via local roads in accordance with state and local regulations including a traffic control plan. Exact contractor acess to the beach will be coordinated in the Real Estate plan with the location of Temporary Work Are Easements and contractor lay down areas, and further refined in the plans and specifications.

Section 13

Corrosion Mitigation

N/A

Section 14

Project Security

Initial Construction and periodic Nourishment of the project wil lnecessatatea temporary restrictive closure of a 1,000'-2,000'section of beach as filling operation move along the beach. Sand ramps over the dredge pipe on the beach will be provided at public acess points during construction.
For security and public safety, temporary fencing along with signage will be required around work areas. Contractor personnel will be required to insure security and public safety. Navigation will not impacted by the submerged pipeline and the coast guard will issue a standard notification to mariners. The District addresses project security and public acess in more detail during the Plans and Specs phase.

Section 15

Cost Engineering Appendix

****** TOTAL PROJECT COST SUMMARY ******

Printed:5/20/2014

PROJECT: New Jersey Shore Protection, Hereford Inlet to Cape May Inlet
PROJECT NO: P2 109882
LOCATION: Wildwood, North Wildwood and Wildwood Crest, NJ

DISTRICT: Philadelphia PREPARED: 5/20/2014
POC: ACTING CHIEF, COST ENGINEERING, HARRY P. STEINER

This Estimate reflects the scope and schedule in report; Draft Final Feasibility Study

Civil Works Work Breakdown Structure		ESTIMATEO COST				PROJECT FIRST COST (Constant Dollar Basis)						TOTAL PROJECT COST (FULLY FUNDED)			
						Program Year (Budget EC): 2014 Effective Price Level Date: 1 OCT 13									
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	**TOTAL ($K)**	Spent Thru: **10/1/2013** ($K)	**FIRST COST** ($K)	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*				*M*	*N*	*O*
02	RELOCATIONS	$0	$0 -		$0	-	$0	$0	$0	$0	$0	-	$0	$0	$0
04	DAMS	$0	$0 -		$0	-	$0	$0	$0	$0	$0	-	$0	$0	$0
05	LOCKS	$0	$0 -		$0	-	$0	$0	$0	$0	$0	-	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$0	$0 -		$0	-	$0	$0	$0	$0	$0	-	$0	$0	$0
17	BEACH REPLENISHMENT - INITIAL	$13,674	$3,432	25.1%	$17,106	0.0%	$13,674	$3,432	$17,106	$0	$17,106	8.1%	$14,787	$3,711	$18,498
	CONSTRUCTION ESTIMATE TOTALS:	$13,674	$3,432		$17,106	0.0%	$13,674	$3,432	$17,106	$0	$17,106	8.1%	$14,787	$3,711	$18,498
01	LANDS AND DAMAGES	$1,019	$254	25%	$1,273	0.0%	$1,019	$254	$1,273	$0	$1,273	7.1%	$1,091	$272	$1,364
30	PLANNING, ENGINEERING & DESIGN	$1,617	$243	15%	$1,860	0.0%	$1,617	$243	$1,860	$4,200	$6,060	11.1%	$1,798	$270	$6,267
31	CONSTRUCTION MANAGEMENT	$1,188	$178	15%	$1,366	0.0%	$1,188	$178	$1,366	$0	$1,366	15.1%	$1,368	$205	$1,573
	PROJECT COST TOTALS:	$17,498	$4,107	23%	$21,605		$17,498	$4,107	**$21,605**	$4,200	**$25,805**	8.6%	$19,043	$4,459	$27,702

_____ ACTING CHIEF, COST ENGINEERING, HARRY P. STEINER

_____ PROJECT MANAGER, BRIAN P. BOGLE

_____ CHIEF, REAL ESTATE, CRAIG R. HOLMESLEY

_____ CHIEF, PLANNING, PETER R. BLUM

_____ CHIEF, ENGINEERING, PETER M. TRANCHIK

_____ CHIEF, OP, xxx

_____ CHIEF, CONSTRUCTION, CHRISTINE D. CLAPP

_____ CHIEF, CONTRACTING, KISHAYRA J. LAMBERT

_____ CHIEF, DP-CW, FRANK R. MASTER

_____ CHIEF, DPM, NATHAN C. BARCOMB

ESTIMATED FEDERAL COST:	**65.0%**	**$18,006**
ESTIMATED NON-FEDERAL COST:	**35.0%**	**$9,696**
INITIAL CG ESTIMATED TOTAL PROJECT COST:		**$27,702**
ESTIMATED FEDERAL COST:	**46.5%**	**$93,126**
ESTIMATED NON-FEDERAL COST:	**53.5%**	**$107,207**
OUT-YEAR (50-YR) FULLY FUNDED COST:		**$200,333**

Filename: HEREFORD_FEAS_Non-CAP_TPCS Mar 2014 Rev 01-2014May14.xlsx
Tab: TPCS

****** TOTAL PROJECT COST SUMMARY ******

Printed:5/20/2014

****** CONTRACT COST SUMMARY ******

PROJECT: New Jersey Shore Protection, Hereford Inlet to Cape May Inlet
LOCATION: Wildwood, North Wildwood and Wildwood Crest, NJ
This Estimate reflects the scope and schedule in report; Draft Final Feasibility Study

DISTRICT: Philadelphia
POC: ACTING CHIEF, COST ENGINEERING, HARRY P. STEINER
PREPARED: 5/20/2014

Civil Works Work Breakdown Structure		ESTIMATED COST				PROJECT FIRST COST (Constant Dollar Basis)				TOTAL PROJECT COST (FULLY FUNDED)				
		Estimate Prepared: 5/20/2014 Effective Price Level: 3/1/2014				Program Year (Budget EC): 2014 Effective Price Level Date: 1 OCT 13								
WBS NUMBER	Civil Works Feature & Sub-Feature Description	COST ($K)	CNTG ($K)	RISK BASED CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	Mid-Point Date	ESC (%)	COST ($K)	CNTG ($K)	FULL ($K)
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*	*J*	*P*	*L*	*M*	*N*	*O*
	PHASE 1													
02	RELOCATIONS	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
04	DAMS	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
05	LOCKS	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
06	FISH & WILDLIFE FACILITIES	$0	$0	0%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
17	BEACH REPLENISHMENT - INITIAL	$13,674	$3,432	25.1%	$17,106	0.0%	$13,674 $0	$3,432	$17,106	2018Q2	8.1%	$14,787	$3,711	$18,498
	CONSTRUCTION ESTIMATE TOTALS:	$13,674	$3,432	25%	**$17,106**		$13,674	$3,432	$17,106			$14,787	$3,711	$18,498
01	LANDS AND DAMAGES	$1,019	$254	25%	$1,273	0.0%	$1,019	$254	$1,273	2017Q4	7.1%	$1,091	$272	$1,364
30	PLANNING, ENGINEERING & DESIGN													
2.3%	Project Management	$310	$47	15%	$357	0.0%	$310	$47	$357	2017Q2	10.8%	$343	$52	$395
3.1%	Planning & Environmental Compliance	$420	$63	15%	$483	0.0%	$420	$63	$483	2017Q2	10.8%	$465	$70	$535
3.6%	Engineering & Design	$487	$73	15%	$560	0.0%	$487	$73	$560	2017Q2	10.8%	$540	$81	$621
0.4%	Reviews, ATRs, IEPRs, VE	$51	$8	15%	$59	0.0%	$51	$8	$59	2017Q2	10.8%	$57	$8	$65
0.5%	Life Cycle Updates (cost, schedule, risks)	$68	$10	15%	$79	0.0%	$68	$10	$79	2017Q2	10.8%	$76	$11	$87
1.1%	Contracting & Reprographics	$154	$23	15%	$177	0.0%	$154	$23	$177	2017Q2	10.8%	$171	$26	$196
0.9%	Engineering During Construction	$127	$19	15%	$146	0.0%	$127	$19	$146	2018Q2	15.1%	$146	$22	$168
0.0%	Planning During Construction	$0	$0	15%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Operations	$0	$0	15%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
31	CONSTRUCTION MANAGEMENT													
8.7%	Construction Management	$1,188	$178	15%	$1,366	0.0%	$1,188	$178	$1,366	2018Q2	15.1%	$1,368	$205	$1,573
0.0%	Project Operation:	$0	$0	15%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
0.0%	Project Management	$0	$0	15%	$0	0.0%	$0	$0	$0	0	0.0%	$0	$0	$0
	CONTRACT COST TOTALS:	$17,498	$4,107		**$21,605**		$17,498	$4,107	$21,605			$19,043	$4,459	**$23,502**

WBS Civil Works WBS Feature Description	ESTIMATED COST Risk Based COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	PROJECT FIRST COST Program Price Level Date: 2014 ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	50-YR COSTS (FULLY FUNDED) INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
2 RELOCATIONS												
3 RESERVOIRS												
4 DAMS												
5 LOCKS												
6 FISH & WILDLIFE FACILITIES												
7 POWER PLAN												
8 ROADS RAILROADS & BRIDGES												
9 CHANNELS & CANALS												
10 BREAKWATER & SEAWALLS												
11 LEVEES & FLOODWALLS												
12 NAVIGATION PORTS & HARBORS												
13 PUMPING PLANT												
14 RECREATION FACILITIES												
15 FLOODWAY CONTROL & DIVERSION STRUCTURE												
16 BANK STABILIZATION												
17 BEACH REPLENISHMENT	55,173	16,556	30.01%	71,730	0.00%	55,173	16,556	71,730	88.37%	103,932	31,517	135,448
18 CULTURAL RESOURCE PRESERVATION												
19 BUILDINGS GROUNDS & UTILITIES												
20 PERMANENT OPERATING EQUIPMENT												
30 PLANNING ENGINEERING and DESIGN	2,703	405	15.00%	3,108	0.00%	2,703	405	3,108	375.15%	12,842	1,926	14,768
31 CONSTRUCTION MANAGEMENT	6,601	990	15.00%	7,591	0.00%	6,601	990	7,591	374.73%	31,336	4,700	36,036
TOTALS	64,477	17,952	27.84%	82,428	0.00%	64,477	17,952	82,428	129.71%	148,109	38,143	186,252
99 OMRR&R	5,779	1,721	29.78%	7,500	0.00%	5,779	1,721	7,500	87.13%	10,814	3,266	14,081

		Federal	Non-Federal
Estimated Federal Cost:	50.00%	93,126	
Estimated Non-Federal Cost:	50.00%		93,126
Operation Maintenance Repair Replacement and Rehabilitation (OMRR&R):			14,081
Estimated Total 50-yr Project Nourishment Cost:		93,126	107,207

		Estimated Price Level		2014.00 Jan-Mar / 2014 2Q 2014		Programmed Level Jan-Mar / 2014 2Q 2014		2014.00		Annual Beach Replenishment Costs					
FEATURE	YEAR	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	MID-PT (DATE)	MID-PT Jul -Sep	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
17 Beach Replenishment	1	172	43	25.10%	215	0.00%	172	43	215	2019.50	2019	10.99%	190	48	238
	2	120	30	25.10%	150	0.00%	120	30	150	2020.50	2020	13.21%	136	34	170
	3	73	18	25.10%	91	0.00%	73	18	91	2021.50	2021	15.47%	84	21	105
PN	4	4,231	1,062	25.10%	5,293	0.00%	4,231	1,062	5,293	2022.50	2022	17.78%	4,983	1,251	6,234
	5	117	29	25.10%	146	0.00%	117	29	146	2023.50	2023	20.14%	140	35	175
	6	73	18	25.10%	91	0.00%	73	18	91	2024.50	2024	22.54%	89	22	111
	7	73	18	25.10%	91	0.00%	73	18	91	2025.50	2025	24.99%	91	23	113
PN	8	4,231	1,062	25.10%	5,293	0.00%	4,231	1,062	5,293	2026.50	2026	27.49%	5,394	1,354	6,748
	9	117	29	25.10%	146	0.00%	117	29	146	2027.50	2027	30.04%	152	38	190
	10	73	18	25.10%	91	0.00%	73	18	91	2028.50	2028	32.64%	96	24	120
	11	69	21	31.00%	91	0.00%	69	21	91	2029.50	2029	35.30%	93	29	122
PN	12	4,223	1,309	31.00%	5,532	0.00%	4,223	1,309	5,532	2030.50	2030	38.00%	5,828	1,807	7,634
	13	111	35	31.00%	146	0.00%	111	35	146	2031.50	2031	40.76%	157	49	206
	14	69	21	31.00%	91	0.00%	69	21	91	2032.50	2032	43.58%	99	31	130
	15	69	21	31.00%	91	0.00%	69	21	91	2033.50	2033	46.45%	101	31	133
PN	16	4,223	1,309	31.00%	5,532	0.00%	4,223	1,309	5,532	2034.50	2034	49.38%	6,308	1,955	8,264
	17	111	35	31.00%	146	0.00%	111	35	146	2035.50	2035	52.36%	170	53	222
	18	69	21	31.00%	91	0.00%	69	21	91	2036.50	2036	55.41%	107	33	141
	19	69	21	31.00%	91	0.00%	69	21	91	2037.50	2037	58.52%	110	34	143
PN	20	4,223	1,309	31.00%	5,532	0.00%	4,223	1,309	5,532	2038.50	2038	61.69%	6,828	2,117	8,945
	21	111	35	31.00%	146	0.00%	111	35	146	2039.50	2039	64.92%	184	57	241
	22	69	21	31.00%	91	0.00%	69	21	91	2040.50	2040	68.22%	116	36	152
	23	69	21	31.00%	91	0.00%	69	21	91	2041.50	2041	71.59%	119	37	155
MR	24	5,394	1,672	31.00%	7,066	0.00%	5,394	1,672	7,066	2042.50	2042	75.02%	9,440	2,926	12,367
	25	111	35	31.00%	146	0.00%	111	35	146	2043.50	2043	78.52%	199	62	261
	26	69	21	31.00%	91	0.00%	69	21	91	2044.50	2044	82.09%	126	39	165
	27	69	21	31.00%	91	0.00%	69	21	91	2045.50	2045	85.73%	128	40	168
PN	28	4,223	1,309	31.00%	5,532	0.00%	4,223	1,309	5,532	2046.50	2046	89.45%	8,000	2,480	10,480
	29	111	35	31.00%	146	0.00%	111	35	146	2047.50	2047	93.23%	215	67	282
	30	69	21	31.00%	91	0.00%	69	21	91	2048.50	2048	97.10%	136	42	178
	31	69	21	31.00%	91	0.00%	69	21	91	2049.50	2049	101.04%	139	43	182
PN	32	4,223	1,309	31.00%	5,532	0.00%	4,223	1,309	5,532	2050.50	2050	105.06%	8,660	2,684	11,344
	33	111	35	31.00%	146	0.00%	111	35	146	2051.50	2051	109.16%	233	72	305
	34	69	21	31.00%	91	0.00%	69	21	91	2052.50	2052	113.35%	147	46	193
	35	69	21	31.00%	91	0.00%	69	21	91	2053.50	2053	117.61%	150	47	197
PN	36	4,223	1,309	31.00%	5,532	0.00%	4,223	1,309	5,532	2054.50	2054	121.97%	9,373	2,906	12,279
	37	111	35	31.00%	146	0.00%	111	35	146	2055.50	2055	126.41%	252	78	331
	38	69	21	31.00%	91	0.00%	69	21	91	2056.50	2056	130.93%	160	49	209
	39	69	21	31.00%	91	0.00%	69	21	91	2057.50	2057	135.55%	163	50	213
PN	40	4,223	1,309	31.00%	5,532	0.00%	4,223	1,309	5,532	2058.50	2058	140.26%	10,146	3,145	13,291
	41	111	35	31.00%	146	0.00%	111	35	146	2059.50	2059	145.07%	273	85	358
	42	69	21	31.00%	91	0.00%	69	21	91	2060.50	2060	149.97%	173	54	226
	43	69	21	31.00%	91	0.00%	69	21	91	2061.50	2061	154.97%	176	55	231
PN	44	4,223	1,309	31.00%	5,532	0.00%	4,223	1,309	5,532	2062.50	2062	160.07%	10,982	3,405	14,387
	45	111	35	31.00%	146	0.00%	111	35	146	2063.50	2063	165.27%	296	92	387
	46	69	21	31.00%	91	0.00%	69	21	91	2064.50	2064	170.58%	187	58	245
	47	69	21	31.00%	91	0.00%	69	21	91	2065.50	2065	175.99%	191	59	250
PN	48	4,223	1,309	31.00%	5,532	0.00%	4,223	1,309	5,532	2066.50	2066	181.51%	11,888	3,685	15,573
	49	111	35	31.00%	146	0.00%	111	35	146	2067.50	2067	187.14%	320	99	419
	50	69	21	31.00%	91	0.00%	69	21	91	2068.50	2068	192.88%	202	63	265
17 Beach Replenishment		55,173	16,556	30.01%	71,730	0.00%	55,173	16,556	71,730			88.37%	103,932	31,517	135,448
17 Beach Replenishment		**55,173**	**16,556**	**30.01%**	**71,730**	**0.00%**	**55,173**	**16,556**	**71,730**			**88.37%**	**103,932**	**31,517**	**135,448**
Feature Being USED		1 (1=YES, 0=NO)													

			2014.00				2014.00									
			Estimated Price Level				Programmed Level				Annual OMRR&R Costs					
					Jan-Mar - 2014				Jan-Mar - 2014							
	FEATURE	YEAR	COST ($K)	CNTG ($K)	CNTG (%)	TOTAL ($K)	ESC (%)	COST ($K)	CNTG ($K)	TOTAL ($K)	MID-PT (DATE)	MID-PT Jul -Sep	INFLATED (%)	COST ($K)	CNTG ($K)	TOTAL ($K)
17_	OMRR&R	1	120	30	25.10%	150	0.00%	120	30	150	2019.50	2019	10.99%	133	33	166
OMRR&R		2	120	30	25.10%	150	0.00%	120	30	150	2020.50	2020	13.21%	136	34	170
		3	120	30	25.10%	150	0.00%	120	30	150	2021.50	2021	15.47%	138	35	173
	PN	4	120	30	25.10%	150	0.00%	120	30	150	2022.50	2022	17.78%	141	35	177
		5	120	30	25.10%	150	0.00%	120	30	150	2023.50	2023	20.14%	144	36	180
		6	120	30	25.10%	150	0.00%	120	30	150	2024.50	2024	22.54%	147	37	184
		7	120	30	25.10%	150	0.00%	120	30	150	2025.50	2025	24.99%	150	38	187
	PN	8	120	30	25.10%	150	0.00%	120	30	150	2026.50	2026	27.49%	153	38	191
		9	120	30	25.10%	150	0.00%	120	30	150	2027.50	2027	30.04%	156	39	195
		10	120	30	25.10%	150	0.00%	120	30	150	2028.50	2028	32.64%	159	40	199
		11	115	35	31.00%	150	0.00%	115	35	150	2029.50	2029	35.30%	155	48	203
	PN	12	115	35	31.00%	150	0.00%	115	35	150	2030.50	2030	38.00%	158	49	207
		13	115	35	31.00%	150	0.00%	115	35	150	2031.50	2031	40.76%	161	50	211
		14	115	35	31.00%	150	0.00%	115	35	150	2032.50	2032	43.58%	164	51	215
		15	115	35	31.00%	150	0.00%	115	35	150	2033.50	2033	46.45%	168	52	220
	PN	16	115	35	31.00%	150	0.00%	115	35	150	2034.50	2034	49.38%	171	53	224
		17	115	35	31.00%	150	0.00%	115	35	150	2035.50	2035	52.36%	174	54	229
		18	115	35	31.00%	150	0.00%	115	35	150	2036.50	2036	55.41%	178	55	233
		19	115	35	31.00%	150	0.00%	115	35	150	2037.50	2037	58.52%	182	56	238
	PN	20	115	35	31.00%	150	0.00%	115	35	150	2038.50	2038	61.69%	185	57	243
		21	115	35	31.00%	150	0.00%	115	35	150	2039.50	2039	64.92%	189	59	247
		22	115	35	31.00%	150	0.00%	115	35	150	2040.50	2040	68.22%	193	60	252
		23	115	35	31.00%	150	0.00%	115	35	150	2041.50	2041	71.59%	196	61	257
	MR	24	115	35	31.00%	150	0.00%	115	35	150	2042.50	2042	75.02%	200	62	263
		25	115	35	31.00%	150	0.00%	115	35	150	2043.50	2043	78.52%	204	63	268
		26	115	35	31.00%	150	0.00%	115	35	150	2044.50	2044	82.09%	208	65	273
		27	115	35	31.00%	150	0.00%	115	35	150	2045.50	2045	85.73%	213	66	279
	PN	28	115	35	31.00%	150	0.00%	115	35	150	2046.50	2046	89.45%	217	67	284
		29	115	35	31.00%	150	0.00%	115	35	150	2047.50	2047	93.23%	221	69	290
		30	115	35	31.00%	150	0.00%	115	35	150	2048.50	2048	97.10%	226	70	296
		31	115	35	31.00%	150	0.00%	115	35	150	2049.50	2049	101.04%	230	71	302
	PN	32	115	35	31.00%	150	0.00%	115	35	150	2050.50	2050	105.06%	235	73	308
		33	115	35	31.00%	150	0.00%	115	35	150	2051.50	2051	109.16%	239	74	314
		34	115	35	31.00%	150	0.00%	115	35	150	2052.50	2052	113.35%	244	76	320
		35	115	35	31.00%	150	0.00%	115	35	150	2053.50	2053	117.61%	249	77	326
	PN	36	115	35	31.00%	150	0.00%	115	35	150	2054.50	2054	121.97%	254	79	333
		37	115	35	31.00%	150	0.00%	115	35	150	2055.50	2055	126.41%	259	80	340
		38	115	35	31.00%	150	0.00%	115	35	150	2056.50	2056	130.93%	264	82	346
		39	115	35	31.00%	150	0.00%	115	35	150	2057.50	2057	135.55%	270	84	353
	PN	40	115	35	31.00%	150	0.00%	115	35	150	2058.50	2058	140.26%	275	85	360
		41	115	35	31.00%	150	0.00%	115	35	150	2059.50	2059	145.07%	281	87	368
		42	115	35	31.00%	150	0.00%	115	35	150	2060.50	2060	149.97%	286	89	375
		43	115	35	31.00%	150	0.00%	115	35	150	2061.50	2061	154.97%	292	91	382
	PN	44	115	35	31.00%	150	0.00%	115	35	150	2062.50	2062	160.07%	298	92	390
		45	115	35	31.00%	150	0.00%	115	35	150	2063.50	2063	165.27%	304	94	398
		46	115	35	31.00%	150	0.00%	115	35	150	2064.50	2064	170.58%	310	96	406
		47	115	35	31.00%	150	0.00%	115	35	150	2065.50	2065	175.99%	316	98	414
	PN	48	115	35	31.00%	150	0.00%	115	35	150	2066.50	2066	181.51%	322	100	422
		49	115	35	31.00%	150	0.00%	115	35	150	2067.50	2067	187.14%	329	102	431
		50	115	35	31.00%	150	0.00%	115	35	150	2068.50	2068	192.88%	335	104	439
17_	OMRR&R		5,779	1,721	29.78%	7,500	0.00%	5,779	1,721	7,500			87.13%	10,814	3,266	14,081
17_	**OMRR&R**		**5,779**	**1,721**	**29.78%**	**7,500**	**0.00%**	**5,779**	**1,721**	**7,500**			**87.13%**	**10,814**	**3,266**	**14,081**
	Feature Being USED		1 (1=YES, 0=NO)													

			Estimated Price Level **Jan-Mar / 2014**			2014.00	Programmed Level Jan-Mar / 2014			2014.00	Annual PE&D Costs					
					2Q 2014				2Q 2014							
FEATURE	**YEAR**		**COST ($K)**	**CNTG ($K)**	**CNTG (%)**	**TOTAL ($K)**	**ESC (%)**	**COST ($K)**	**CNTG ($K)**	**TOTAL ($K)**	**MID-PT (DATE)**	**MID-PT Jul -Sep**	**INFLATED (%)**	**COST ($K)**	**CNTG ($K)**	**TOTAL ($K)**
30 Planning Engineering &	1			0	15.00%	0	0.00%	0	0	0	2019.50	2019	21.22%	0	0	0
Design (PE&D)	2			0	15.00%	0	0.00%	0	0	0	2020.50	2020	26.04%	0	0	0
	3			0	15.00%	0	0.00%	0	0	0	2021.50	2021	31.08%	0	0	0
PN	4		222	33	15.00%	255	0.00%	222	33	255	2022.50	2022	36.35%	302	45	348
	5			0	15.00%	0	0.00%	0	0	0	2023.50	2023	41.91%	0	0	0
	6			0	15.00%	0	0.00%	0	0	0	2024.50	2024	47.81%	0	0	0
	7			0	15.00%	0	0.00%	0	0	0	2025.50	2025	54.08%	0	0	0
PN	8		222	33	15.00%	255	0.00%	222	33	255	2026.50	2026	60.74%	356	53	410
	9			0	15.00%	0	0.00%	0	0	0	2027.50	2027	67.80%	0	0	0
	10			0	15.00%	0	0.00%	0	0	0	2028.50	2028	75.30%	0	0	0
	11			0	15.00%	0	0.00%	0	0	0	2029.50	2029	83.30%	0	0	0
PN	12		222	33	15.00%	255	0.00%	222	33	255	2030.50	2030	91.84%	425	64	489
	13			0	15.00%	0	0.00%	0	0	0	2031.50	2031	100.95%	0	0	0
	14			0	15.00%	0	0.00%	0	0	0	2032.50	2032	110.67%	0	0	0
	15			0	15.00%	0	0.00%	0	0	0	2033.50	2033	121.01%	0	0	0
PN	16		222	33	15.00%	255	0.00%	222	33	255	2034.50	2034	132.09%	514	77	592
	17			0	15.00%	0	0.00%	0	0	0	2035.50	2035	143.87%	0	0	0
	18			0	15.00%	0	0.00%	0	0	0	2036.50	2036	156.25%	0	0	0
	19			0	15.00%	0	0.00%	0	0	0	2037.50	2037	169.25%	0	0	0
PN	20		222	33	15.00%	255	0.00%	222	33	255	2038.50	2038	182.91%	627	94	721
	21			0	15.00%	0	0.00%	0	0	0	2039.50	2039	197.27%	0	0	0
	22			0	15.00%	0	0.00%	0	0	0	2040.50	2040	212.36%	0	0	0
	23			0	15.00%	0	0.00%	0	0	0	2041.50	2041	228.21%	0	0	0
MR	24		265	40	15.00%	304	0.00%	265	40	304	2042.50	2042	244.86%	913	137	1,050
	25			0	15.00%	0	0.00%	0	0	0	2043.50	2043	262.36%	0	0	0
	26			0	15.00%	0	0.00%	0	0	0	2044.50	2044	280.75%	0	0	0
	27			0	15.00%	0	0.00%	0	0	0	2045.50	2045	300.07%	0	0	0
PN	28		222	33	15.00%	255	0.00%	222	33	255	2046.50	2046	320.38%	932	140	1,071
	29			0	15.00%	0	0.00%	0	0	0	2047.50	2047	341.71%	0	0	0
	30			0	15.00%	0	0.00%	0	0	0	2048.50	2048	364.12%	0	0	0
	31			0	15.00%	0	0.00%	0	0	0	2049.50	2049	387.68%	0	0	0
PN	32		222	33	15.00%	255	0.00%	222	33	255	2050.50	2050	412.43%	1,136	170	1,306
	33			0	15.00%	0	0.00%	0	0	0	2051.50	2051	438.43%	0	0	0
	34			0	15.00%	0	0.00%	0	0	0	2052.50	2052	465.75%	0	0	0
	35			0	15.00%	0	0.00%	0	0	0	2053.50	2053	494.46%	0	0	0
PN	36		222	33	15.00%	255	0.00%	222	33	255	2054.50	2054	524.63%	1,384	208	1,592
	37			0	15.00%	0	0.00%	0	0	0	2055.50	2055	556.33%	0	0	0
	38			0	15.00%	0	0.00%	0	0	0	2056.50	2056	589.64%	0	0	0
	39			0	15.00%	0	0.00%	0	0	0	2057.50	2057	624.63%	0	0	0
PN	40		222	33	15.00%	255	0.00%	222	33	255	2058.50	2058	661.41%	1,688	253	1,941
	41			0	15.00%	0	0.00%	0	0	0	2059.50	2059	700.05%	0	0	0
	42			0	15.00%	0	0.00%	0	0	0	2060.50	2060	740.65%	0	0	0
	43			0	15.00%	0	0.00%	0	0	0	2061.50	2061	783.31%	0	0	0
PN	44		222	33	15.00%	255	0.00%	222	33	255	2062.50	2062	828.13%	2,057	309	2,366
	45			0	15.00%	0	0.00%	0	0	0	2063.50	2063	875.23%	0	0	0
	46			0	15.00%	0	0.00%	0	0	0	2064.50	2064	924.72%	0	0	0
	47			0	15.00%	0	0.00%	0	0	0	2065.50	2065	976.72%	0	0	0
PN	48		222	33	15.00%	255	0.00%	222	33	255	2066.50	2066	1031.36%	2,507	376	2,884
	49			0	15.00%	0	0.00%	0	0	0	2067.50	2067	1088.78%	0	0	0
	50			0	15.00%	0	0.00%	0	0	0	2068.50	2068	1149.10%	0	0	0
30 Planning Engineering &			2,703	405	15.00%	3,108	0.00%	2,703	405	3,108			375.15%	12,842	1,926	14,768
30 Planning Engineering &			**2,703**	**405**	**15.00%**	**3,108**	**0.00%**	**2,703**	**405**	**3,108**			**375.15%**	**12,842**	**1,926**	**14,768**
Feature Being USED		1 (1=YES, 0=NO)														

			Estimated Price Level Jan-Mar / 2014 2Q 2014				Programmed Level Jan-Mar / 2014 2Q 2014				Annual Construction Management Costs					
					2014.00				2014.00							
FEATURE		YEAR	COST (SK)	CNTG (SK)	CNTG (%)	TOTAL (SK)	ESC (%)	COST (SK)	CNTG (SK)	TOTAL (SK)	MID-PT (DATE)	MID-PT Jul -Sep	INFLATED (%)	COST (SK)	CNTG (SK)	TOTAL (SK)
31 Construction Management	(S&A)	1		0	15.00%	0	0.00%	0	0	0	2019.50	2019	21.22%	0	0	0
		2		0	15.00%	0	0.00%	0	0	0	2020.50	2020	26.04%	0	0	0
		3		0	15.00%	0	0.00%	0	0	0	2021.50	2021	31.08%	0	0	0
PN		4	540	81	15.00%	620	0.00%	540	81	620	2022.50	2022	36.35%	736	110	846
		5		0	15.00%	0	0.00%	0	0	0	2023.50	2023	41.91%	0	0	0
		6		0	15.00%	0	0.00%	0	0	0	2024.50	2024	47.81%	0	0	0
		7		0	15.00%	0	0.00%	0	0	0	2025.50	2025	54.08%	0	0	0
PN		8	540	81	15.00%	620	0.00%	540	81	620	2026.50	2026	60.74%	867	130	997
		9		0	15.00%	0	0.00%	0	0	0	2027.50	2027	67.80%	0	0	0
		10		0	15.00%	0	0.00%	0	0	0	2028.50	2028	75.30%	0	0	0
		11		0	15.00%	0	0.00%	0	0	0	2029.50	2029	83.30%	0	0	0
PN		12	540	81	15.00%	620	0.00%	540	81	620	2030.50	2030	91.84%	1,035	155	1,190
		13		0	15.00%	0	0.00%	0	0	0	2031.50	2031	100.95%	0	0	0
		14		0	15.00%	0	0.00%	0	0	0	2032.50	2032	110.67%	0	0	0
		15		0	15.00%	0	0.00%	0	0	0	2033.50	2033	121.01%	0	0	0
PN		16	540	81	15.00%	620	0.00%	540	81	620	2034.50	2034	132.09%	1,252	188	1,440
		17		0	15.00%	0	0.00%	0	0	0	2035.50	2035	143.87%	0	0	0
		18		0	15.00%	0	0.00%	0	0	0	2036.50	2036	156.25%	0	0	0
		19		0	15.00%	0	0.00%	0	0	0	2037.50	2037	169.25%	0	0	0
PN		20	540	81	15.00%	620	0.00%	540	81	620	2038.50	2038	182.91%	1,526	229	1,755
		21		0	15.00%	0	0.00%	0	0	0	2039.50	2039	197.27%	0	0	0
		22		0	15.00%	0	0.00%	0	0	0	2040.50	2040	212.36%	0	0	0
		23		0	15.00%	0	0.00%	0	0	0	2041.50	2041	228.21%	0	0	0
MR		24	666	100	15.00%	766	0.00%	666	100	766	2042.50	2042	244.86%	2,296	344	2,640
		25		0	15.00%	0	0.00%	0	0	0	2043.50	2043	262.36%	0	0	0
		26		0	15.00%	0	0.00%	0	0	0	2044.50	2044	280.75%	0	0	0
		27		0	15.00%	0	0.00%	0	0	0	2045.50	2045	300.07%	0	0	0
PN		28	540	81	15.00%	620	0.00%	540	81	620	2046.50	2046	320.38%	2,268	340	2,608
		29		0	15.00%	0	0.00%	0	0	0	2047.50	2047	341.71%	0	0	0
		30		0	15.00%	0	0.00%	0	0	0	2048.50	2048	364.12%	0	0	0
		31		0	15.00%	0	0.00%	0	0	0	2049.50	2049	387.68%	0	0	0
PN		32	540	81	15.00%	620	0.00%	540	81	620	2050.50	2050	412.43%	2,765	415	3,180
		33		0	15.00%	0	0.00%	0	0	0	2051.50	2051	438.43%	0	0	0
		34		0	15.00%	0	0.00%	0	0	0	2052.50	2052	465.75%	0	0	0
		35		0	15.00%	0	0.00%	0	0	0	2053.50	2053	494.46%	0	0	0
PN		36	540	81	15.00%	620	0.00%	540	81	620	2054.50	2054	524.63%	3,370	506	3,876
		37		0	15.00%	0	0.00%	0	0	0	2055.50	2055	556.33%	0	0	0
		38		0	15.00%	0	0.00%	0	0	0	2056.50	2056	589.64%	0	0	0
		39		0	15.00%	0	0.00%	0	0	0	2057.50	2057	624.63%	0	0	0
PN		40	540	81	15.00%	620	0.00%	540	81	620	2058.50	2058	661.41%	4,108	616	4,724
		41		0	15.00%	0	0.00%	0	0	0	2059.50	2059	700.05%	0	0	0
		42		0	15.00%	0	0.00%	0	0	0	2060.50	2060	740.65%	0	0	0
		43		0	15.00%	0	0.00%	0	0	0	2061.50	2061	783.31%	0	0	0
PN		44	540	81	15.00%	620	0.00%	540	81	620	2062.50	2062	828.13%	5,008	751	5,759
		45		0	15.00%	0	0.00%	0	0	0	2063.50	2063	875.23%	0	0	0
		46		0	15.00%	0	0.00%	0	0	0	2064.50	2064	924.72%	0	0	0
		47		0	15.00%	0	0.00%	0	0	0	2065.50	2065	976.72%	0	0	0
PN		48	540	81	15.00%	620	0.00%	540	81	620	2066.50	2066	1031.36%	6,104	916	7,020
		49		0	15.00%	0	0.00%	0	0	0	2067.50	2067	1088.78%	0	0	0
		50		0	15.00%	0	0.00%	0	0	0	2068.50	2068	1149.10%	0	0	0
31 Construction Management			6,601	990	15.00%	7,591	0.00%	6,601	990	7,591			374.73%	31,336	4,700	36,036
31 Construction Management			**6,601**	**990**	**15.00%**	**7,591**	**0.00%**	**6,601**	**990**	**7,591**			**374.73%**	**31,336**	**4,700**	**36,036**
Feature Being USED			1 (1=YES, 0=NO)													

SECTION 15 - COST ESTIMATE

Paragraph	Description	Page
1	Introduction	3
	INITIAL PROJECT CHARGES USING MOBILE HYDRAULIC SAND BACK-PASSING FOR BEACH FILL	
2	General	3
3	Basis of Cost	3
11	Alternatives Considered	4
13	Renourishment Interval Optimization	5
14	Total First Cost for Selected Plan	5
	ANNUAL CHARGES FOR THE SELECTED PLAN	
15	General	5
16	Periodic Nourishment	5
17	Major Replacement Costs	6
18	OMRR&R Costs	6
19	Monitoring Costs	6
	CONTINGENCIES, PRECONSTRUCTION ENGINEERING & DESIGN, AND CONSTRUCTION MANAGEMENT FOR THE SELECTED PLAN	
20	Contingencies	6
21	Preconstruction Engineering & Design	6
22	Construction Management	6
	CONSTRUCTION AND PROJECT SCHEDULE FOR THE SELECTED PLAN	
23	General	7

LIST OF TABLES USING MOBILE HYDRAULIC SAND BACK-PASSING FOR BEACH FILL

No.	Description	Page
1	Total First Cost - Selected Plan	8
2A thru 2N	Total First Cost - Plans A thru N	9 - 22
3	Periodic Nourishment Cost (Years 4 and 8)	23
4	Periodic Nourishment Cost (Years 12 thru 48)	24
5	Major Replacement Cost (Year 24)	25

No.	Description	Page
6	Construction Schedule	26
7	Project Schedule	27

Paragraph	Description	Page
	INITIAL PROJECT CHARGES USING HOPPER DREDGING FOR BEACH FILL	
24	General	46
25	Basis of Cost	46
32	Alternatives Considered	47
34	Renourishment Interval Optimization	47
35	Total First Cost for Selected Plan	47

LIST OF TABLES USING HOPPER DREDGING FOR BEACH FILL

No.	Description	Page
5A thru 5N	Total First Cost - Plans A thru N	48 - 61

SECTION 15 - COST ESTIMATE

1. Introduction: Two separate beach fill methods were considered for this project: mobile hydraulic sand back-passing and hopper dredging. Mobile hydraulic sand back passing will be discussed first followed by hopper dredging

INITIAL PROJECT CHARGES USING MOBILE HYDRAULIC SAND BACK-PASSING FOR BEACH FILL

2. General: This section presents detailed cost estimates for initial construction, nourishment, maintenance, monitoring and major replacement resulting in total and annualized project costs for alternative storm damage reduction plans for mobile hydraulic sand back-passing. The fifteen alternative plans developed for mobile hydraulic sand back-passing include:

Plan	Description
A	115' wide berm with +12' NAVD dune using 4 Yr. Cycle
B	95' wide berm with +14' NAVD dune using 4 Yr. Cycle
C	75' wide berm with +16' NAVD dune using 4 Yr. Cycle
D	140' wide berm with +12' NAVD dune using 4 Yr. Cycle
E	120' wide berm with +14' NAVD dune using 4 Yr. Cycle
F	100' wide berm with +16' NAVD dune using 4 Yr. Cycle
G	165' wide berm with +12' NAVD dune using 4 Yr. Cycle
H	145' wide berm with +14' NAVD dune using 4 Yr. Cycle
I	125' wide berm with +16' NAVD dune using 4 Yr. Cycle
J	80' wide berm with +18' NAVD dune using 4 Yr. Cycle
K	105' wide berm with +18' NAVD dune using 4 Yr. Cycle
L	85' wide berm with +20' NAVD dune using 4 Yr. Cycle
M	110' wide berm with +20' NAVD dune using 4 Yr. Cycle
N	160' wide berm with +20' NAVD dune using 4 Yr. Cycle
O	No action

The top of the berm is at an elevation of +6.5' NAVD and extends from 2nd Avenue in North Wildwood to Juniper Avenue in Wildwood. The dune for each alternative has 1 on 5 side slopes and a top width of 25'. The dune extends the same distance as the berm. The initial construction for each of the above plans includes design and advanced nourishment beach fill. Also included are provisions for periodic nourishment, beach profile and environmental monitoring, and major replacement to restore the design beach profile damaged by significant storm events beyond that designed for in the nourishment cycle quantity. The plan layout of the NED plan with typical improved beach sections is shown in the section of the Feasibility Study, Main Report describing the NED Plan.

3. Basis of Cost: Cost estimates presented herein for the Cycle 3 analysis are based on June 2007 price levels. Initial beach fill costs are based on beach surveys taken in October 2003. The unit prices were developed in accordance with the construction procedures outlined herein. All initial construction, nourishment costs, and major replacement costs presented in this appendix are NED costs.

4. Initial fill costs are based on the assumption that mobile hydraulic sand back-passing was used for placement of the beach fill. Approximately 975,000 C.Y. of beach fill from onshore borrow area WW/WC was placed in Cells 1 and 2. The average pumping distance for the initial beach fill uses an average pipeline length of 14,667 L.F. A 150 hp electric submersible agitator dredge pump would be suspended from a crawler crane with a minimum 100' boom. A 300 kW generator would be mounted on the back of the crane to power the dredge pump. Sand up to 50% solids by weight, to be transferred through 10-inch gum tube-lined dredge hose to 12-inch HDPE pipe on the beach. Diesel engine, skid mounted booster pumps would be placed every 5,000 feet to transfer the sand slurry to the outlet location where the beach fill would take place. Horsepower for each booster is 400 hp. Instrumentation including magnetic flow meters would provide flow rates and production numbers. A 350 C.Y. per hour production rate was used for cost estimating purposes and is based on the Sand Bypass Plant, Indian River Inlet, Delaware Coast Protection job constructed by NAP in 1989 and operated by Delaware Department of Natural Resources and Environmental Control (DENREC).

5. Periodic nourishment fill costs are based on the assumption that mobile hydraulic sand back-passing was used for placement of the beach fill. Approximately 366,000 C.Y. of beach fill material from onshore borrow area WW/WC was placed in Cells 1 and 2. The average pumping distance for the nourishment cycle uses an average pipeline length of 14,667 L.F. The placement of this material will follow the constructability outlines in paragraph 4.

6. Mobilization and demobilization costs are based on the assumption that beach filling equipment located within 250 miles from the project site will perform the work. Mobilization and demobilization costs also include subcontractor mob and demob. Construction access would be by local streets. The locations of the borrow areas are displayed in the section of the Feasibility Study, Main Report describing the NED Plan.

7. Real estate costs for the fifteen alternatives included in the Cycle 3 screening were not included since they are expected to be minimal as most of the land is a public beach owned by the sponsor. Real estate costs as shown in Table 1 are included as NED costs and reflect acquisition of easements on private beach and include surveys, appraisal, and administrative costs between the limits of beach filling. For more information refer to the Real Estate Appendix.

8. Environmental monitoring costs for the fifteen alternatives included in the Cycle 3 screening were not included since they are dependent on the EA document and that document was not finalized at the time of the Cycle 3 screening.

9. Construction Management costs for the fifteen alternatives included in the Cycle 3 screening were included as a percent of the construction cost and is based on ER415-1-16, Table E-1. A 15 percent contingency has been included in S&A costs.

10. Contingency allowances used for the fifteen alternatives included in the Cycle 3 screening were 15 percent for the beach fill work and 12 percent for the mobilization and demobilization work and is based on EM1110-2-1301, Appendix C.

11. Alternatives Considered: Alternative plans were developed in two phases for the plan selection process. In the first phase the alternative plans were compared during the Cycle 1 and Cycle 2 screening process. For more information on these plans, refer to the section of the

Feasibility Study, Main Report describing the NED Plan. Based on an analysis of these annual costs with their associated benefits, the beach restoration only plan was selected for the second phase for final plan optimization and selection.

12. The costs for the fifteen alternatives as described in paragraph 2 for this second phase of plan selection are shown in Tables 2A thru 2N.

13. Renourishment Interval Optimization: For more information on the renourishment interval optimization that selected the 4-year cycle, refer to the section of the Feasibility Study, Main Report describing the NED plan.

14. Total First Cost for Selected Plan: The estimated project first cost is for the selected plan - a dune and berm constructed using 1,007,250 CY of sand obtained from onshore borrow area WW/WC located on the beach in Wildwood and Wildwood Crest. A +16' NAVD high dune with a top width of 25' on a 75' wide berm that is 6.5' NAVD high would be constructed from North Wildwood to the northern border of Wildwood and is based on a selected nourishment cycle of 4 years. In Wildwood and Wildwood Crest, the project will consist of placing 520,000 CY of beach fill to construct a +16' NAVD high dune and raising the elevation of the existing berm to 6.5' NAVD. Side slopes for the dunes will be 1 on 5. The average pumping distance for the initial beach fill uses an average pipeline length of 15,600 L.F. In Wildwood and Wildwood Crest, the average pipeline length is 1,000 L.F. Also included is the placement of 64 acres of dune grass, 28,000 L.F of sand fence, extending 44 existing pedestrian crossovers, 7 new pedestrian crossovers, extending 7 existing handicap crossovers, 6 new handicap crossovers, extending 8 existing vehicle crossovers and 5 new vehicle crossovers. It was assumed that beach filling work would be performed by an earth moving contractor and the work for installing the dune appurtenances performed by a subcontractor. NED real estate acquisition costs and pertinent contingency, engineering and design and construction management costs are also included. Details of the initial construction cost estimate are shown in Table 1.

ANNUAL CHARGES FOR THE SELECTED PLAN

15. General: The estimate of annual charges for the selected plan is based on an economic project life of 50 years, an interest rate of 3.50% and a March 2014 price level. The annual charges include annualized first cost and interest during construction, the annualized periodic nourishment costs, post construction monitoring costs, and OMRR&R costs. It is noted that interest during construction was developed for the first cost of the project constructed over a nine-month period. For the selected plan, the total annualized cost is $2,688,000.

16. Periodic Nourishment: The periodic nourishment volume to be placed at 4 year cycles, subsequent to commencement of construction and throughout the 50 year economic life is 391,250 C.Y. from onshore borrow area WW/WC. Mobile hydraulic back-passing was used for placement of the beach fill. This volume includes overfill and tolerance. The placement of this material will follow the constructability outlines in paragraph 4. For more details on the development of the periodic nourishment quantity refer to the section of the Feasibility Study, Main Report describing the NED Plan. The borrow area for periodic nourishment are also shown in the section of the Feasibility Study, Main Report describing the NED Plan. Periodic nourishment costs for the selected cycle are shown in Tables 3 and 4.

17. Major Replacement Costs: Major replacement costs are included as an additional cost for significant storm events beyond that designed for in the selected nourishment cycle to restore the design profile. The major replacement losses are computed as the losses that would occur from the 50% risk event over the project life. For more detail on the development of the major replacement quantity, refer to the section of the Feasibility Study, Main Report describing the NED Plan. Major replacement costs are shown in Table 5.

18. OMRR&R Costs: OMRR&R costs for the selected plan were estimated to be $150,000 annually and cover maintenance of the beaches, dune grass, sand fencing, dune crossovers and some project monitoring.

19. Monitoring Costs: Post construction monitoring costs include coastal and environmental monitoring over the 50-year project life. Average annualized monitoring costs are $140,000.

CONTINGENCIES, PRECONSTRUCTION ENGINEERING & DESIGN, AND CONSTRUCTION MANAGEMENT FOR THE SELECTED PLAN

20. Contingencies: The estimated cost for each major subdivision or feature of the recommended project includes an item for "contingencies". The item for "contingencies" is an allowance against some adverse or unanticipated condition not susceptible to exact evaluation from the data at hand but which must be expressed or represented in the cost estimate. The contingency allowances used in the development of the cost estimate for the selected project were estimated as an appropriate percentage using Crystal Ball software for preparing risk analysis. 25.1 percent was applied to beach placement work for years 0 to 10 and 31 percent was applied to beach placement work for years 11 to 50 to account for concerns about pumping distances and borrow area selection, and to account for larger required beach fill quantities at the time of construction due to future preconstruction erosion, concerns about availability of pumping equipment, variances in the travel distance for the pump plant, and for increases in labor and fuel prices.

21. Preconstruction Engineering & Design (P, E & D): Preconstruction Engineering and Design costs include local cooperative agreements, environmental and regulatory activities, general design memorandum, preparation of plans and specifications, engineering during construction, A/E liability actions, cost engineering, construction and supply contract award activities, project management, and the development of the PCA. P, E & D costs were estimated as lump sums of $1,859,894 for the initial beach fill construction, $254,877 for the nourishment cycle, and $304,402 for the major replacement and are based on similar Corps of Engineers projects of the same magnitude and include 0.5% of construction costs to cover NAD labor requirements. A contingency factor of 15% is included in the P, E & D costs.

22. Construction Management (S&A): Construction Management costs include contract administration, review of shop drawings, inspection and quality assurance, project office operation, contractor initiated claims and litigations, and government initiated claims and litigations. S&A related costs were estimated as lump sums of $1,366,020 for the initial beach fill construction, $620,485 for the nourishment cycle, and $765,577 for the major replacement and were based on similar Corps of Engineers projects of the same magnitude. A contingency factor of 15% was included in all S&A costs.

CONSTRUCTION AND PROJECT SCHEDULE FOR THE SELECTED PLAN

23. General: The construction and project schedules of the selected plan are shown in Tables 6 and 7 of this Engineering Technical Appendix. The schedule is based on the timeliness of the report's approval and allocation of funds by Congress, the foregoing construction procedures, and the ability of local interests to implement the necessary items of local cooperation.

Table 1 - Total First Cost - Selected Plan
Plan C (75' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)

Price Level: Mar 14
Construction duration: 9-months

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
						@ 25.0%	
01.	Lands and Damages	1	Job	LS	$1,018,972	$254,539	$1,273,511
17.	Beach Replenishment					**@ 25.1%**	
17.01	Mobilization, Demob. And Preparatory Work	1	Job	LS	$1,026,656	$257,691	$1,284,346
17.70	Beach Fill	1	Job	LS	$9,883,656	$2,480,798	$12,364,454
17.99	Associated General Items	1	Job	LS	$2,763,564	$693,655	$3,457,219
	Total Beach Replenishment				$13,673,876	$3,432,143	$17,106,019
						@ 15.0%	
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,617,299	$242,595	$1,859,894
31.	Construction Management (S & A)	1	Job	LS	$1,187,843	$178,177	$1,366,020
	Total Project First Cost				$17,497,990	$4,107,453	$21,605,444
	(Rounded)				$17,498,000	$4,107,000	$21,605,000

Notes:
Beachfill quantity includes 4 yr. nourishment cycle.

Table 2A - Total First Cost
Plan A (115' Berm w/ 12' NAVD Dune using 4 Yr. Cycle)

Price Level: Jun 07

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$426,853	$51,222	$478,075
	Beach Fill						
	Site Work - Cells 1 and 2						
	Excavation/Pumping Sand	879,000	CY	$6.66	$5,852,382	$877,857	$6,730,239
	Survey Crew @ Borrow Area D	5.71	Mo.	$144,980	$827,836	$124,175	$952,011
	Survey Crew @ Berm w/ Dune	5.71	Mo.	$87,471	$499,459	$74,919	$574,378
	Grading @ Berm w/ Dune	5.71	Mo.	$128,172	$731,862	$109,779	$841,641
	Site Security	5.72	Mo.	$6,572	$37,560	$5,634	$43,194
	Night Lighting	5.71	Mo.	$47,044	$268,668	$40,300	$308,969
	Total Beach Replacement				$8,644,620	$1,283,887	$9,928,508
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 8.60%)	1	Job	LS	$743,437	$111,516	$854,953
	Total Project First Cost				$10,388,058	$1,545,403	$11,933,461
	(Rounded)				$10,388,000	$1,545,000	$11,933,000

Notes:
Beach fill quantity includes 4 yr. nourishment cycle.

Table 2B - Total First Cost Price Level: Jun 07

Plan B (95' Berm w/ 14' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$444,860	$53,383	$498,243
	Beach Fill						
	Site Work - Cells 1 and 2						
	Excavation/Pumping Sand	922,000	CY	$6.66	$6,145,038	$921,756	$7,066,793
	Survey Crew @ Borrow Area D	5.99	Mo.	$144,980	$869,025	$130,354	$999,378
	Survey Crew @ Berm w/ Dune	5.99	Mo.	$87,471	$524,301	$78,645	$602,946
	Grading @ Berm w/ Dune	5.99	Mo.	$128,172	$767,750	$115,163	$882,913
	Site Security	5.99	Mo.	$6,832	$40,944	$6,142	$47,086
	Night Lighting	5.99	Mo.	$47,044	$281,982	$42,297	$324,279
	Total Beach Replacement				$9,073,900	$1,347,739	$10,421,639
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 8.23%)	1	Job	LS	$746,782	$112,017	$858,799
	Total Project First Cost				$10,820,682	$1,609,756	$12,430,438
	(Rounded)				$10,821,000	$1,610,000	$12,430,000

Notes:
Beach fill quantity includes 4 yr. nourishment cycle.

Table 2C - Total First Cost Price Level: Jun 07

Plan C (75' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$467,073	$56,049	$523,122
	Beach Fill						
	Site Work - Cells 1 and 2						
	Excavation/Pumping Sand	975,000	CY	$6.66	$6,498,083	$974,712	$7,472,795
	Survey Crew @ Borrow Area D	6.34	Mo.	$144,980	$919,608	$137,941	$1,057,549
	Survey Crew @ Berm w/ Dune	6.34	Mo.	$87,471	$554,829	$83,224	$638,053
	Grading @ Berm w/ Dune	6.34	Mo.	$128,172	$812,610	$121,892	$934,502
	Site Security	6.34	Mo.	$6,572	$41,686	$6,253	$47,939
	Night Lighting	6.34	Mo.	$47,044	$298,259	$44,739	$342,998
	Total Beach Replacement				$9,592,148	$1,424,810	$11,016,958
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 8.23%)	1	Job	LS	$789,434	$118,415	$907,849
	Total Project First Cost				$11,381,582	$1,693,225	$13,074,807
	(Rounded)				$11,382,000	$1,693,000	$13,075,000

Notes:

Beach fill quantity includes 4 yr. nourishment cycle.

Table 2D - Total First Cost Price Level: Jun 07

Plan D (140' Berm w/ 12' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$502,344	$60,281	$562,625
	Beach Fill						
	Site Work - Cells 1 and 2						
	Excavation/Pumping Sand	1,081,400	CY	$6.54	$7,077,655	$1,061,648	$8,139,303
	Survey Crew @ Borrow Area D	7.03	Mo.	$142,344	$1,000,806	$150,121	$1,150,927
	Survey Crew @ Berm w/ Dune	7.03	Mo.	$85,881	$603,829	$90,574	$694,404
	Grading @ Berm w/ Dune	7.03	Mo.	$125,841	$884,662	$132,699	$1,017,362
	Site Security	7.03	Mo.	$6,452	$45,363	$6,805	$52,168
	Night Lighting	7.03	Mo.	$46,189	$324,755	$48,713	$373,468
	Total Beach Replacement				$10,439,415	$1,550,842	$11,990,257
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 8.23%)	1	Job	LS	$859,164	$128,875	$988,038
	Total Project First Cost				$12,298,579	$1,829,717	$14,128,295
	(Rounded)				$12,299,000	$1,830,000	$14,128,000

Notes:

Beach fill quantity includes 4 yr. nourishment cycle.

Table 2E - Total First Cost Price Level: Jun 07

Plan E (120' Berm w/ 14' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$1,040,079	$124,809	$1,164,888
	Beach Fill						
	Site Work - Cells 1 and 2						
	Excavation/Pumping Sand	1,124,400	CY	$6.44	$7,246,646	$1,086,997	$8,333,642
	Survey Crew @ Borrow Area D	5.42	Mo.	$188,056	$1,019,959	$152,994	$1,172,953
	Survey Crew @ Berm w/ Dune	5.42	Mo.	$113,438	$614,834	$92,225	$707,059
	Grading @ Berm w/ Dune	5.42	Mo.	$167,122	$905,801	$135,870	$1,041,671
	Site Security	5.42	Mo.	$6,452	$34,976	$5,246	$40,223
	Night Lighting	5.42	Mo.	$46,189	$250,344	$37,552	$287,896
	Total Beach Replacement				$11,112,640	$1,635,694	$12,748,333
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 8.23%)	1	Job	LS	$914,570	$137,186	$1,051,756
	Total Project First Cost				$13,027,210	$1,922,879	$14,950,089
	(Rounded)				$13,027,000	$1,923,000	$14,950,000

Notes:
Beach fill quantity includes 4 yr. nourishment cycle.

Table 2F - Total First Cost Price Level: Jun 07

Plan F (100' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$1,083,665	$130,040	$1,213,705
	Beach Fill						
	Site Work - Cells 1 and 2						
	Excavation/Pumping Sand	1,177,400	CY	$6.44	$7,585,988	$1,137,898	$8,723,886
	Survey Crew @ Borrow Area D	5.68	Mo.	$188,056	$1,068,722	$160,308	$1,229,031
	Survey Crew @ Berm w/ Dune	5.68	Mo.	$113,438	$644,328	$96,649	$740,977
	Grading @ Berm w/ Dune	5.68	Mo.	$167,122	$949,253	$142,388	$1,091,641
	Site Security	5.68	Mo.	$6,452	$36,662	$5,499	$42,161
	Night Lighting	5.68	Mo.	$46,189	$262,400	$39,360	$301,760
	Total Beach Replacement				$11,631,018	$1,712,143	$13,343,160
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 8.23%)	1	Job	LS	$957,233	$143,585	$1,100,818
	Total Project First Cost				$13,588,250	$2,005,728	$15,593,978
	(Rounded)				$13,588,000	$2,006,000	$15,594,000

Notes:

Beach fill quantity includes 4 yr. nourishment cycle.

Table 2G - Total First Cost Price Level: Jun 07

Plan G (165' Berm w/ 12' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$871,659	$104,599	$976,258
	Beach Fill						
	Site Work - Cells 1 and 2						
	Excavation/Pumping Sand	1,306,400	CY	$6.44	$8,419,617	$1,262,943	$9,682,560
	Survey Crew @ Borrow Area D	6.30	Mo.	$188,056	$1,184,866	$177,730	$1,362,595
	Survey Crew @ Berm w/ Dune	6.30	Mo.	$113,438	$714,659	$107,199	$821,858
	Grading @ Berm w/ Dune	6.30	Mo.	$167,122	$1,052,869	$157,930	$1,210,799
	Site Security	6.30	Mo.	$6,452	$40,666	$6,100	$46,766
	Night Lighting	6.30	Mo.	$46,189	$290,991	$43,649	$334,639
	Total Beach Replacement				$12,575,326	$1,860,149	$14,435,476
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,304,348	$195,652	$1,500,000
31.	Construction Management (S & A @ 7.97%)	1	Job	LS	$1,002,254	$150,338	$1,152,592
	Total Project First Cost				$14,881,928	$2,206,139	$17,088,067
	(Rounded)				$14,882,000	$2,206,000	$17,088,000

Notes:
Beach fill quantity includes 4 yr. nourishment cycle.

Table 2H - Total First Cost Price Level: Jun 07

Plan H (145' Berm w/ 14' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$1,225,165	$147,020	$1,372,185
	Beach Fill						
	Site Work - Cells 1 and 2						
	Excavation/Pumping Sand	1,349,400	CY	$6.44	$8,694,872	$1,304,231	$9,999,103
	Survey Crew @ Borrow Area D	6.51	Mo.	$188,056	$1,224,245	$183,637	$1,407,881
	Survey Crew @ Berm w/ Dune	6.51	Mo.	$113,438	$738,481	$110,772	$849,254
	Grading @ Berm w/ Dune	6.51	Mo.	$167,122	$1,087,964	$163,195	$1,251,159
	Site Security	6.51	Mo.	$6,452	$42,012	$6,302	$48,314
	Night Lighting	6.51	Mo.	$46,189	$300,690	$45,104	$345,794
	Total Beach Replacement				$13,313,430	$1,960,260	$15,273,690
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 7.97%)	1	Job	LS	$1,061,080	$159,162	$1,220,242
	Total Project First Cost				$15,374,511	$2,269,422	$17,643,932
	(Rounded)				$15,375,000	$2,269,000	$17,644,000

Notes:

Beach fill quantity includes 4 yr. nourishment cycle.

Table 21 - Total First Cost Price Level: Jun 07

Plan I (125' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$1,268,783	$152,254	$1,421,037
	Beach Fill						
	Site Work - Cells 1 and 2						
	Excavation/Pumping Sand	1,402,400	CY	$6.44	$9,038,328	$1,355,749	$10,394,077
	Survey Crew @ Borrow Area D	6.76	Mo.	$188,056	$1,272,180	$190,827	$1,463,007
	Survey Crew @ Berm w/ Dune	6.76	Mo.	$113,438	$766,841	$115,026	$881,867
	Grading @ Berm w/ Dune	6.76	Mo.	$167,122	$1,129,745	$169,462	$1,299,206
	Site Security	6.76	Mo.	$6,452	$43,616	$6,542	$50,158
	Night Lighting	6.76	Mo.	$46,189	$312,353	$46,853	$359,206
	Total Beach Replacement				$13,831,845	$2,036,713	$15,868,558
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 7.97%)	1	Job	LS	$1,102,398	$165,360	$1,267,758
	Total Project First Cost				$15,934,243	$2,352,073	$18,286,316
	(Rounded)				$15,934,000	$2,352,000	$18,286,000

Notes:
Beach fill quantity includes 4 yr. nourishment cycle.

Table 2J - Total First Cost Price Level: Jun 07

Plan J (80' Berm w/ 18' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$1,136,316	$136,358	$1,272,674
	Beach Fill						
	Site Work - Cells 1 and 2						
	Excavation/Pumping Sand	1,241,400	CY	$6.44	$7,998,278	$1,199,742	$9,198,020
	Survey Crew @ Borrow Area D	5.99	Mo.	$188,056	$1,126,455	$168,968	$1,295,424
	Survey Crew @ Berm w/ Dune	5.99	Mo.	$113,438	$679,494	$101,924	$781,418
	Grading @ Berm w/ Dune	5.99	Mo.	$167,122	$1,001,061	$150,159	$1,151,220
	Site Security	5.99	Mo.	$6,452	$38,659	$5,799	$44,458
	Night Lighting	5.99	Mo.	$46,189	$276,741	$41,511	$318,253
	Total Beach Replacement				$12,257,004	$1,804,461	$14,061,466
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 8.23%)	1	Job	LS	$1,008,751	$151,313	$1,160,064
	Total Project First Cost				$14,265,756	$2,105,774	$16,371,530
	(Rounded)				$14,266,000	$2,106,000	$16,372,000

Notes:

Beach fill quantity includes 4 yr. nourishment cycle.

Table 2K - Total First Cost Price Level: Jun 07

Plan K (105' Berm w/ 18' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$1,321,434	$158,572	$1,480,006
	Beach Fill						
	Site Work - Cells 1 and 2						
	Excavation/Pumping Sand	1,466,400	CY	$6.48	$9,508,284	$1,426,243	$10,934,527
	Survey Crew @ Borrow Area D	5.69	Mo.	$235,029	$1,337,315	$200,597	$1,537,912
	Survey Crew @ Berm w/ Dune	5.69	Mo.	$141,773	$806,688	$121,003	$927,692
	Grading @ Berm w/ Dune	5.69	Mo.	$208,887	$1,188,567	$178,285	$1,366,852
	Site Security	5.69	Mo.	$6,452	$36,737	$5,511	$42,248
	Night Lighting	5.69	Mo.	$68,679	$390,784	$58,618	$449,401
	Total Beach Replacement				$14,589,809	$2,148,828	$16,738,638
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 7.97%)	1	Job	LS	$1,162,808	$174,421	$1,337,229
	Total Project First Cost				$16,752,617	$2,473,250	$19,225,867
	(Rounded)				$16,753,000	$2,473,000	$19,226,000

Notes:
Beach fill quantity includes 4 yr. nourishment cycle.

Table 2L - Total First Cost Price Level: Jun 07

Plan L (85' Berm w/ 20' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$1,380,667	$165,680	$1,546,347
	Beach Fill						
	Site Work - Cells 1 and 2						
	Excavation/Pumping Sand	1,538,400	CY	$6.48	$9,974,755	$1,496,213	$11,470,968
	Survey Crew @ Borrow Area D	5.97	Mo.	$235,029	$1,403,123	$210,468	$1,613,592
	Survey Crew @ Berm w/ Dune	5.97	Mo.	$141,773	$846,385	$126,958	$973,343
	Grading @ Berm w/ Dune	5.97	Mo.	$208,887	$1,247,055	$187,058	$1,434,114
	Site Security	5.97	Mo.	$6,452	$38,530	$5,780	$44,310
	Night Lighting	5.97	Mo.	$68,679	$410,014	$61,502	$471,516
	Total Beach Replacement				$15,300,529	$2,253,659	$17,554,188
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 7.97%)	1	Job	LS	$1,219,452	$182,918	$1,402,370
	Total Project First Cost				$17,519,981	$2,586,577	$20,106,558
	(Rounded)				$17,520,000	$2,587,000	$20,107,000

Notes:

Beach fill quantity includes 4 yr. nourishment cycle.

Table 2M - Total First Cost Price Level: Jun 07

Plan M (110' Berm w/ 20' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$1,431,318	$171,758	$1,603,076
	Beach Fill						
	Site Work - Cells 1 and 2						
	Excavation/Pumping Sand	1,906,600	CY	$6.54	$12,477,553	$1,871,633	$14,349,186
	Survey Crew @ Borrow Area D	6.20	Mo.	$284,688	$1,765,066	$264,760	$2,029,825
	Survey Crew @ Berm w/ Dune	6.20	Mo.	$171,762	$1,064,924	$159,739	$1,224,663
	Grading @ Berm w/ Dune	6.20	Mo.	$251,683	$1,560,435	$234,065	$1,794,500
	Site Security	6.20	Mo.	$6,452	$40,022	$6,003	$46,025
	Night Lighting	6.20	Mo.	$92,378	$572,836	$85,925	$658,761
	Total Beach Replacement				$18,912,153	$2,793,883	$21,706,037
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 7.76%)	1	Job	LS	$1,467,583	$220,137	$1,687,721
	Total Project First Cost				$21,379,736	$3,164,021	$24,543,757
	(Rounded)				$21,380,000	$3,164,000	$24,544,000

Notes:
Beach fill quantity includes 4 yr. nourishment cycle.

Table 2N - Total First Cost Price Level: Jun 07

Plan N (160' Berm w/ 20' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$1,900,174	$228,021	$2,128,195
	Beach Fill						
	Site Work - Cells 1 and 2						
	Excavation/Pumping Sand	2,674,600	CY	$6.51	$17,411,646	$2,611,747	$20,023,393
	Survey Crew @ Borrow Area D	6.50	Mo.	$377,373	$2,452,925	$367,939	$2,820,863
	Survey Crew @ Berm w/ Dune	6.50	Mo.	$227,654	$1,479,751	$221,963	$1,701,714
	Grading @ Berm w/ Dune	6.50	Mo.	$334,728	$2,175,732	$326,360	$2,502,092
	Site Security	6.50	Mo.	$6,452	$41,938	$6,291	$48,229
	Night Lighting	6.50	Mo.	$114,868	$746,734	$112,010	$858,744
	Total Beach Replacement				$26,208,899	$3,874,330	$30,083,229
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 7.34%)	1	Job	LS	$1,923,733	$288,560	$2,212,293
	Total Project First Cost				$29,132,633	$4,312,890	$33,445,522
	(Rounded)				$29,133,000	$4,313,000	$33,446,000

Notes:

Beach fill quantity includes 4 yr. nourishment cycle.

Table 3 - Periodic Nourishment Cost (Years 4 and 8)

Price Level: Mar 14
Construction duration: 4-months

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
17.	Beach Replenishment					**@ 25.1%**	
17.01	Mobilization, Demob. And Preparatory Work	1	Job	LS	$895,921	$224,876	$1,120,797
17.70	Beach Fill	1	Job	LS	$2,904,614	$729,058	$3,633,672
17.99	Associated General Items	1	Job	LS	$257,874	$64,726	$322,600
	Total Beach Replenishment				$4,058,408	$1,018,661	$5,077,069
						@ 15%	
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$221,632	$33,245	$254,877
31.	Construction Management (S & A)	1	Job	LS	$539,552	$80,933	$620,485
	Total Project First Cost				$4,819,593	$1,132,838	$5,952,431
	(Rounded)				$4,820,000	$1,133,000	$5,952,000

Table 4 - Periodic Nourishment Cost (Years 12, 16, 20, 28, 32, 36, 40, 44 and 48)

Price Level: Mar 14
Construction duration: 4-months

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
17.	Beach Replenishment					@ 31%	
17.01	Mobilization, Demob. And Preparatory Work	1	Job	LS	$895,921	$277,735	$1,173,656
17.70	Beach Fill	1	Job	LS	$2,904,614	$900,430	$3,805,045
17.99	Associated General Items	1	Job	LS	$257,874	$79,941	$337,814
	Total Beach Replenishment				$4,058,408	$1,258,107	$5,316,515
						@ 15%	
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$221,632	$33,245	$254,877
31.	Construction Management (S & A)	1	Job	LS	$539,552	$80,933	$620,485
	Total Project First Cost				$4,819,593	$1,372,284	$6,191,877
	(Rounded)				$4,820,000	$1,372,000	$6,192,000

Table 5 - Major Replacement Cost (Yr. 24)

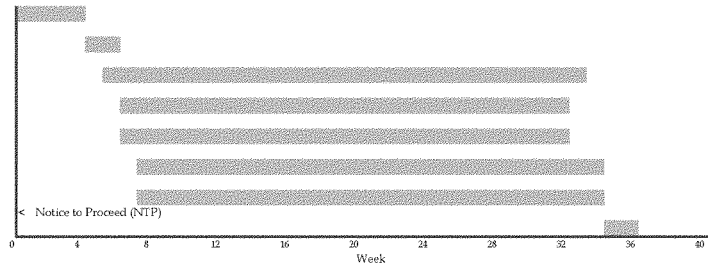
Price Level: Mar 14
Construction duration: 5-months

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
17.	Beach Replenishment					@ 31%	
17.01	Mobilization, Demob. And Preparatory Work	1	Job	LS	$935,261	$289,931	$1,225,192
17.70	Beach Fill	1	Job	LS	$3,961,931	$1,228,199	$5,190,130
17.99	Associated General Items	1	Job	LS	$332,175	$102,974	$435,149
	Total Beach Replenishment				$5,229,368	$1,621,104	$6,850,472
						@ 15%	
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$264,697	$39,705	$304,402
31.	Construction Management (S & A)	1	Job	LS	$665,719	$99,858	$765,577
	Total Project First Cost				$6,159,784	$1,760,666	$7,920,450
	(Rounded)				$6,160,000	$1,761,000	$7,920,000

Notes:
Beachfill quantity includes 4 yr. nourishment cycle.

Table 6 - Herford to Cape May Feasibility Study Beach Fill Initial Construction Schedule

#	TASK	WEEKS
1	Work Plans & Submittals	4
2	Mobilization	2
3	Surveys	28
4	Beach Fill	26
5	Structure Monitoring	26
6	Dune Crossover Work	27
7	Dune Planting and Seeding	27
8	Demobilization	2



Notes:

Herford to Cape May Feasibility Study initial construction duration = 36 weeks, use 9 months.

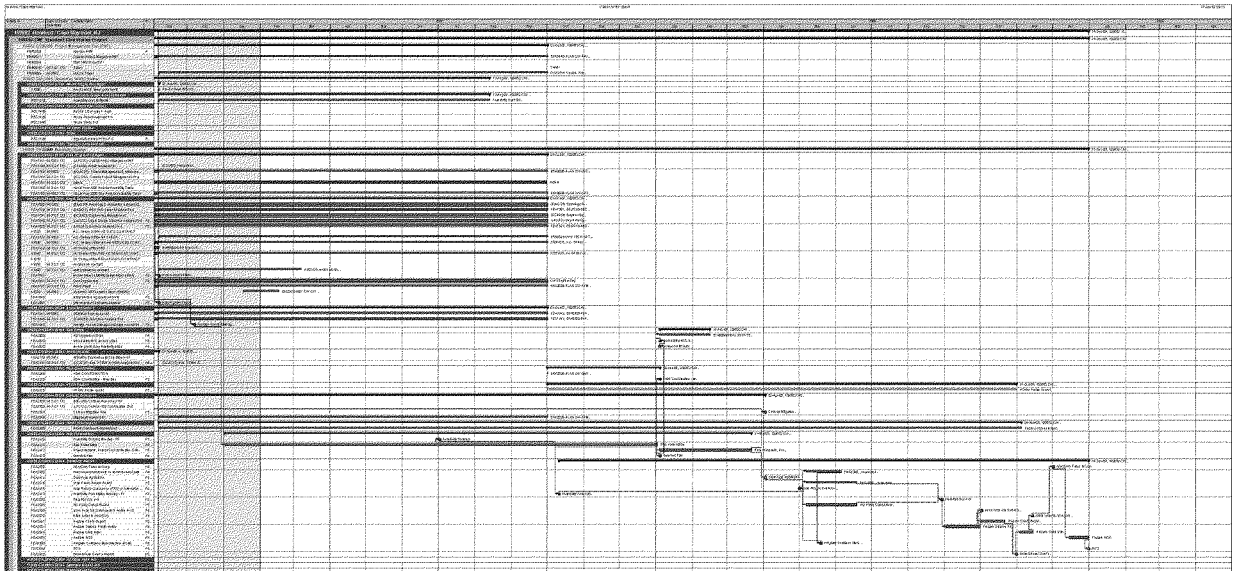


Table 7 - Project Schedule

HERF2CAPEMAY_FEAS3v4-2

Hereford Inlet to Cape May Inlet, NJ
New Jersey Shore Protection Study
Draft Final Feasibility Report

581

Estimated by	Cost Engineering Section
Designed by	Peter Gori, EC-EG; Alyssa Dunlap, EC-EC
Prepared by	William Welk
Preparation Date	5/12/2014
Effective Date of Pricing	3/1/2014
Estimated Construction Time	270 Days

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Description	Page
Library Properties	**i**
Project Notes	**ii**
Markup Properties	**iv**
Project Cost Summary	**1**
HEREFORD TO CAPE MAY INLETS FEASIBILITY STUDY - SELECTED PLAN COST ESTIMATE	1
01. LANDS AND DAMAGES	1
01. Lands and Damages	1
17.IC INITAL CONSTRUCTION BEACH REPLENISHMENT - Move Beach Fill w/ Mobile Hydraulic Backpass System	1
01. Mobilization, Demobilization and Preparatory Work	1
70. Beach Fill	1
99. Associated General Items	1
30. PLANNING ENGINEERING & DESIGN	1
01. Planning Engineering & Design	1
31. CONSTRUCTION MANAGEMENT	1
01. Construction Management	1
Project Indirect Summary	**2**
HEREFORD TO CAPE MAY INLETS FEASIBILITY STUDY - SELECTED PLAN COST ESTIMATE	2
01. LANDS AND DAMAGES	2
01. Lands and Damages	2
17.IC INITAL CONSTRUCTION BEACH REPLENISHMENT - Move Beach Fill w/ Mobile Hydraulic Backpass System	2
01. Mobilization, Demobilization and Preparatory Work	2
70. Beach Fill	2
99. Associated General Items	2
30. PLANNING ENGINEERING & DESIGN	2
01. Planning Engineering & Design	2
31. CONSTRUCTION MANAGEMENT	2
01. Construction Management	2
Contractor Indirect Summary	**3**
AA Prime Contractor (Initial Construction) - Land Based Equipment	3
AB Prime Contractor - No markups.	3
Crews Backup	**4**
Contractors Labor Payroll Markup Report	**6**
1 AA Prime Contractor (Initial Construction) - Land Based Equipment	6
1.2 SU Survey Sub	6
1.3 EL Electrical Sub	6
1.4 SE Security Sub	6
2 AB Prime Contractor - No markups.	6

582

Description	Page
Labor Backup	**7**
Equipment Backup	**9**

Designed by
Peter Gori, EC-EG; Alyssa Dunlap, EC-EC
Estimated by
Cost Engineering Section
Prepared by
William Welk

Design Document	Draft Final Feasibility Report
Document Date	5/12/2014
District	Philadelphia District
Contact	William Welk
Budget Year	2014
UOM System	Original

Direct Costs
LaborCost
EQCost
MatlCost
SubBidCost
Lump Sum

Timeline/Currency

Preparation Date	5/12/2014
Escalation Date	3/1/2014
Eff. Pricing Date	3/1/2014
Estimated Duration	270 Day(s)
Currency	US dollars
Exchange Rate	1.000000

Costbook CB12EB-b: MII English Cost Book 2012-b

Labor Region 1: Labor Region 1 -2012

Labor Rates
LaborCost1
LaborCost2
LaborCost3
LaborCost4

Equipment EP11R01: MII Equipment 2011 Region 01

01 NORTHEAST

Sales Tax	7.00
Working Hours per Year	1,360
Labor Adjustment Factor	1.12
Cost of Money	2.50
Cost of Money Discount	25.00
Tire Recap Cost Factor	1.50
Tire Recap Wear Factor	1.80
Tire Repair Factor	0.15
Equipment Cost Factor	1.00
Standby Depreciation Factor	0.50

Fuel

Electricity	0.190
Gas	3.600
Diesel Off-Road	3.860
Diesel On-Road	4.350

Shipping Rates

Over 0 CWT	18.08
Over 240 CWT	16.61
Over 300 CWT	14.46
Over 400 CWT	12.44
Over 500 CWT	6.96
Over 700 CWT	6.96
Over 800 CWT	10.55

584

Date	Author	Note
5/19/2008	Bill Welk	1. Prepared by the U.S. Army Corps of Engineers, Philadelphia District, Wanamaker Building, 100 Penn Square East, Philadelphia, PA 19107-3391.
7/10/2012		2. SUMMARY OF WORK: Work includes, but is not limited to beach fill in North Wildwood, Wildwood, and Wildwood Crest, NJ. The major work items for the selected plan: Plan C - 75' wide berm with +16' NAVD high dune including 4-year nourishment cycle using mobile hydraulic sand backpassing, are as follows:
7/10/2012		Approximately 1,007,250 C.Y. of beach fill from onshore borrow Area WW/WC will be placed in North Wildwood (Cells 1 and 2). The average pumping distance for the initial construction beach fill uses an average pipeline length of 15,600 L.F. A 150 hp electric submersible agitator dredge pump would be suspended from a crawler crane with a minimum 100' boom. A 300 kW generator would be mounted on the back of the crane to power the dradge pump. Sand up to 50% solids by weight, to be transferred through 10-inch gum tube-lined hose to 12-inch HDPE pipe on the beach. Diesel engine, skid mounted booster pumps would be placed every 5,000 feet to transfer the sand slurry to the outlet location where the beach fill would take place. Horsepower for each booster is 400 hp. Instrumentation including magnetic flow meters would provide flow rates and production numbers.
7/10/2012		In Wildwood and Wildwood Crest, the project will consist of placing 520,000 CY of beach fill to construct a +16' NAVD high dune and raising the existing berm elevation to 6.5' NAVD. Side slopes for the dunes will be 1 on 5. In Wildwood and Wildwood crest, the average pipeline length is 1,000LF. Aso included is the placement of 64 acres of dune grass, 28,000 LF of sand fence, extending 44 existing pedestrian crossovers, 7 new pedestrian crossovers, extending 7 exinting handicap crossovers, 6 new handicap crossovers, extending 8 existing vehicle crossovers and 5 new vehicle crossovers.
7/10/2012		3. Construction schedule:
7/10/2012		- Report completion (Program Year) - September 2014
5/14/2013		- Estimated start of construction - October 2017
5/14/2013		- Mid-point of construction - February 2018 based on 9-month construction duration.
5/14/2013		4. Used Cape May County, NJ labor rates, General Decision Number NJ140050, Mod. No. 0 dated 01/03/14.
5/14/2013		5. Real estate costs (project feature 01) provided thriugh PL-PC and furnished by CENAB-RE.
5/14/2013		6. P,E&D costs (project feature 30) and S&A costs (project feature 31) provided by PL-PC.
5/14/2013		7. Price level: March 2014
5/14/2013		8. Contingencies are based on Crystal Ball software for preparing risk analysis and are:
5/14/2013		- Initial construction work - 25.1%; Nourishment (Years 4 and 8) - 25.1%; Nourishment (all other years) and Major Replacement (year 24) - 31%
5/14/2013		- Real estate costs - 24.9%
5/14/2013		- S&A and P,E&D - 15%
5/14/2013		9. Critical assumptions:
5/14/2013		- Beach fill work will be permitted only from September to April due to the tourist season.
5/14/2013		- A 350 C.Y. per hour production rate was used for cost estimating purposes and is based on the Sand Bypass Plant, Indian River Inlet, Delaware Coast Protection job constructed by NAP in 1989 and operated by Delaware Department of Natural Resources and Environmental Control (DENREC).

Date	Author	Note
5/14/2013		- There will be no severe weather events during construction.
2/12/2014		- Beach fill work will take place Monday to Friday, 24-hours per day.
3/12/2014		- Job will be open bid.
3/12/2014		10. Used R.S. Means, MII Cost Book, price quotes and historic data for material costs as noted.

Direct Cost Markups	**Category**	**Method**
Productivity	Productivity	Productivity
Overtime	Overtime	Overtime

	Days/Week	*Hours/Shift*	*Shifts/Day*	*1st Shift*	*2nd Shift*	*3rd Shift*
Standard	5.00	8.00	2.00	8.00	7.50	0.00
Actual	5.00	8.00	2.00	12.00	12.00	0.00

Day	*OT Factor*	*Working*	*OT Percent*	*FCCM Percent*
Monday	1.50	Yes	19.79	(66.67)
Tuesday	1.50	Yes		
Wednesday	1.50	Yes		
Thursday	1.50	Yes		
Friday	1.50	Yes		
Saturday	1.50	No		
Sunday	2.00	No		

Sales Tax	TaxAdj	Running % on Selected Costs
LaborCost		

Contractor Markups	**Category**	**Method**
JOOH (Small Tools)	JOOH	% of Labor
JOOH	JOOH	JOOH (Calculated)
JOOH %	JOOH	Running %
HOOH	HOOH	Running %
Profit %	Profit	Running %
Profit WG	Profit	Profit Weighted Guidelines

Guideline	*Value*	*Weight*	*Percentage*
Risk	0.080	20	1.60
Difficulty	0.080	15	1.20
Size	0.030	15	0.45
Period	0.070	15	1.05
Invest (Contractor's)	0.070	5	0.35
Assist (Assistance by)	0.090	5	0.45
SubContracting	0.090	25	2.25
Total		100	7.35

Bond	Bond	Bond Table
Class A, Tiered, 24 months, 1.00% Surcharge		

Contract Price	*Bond Rate*
500,000	11.88
2,000,000	7.39
2,500,000	5.81
2,500,000	5.41

	100,000,000,000	*4.88*	
Bond %		Bond	Running %
Owner Markups		**Category**	**Method**
Contingency		Contingency	Running %
Escalation		Escalation	Running %
SIOH		SIOH	Running %

588

Description	Quantity	UOM	ContractCost	Escalation	Contingency	SIOH	ProjectCost
Project Cost Summary			**17,497,990**	**0**	**0**	**0**	**17,497,990**
HEREFORD TO CAPE MAY INLETS FEASIBILITY STUDY - SELECTED PLAN COST ESTIMATE	**1.0**	**LS**	**17,497,990**	**0**	**0**	**0**	**17,497,990**
01. LANDS AND DAMAGES	**1.0**	**LS**	**1,018,972**	**0**	**0**	**0**	**1,018,972**
01. Lands and Damages	**1.0**	**LS**	**1,018,972**	**0**	**0**	**0**	**1,018,972**
17.IC INITAL CONSTRUCTION BEACH REPLENISHMENT - Move Beach Fill w/ Mobile Hydraulic Backpass System	**1.0**	**LS**	**13,673,876**	**0**	**0**	**0**	**13,673,876**
01. Mobilization, Demobilization and Preparatory Work	**1.0**	**LS**	**1,026,656**	**0**	**0**	**0**	**1,026,656**
70. Beach Fill	**1.0**	**LS**	**9,883,656**	**0**	**0**	**0**	**9,883,656**
99. Associated General Items	**1.0**	**LS**	**2,763,564**	**0**	**0**	**0**	**2,763,564**
30. PLANNING ENGINEERING & DESIGN	**1.0**	**LS**	**1,617,299**	**0**	**0**	**0**	**1,617,299**
01. Planning Engineering & Design	**1.0**	**LS**	**1,617,299**	**0**	**0**	**0**	**1,617,299**
31. CONSTRUCTION MANAGEMENT	**1.0**	**LS**	**1,187,843**	**0**	**0**	**0**	**1,187,843**
01. Construction Management	**1.0**	**LS**	**1,187,843**	**0**	**0**	**0**	**1,187,843**

Description	Quantity	UOM	DirectCost	SubCMU	CostToPrime	PrimeCMU	ContractCost
Project Indirect Summary			14,816,763	115,234	14,931,997	2,565,993	17,497,990
HEREFORD TO CAPE MAY INLETS FEASIBILITY STUDY - SELECTED PLAN COST ESTIMATE	1.0	LS	14,816,763	115,234	14,931,997	2,565,993	17,497,990
01. LANDS AND DAMAGES	1.0	LS	1,018,972	0	1,018,972	0	1,018,972
01. Lands and Damages	1.0	LS	1,018,972	0	1,018,972	0	1,018,972
17.IC INITAL CONSTRUCTION BEACH REPLENISHMENT - Move Beach Fill w/ Mobile Hydraulic Backpass System	1.0	LS	10,992,649	115,234	11,107,883	2,565,993	13,673,876
01. Mobilization, Demobilization and Preparatory Work	1.0	LS	780,423	20,739	801,162	225,494	1,026,656
70. Beach Fill	1.0	LS	7,641,891	70,926	7,712,817	2,170,839	9,883,656
99. Associated General Items	1.0	LS	2,570,335	23,569	2,593,904	169,661	2,763,564
30. PLANNING ENGINEERING & DESIGN	1.0	LS	1,617,299	0	1,617,299	0	1,617,299
01. Planning Engineering & Design	1.0	LS	1,617,299	0	1,617,299	0	1,617,299
31. CONSTRUCTION MANAGEMENT	1.0	LS	1,187,843	0	1,187,843	0	1,187,843
01. Construction Management	1.0	LS	1,187,843	0	1,187,843	0	1,187,843

Description	DirectCost	JOOH	HOOH	Profit	Bond	Escalation	CostToPrime	ContractorOwnCost
Contractor Indirect Summary								
AA Prime Contractor (Initial Construction) - Land Based Equipment	**8,602,507**	**811,672**	**753,134**	**747,298**	**109,146**	**0**	**8,602,507**	**11,538,019**
SU Survey Sub	**245,437**	**24,544**	**21,598**	**24,784**	**0**	**0**	**316,363**	**316,363**
EL Electrical Sub	**70,320**	**7,032**	**6,188**	**7,519**	**0**	**0**	**91,059**	**91,059**
SE Security Sub	**83,271**	**8,327**	**7,328**	**7,914**	**0**	**0**	**106,840**	**106,840**
AB Prime Contractor - No markups.	**5,815,228**	**0**	**0**	**0**	**0**	**0**	**5,815,228**	**5,815,228**

Description	ManHours	LaborCost	EQHours	CrewHours	CrewCost
Crews Backup					
	1.00	*69.98*	*0.00*		*69.98*
GOV COEMEQMD1 1 eqoprmed	10,528.0	736,749	0.0	10,528.0	736,749
MIL B-EQOPRMED Equip. Operators, Medium	*1.0*	*70*			
	1.00	*80.90*	*0.00*		*80.90*
RSM ELEC ELEC	263.2	21,290	0.0	263.2	21,290
MIL B-ELECTRN Electricians	*1.0*	*81*			
	3.00	*215.24*	*0.00*		*215.24*
RSM Q19 Q19	40.0	2,870	0.0	13.3	2,870
MIL B-STM/PIPE Steam/Pipefitters	*1.0*	*59*			
MIL B-STM/PIPE Steam/Pipefitters	*1.0*	*76*			
MIL B-ELECTRN Electricians	*1.0*	*81*			
	1.00	*56.30*	*0.00*		*56.30*
USR CLABA1 1 laborer	11,658.0	656,345	0.0	11,658.0	656,345
MIL X-LABORER Outside Laborers, (Semi-Skilled)	*1.0*	*56*			
	1.00	*57.30*	*0.00*		*57.30*
USR CLABA2 1 laborer foreman	1,793.0	102,739	0.0	1,793.0	102,739
MIL X-LABORER Outside Laborers, (Semi-Skilled)	*1.0*	*57*			
	1.00	*66.44*	*0.00*		*66.44*
USR COELB1 1 eqoprlt	16,224.0	1,077,923	0.0	16,224.0	1,077,923
MIL X-EQOPRLT Outside Equip. Operators, Light	*1.0*	*66*			
	1.00	*71.65*	*0.00*		*71.65*
USR COEMEQHY1 1 eqoprhvy	5,389.0	386,122	0.0	5,389.0	386,122
MIL X-EQOPRHVY Outside Equip. Operators, Heavy	*1.0*	*72*			
	1.00	*75.56*	*0.00*		*75.56*
USR MPLUPLUM1 1 plumber	320.0	24,179	0.0	320.0	24,179
MIL X-PLUMBER Outside Plumbers	*1.0*	*76*			
	0.00	*0.00*	*0.00*		*0.00*
USR N/A No Crew	0.0	0	0.0	5,112.0	0
	1.00	*25.56*	*0.00*		*25.56*
USR USURSURV1 Surveyor, Chief	1,600.0	40,896	0.0	1,600.0	40,896
FOP FC-SURYC Surveyors, Chief	*1.0*	*26*			
	1.00	*24.02*	*0.00*		*24.02*
USR USURSURVS Surveyors	2,400.0	57,648	0.0	2,400.0	57,648
FOP FC-SURYR Surveyors	*1.0*	*24*			

Description	ManHours	LaborCost	EQHours	CrewHours	CrewCost
	0.00	*0.00*	*1.00*		*53.28*
USR ZCRA14T Crane, hydraulic, truck mtd, 14 ton	0.0	0	589.0	589.0	31,380
GEN C80Z2240 CRANE, HYDRAULIC, TRUCK MOUNTED, 14 TON (12.7 MT), 80' (24.4 M) BOOM, 6X4			*1.0*		
	0.00	*0.00*	*1.00*		*144.21*
USR ZDOZHVY2 Dozer, 310 HP, w/blade	0.0	0	9,640.0	9,640.0	1,390,190
MAP T15CA016 TRACTOR, CRAWLER (DOZER), 310 HP, POWERSHIFT, W/15.3 CY SEMI-U BLADE (ADD ATTACHMENTS)			*1.0*		
	0.00	*0.00*	*1.00*		*3.21*
USR ZGENPORT5.6KW Generator set, portable, 5.6 Kw, 120/240V	0.0	0	286.0	286.0	919
MAP G10WC002 GENERATOR SET, PORTABLE, 5.6 KW, 120/240V, 60 HZ			*1.0*		
	0.00	*0.00*	*1.00*		*66.81*
USR ZGENSKIDMTD300KW Generator set, skid mtd. 300 KW	0.0	0	4,800.0	4,800.0	320,707
EP G10XX012 GENERATOR SET, SKID MTD, 300 KW			*1.0*		
	0.00	*0.00*	*1.00*		*32.28*
USR ZMARBOAT18-FTW/OCABIN Boat, 18' River Runner, w/o Cabin Vee Hull, Cap 1,350 lbs, Outboard, 18'x7.9'x0.5'	0.0	0	800.0	800.0	25,825
MAP M10SM005 MARINE EQUIPMENT, BOATS & LAUNCHES, 18' RIVER RUNNER, VEE HULL, NO CABIN, CAP 1,350 LBS, OUTBOARD, 18' X 7.9' X 0.5'			*1.0*		
	0.00	*0.00*	*1.00*		*1.58*
USR ZMISSMTOOL1 Small Tools	0.0	0	21,378.0	21,378.0	33,777
NON XMIXX020 SMALL TOOLS			*1.0*		
	0.00	*0.00*	*1.00*		*16.23*
USR ZTRKTRPKP1 Truck, pickup, 1 ton	0.0	0	6,290.0	6,290.0	102,096
EP T50XX012 TRUCK, HIGHWAY, CREW, 1 TON PICKUP, 4X4			*1.0*		
	0.00	*0.00*	*1.00*		*15.58*
USR ZWELGAS3KWTRMTD Welder, Engine Driven, Gas, 300 Amp, 3 KW, Trailer Mtd.	0.0	0	210.0	210.0	3,272
EP W35XX023 WELDER, ENGINE DRIVEN, GAS, DC-CC, 300 AMP, 3 KW, TRAILER MTD			*1.0*		

Description	SUIExperience	SUIRate	FICA	FUIRate	PayrollTax	State	ContractorCla	WCIBaseRate	WCIExperience	WCIRate
Contractors Labor Payroll Markup Report										
1 AA Prime Contractor (Initial Construction) - Land Based Equipment	**256.60**	**6.88**	**7.65**	**0.60**	**15.13**	**NJ**	**Excavation -- rock/earth NOC**	**5.32**	**98.01**	**17.48**
1.2 SU Survey Sub	**256.60**	**6.88**	**7.65**	**0.60**	**15.13**	**NJ**	**Excavation -- rock/earth NOC**	**5.32**	**328.66**	**17.48**
1.3 EL Electrical Sub	**256.60**	**6.88**	**7.65**	**0.60**	**15.13**	**NJ**	**Electrical Wiring -- inside**	**3.32**	**526.51**	**17.48**
1.4 SE Security Sub	**256.60**	**6.88**	**7.65**	**0.60**	**15.13**	**NJ**	**Clerical Help**	**0.24**	**7,284.06**	**17.48**
2 AB Prime Contractor - No markups.	**256.60**	**6.88**	**7.65**	**0.60**	**15.13**	**NJ**	**Excavation -- rock/earth NOC**	**5.32**	**98.01**	**17.48**

Description	BaseWage	Overtime	Payroll	WCI	TaxableFringe	NonTaxFringe	Travel	Total	ManHours
Labor Backup									
	37.71				*0.00*	*7.92*	*0.00*	*57.93*	
FOP FA-AGENS General Superintendents (P.M.)	144,429	0	21,857	25,251	0	30,334	0	221,870	3,830.0
	37.71				*0.00*	*7.92*	*0.00*	*57.93*	
FOP FA-PROJM Project Managers	1,057	0	160	185	0	222	0	1,623	28.0
	25.74				*0.00*	*6.62*	*0.00*	*40.76*	
FOP FB-ACONT Contract Administrators	8,160	0	1,235	1,427	0	2,099	0	12,919	317.0
	14.72				*0.00*	*5.42*	*0.00*	*24.94*	
FOP FB-CLTYP Clerks, Typists, Bookkeepers & Receptionist	589	0	89	103	0	217	0	998	40.0
	35.18				*0.00*	*7.65*	*0.00*	*54.30*	
FOP FC-ENGCI Engineers, Civil	149,867	0	22,680	26,201	0	32,589	0	231,337	4,260.0
	25.36				*0.00*	*6.58*	*0.00*	*40.21*	
FOP FC-FLDRT Field Draftsmen	5,807	0	879	1,015	0	1,507	0	9,208	229.0
	19.61				*0.00*	*5.95*	*0.00*	*31.96*	
FOP FC-SURYC Surveyors, Chief	31,376	0	4,748	5,486	0	9,520	0	51,130	1,600.0
	18.22				*0.00*	*5.80*	*0.00*	*29.96*	
FOP FC-SURYR Surveyors	43,728	0	6,617	7,646	0	13,920	0	71,911	2,400.0
	35.18				*0.00*	*7.65*	*0.00*	*54.30*	
FOP FD-SAENG Safety Engineers	145,504	0	22,020	25,439	0	31,640	0	224,603	4,136.0
	18.63				*0.00*	*5.84*	*0.00*	*30.55*	
FOP FD-SECWT Security, Watchmen/Guards	48,289	0	7,308	8,442	0	15,137	0	79,176	2,592.0
	41.49				*0.00*	*23.23*	*0.00*	*78.25*	
MIL B-CARPNTER Carpenters	8,630	0	1,306	1,509	0	4,832	0	16,277	208.0
	46.51				*0.00*	*34.39*	*0.00*	*96.07*	
MIL B-ELECTRN Electricians	17,697	0	2,678	3,093	0	13,086	0	36,554	380.5
	41.48				*0.00*	*28.50*	*0.00*	*83.51*	
MIL B-EQOPRMED Equip. Operators, Medium	436,701	78,805	131,679	76,349	0	300,048	0	1,023,583	10,528.0
	36.23				*0.00*	*28.50*	*0.00*	*76.55*	
MIL B-EQOPROIL Equip. Operators, Oilers	4,058	0	614	709	0	3,192	0	8,573	112.0
	43.02				*0.00*	*32.54*	*0.00*	*89.59*	
MIL B-STM/PIPE Steam/Pipefitters	574	0	87	100	0	434	0	1,195	13.3

Description	BaseWage	Overtime	Payroll	WCI	TaxableFringe	NonTaxFringe	Travel	Total	ManHours
	26.24				*0.00*	*32.54*	*0.00*	*67.34*	
MIL B-STM/PIPE Steam/Pipefitters	350	0	53	61	0	434	0	898	13.3
	31.05				*0.00*	*21.49*	*0.00*	*62.67*	
MIL B-TRKDVRHV Truck Drivers, Heavy	8,135	0	1,231	1,422	0	5,630	0	16,419	262.0
	43.07				*0.00*	*28.58*	*0.00*	*95.23*	
MIL X-EQOPRHVY Outside Equip. Operators, Heavy	232,104	40,913	45,589	40,579	0	154,018	0	513,202	5,389.0
	37.94				*0.00*	*28.50*	*0.00*	*89.06*	
MIL X-EQOPRLT Outside Equip. Operators, Light	615,539	121,815	137,547	107,615	0	462,384	0	1,444,899	16,224.0
	33.90				*0.00*	*22.40*	*0.00*	*77.77*	
MIL X-LABORER Outside Laborers, (Semi-Skilled)	395,206	32,202	149,037	69,094	0	261,139	0	906,679	11,658.0
	34.90				*0.00*	*22.40*	*0.00*	*68.68*	
MIL X-LABORER Outside Laborers, (Semi-Skilled)	62,576	0	9,470	10,940	0	40,163	0	123,149	1,793.0
	43.02				*0.00*	*32.54*	*0.00*	*89.59*	
MIL X-PLUMBER Outside Plumbers	13,766	0	2,083	2,407	0	10,413	0	28,669	320.0

596

Description	Depr/Rntl	FCCM	Fuel	FOG	TireWear	TireRepair	EQRepair	Total	EQHours
Equipment Backup									
	4.77	*0.16*	*51.21*	*5.83*	*0.00*	*0.00*	*4.52*	*66.50*	
EP G10XX012 GENERATOR SET, SKID MTD, 300 KW	22,910	763	245,830	27,973	0	0	21,706	319,182	4,800.0
	2.61	*0.26*	*9.07*	*1.21*	*0.23*	*0.04*	*2.81*	*16.23*	
EP T50XX012 TRUCK, HIGHWAY, CREW, 1 TON PICKUP, 4X4	16,431	1,666	57,063	7,593	1,445	243	17,655	102,096	6,290.0
	1.11	*0.12*	*11.66*	*1.33*	*0.03*	*0.00*	*1.32*	*15.58*	
EP W35XX023 WELDER, ENGINE DRIVEN, GAS, DC-CC, 300 AMP, 3 KW, TRAILER MTD	234	26	2,449	279	5	1	278	3,272	210.0
	8.90	*1.37*	*29.32*	*5.02*	*1.11*	*0.19*	*7.38*	*53.28*	
GEN C80Z2240 CRANE, HYDRAULIC, TRUCK MOUNTED, 14 TON (12.7 MT), 80' (24.4 M) BOOM, 6X4	5,243	805	17,268	2,955	653	110	4,347	31,380	589.0
	7.20	*0.97*	*8.51*	*1.13*	*0.14*	*0.02*	*11.37*	*29.34*	
GEN D30Z2840 DRILL, EARTH/AUGER, HYDRAULIC AUGER, 14" (356 MM) DIA, 30' (9.1 M) DEPTH, 3,500 FT-LBS (483.9 KGF-M), W/TRAILER (ADD COST FOR DRILL STEEL AND CUTTING EDGE WEAR)	231	31	272	36	4	1	364	939	32.0
	5.41	*0.74*	*6.21*	*3.07*	*0.70*	*0.12*	*6.85*	*23.09*	
GEN L50Z4640 LOADER/BACKHOE, WHEEL, 0.80 CY (0.6 M3) FRONT END BUCKET, 9.8' (3.0 M) DEPTH OF HOE, 24" (0.61 M) DIPPER, 4X4	130	18	149	74	17	3	164	554	24.0
	1.25	*0.10*	*0.00*	*0.00*	*0.00*	*0.00*	*1.15*	*2.51*	
GEN T40Z7090 TRUCK OPTION, DUMP BODY, REAR, 12 CY (9.2 M3) (ADD 45,000 LB (20,412 KG) GVW TRUCK)	58	5	0	0	0	0	53	115	46.0
	2.85	*0.36*	*24.19*	*3.45*	*0.42*	*0.07*	*2.86*	*34.21*	
GEN T50Z7400 TRUCK, HIGHWAY, 25,000 LB (11,340 KG) GVW, 4X2, 2 AXLE (ADD ACCESSORIES)	68	9	581	83	10	2	69	821	24.0
	30.63	*1.69*	*33.35*	*4.75*	*15.91*	*2.67*	*34.05*	*123.06*	
MAP C75GV019 CRANES, HYDRAULIC, SELF-PROPELLED, ROUGH TERRAIN, 50 TON, 110' BOOM, 4X4	149,974	8,253	163,284	23,262	77,915	13,090	166,707	602,484	4,896.0
	0.32	*0.03*	*2.34*	*0.27*	*0.00*	*0.00*	*0.26*	*3.21*	
MAP G10WC002 GENERATOR SET, PORTABLE, 5.6 KW, 120/240V, 60 HZ	92	8	668	76	0	0	75	919	286.0
	1.91	*0.32*	*24.43*	*3.71*	*0.00*	*0.00*	*1.91*	*32.28*	

597

Description	Depr/Rntl	FCCM	Fuel	FOG	TireWear	TireRepair	EQRepair	Total	EQHours
MAP M10SM005 MARINE EQUIPMENT, BOATS & LAUNCHES, 18' RIVER RUNNER, VEE HULL, NO CABIN, CAP 1,350 LBS, OUTBOARD, 18' X 7.9' X 0.5'	1,528	259	19,541	2,968	0	0	1,530	25,825	800.0
	32.23	*1.77*	*40.68*	*5.42*	*0.00*	*0.00*	*60.61*	*140.72*	
MAP T15CA016 TRACTOR, CRAWLER (DOZER), 310 HP, POWERSHIFT, W/15.3 CY SEMI-U BLADE (ADD ATTACHMENTS)	310,722	17,040	392,198	52,272	0	0	584,293	1,356,525	9,640.0
	5.34	*0.59*	*0.00*	*0.50*	*1.58*	*0.27*	*3.54*	*11.82*	
MAP T45XX019 TRUCK TRAILER, LOWBOY, 75 TON, 3 AXLE (ADD TOWING TRUCK)	1,195	133	0	112	354	59	794	2,648	224.0
	6.87	*1.02*	*32.36*	*4.31*	*0.94*	*0.16*	*6.87*	*52.52*	
MAP T50XX029 TRUCK, HIGHWAY, 50,000 LBS GVW, 3 AXLE, 6X4 (CHASSIS ONLY-ADD OPTIONS)	1,854	275	8,738	1,163	253	43	1,854	14,180	270.0
	0.50	*0.22*	*0.16*	*0.07*	*0.00*	*0.00*	*0.63*	*1.58*	
NON XMIXX020 SMALL TOOLS	10,892	3,384	3,485	1,525	0	0	13,723	34,417	21,783.0

598

INITIAL PROJECT CHARGES USING HOPPER DREDGING FOR BEACH FILL

24. General: This section presents detailed cost estimates for initial construction, nourishment, maintenance, monitoring and major rehabilitation resulting in total and annualized project costs for alternative storm damage reduction plans using hopper dredging for beach fill. The fifteen alternative plans developed using hopper dredging for beach fill include:

Plan	Description
A	115' wide berm with +12' NAVD dune using 4 Yr. Cycle
B	95' wide berm with +14' NAVD dune using 4 Yr. Cycle
C	75' wide berm with +16' NAVD dune using 4 Yr. Cycle
D	140' wide berm with +12' NAVD dune using 4 Yr. Cycle
E	120' wide berm with +14' NAVD dune using 4 Yr. Cycle
F	100' wide berm with +16' NAVD dune using 4 Yr. Cycle
G	165' wide berm with +12' NAVD dune using 4 Yr. Cycle
H	145' wide berm with +14' NAVD dune using 4 Yr. Cycle
I	125' wide berm with +16' NAVD dune using 4 Yr. Cycle
J	80' wide berm with +18' NAVD dune using 4 Yr. Cycle
K	105' wide berm with +18' NAVD dune using 4 Yr. Cycle
L	85' wide berm with +20' NAVD dune using 4 Yr. Cycle
M	110' wide berm with +20' NAVD dune using 4 Yr. Cycle
N	160' wide berm with +20' NAVD dune using 4 Yr. Cycle
O	No action

The top of the berm is at an elevation of +6.5' NAVD and extends from 2nd Avenue in North Wildwood to Juniper Avenue in Wildwood. The dune for each alternative has 1 on 5 side slopes and a top width of 25'. The dune extends the same distance as the berm. The initial construction for each of the above plans includes design and advanced nourishment beach fill. Also included are provisions for periodic nourishment, beach profile and environmental monitoring, and major replacement to restore the design beach profile damaged by significant storm events beyond that designed for in the nourishment cycle quantity. The plan layout of the NED plan with typical improved beach sections is shown in the section of the Feasibility Study, Main Report describing the NED Plan.

25. Basis of Cost: Cost estimates presented herein are based on June 2007 price levels. Initial beach fill costs are based on beach surveys taken in October 2003. The unit prices were developed in accordance with the construction procedures outlined herein. All initial construction and nourishment costs and major rehabilitation costs presented in this appendix are NED costs.

26. Initial beach fill costs are based on the assumption that a generic medium-size hopper dredge was used for placement of the beach fill. Approximately 944,500 C.Y. of beach fill material from offshore borrow area H was placed in Cells 1 and 2. The average haul distance for the initial beach fill is 0.47 miles. A mooring barge was located approximately 3,400 feet offshore of North Wildwood beach based on the benthics to allow access for a loaded dredge. The average pumping distance for these cells uses an average pipeline length of 6,640 L.F. for the initial beach fill.

27. Periodic nourishment beach fill costs are based on the assumption that a generic medium-size hopper dredge was used for placement of the beach fill. Approximately 341,600 C.Y.of beach fill material from offshore borrow area OS-2 was placed in Cells 1 and 2. The average haul distance for the nourishment cycle is 7.1 miles. A mooring barge was located approximately 5,100 feet off shore of Wildwood beach based on the benthics to allow access for a loaded dredge. The average pumping distance for the nourishment cycle uses an average pipeline length of 5,120 L.F.

28. Mobilization and demobilization costs are based on the assumption that beach filling equipment located within 250 miles from the project site will perform the work. Construction access would be by local streets. The locations of the borrow areas are displayed in the section of the Feasibility Study, Main Report describing the NED Plan.

29. Real estate costs for the fifteen alternatives included in the Cycle 3 screening were not included since they are expected to be minimal as most of the land is a public beach owned by the sponsor.

30. Environmental monitoring costs for the fifteen alternatives included in the Cycle 3 screening were not included since they are dependent on the EA document and that document was not finalized at the time of the Cycle 3 screening.

31. Construction Management costs for the fifteen alternatives included in the Cycle 3 screening were included as a percent of the construction cost and is based on ER415-1-16, Table E-1. A 15 percent contingency has been included in S&A costs.

32. Alternatives Considered: Alternative plans were developed in two phases for the plan selection process. In the first phase the alternative plans were compared during the Cycle 1 and Cycle 2 screening process. For more information on these plans, refer to the section of the Feasibility Study, Main Report describing the NED Plan. Based on an analysis of these annual costs with their associated benefits, the beach restoration only plan was selected for the second phase for final plan optimization and selection.

33. The costs for the fifteen alternatives as described in paragraph 24 for this second phase of plan selection are shown in Tables 5A thru 5N.

34. Renourishment Interval Optimization: For more information on the renourishment interval optimization that selected the 4-year cycle, refer to the section of the Feasibility Study, Main Report describing the NED plan.

35. Total First Cost for Selected Plan: The estimated project first cost is for the selected plan - dune and berm constructed using 944,500 CY of hydraulically placed design and advanced nourishment beach fill from offshore borrow area H. A +16' NAVD high dune with a top width of 25' on a 75' wide berm that is 6.5' NAVD high would be constructed from North Wildwood to the northern border of Wildwood and is based on a selected nourishment cycle of 4 years. It was assumed that beach filling work would be performed by a dredging contractor. Pertinent contingency, engineering and design and construction management costs are also included. For more information on the selected plan using hopper dredging for beach fill as an option, refer to the section of the Feasibility Study, Main Report describing the NED plan.

Table 5A - Total First Cost Price Level: Jun 07

Plan A (115' Berm w/ 12' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$688,723	$82,647	$771,370
	Hopper Dredging						
	Site Work, Excavation and Disposal						
	Cell 1	801,900	CY	$6.50	$5,212,350	$781,853	$5,994,203
	Cell 2	46,600	CY	$6.63	$308,958	$46,344	$355,302
	Total Beach Replacement				$6,210,031	$910,843	$7,120,874
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 9.89%)	1	Job	LS	$614,172	$90,082	$704,254
	Total Project First Cost				$7,824,203	$1,150,925	$8,975,128
	(Rounded)				$7,824,000	$1,151,000	$8,975,000

Notes:
Dredging quantity includes 4 yr. nourishment cycle.

Table 5B - Total First Cost Price Level: Jun 07

Plan B (95' Berm w/ 14' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$688,723	$82,647	$771,370
	Hopper Dredging						
	Site Work, Excavation and Disposal						
	Cell 1	824,900	CY	$6.49	$5,353,601	$803,040	$6,156,641
	Cell 2	66,600	CY	$6.61	$440,226	$66,034	$506,260
	Total Beach Replacement				$6,482,550	$951,721	$7,434,271
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 9.89%)	1	Job	LS	$641,124	$94,125	$735,249
	Total Project First Cost				$8,123,674	$1,195,846	$9,319,520
	(Rounded)				$8,124,000	$1,196,000	$9,320,000

Notes:
Dredging quantity includes 4 yr. nourishment cycle.

Table 5C - Total First Cost Price Level: Jun 07

Plan C (75' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$688,723	$82,647	$771,370
	Hopper Dredging						
	Site Work, Excavation and Disposal						
	Cell 1	853,900	CY	$6.47	$5,524,733	$828,710	$6,353,443
	Cell 2	90,600	CY	$6.60	$597,960	$89,694	$687,654
	Total Beach Replacement				$6,811,416	$1,001,051	$7,812,467
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 9.89%)	1	Job	LS	$673,649	$99,004	$772,653
	Total Project First Cost				$8,485,065	$1,250,055	$9,735,120
	(Rounded)				$8,485,000	$1,250,000	$9,735,000

Notes:
Dredging quantity includes 4 yr. nourishment cycle.

Table 5D - Total First Cost Price Level: Jun 07

Plan D (140' Berm w/ 12' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$688,723	$82,647	$771,370
	Hopper Dredging						
	Site Work, Excavation and Disposal						
	Cell 1	981,500	CY	$6.46	$6,340,490	$951,074	$7,291,564
	Cell 2	60,200	CY	$6.58	$396,116	$59,417	$455,533
	Total Beach Replacement				$7,425,329	$1,093,138	$8,518,467
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 9.89%)	1	Job	LS	$734,365	$108,111	$842,476
	Total Project First Cost				$9,159,694	$1,351,249	$10,510,943
	(Rounded)				$9,160,000	$1,351,000	$10,511,000

Notes:
Dredging quantity includes 4 yr. nourishment cycle.

Table 5E - Total First Cost Price Level: Jun 07

Plan E (120' Berm w/ 14' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$688,723	$82,647	$771,370
	Hopper Dredging						
	Site Work, Excavation and Disposal						
	Cell 1	1,004,500	CY	$6.45	$6,479,025	$971,854	$7,450,879
	Cell 2	80,200	CY	$6.57	$526,914	$79,037	$605,951
	Total Beach Replacement				$7,694,662	$1,133,538	$8,828,200
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 9.89%)	1	Job	LS	$761,002	$112,107	$873,109
	Total Project First Cost				$9,455,664	$1,395,644	$10,851,309
	(Rounded)				$9,456,000	$1,396,000	$10,851,000

Notes:
Dredging quantity includes 4 yr. nourishment cycle.

Table 5F - Total First Cost Price Level: Jun 07

Plan F (100' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$688,723	$82,647	$771,370
	Hopper Dredging						
	Site Work, Excavation and Disposal						
	Cell 1	1,033,500	CY	$6.43	$6,645,405	$996,811	$7,642,216
	Cell 2	104,200	CY	$6.56	$683,552	$102,533	$786,085
	Total Beach Replacement				$8,017,680	$1,181,990	$9,199,670
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 9.89%)	1	Job	LS	$792,949	$116,899	$909,847
	Total Project First Cost				$9,810,629	$1,448,889	$11,259,518
	(Rounded)				$9,811,000	$1,449,000	$11,260,000

Notes:
Dredging quantity includes 4 yr. nourishment cycle.

Table 5G - Total First Cost Price Level: Jun 07

Plan G (165' Berm w/ 12' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$688,723	$82,647	$771,370
	Hopper Dredging						
	Site Work, Excavation and Disposal						
	Cell 1	1,178,200	CY	$6.42	$7,564,044	$1,134,607	$8,698,651
	Cell 2	78,000	CY	$6.54	$510,120	$76,518	$586,638
	Total Beach Replacement				$8,762,887	$1,293,771	$10,056,658
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 9.46%)	1	Job	LS	$828,969	$122,391	$951,360
	Total Project First Cost				$10,591,856	$1,566,162	$12,158,018
	(Rounded)				$10,592,000	$1,566,000	$12,158,000

Notes:
Dredging quantity includes 4 yr. nourishment cycle.

Table 5H - Total First Cost Price Level: Jun 07

Plan H (145' Berm w/ 14' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$688,723	$82,647	$771,370
	Hopper Dredging						
	Site Work, Excavation and Disposal						
	Cell 1	1,201,200	CY	$6.40	$7,687,680	$1,153,152	$8,840,832
	Cell 2	98,000	CY	$6.53	$639,940	$95,991	$735,931
	Total Beach Replacement				$9,016,343	$1,331,790	$10,348,133
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 9.46%)	1	Job	LS	$852,946	$125,987	$978,933
	Total Project First Cost				$10,869,289	$1,607,777	$12,477,066
	(Rounded)				$10,869,000	$1,608,000	$12,477,000

Notes:
Dredging quantity includes 4 yr. nourishment cycle.

Table 51 - Total First Cost Price Level: Jun 07

Plan I (125' Berm w/ 16' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$688,723	$82,647	$771,370
	Hopper Dredging						
	Site Work, Excavation and Disposal						
	Cell 1	1,230,200	CY	$6.39	$7,860,978	$1,179,147	$9,040,125
	Cell 2	122,000	CY	$6.52	$795,440	$119,316	$914,756
	Total Beach Replacement				$9,345,141	$1,381,109	$10,726,250
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 9.46%)	1	Job	LS	$884,050	$130,653	$1,014,703
	Total Project First Cost				$11,229,191	$1,661,762	$12,890,954
	(Rounded)				$11,229,000	$1,662,000	$12,891,000

Notes:
Dredging quantity includes 4 yr. nourishment cycle.

Table 5J - Total First Cost Price Level: Jun 07

Plan J (80' Berm w/ 18' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$688,723	$82,647	$771,370
	Hopper Dredging						
	Site Work, Excavation and Disposal						
	Cell 1	1,068,500	CY	$6.47	$6,913,195	$1,036,979	$7,950,174
	Cell 2	133,200	CY	$6.55	$872,460	$130,869	$1,003,329
	Total Beach Replacement				$8,474,378	$1,250,495	$9,724,873
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 9.89%)	1	Job	LS	$838,116	$123,674	$961,790
	Total Project First Cost				$10,312,494	$1,524,169	$11,836,663
	(Rounded)				$10,312,000	$1,524,000	$11,837,000

Notes:
Dredging quantity includes 4 yr. nourishment cycle.

Table 5K - Total First Cost Price Level: Jun 07

Plan K (105' Berm w/ 18' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$688,723	$82,647	$771,370
	Hopper Dredging						
	Site Work, Excavation and Disposal						
	Cell 1	1,265,200	CY	$6.37	$8,059,324	$1,208,899	$9,268,223
	Cell 2	151,000	CY	$6.50	$981,500	$147,225	$1,128,725
	Total Beach Replacement				$9,729,547	$1,438,770	$11,168,317
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 9.46%)	1	Job	LS	$920,415	$136,108	$1,056,523
	Total Project First Cost				$11,649,962	$1,724,878	$13,374,840
	(Rounded)				$11,650,000	$1,725,000	$13,375,000

Notes:
Dredging quantity includes 4 yr. nourishment cycle.

Table 5L - Total First Cost Price Level: Jun 07

Plan L (85' Berm w/ 20' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$688,723	$82,647	$771,370
	Hopper Dredging						
	Site Work, Excavation and Disposal						
	Cell 1	1,304,200	CY	$6.35	$8,281,670	$1,242,251	$9,523,921
	Cell 2	184,000	CY	$6.49	$1,194,160	$179,124	$1,373,284
	Total Beach Replacement				$10,164,553	$1,504,021	$11,668,574
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 9.46%)	1	Job	LS	$961,567	$142,280	$1,103,847
	Total Project First Cost				$12,126,120	$1,796,302	$13,922,421
	(Rounded)				$12,126,000	$1,796,000	$13,922,000

Notes:
Dredging quantity includes 4 yr. nourishment cycle.

Table 5M - Total First Cost
Plan M (110' Berm w/ 20' NAVD Dune using 4 Yr. Cycle)

Price Level: Jun 07

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$688,723	$82,647	$771,370
	Hopper Dredging						
	Site Work, Excavation and Disposal						
	Cell 1	1,624,900	CY	$6.32	$10,269,368	$1,540,405	$11,809,773
	Cell 2	209,400	CY	$6.45	$1,350,630	$202,595	$1,553,225
	Total Beach Replacement				$12,308,721	$1,825,646	$14,134,367
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 9.46%)	1	Job	LS	$1,164,405	$172,706	$1,337,111
	Total Project First Cost				$14,473,126	$2,148,353	$16,621,479
	(Rounded)				$14,473,000	$2,148,000	$16,621,000

Notes:
Dredging quantity includes 4 yr. nourishment cycle.

Table 5N - Total First Cost Price Level: Jun 07

Plan N (160' Berm w/ 20' NAVD Dune using 4 Yr. Cycle)

ACCOUNT NUMBER	DESCRIPTION OF ITEM	QUANTITY	UOM	UNIT PRICE	ESTIMATED AMOUNT	CONTINGENCY	TOTAL COST
01.	Lands and Damages	1	Job	LS	$0	$0	$0
17.	Beach Replenishment						
	Mobilization, Demob. And Preparatory Work	1	Job	LS	$1,377,446	$165,294	$1,542,740
	Hopper Dredging						
	Site Work, Excavation and Disposal						
	Cell 1	2,306,900	CY	$6.27	$14,464,263	$2,169,639	$16,633,902
	Cell 2	248,900	CY	$6.40	$1,592,960	$238,944	$1,831,904
	Total Beach Replacement				$17,434,669	$2,573,877	$20,008,546
30.	Planning, Engineering and Design (P,E & D)	1	Job	LS	$1,000,000	$150,000	$1,150,000
31.	Construction Management (S & A @ 8.92%)	1	Job	LS	$1,555,172	$229,590	$1,784,762
	Total Project First Cost				$19,989,841	$2,953,467	$22,943,308
	(Rounded)				$19,990,000	$2,953,000	$22,943,000

Notes:
Dredging quantity includes 4 yr. nourishment cycle.

Section 16

Dredging Technology

1. Coastal and Hydraulics Laboratory Letter Report
2. A Guide to the Planning and Design of Jet Pump Remedial Sand Bypassing Systems
3. World Wide Sand By-passing Systems: Data Report

March 26, 2008

Coastal and Hydraulics Laboratory Letter Report

Mobile Hydraulic Backpassing System for the Hereford to Cape May Feasibility Study

March 26, 2008

James E. Clausner, PE
Timothy L. Welp

March 26, 2008

Coastal and Hydraulics Laboratory Letter Report -
Mobile Hydraulic Backpassing System for the
Hereford to Cape May Feasibility Study

Table of Contents

Note – this page is considered optional, and if needed, completed after receipt of comments.

Section	**Page**
Background	2
Study Approach	4
Conclusions	10
Recommendations	12
References	12
Figures 1-5	14-18
Tables 1-6	19-24
Appendix A – Contractor Contact Information	25
Appendix B – Request for Information provided to contractors	26-31
Appendix C – DOP Information Provided	32-38
Appendix D – Javeler Information Provided	39-41

March 26, 2008

Background:

Beach erosion is a problem at North Wildwood, NJ, which is immediately south of Hereford Inlet (Figure 1). As part of the Hereford to Cape May Feasibility Study (simply referred to as the feasibility study from now on) the US Army Corps of Engineers Philadelphia District (NAP) is investigating various options to economically backpass sand from the wide beach to the south, Wildwood, NJ, to North Wildwood (Figure 2). In early February 2008, Mr. Brian Bogle, the project manager for the NAP's Hereford Inlet to Cape May Feasibility study, contacted Messrs. James Clausner (Associate Technical Director for Navigation) and Timothy Welp (Hydraulic Engineer, Coastal Engineering Branch) of the U.S. Army Engineer Research Development Center's (ERDC) Coastal and Hydraulic Laboratory (CHL). Based on recommendations Mr. Jeffrey Gebert (NAP), Mr. Bogle requested CHL assistance in evaluating mobile hydraulic based backpassing systems as possible solutions to the beach erosion problem at North Wildwood. Due to Mr. Welp's prior commitments, Mr. Clausner agreed to conduct the study and have Mr. Welp review the final report. The remainder of this section describes volumes to be backpassed, conventional backpassing options, why mobile submersible pumps may be more desirable for this application, desired submersible pump operating features for this project, and other pertinent engineering details related to this project.

Backpass Volumes. The NAP estimates between 100K and 200K cy/yr need to be backpassed from Wildwood to North Wildwood on an annual basis. However, because of the existing deficit on the North Wildwood beach, a one time "beach nourishment level" effort of 500,000 to 1,000,000 cy is needed prior to the annual backpassing.

Conventional Backpass Options. A proven option for bypassing/backpassing modest volumes is to use conventional earthmoving equipment to collect the sand and then truck it from one location to another. This has been done at Avalon, NJ, twice in the past five years and is being considered at Wildwood. However, the cost of this option, estimated at about $20/cy by NAP for the Wildwood application, is considered to be too expensive. This option also significantly interferes with beach use.

Submersible Pump Options. The high cost and interference with beach use resulting from the conventional earthmoving option for backpassing led to NAP's interest in evaluating mobile hydraulic pumps to entrain the sand at Wildwood in conjunction with booster pumps to transfer the sand to North Wildwood with the desire to reduce costs (ideally to less than $10 per cubic yard). In a recent paper, Chase (2006), described a system based on a submersible pump (Figure 3) deployed from a crane that appears to meet many of the NAP's requirements. The goal Chase's system was to mine a specific volume, 100 to 200K cy from over as limited an area as possible. Chase's (2006) system used a crane for deployment, creating pits in the nearshore zone 15 to 20 ft deep and based costs on backpassing 200K cy a distance of up to 24,000 ft over a period of four months. He also provided data for shorter distances and 100K cy. Chase also included as an option a sheet pile that could be used to increase production by allowing the crane to be positioned further seaward. This sheet pile wall, if used, would have to be removed and moved periodically to mine the relatively thin layer of sand proposed for this project.

NAP Desired Submersible Pump Back Passing Methods. The NAP desires a more mobile system than that described in Chase (2006) with minimal infrastructure support and impact to beach users. Also, rather than dig a series of relatively deep pits, NAP would prefer to remove sand in a thin layer over a wide area with excavation pits no deeper than 10 ft below the zero elevation on the cross section provided by NAP (Figure 4), thought to be typical of the Wildwood Beach. Initially, NAP expressed a desire to remove the material between the blue line (original shoreline) and the red line (minimum cut width) or the black line (maximum cut width) between +5 and -10 ft elevation. Note the datum on this figure in NAVD88. Also, NAP (after discussions with Messrs. Clausner and Welp) requested the contractors consider options to deploy a submersible pump or eductor (jet pump) that could be less expensive than using a crane. Other less expensive deployment options include an A-frame or tripod to deploy the submersible pump. Another option considered by NAP, as described in an e-mail from Mr. Gebert, was to use mechanical equipment, scrapers and dozers to stockpile sand and then use hydraulic pumps to transfer the sand to North Wildwood.

Other Pertinent Details.

Sand Grain Size. The sand to be backpassed is 0.15 mm.

Backpass Distance. Required distance for backpassing is between 5,000 and 15,000 ft, thus booster pumps will be required.

Tide Range. Tide range at the site is 4 ft.

Schedule. Ideally the system would transfer sand outside of the summer tourist season when the beach is most heavily used, thus the material should be transferred from Sep 15th to May15th, a total of 8 months.

With the above background information, most of which was provided during a conference call on Feb 14, 08, Mr. Clausner began the study in early March 2008. Over the course of the study, NAP supplied additional information in response to Mr. Clausner's requests and those from the various companies. An important piece of information was that the datum on the cross section provided was NAVD88. Dr. Don Stauble (CHL), who has done considerable work in the Cape May, provided an estimate of MLLW at Wildwood, which based on NOAA tidal station data, is estimated to be 3 ft below 0.0 NAVD (Stauble 2008).

Study Approach:

Based on the limited time available, less than one month, Mr. Clausner decided to contact a number of reputable companies that sell and, in some cases, perform dredging, with submersible pumps or eductors. Mr. Clausner developed a short Request for Information (RFI) that he supplied to five companies: Javeler Construction Company (Toyo Pumps), Hagler Pumps, Heger Pumps (trade name Drag Flow), DOP (a Dutch company), and Standard Gravel (Genflo Jet Pumps). Appendix A contains the names, phone numbers, e-mail addresses and web sites of the companies contacted. Appendix B contains the full RFI. Following the initial contact, Mr. Clausner had subsequent e-mails and phone conversations with several of the company representatives. Note, we did not investigate any environmental concerns that might be associated with this type of beach mining operation.

March 26, 2008

Results from Contractor Input and CHL Calculations

Between the conference call on February 14, 2008 and late February, 2008, Messrs Clausner and Bogle developed a mutually agreeable SOW and Mr. Bogle provided funds. During the first week in March, Mr. Clausner, with the assistance of Mr. Welp, developed the list of contractors and POCs, and Mr. Clausner developed the RFI. On March 5th, Mr. Clausner provided the RFI to the above listed contractors. The results of the initial contacts follow.

1. Heger Pumps, which sells Drag Flow Pumps, POC is Siegfried Heger. Mr. Heger responded to the initial RFI, and had a phone conversation with Mr. Clausner. The phone conversation with Mr. Heger showed him to be quite knowledgeable (he also provided information to Mr. Chase in the preparation of his 2006 paper). Mr. Clausner was under the impression that Mr. Heger would provide a written response. However, that did not occur.

2. Hagler Pumps, POC's were Mr. Robert Hagler and Ms. Laurie Nalley. Mr. Hagler and Ms. Nalley did not respond to the RFI.

3. Standard Gravel, POC's were Mr. Spencer Green and Mr. John Green. After the initial RFI, Mr. Spencer Green e-mailed Mr. Clausner that he and his father were leaving shortly on an extended trip would not be able to review the RFI until 14 March at the earliest. Mr. Green did not provide any response.

4. Damen Dredging Equipment, a Dutch Company, which sells DOP Submersible Dredge Pumps, POC was Mr. David Tenwolde. Mr. Tenwolde provided considerable information on appropriate DOP submersible pumps, booster pumps and related equipment appropriate for this application. The complete set of information is provided in Appendix C. Perhaps of most interest were details of a somewhat similar application on the east coast of Italy between Venice and Ravenna conducted in 2003, which used two DOP 2320 submersible pumps and a diesel driven booster and associated instrumentation. In this application, the pumping distances ranged from 3,000 to 18,000 ft, and material was transported through a 300 mm (12-inch) pipe. The submersible pump was deployed from a CAT 320 excavator removing sand from a sheet pile lined pit to prevent the excavator from falling into the pit. Average production rate was 400 cu m/hr (520 cy/hr) over the entire operation.
    a. While the information on this Italian application showed the DOP equipment is very likely quite suitable for the Wildwood Backpass project, specific information on proposed operating scenarios, and total costs for the Wildwood Backpass project were not provided. A rough cost for the full set of equipment specified was provided by Mr. Tenwolde, which included a D2320 pump, diesel driven hydraulic power unit and instrumentation ($410,000), production meter ($66,000), and diesel powered booster pump station ($257,000), which totals to $733,000 based on a $1.56 per Euro conversion rate.
    b. Requesting additional information on the Italian application and attempt to get more detailed costs for Wildwood application was considered. However, our

expectation of success was low, so it was decided to focus our efforts in the information provided by Javeler Construction Company described next.

5. Javeler Construction Company (Toyo Pumps), our initial POC was Mr. Leslie Cross, however, following the initial e-mail, Mr. Richard Binning responded to the RFP. Toyo is a Japanese submersible pump, sold in the US via the Toyo Pumps office in Vancouver, BC, Canada (associated with Javeler Construction Company). Javeler Construction company has its main office in New Iberia, LA, and while the office in Vancouver, BC that helps to market Toyo Pumps, it is primarily a specialized construction company. Mr. Binning in the Vancouver, BC office provided considerable information that specifically addressed the RFI. The remainder of the report is based on information provided by Mr. Binning and developed by Mr. Clausner and modifications to the operating details developed through a series of e-mails between Messrs Clausner, Bogle and Gebert. Provided initially is the information developed by Mr. Clausner, followed by input from Mr. Binning.

CHL Calculations of Project Duration. To assist both the contractors and NAP, we calculated the time required to backpass 100K cy, 200K cy, 500K cy, and 1 M cy at average production rates of 400 cy/hr and 600 cy/hr. The calculation rates of 400 cy/hr and 600 cy/hr calculations were based on initial information from Mr. Binning as possible production rates for a 12 inch and 14 inch Toyo pump, respectively. Not knowing the specific operating schedule, calculations were made for 5, 6, and 7 day/week operations and daily work times of 8, 9, 10, 12, 16 and 24 hr. A subsequent set of calculations were made at a 300 cy/hr production rate. This was based on a March 18th e-mail from Mr. Binning where he indicated a production rate of 300 cy/hr was assumed as a long-term average production rate to include crane movement. Using this same logic, i.e., a 25% reduction in production in the 600 cy/hr rate for the larger Toyo pump to account for crane movement, a set of calculations using a production rate of 450 cy/hr was made. Tables 1and 2 provide the project durations based on the 300 and 450 cy/hr production rates, respectively. An Excel spreadsheet with the full set of production rate calculations is being provided to NAP along with this report.

Because the vast majority of the Javeler information is based on a 300 cy/hr production rate, most of the following discussions are based on Table 1. Also, the discussions focus on the assumptions made by Mr. Binning: a 5-day work week, 8 dredging hours per day, 22 working days per month (4.33 weeks/month) a 15,000 ft pumping distance. Of prime importance is the assumption is that the long term average production rate of 300 cy/hr is based on being able to mine sand from an elevation of +5 NAVD to -10 NAVD, or a vertical height of 15 ft. For the annual backpass rates of 100,000 and 200,000 cy/hr, the actual project durations, defined as the months required for pumping only, not including mob and demob, based on the 5 day, 8 hr/day are 1.9 months (100K cy) and 3.8 months (200 K cy). Based on the same pumping rate and schedule, backpassing 500K cy is probably marginal, 9.5 months, which is longer than the 8 month non-summer season). Backpassing 1.0M cy at the 300 cy/hr, 8 hr/day, 5 day/week would take almost 19 months, and is assumed to be unacceptable.

From Table 1, it can be seen that increasing the number of hours per day of pumping or the number of days/week pumping occurs, shortens the duration required, for example pumping 9 hours per day reduces the pumping time to 3.4 months (200K cy) and 1.7 months (100K cy).

To backpass 500K or 1M cy in less than 8 months would require higher production rates. Examining Table 2 shows 500K cy could be backpassed in 6.3 months at the 8-hr/day, 5 day/wk work schedule and 1.0 M cy could be backpassed in 7 months on a 12-hr/day, 6 day per week schedule. These larger backpass volume requirements might be more logically treated as a more conventional beach nourishment job, i.e., a 24-hr/day, 7-day/wk schedule. In that case, the pumping duration would reduce to 1.5 months for the 500K cy and 3.0 months for the 1.0M cy. The tables also provide information on pumping duration based on other schedules, e.g., 12-hr/day and 16-hr/day which might be better received by the residents.

CHL Calculations of Volumes Available for Different Beach Mining Swath Widths. To assist the contractors and NAP, we calculated volumes of sand available per unit width of beach and used that information to calculate the volumes available for a given swath width. A swath is defined as the width of the beach that can be mined without moving the submersible pump deployment device. For example a crane with a 100 ft boom, would have a swath width of approximately 200 ft.

The vertical datum on the cross section (Figure 4) is NAVD88. At this location in New Jersey, the Mean Lower Low Water (MLLW) datum is approximately 3.0 ft below NAVD88. NAP indicated they would like to limit the sand mining depth to about -3.0 ft MLLW (-6.0 ft NAVD88) to minimize offshore beach impacts. Based on this assumption, slopes of the various profiles were measured, including the max cut profile (Black line), minimum cut profile (Red line), and original profile (Blue Line), both on the "dry beach" assumed to be between +5 ft NAVD88 (+8 ft MLLW) and 0.0 ft NAVD88 (+3 ft MLLW); and on the "wet beach" 0.0 ft NAVD88 (+3 ft MLLW) and -6.0 ft NAVD88 (-3.0 ft MLLW). The somewhat arbitrary division between the "dry beach" and "wet beach" was based on the change in the slope at the 0.0 ft elevation NAVD88. The average distances between the lines were also measured and converted to feet, with the results shown in Table 3.

The dry beach widths listed in the top of Table 3 are easy to visualize and were used in volume computations described below. The wet beach slopes may help contractors decide operating methods.

Using this information, the cross sectional areas of the dry and wet beaches were computed as shown in Table 4. For example, the cross sectional area of dry beach for the max cut is 1,500 ft^2. Per foot of beach width, that corresponds to a volume of 55.6 cy. To assist in computing how many cubic yards could be removed from a "single" positioning of the submersible pump, the volume available in 50 ft increments were computed from 50 to 250 ft for both the "maxim cut" and "minimum cut" for the dry beach and wet beach. For example, if a large crane is used to mine a 250 ft wide swath of beach (i.e., a crane with a boom length of 125 ft), the volume available is 22,000 cy from single locations. For the dry beach I assumed a rectangular area (plan view), while for the wet beach, I assumed a half circle in area to account for the swing radius of the crane.

Table 5 shows the length of beach required to provide a given volume, from 100K cy to 1M cy based on both the maximum and minimum cuts. Noteworthy is the length of beach required for mining to get 1M cy; over 10,000 ft for the max cut and almost 17,000 ft for the minimum cut. These required lengths may cause the District to consider increasing the maximum mining depth of –3.0 ft MLLW.

Table 6 provides he number of times the system would have to be moved to remove the volumes required at the minimum and maximum cut for a range of swath widths. This clearly shows the value of having a system that can remove sediment from a wide swath width. For example using the minimum cut at a 50 ft swath width to move the larger beach nourishment volume of 1M cy would require 370 moves, while a 250 ft swath width would required only 74 moves. For the smaller, annual backpassing requirements, the narrow swath widths are not as much of a burden. For example to transfer 100K cy at a 50 ft swath width for the maximum cut requires the system to be repositioned 22 times, while at the 250 ft swath width and the maximum cut only requires 4 moves. Thus, for the renourishment, a system with a larger swath removal width would likely be required to keep costs low, while for the smaller annual backpassing, a less costly system based on a smaller swath width may be suitable.

Response to CHL REP from Richard Binning (Javeler Construction Company). The information below has been extracted from the response provided by Mr. Richard Binning on March 11th, 2009. The complete original response can be found in Appendix D. Mr. Binning stated in his introduction that

> " Based on your description of the North Wildwood application, we can meet your target price of $ 10 per cubic yard. There are a lot of details to go over, but conceptually, this is achievable. Javeler has the capability to do the work as a contractor or to provide equipment and technical support. "

Mr. Binning provided information for two options, the first option, on which his more detailed cost estimates were based, was for a Javeler 12 inch Electric Submersible Mobile Dredging System. The second option was based on a Javeler 14 inch Submersible Mobile Dredging System.

Option 1 – 12 Inch System. The 12-inch electric system is capable of transferring 3,000 – 4,000 gpm of slurry at a maximum distance of 15,000 ft. Sand production of up to 400 cubic yards per hour of material is possible with this system. The prime mover in this system is a Toyo 150 hp electric submersible agitator dredge pump which would be suspended from a crane with 120 – 160 feet of boom. Power would be from a 300kW generator to be mounted on the back of the crane, fuel usage is estimated at18 gal/hr. The unit is capable of transferring sand at up to 50 % solids by weight. Output from the pump is through a 10-inch gum lined dredge hose to 12 inch HPDE pipe on the beach. Diesel engine powered, skid mounted boosters would be placed every 5,000 feet to transfer the sand slurry to the south inlet location. Horsepower requirement for each booster is 400 hp.

Responding to a subsequent e-mail from Mr. Clausner, Mr. Binning provided the following assumptions on which the $10/ per cubic yard estimate was based.

1. The Javeler proposal at $10/yd was based on dredging from +5 to -10 NAVD88.
2. Javeler assumed 100,000 to 200,000 cubic yards of sand to be moved.
3. The cost estimate was based on:
    a. Single shift (8 dredging hours per day); 5 days/wk; 22 days per month.
    b. $ 4/gallon diesel fuel.
    c. Included beach grading on discharge side.
    d. 15,000 feet pumping distance with maximum 15' vertical lift.
4. The cost estimate was based on utilizing the most standard, readily available submersible dredging system that Javeler has, the 150 hp Toyo electric submersible dredge pump through 12 inch HDPE pipe with boosters every 5,000 ft.
5. Production was based on an average production of 300 cy/hr, although at times, the system will be pumping in excess of 400 cy/hr. Time to relocating the crane is included in the average production rate.

Option 2 - 14 inch System. The 14 inch hydraulic system is capable of transferring 5,000 – 6,000 gpm of slurry at a maximum distance of 15,000 ft. The maximum sand production rate of the system is 600 cy/hr. The system consists of a Toyo 12-inch hydraulic driven submersible agitator dredge pump suspended from a crane with 120 – 160 feet of boom, or mount directly to a large excavator and use the hydraulics from the rig to run the pump. An external hydraulic power unit (350 hp), if required, would be mounted on the back of the crane. The system will pump a sand slurry up to 50 % solids by weight through a 12 inch gum tube lined dredge hose to 14 inch HPDE pipe on the beach. Diesel engine powered, skid mounted booster pumps with marine gear drives, will be placed every 5,000 feet to transfer the sand slurry to the south inlet location. The horsepower requirement for each booster is 500 hp.

Manpower required for the backpassing system is a function of pumping distance. Javeler likes to have one additional man per booster station (every 5,000 ft). The base system with 5,000 ft of line requires 3 people to operate it (Javeler is non union).

Mr. Binning noted that the deeper the "cut" the more efficient the submersible agitator dredging system is. Also allowing a cut to -10 ft NAVD ensures an adequate water supply to the submersible and uninterrupted dredging operations. Excavation in the intertidal zone should ensure quick sand replacement. The simplest, most effective system is to hang the submersible from a crane.

BullDozer Production and Cost Information. This is not an area of our expertise, however, between the internet and other sources we compiled the following information that may prove useful in developing backpass options that use land based equipment. An internet search found Figure 5, maximum production rates for a range of Caterpillar bulldozers for a range of haul distances. This information came from the Food and Agriculture Organization of the United Nations (1998). The chapter provided factors that can be used to compute production under a range of materials, slopes and conditions. Not having any background in this area, we choose not to attempt to modify these production rates. However, it provides a starting point. For

example a D8 dozer's maximum production rate with loose material is about 400 cu m/hr (520 cy/hr) for a 50 meter (164 ft) average dozing distance. This is approximately equal to the production rate of the submersible pumps and thus appears to be a reasonable option to "feed" the submersible pump in a backpassing situation.

We also developed some limited cost data that may be useful in evaluating options that make greater use of land based equipment. Mr. Brian Peterson of St. Paul District Fountain City Area Office (personal communication), estimated a D-7 dozer uses 100 gallons of diesel fuel in a 10-hr day of moving sand. Assuming fuel consumption is roughly comparable to hp, and a D-7 bulldozer hp is 240, while a D8 bulldozer hp is 310, thus fuel consumption of a D-8 bulldozer is 130 gallons in a 10 hr day or 13 gallons per hour. Mr. William Welk (personal communication), cost estimator at NAP, provided a cost estimate for a D-8 Bulldozer. The estimate, based on an 8-hr day at fuel at about $3.10 per gallon in bulk, was $2,250 per day. Details of the cost estimate are attached (PDF file).

Hopefully, the above information could be used by a competent cost estimator or dredging contractor in producing cost estimates for bulldozer assistance in a hydraulic based mobile backpass system.

Chase (2006) Review Comments. Mr. Clausner reviewed the Chase (2006) paper in light of this study and has the following comments. The backpass system proposed by Chase is somewhat different than the system desired in this study as noted earlier. The backpass fuel costs, assumed to be for crane, submersible pump and booster pumps are based on a fuel cost of $2.00 per gallon. Increasing the fuel cost to $4.00 per gallon raises the estimated backpass costs by about 9%, increasing the cost for bypassing 200,000 cy from $7.05/cy to $7.65. Note, there was no attempt to update any of the other costs presented in the Chase paper. We assume that other fuel costs are associated with the nourished area grading, but were not broken out separately and thus the overall increase associated with the increasing cost of fuel could not be calculated. For future efforts on this study, persuading Mr. Chase to provide the details he used to develop his paper would be worthwhile.

Conclusions

Information provided by Javeler Construction Company concludes it is possible to backpass 200K cy of beach sand a distance of 15,000 ft over a period of about two to four months using a crawler crane to deploy a submersible pump at a cost of about $10/cy. This is based on the following assumptions: use of a rented crane with a 120 to 160 ft boom, mining pits down to – 10 ft NAVD88, and $4/gallon diesel fuel. Mr. Welp's experience with Javeler Construction Company has been positive, and Mr. Clausner's limited experience with Javeler has also been positive. The bottom line is that the information from Chase 2006, reinforced by the more recent and Wildwood project specific information from Javeler Construction Company leads us to believe that a mobile based hydraulic backpass system has good potential for meeting NAP's goal of approximately $10/ cy.

However, it must be noted that with the limited information we developed, we cannot conclude that the $10/cy unit price is possible with "surgical" or a limited depth beach (-3 ft MLLW) mining plan. Also, we were not able to get feedback from our contractors on backpassing costs that included the use of land based equipment, i.e., bulldozers and scrapers, to feed material to a hydraulic based system. Our intuition is that this option would be more expensive than the crane based system, but we cannot say for sure or how much more expensive. We were able to gather some data that may assist others in conducting that analysis.

Another question we were unable to answer is potential cost savings associated with a less expensive deployment method. We think the lower cost of the simpler deployment system may be more than offset by the smaller capture area with the simpler deployment system and large number of times the system would have to be moved. In fact, after additional discussions, we believe a crawler crane is probably by far the best method to effectively deploy the submersible pump.

In addition to examining the annual backpassing requirements, NAP requested unit cost estimates for a one time backpassing of 500K to 1 M cy. The duration to backpass 500K cy, 7.7 months working 10 hr days five days a week and 1 M cy, 8 months working 16-hr days, 6 days/wk, make use of the smaller system marginal at best. The larger system proposed by Javeler Construction Company appears capable of bypassing these larger amounts in a reasonable amount of time, i.e., easily less than one eight month beach off season, e.g., 500K cy in 6.4 months pumping 8-hr/day, 5 days/week, and 1 M cy in 7.1 months pumping 12-hr/days and 6days/wk. Working 24/7 makes these durations much shorter, 1.5 months for 500K cy and 3.1 months for 1M cy.

A major issue for the large one time beach nourishment volumes is the long length of beach required to provide sufficient volume if the shallower sand mining limit (-3 ft MLLW) is used. For example, to mine 500 K cy over the minimum cut width would require about 8,400 ft of beach and to mine 1 M cy over the minimum cut width would require almost 17,000 ft of beach. Even at the maximum cut width, the beach length required is over 5,000 ft for 500K cy and 10,000 ft for 1M cy.

The shallower mining depths will increase costs due to the frequency the system would have to be moved. Assuming no infilling occurs and a 100 ft wide swath width is being removed, the system would have to be moved 19 times if the minimum beach width cut is used. For a 500K or 1M cy backpassing, the number of movements required with a 100 ft wide swath range from 56 (500K cy, max cut width), to 185 (1M cy, min cut width). While repositioning a crane and using a flexible HDPE pipeline is not a major issue, these figures imply that without significant infilling of the craters during operation, these minimum swath widths would likely be impractical for the beach nourishment volume and significantly increase costs for the smaller annual volumes, particularly for a non-crane deployment option.

The 100 to 200K cy annual backpassing duration is not excessive, so "aesthetics" (i.e., a large crane on the beach) may be less of a problem." For a 500K to 1,000 K cy backpass operation, where the crane/dozers, etc., will be on the beach longer, this may become more of an issue.

However, using a larger, more robust system on a longer work schedule, perhaps even a 24/7 basis would reduce beach impacts by lessening the time required to complete the project.

Recommendations

First get good data on crater infilling rates. While sediment transport models can provide some estimates, the rate of filling of the craters at Indian River Inlet will provide the best information. If the rates of filling are sufficiently high, then allowing deeper mining depths may be justified. Also, as recommended by Chase (2006), a bucket could be mounted on the crane and the crater refilled to some degree to reduce safety issues. This would, obviously, add to costs and durations.

Perhaps the best recommendation would be to provide a modest sum to an experienced contactor, e.g., Javeler, and have them do several more detailed cost estimates with various options; submersible pumps deployed with a crane, other deployment options, e.g., using land based equipment for a large portion of the sub aerial sand removal.

Another issue to consider when developing options would be to examine purchasing the majority of the HDPE pipeline as opposed to renting it. The last 5,000 to 8,000 ft could remain buried on the North Wildwood beach once a sufficient beach width is established.

Consider a small demonstration project, by identifying an application with a current need for backpassing some modest amount of sedments. Javeler Construction Company has indicated they could mobilize a 12 inch system to pump up to 5,000 feet within 2 weeks. They estimate the dredging costs would not exceed $10/yard, based on a minimum volume of 40,000 yards. Prior to this demonstration, the contractor should visit the Indian River Inlet Bypass plant to get information on present operating methods and lessons learned, e.g., the influence of waves and tide on crater infilling and production rates and advantages and disadvantage of working alongshore vs cross shore. This information would also be valuable for the contractor performing the more detailed cost estimates described above.

Finally, the recent increases in the price of diesel fuel will likely raise prices across the board. We believe the purely land based backpassing option, i.e., using scrapers, dozers, and dump trucks, would be more impacted than the hydraulic based backpassing options.

References

Chase, S. (2006). "Sand back-passing with land based equipment, a cost-effective approach for beach restoration," Shore and Beach Vol 74, No 2, Spring 2006), pp 19-25.

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March 26, 2008

Peterson, B. (2008). Personal communication, telephone call with Mr. Tim Welp, March 24, 2008.

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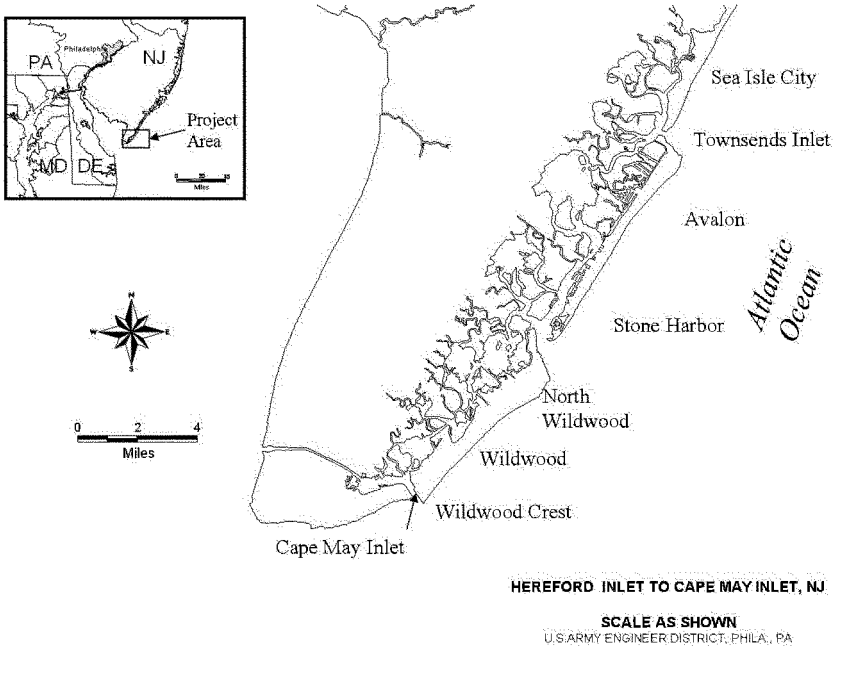


Figure 1. Location map.

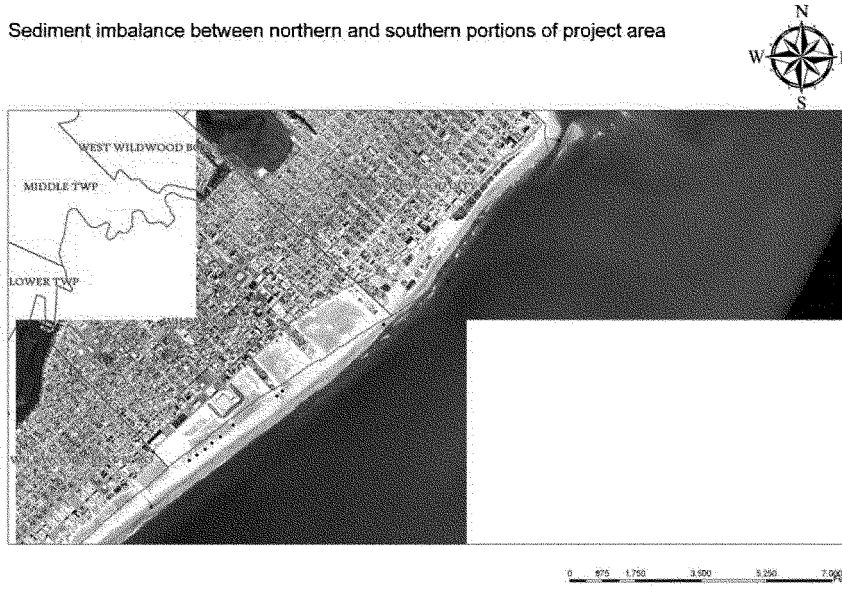


Figure 2. Aerial photo of project area.

Figure 3. Crane deploying submersible pump from jetty

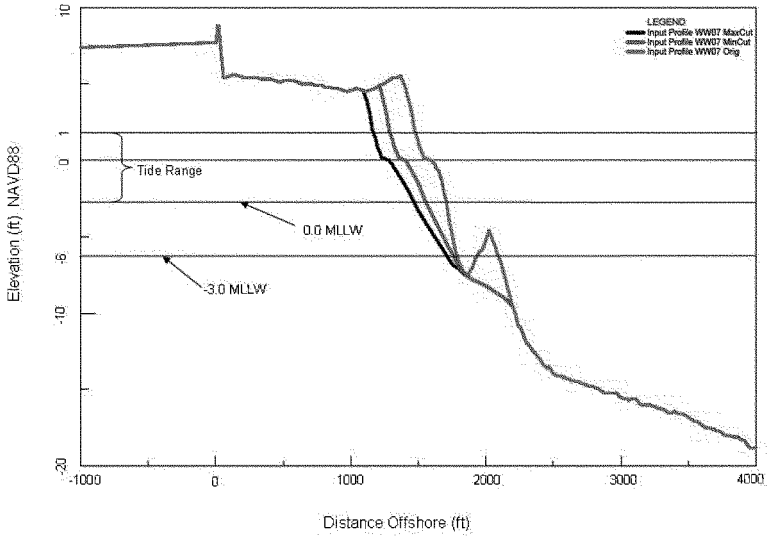


Figure 4. Beach profile at Wildwood showing proposed borrow location. Note this figure has an error, it shows the tide range as 6 ft. This will be corrected on Wednesday AM.

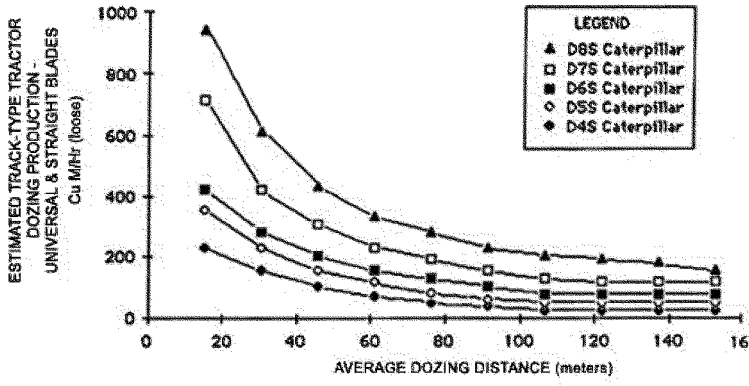


Figure 5. Maximum production rates for different bulldozers equipped with straight blades in relation to haul distance (from Caterpillar Handbook, 1984).

Table 1. Hereford Inlet - Wildwood Beach Backpassing Rates and Durations
Based on 300 cy/hr long term average production

Scenario Number	Volume Backpassed (cy)	Average production Rate cy/hr	Working hours per day	Avg Daily Production (cy)	Working days per week	Avg Weekly Production (cy)	Job Duration (months)
1	1,000,000	300	8	2,400	5	12,000	18.9
2	1,000,000	300	9	2,700	5	13,500	16.8
3	1,000,000	300	10	3,000	5	15,000	15.2
4	1,000,000	300	12	3,600	5	18,000	12.6
5	1,000,000	300	16	4,800	5	24,000	9.5
6	1,000,000	300	8	2,400	6	14,400	15.8
7	1,000,000	300	9	2,700	6	16,200	14.0
8	1,000,000	300	10	3,000	6	18,000	12.6
9	1,000,000	300	12	3,600	6	21,600	10.5
10	1,000,000	300	16	4,800	6	28,800	7.9
11	1,000,000	300	24	7,200	7	50,400	4.5
12	500,000	300	8	2,400	5	12,000	9.5
13	500,000	300	9	2,700	5	13,500	8.4
14	500,000	300	10	3,000	5	15,000	7.6
15	500,000	300	12	3,600	5	18,000	6.3
16	500,000	300	16	4,800	5	24,000	4.7
17	500,000	300	8	2,400	6	14,400	7.9
18	500,000	300	9	2,700	6	16,200	7.0
19	500,000	300	10	3,000	6	18,000	6.3
20	500,000	300	12	3,600	6	21,600	5.3
21	500,000	300	16	4,800	6	28,800	3.9
22	500,000	300	24	7,200	7	50,400	2.3
23	200,000	300	8	2,400	5	12,000	3.8
24	200,000	300	9	2,700	5	13,500	3.4
25	200,000	300	10	3,000	5	15,000	3.0
26	200,000	300	12	3,600	5	18,000	2.5
27	200,000	300	16	4,800	5	24,000	1.9
28	200,000	300	8	2,400	6	14,400	3.2
29	200,000	300	9	2,700	6	16,200	2.8
30	200,000	300	10	3,000	6	18,000	2.5
31	200,000	300	12	3,600	6	21,600	2.1
32	200,000	300	16	4,800	6	28,800	1.6
33	200,000	300	24	7,200	7	50,400	0.9

Scenario Number	Volume Backpassed (cy)	Average production Rate cy/hr	Working hours per day	Avg Daily Production (cy)	Working days per week	Avg Weekly Production (cy)	Job Duration (months)
34	100,000	300	8	2,400	5	12,000	1.9
35	100,000	300	9	2,700	5	13,500	1.7
36	100,000	300	10	3,000	5	15,000	1.5
37	100,000	300	12	3,600	5	18,000	1.3
38	100,000	300	16	4,800	5	24,000	1.0
39	100,000	300	8	2,400	6	14,400	1.6
40	100,000	300	9	2,700	6	16,200	1.4
41	100,000	300	10	3,000	6	18,000	1.3
42	100,000	300	12	3,600	6	21,600	1.1
43	100,000	300	16	4,800	6	28,800	0.8
44	100,000	300	24	7,200	7	50,400	0.5

Table 2. Hereford Inlet - Wildwood Beach Backpassing Rates and Durations

Based on 450 cy/hr long term average production

Scenario Number	Volume Backpassed (cy)	Average production Rate cy/hr	Working hours per day	Avg Daily Production (cy)	Working days per week	Avg Weekly Production (cy)	Job Duration (months)
1	1,000,000	450	8	3,600	5	18,000	12.6
2	1,000,000	450	9	4,050	5	20,250	11.2
3	1,000,000	450	10	4,500	5	22,500	10.1
4	1,000,000	450	12	5,400	5	27,000	8.4
5	1,000,000	450	16	7,200	5	36,000	6.3
6	1,000,000	450	8	3,600	6	21,600	10.5
7	1,000,000	450	9	4,050	6	24,300	9.4
8	1,000,000	450	10	4,500	6	27,000	8.4
9	1,000,000	450	12	5,400	6	32,400	7.0
10	1,000,000	450	16	7,200	6	43,200	5.3
11	1,000,000	450	24	10,800	7	75,600	3.0
12	500,000	450	8	3,600	5	18,000	6.3
13	500,000	450	9	4,050	5	20,250	5.6
14	500,000	450	10	4,500	5	22,500	5.1

15	500,000	450	12	5,400	5	27,000	4.2
16	500,000	450	16	7,200	5	36,000	3.2
Scenario Number	Volume Backpassed (cy)	Average production Rate cy/hr	Working hours per day	Avg Daily Production (cy)	Working days per week	Avg Weekly Production (cy)	Job Duration (months)
17	500,000	450	8	3,600	6	21,600	5.3
18	500,000	450	9	4,050	6	24,300	4.7
19	500,000	450	10	4,500	6	27,000	4.2
20	500,000	450	12	5,400	6	32,400	3.5
21	500,000	450	16	7,200	6	43,200	2.6
22	500,000	450	24	10,800	7	75,600	1.5
23	200,000	450	8	3,600	5	18,000	2.5
24	200,000	450	9	4,050	5	20,250	2.2
25	200,000	450	10	4,500	5	22,500	2.0
26	200,000	450	12	5,400	5	27,000	1.7
27	200,000	450	16	7,200	5	36,000	1.3
28	200,000	450	8	3,600	6	21,600	2.1
29	200,000	450	9	4,050	6	24,300	1.9
30	200,000	450	10	4,500	6	27,000	1.7
31	200,000	450	12	5,400	6	32,400	1.4
32	200,000	450	16	7,200	6	43,200	1.1
33	200,000	450	24	10,800	7	75,600	0.6
34	100,000	450	8	3,600	5	18,000	1.3
35	100,000	450	9	4,050	5	20,250	1.1
36	100,000	450	10	4,500	5	22,500	1.0
37	100,000	450	12	5,400	5	27,000	0.8
38	100,000	450	16	7,200	5	36,000	0.6
39	100,000	450	8	3,600	6	21,600	1.1
40	100,000	450	9	4,050	6	24,300	0.9
41	100,000	450	10	4,500	6	27,000	0.8
42	100,000	450	12	5,400	6	32,400	0.7
43	100,000	450	16	7,200	6	43,200	0.5
44	100,000	450	24	10,800	7	75,600	0.3

Table 3. Beach widths used to compute backpass volumes				
Beach Segment	Elevation	Line Color – Average Slope	Max Cut Width	Min Cut Width
Dry Beach	+5.0 ft NAVD 88 (+8.0 ft MLLW) to 0.0 ft NAVD 88 (+3.0 ft MLLW)	All colors 1V:25H	300 ft	185 ft
Wet Beach	0.0 NAVD88 (+3 ft MLLW) to -6.0 ft NAVD 88 (-3.0 ft MLLW)			
		Blue Line - original 1V:26 H		
		Black Line – max cut 1V:69H		
		Red line – min cut 1V:54H		

Table 4. Hereford Inlet - Wildwood Beach Sand Volumes Available for Different Mining Depths										
Cross Sectional Areas										
"Dry Beach - +5 NAVD88 (+8 ft MLLW) to 0.0 NAVD88 (+3 ft MLLW)										
		Width (ft)	Height (ft)	Area (sq ft)	Volume (cy per ft/beach)	Volume per 50 ft (cy)	Volume per 100 ft (cy)	Volume per 150 ft (cy)	Volume per 200 ft (cy)	Volume per 250 ft width (cy)
Max Cut - Blue to Black Line		300	5	1,500	56	2,800	5,600	8,300	11,000	14,000
Min Cut – Red to Black Line		185	5	925	34	1,700	3,400	5,100	6,900	8,600
"Wet Beach - 0.0 NAVD88 (+3 ft MLLW) to - 6 NAVD88 (-3 ft MLLW)										
Assume a trapezoidal shape	Top Width (ft)	Bottom Width (ft)	Height (ft)							
Max Cut - Blue to Black Line	300	83	6	1140	42.6	1,700	3,300	5,000	6,700	8,400
Min Cut – Red to Black Line	185	41.4	6	679	25.2	990	2000	3,000	3,900	4,900
			Total Volume Available for wet and dry beach							
					Max Cut	4,400	8,900	13,000	18,000	22,000
					Min Cut	2,700	5,400	8,100	11,000	14,000

638

Table 5. Total Volume Available/ft of beach width						
			Length of beach (ft) needed to remove			
		Volume (CY per ft/beach)	100,000 cy	200,000 cy	500,000 cy	1,000,000 cy
	Max Cut - Blue to Black Line	98	1,000	2,000	5,100	10,000
	Min Cut - Red to Black Line	59	1700	3,400	8,400	17,000

Table 6. Number of deployment system movements required to move a given volume of sand

			100,000 cy	200,000 cy	500,000 cy	1,000,000 cy
Movements for a 50 ft swath		Max	22	45	112	225
Movements for a 50 ft swath		Min	37	74	185	370
Movements for a 100 ft swath		Max	11	22	56	112
Movements for a 100 ft swath		Min	19	37	93	185
Movements for a 150 ft swath		Max	7	15	37	75
Movements for a 150 ft swath		Min	12	25	62	123
Movements for a 200 ft swath		Max	6	11	28	56
Movements for a 200 ft swath		Min	9	19	46	93
Movements for a 250 ft swath		Max	4	9	22	45
Movements for a 250 ft swath		Min	7	15	37	74

March 26, 2008

Appendix A
Contractor Contact Information

1. Heger Pumps. POC - Mr. Siegfried Heger, (562)-989-5432, Sheger@hegerpumps.com http://www.dragflow.com/Default.htm

2. Hagler Pumps. POC – Mr. Robert Hagler and Ms. Laurie Nalley, 803-278-2728, bobhagler@haglersystems.com , laurieNalley@haglersystems.com http://www.haglersystems.com/about.htm

3. Javeler Construction Company. POC – Mr. Richard Binning, 604-929-9543, rbinning@telus.net http://www.toyopumps.com/pumps/submersibles/submersiblelist.html

4. Standard Gravel Company, POC – Mr. Spencer Green, (985) 839-3442, sgreen@genflopumps.com http://www.genflopumps.com/

5. Damen Dredging Equipment, POC – Mr. David Tenwolde, +31(0)33 247 40 40 dt@damendredging.com http://damendredging.com/html/en/dop.htm

March 26, 2008

Appendix B
Request for Information Provided to Contractors

Request for Conceptual Mobile Hydraulic Backpassing System for the Hereford to Cape May Feasibility Study

Background: The beach immediate south of Hereford Inlet, North Wildwood, NJ, is experiencing erosion (Figure 1). As part of the solution to this erosion problem, the US Army Corps of Engineers Philadelphia District (NAP) is investigating the various options to that would economically backpass sand from the wide beach to the south, Wildwood, NJ, to North Wildwood (Figure 2).

The NAP estimates between 100,000 and 200,000 cy/yr need to be bypassed on an annual basis. However, because of the existing deficit on the North Wildwood beach, a one time "beach nourishment" effort of 500,000 to 1,000,000 cy is needed initially.

Need/Requirements: A proven option for bypassing/backpassing modest volumes is to use conventional earthmoving equipment to collect the sand and then trucking the sand from one location to another. This has been done at Avalon, NJ, twice in the past five years and is being considered at Wildwood. However, the cost of this option, estimated a $20/cy by NAP for the Wildwood application, is considered to be too expensive, it also significantly interferes with beach use. NAP is interested in looking at mobile hydraulic pumps to entrain the sand at Wildwood in conjunction with booster pumps to transfer the sand to North Wildwood with the desire to reduce costs, ideally to less than $10 per cubic yard. The attached paper by Stuart Chase (Shore and Beach Vol 74, No 2, Spring 2006), describes a system based on a submersible pump deployed from a crane that meets many of the NAP's requirements. However, the sheet pile wall specified as part of the system, would add to the cost and create a feature that would have to be removed and moved periodically.

The NAP desires a more mobile system with minimal infrastructure support and impact to beach users. Also, rather than digging series of relatively deep pits, NAP would prefer to remove sand in a thin layer over a wide area with excavation pits no deeper than 10 ft below mlw. A typical cross section of the Wildwood beach is shown in Figure 4. NAP desires to remove the material between the blue and black lines between +5 and -10 (the outermost lines in case the colors are not visible), a horizontal distance of between 250 and 350 ft. Also, to reduce costs they would like to avoid using a crane to deploy the submersible pump (or eductor), instead using less expensive system such as an A-frame or tripod to deploy the submersible pump. Another option is to use mechanical equipment, scrapers and dozers to stockpile sand and then use hydraulic pumps to transfer the sand to North Wildwood.

The sand to be backpassed is 0.15 mm. A challenge will be the distance to bypass the sand, between 5,000 and 15,000 ft, thus booster pumps will be required. Tide range at the site is 4 ft.

Ideally the system would transfer sand outside of the summer tourist season when the beach is most heavily used, thus the material should be transferred from 15 Sep to 15 May.

Additional Needs for Portable, Mobile Hydraulic Backpass Systems. As noted, this information is for a feasibility study, and thus the information provided is not a commitment to you for actual work. The actual work for the Wildwood to North Wildwood backpassing is probably several years away. However, the need to backpass sediments from wider beaches to erosion "hot spots" is a problem at many locations around the US. While typical beach renourishment intervals are 5 to 10 years, in many locations erosion "hot spots" develop quickly (within months to a couple of years) that require from a few 10K cy to 100 K cy with distances on the order of a few thousand feet or more. In New Jersey alone, NAP estimates there are currently several projects, e.g., Avalon, Atlantic City, Brigantine, and Ocean City, that could make use of a low-cost hydraulic based system now. Obviously, for the smaller volume projects, a very mobile system that could be easily moved to another site would be advantageous. **Hopefully the potential to quickly turn a good conceptual system into a functioning system will motivate you to devote some serious effort to this request.**

Deliverables: This is a request for you to describe a conceptual system/systems that can meet the requirements stated above. Please include the following.

1. A description of the system components including specific pump(s), hp, discharge line sizes, power sources, etc.
2. A description how the system would be operated.
3. Manpower requirements and skills for the operators (ideally the system or most if it could be operated by city workers)
4. Estimated costs and durations (please state assumed schedule, i.e., 5 days/per week, 8 hours/day, etc.) to backpass annual volumes of 100K cy, 200k cy, 500K cy, and 1,000,00 cy. The cost estimate should be based on an assumed cost for diesel fuel of $4.00/gallon. The cost estimate should have sufficient information so the cost estimate can be updated based on changes in the cost of diesel fuel.
5. Please note any uncertainties or additional information that would be needed for improving the accuracy of your proposal.
6. Typical "beach nourishment" grading of the sand placed in North Wildwood will be required, i.e., a specific berm width, height, and foreshore slope.
7. We realize that some systems may not be able to fully meet every requirement. However, please feel free to submit a system that meets most the requirements and note the limitations.
8. As noted above, if time permits, you may want to provide information for a second, smaller, and more portable system.
9. We hope to have cost and performance data on the land based backpassing at Avalon, NJ, in a day or two.

Deadline: Final input is desired by COB on 13 March, and no later than COB 14 March. Ideally this will be in the form of MS Word document.

March 26, 2008

Follow-on Questions. I expect in most cases, you will have additional questions. I, James Clausner (US Army Engineer Research and Development Center, Vicksburg, MS), and NAP staff will be available for follow-up phone calls on Thursday and Friday, March 6 and 7, and Monday, March 10th, to answer additional questions. Please contact me to set up a time.

POC:
James E. Clausner, PE
Associate Technical Director for Navigation,
Coastal and Hydraulics Laboratory,
CEERD-HV-T
3909 Halls Ferry Rd
Vicksburg, MS 39180, 601-634-2009
james.e.clausner@usace.army.mil

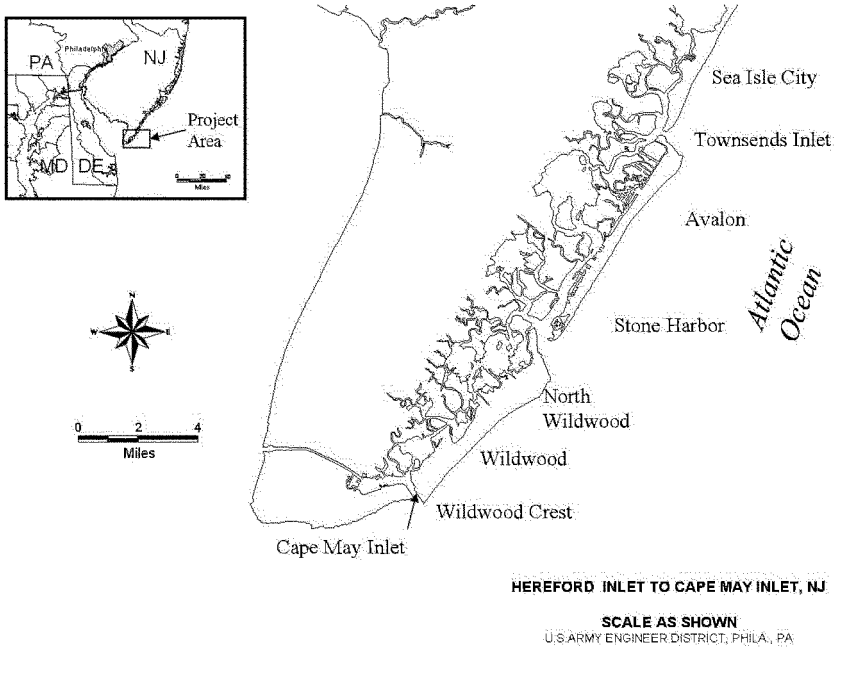


Figure 1. Location map.

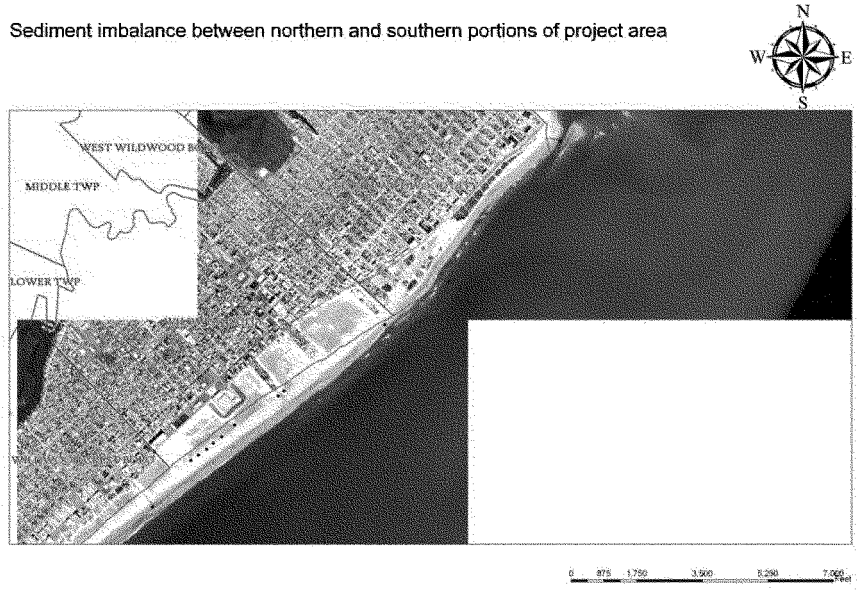


Figure 2. Aerial photo of project area.

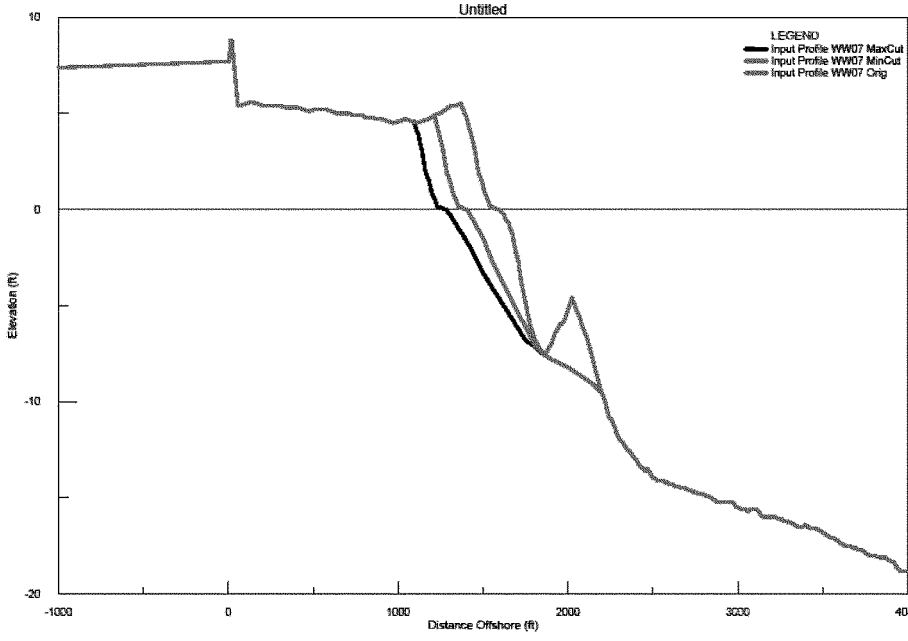


Figure 4. Beach profile at Wildwood showing proposed borrow location

March 26, 2008

Appendix C
Information Provided by Damen Dredging Equipment on DOP Submersible Pumps

Project description Sand Backpass Italy

Project location	: East coast of Italy between Venice and Ravenna
Year	: 2003/2004
Equipment	: 2 * DOP 2320 + Diesel driven Booster BS 250 + Instrumentation
Pumping distance	: 3000 – 18000 ft
Pipe Diameter	: 300 mm ID (12 inch)

General:

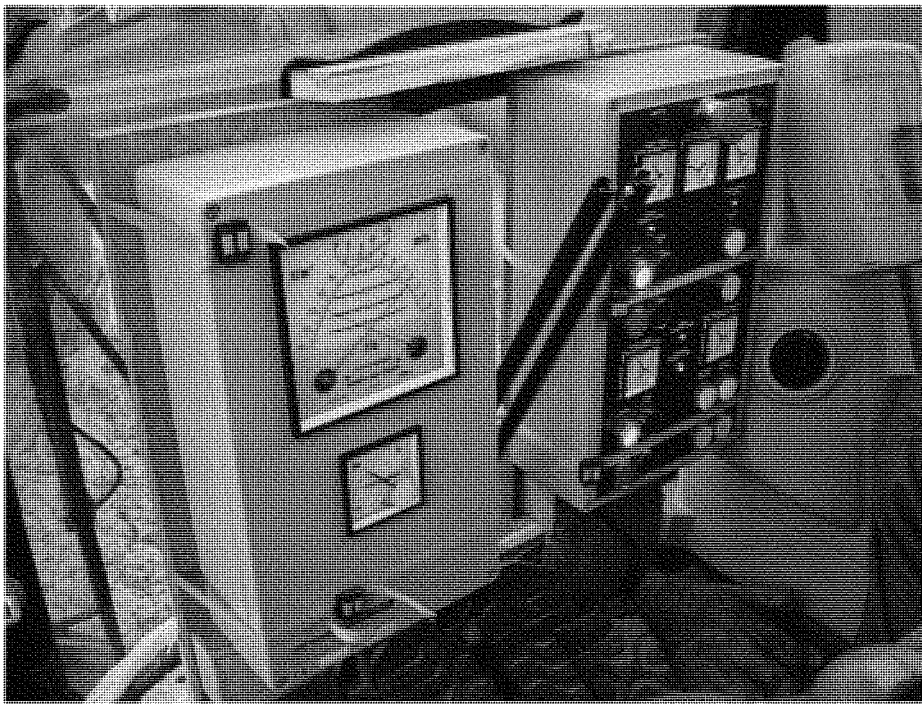
As the DOP pumps are designed for pumping high densities and long distances, it is the ideal tool for this kind of operations. A relatively low investments and it's multipurpose use (excavator, pump and power pack -> the power pack can be a Pileco/Ice Europe Powerpack suitable for vibratory hammers, can all be used separated from each other) make it a versatile tool for USACE and their contractors.

More detailed technical information can be downloaded from our website WWW.damendredging.com

Loading:

At this location truck's where loaded with an hydraulic excavator for logistic purposes.
The first DOP 2320 pump was mounted on a CAT 320 excavator and a fixed position was created using Sheet piles in order to prevent sliding of the excavator in the Dredged pit. The DOP pump was fitted with a sand production head with jetwater nozzles. A separate pump provided Jetwater. A separate, cabin controlled Diesel-Hydraulic Power pack provides the power for the DOP pump drive.

The operator has a cross needle indicator and operational instrumentation in his cabin for an optimal and safe production process. Client fitted instrumentation can be more professional with steel supports etc.

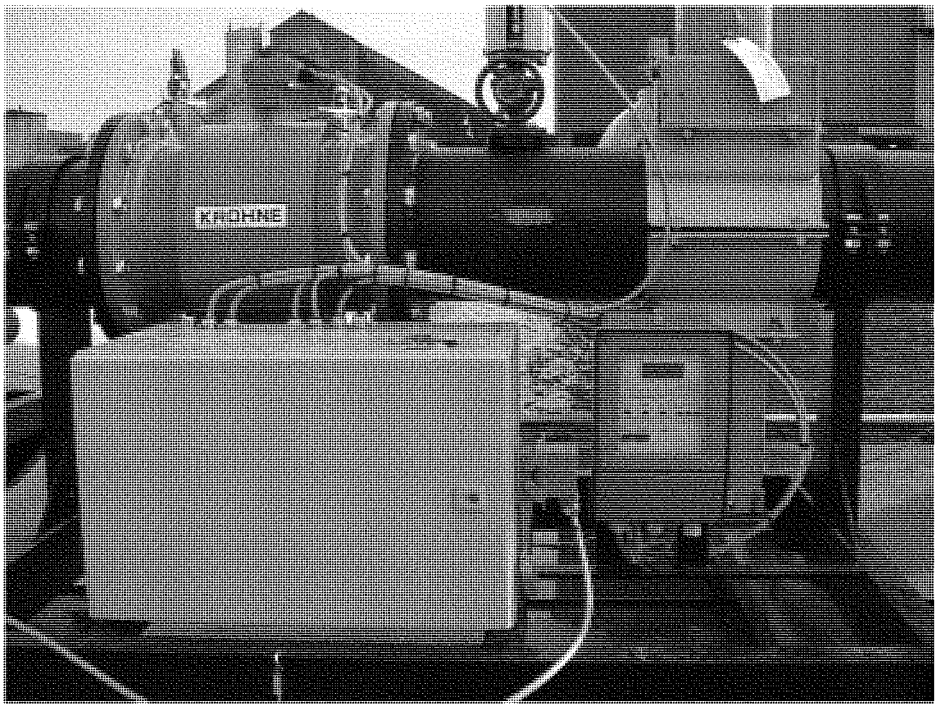


The pump is connected to a flexible discharge hose with floats and connected to a bud-welded HDPE pipe with an internal diameter of 300 mm.

Production measurement & registration (PMR unit) :

The HDPE pipe feeds into a production measurement and control unit that feeds a signal of Velocity and Density into the operators cabin and finally to the Cross Needle yield indicator unit. All data is stored on a PC and registers Velocity, Density and Production (dry material). This data can be used for payment purposes but also for analyses of the project.

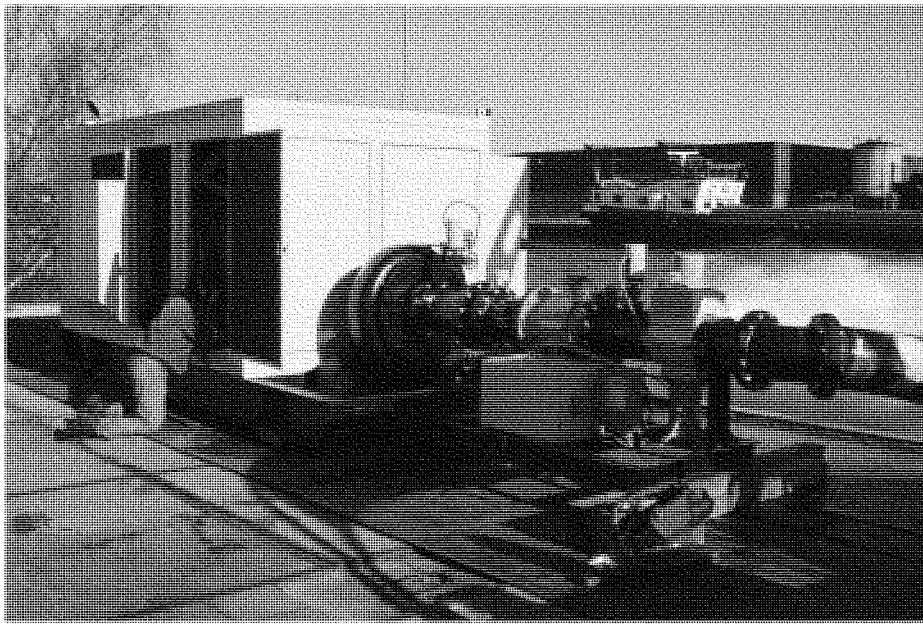
PMR unit with protective cover.



Internals of PMR unit

Boosters:

A second DOP 2320 unit is located on the beach and used as booster and/or back-up unit for the excavator mounted DOP. Pressure and Vacuum signals are fed to the operators cabin in order to follow and control the long distance pumping process. A second (diesel driven) Booster is located further down the beach and is also remote operated from the operators cabin. The diesel driven booster is equipped with a mechanical seal and therefore no additional water supply systems are required, and make the operation very flexible and not labor intensive during repositioning of the equipment.



Booster BS 250 & PMR unit during test in Holland

Result:

Production estimates for Hereford Inlet:

The **estimated production** for the **maximum distance** results in an average production of **400 m3/hr** without downtime and pipe/equipment shifts taken into account. This requires a careful and dedicated excavator operator who has basic knowledge about pumping liquefied slurries. Qualified general mechanics and operators can be involved for general assistance and maintenance.

These production estimates are based on 300 mm ID pipes and pump revolutions of approx. 1000 RPM (which is higher then the usual 850 RPM), Influence of wear will be lower due to low velocities, the higher pump revolutions will increase wear however this is partly compensated by the fine grains of the material to be pumped. The velocities are close to the critical velocity for this kind of material.
If the contractor desires to pump at higher velocities, an extra booster will be required.

March 26, 2008

Appendix D
Information Provided by Javeler Construction Company

Jim Clausner
US Army Engineer Research Center
3909 Halls Ferry Road
Vicksburg, MS 39180
Tel: 601.634.2009
james.e.clausner@us.army.mil

March 12, 2008

Subject: Javeler Mobile Sand Backpassing Dredging System

Dear Jim:

With regards to your March 5 email about mobile sand backpassing systems; specifically, the beach erosion problem at North Wildwood, NJ, please find enclosed our response. Javeler is very interested in this application. As one of the most experienced mobile sand dredging contractors/equipment providers in the country, we look forward to providing assistance.

Based on your description of the North Wildwood application, we can meet your target price of $ 10 per cubic yard. There are a lot of details to go over, but conceptually, this is achievable.

Javeler has the capability to do the work as a contractor or to provide equipment and technical support.

The Toyo submersible dredge pumps have a reputation as the most rugged solids handling submersible pumps available. On the first job we used the Toyo in 1983, we pumped over 500,000 cubic yards of sand with zero unscheduled down time. We simply mounted the Toyo submersible from a dragline. The simplicity of this dredging system made it very easy to operate and the reliability of the equipment eliminated down time.

Various size submersible dredge pump systems are available – both hydraulic and electric drive. I have provided both an electric 12" and a hydraulic 14" option below. The electric 12" pump system option is more readily available. Additional capital costs are required to set up for the 14" hydraulic system.

Option 1 - Javeler 12 inch Electric Submersible Mobile Dredging System

The 12 inch electric system is capable of transferring 3,000 – 4,00 gpm of slurry at a maximum distance of 15,000'. Sand production up to 400 cubic yards per hour of material.

Suspend a Toyo 150 hp electric submersible agitator dredge pump from a crane with 120 – 160 feet of boom. Generator (300 kw), to be mounted on the back of the crane. Sand up to 50 % solids by weight, to be transferred through 10 inch gum tube lined dredge hose to 12 inch HPDE pipe on the beach.

Diesel engine, skid mounted boosters will be placed every 5,000 feet to transfer the sand slurry to the south inlet location. Horsepower requirement for each booster is 400 hp.

Javeler Electric Submersible System Components

- Toyo 150 hp submersible agitator pump and will produce 3,000 – 4,000 gpm at 64 – 74 feet of head. The pump weighs 8,000 lbs and will pass a 4.7 inch rock. The motor is 460 volt/3 phase/60hz and has 150' of cable. Nema starter included.

- One hundred twenty feet of 10 inch heavy duty, 3/8 inch gum tube lined, dredge hose. The 150 psi rated hose is in 40 foot lengths, and has 150 # flange connections.

- 300 kw sound attenuated diesel engine driven generator (fuel usage estimated at 18 gal/hr).

- GIW (or equal) horizontal booster pumps; diesel engine 400 hp; marine gear drives; skid mounted. Gland water from portable seal water tanks.

- 12 inch SDR 17 HDPE pipe welded together; flange connections every 400' for access.

- magnetic flow meter to provide flow rates and production numbers

Option 2 - Javeler 14 inch Submersible Mobile Dredging System

The 14 inch hydraulic system is capable of transferring 5,000 – 6,00 gpm of slurry at a maximum distance of 15,000'. Sand production up to 600 cubic yards per hour of material.

Suspend a Toyo 12 inch hydraulic driven submersible agitator dredge pump from a crane with 120 – 160 feet of boom, or mount directly to a large excavator and use the hydraulics from the rig to run the pump. Hydraulic power unit (350 hp), if required, to be mounted on the back of the crane. Sand up to 50 % solids by weight, to be transferred through 12 inch gum tube lined dredge hose to 14 inch HPDE pipe on the beach. Diesel engine, skid mounted boosters with marine gear drives, will be placed every 5,000 feet to transfer the sand slurry to the south inlet location. Horsepower requirement for each booster is 500 hp.

Javeler Hydraulic Pump System Components

- Toyo TO 160B submersible agitator pump, has variable speed capability up to 850 rpm and will produce 5,000 – 6,000 gpm at 100 – 115 feet of head. The pump weighs 8,000 lbs and will pass a 4.7 inch rock. The TO 160B has a Rexroth 500 hydraulic motor and 200 feet of hydraulic lines.

March 26, 2008

- One hundred twenty feet of 12 inch heavy duty, 3/8 inch gum tube lined, dredge hose. The 150 psi rated hose is in 40 foot lengths, and has 150 # flange connections.

- Hydraulic power unit with Cat Tier 3 engine; Chevron Clarity biodegradable hydraulic oil, electronic monitoring warns of engine trouble, Rexroth piston motor.

- GIW (or equal) horizontal booster pumps; diesel engine 500 hp; marine gear drives; skid mounted. Gland water from portable seal water tanks.

- 14 inch SDR 11 HDPE pipe welded together; flange connections every 400' for access.

- magnetic flow meter to provide flow rates and production numbers

Manpower required for the backpassing system is a function of pumping distance. We like to have one additional man per booster station (every 5,000 feet). Base system with 5,000 feet of line requires 3 people to operate it (Javeler is non union).

We look forward to working with the Corps of Engineers on this and other sand backpassing projects. You can reach me at 604-929-9543 or Les Cross at our Louisiana office at 337-364-5841.

Regards
Javeler Construction Co., Inc.

Richard Binning

INSTRUCTION REPORT HL-81-1

A GUIDE TO THE PLANNING AND HYDRAULIC DESIGN OF JET PUMP REMEDIAL SAND BYPASSING SYSTEMS

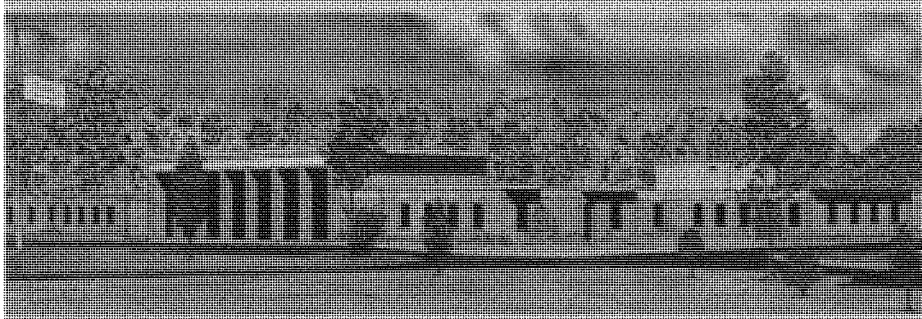
by

Thomas W. Richardson, Ernest C. McNair, Jr.

Hydraulics Laboratory
U. S. Army Engineer Waterways Experiment Station
P. O. Box 631, Vicksburg, Miss. 39180

September 1981
Final Report

Approved for Public Release; Distribution Unlimited



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Hydraulic machinery
Jet pumps
Sand

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This report is intended as an aid to engineers studying alternative solutions to a coastal sand bypassing problem. Using this report, engineers already familiar with coastal processes and centrifugal pumping systems will be able to: (a) determine the feasibility of a jet pump remedial bypassing system at a given site, (b) develop initial layouts for such a system, and (c) perform the system basic hydraulic design. A set of considerations and

(Continued)

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20. ABSTRACT (Continued).

guidelines relative to feasibility and intial layout are discussed in varying degrees of detail. Two step-by-step hydraulic design procedures are presented, one being an iterative type adaptable to computer solution, the other a graphical approach. Both procedures are keyed to a simple system with one jet pump and one booster pump. Additional considerations are given for systems using multiple jet and/or booster pumps. A companion report to be issued at a later date will describe techniques and equipment for building, operating, and monitoring a jet pump bypassing system.

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PREFACE

This report is the result of research performed under the Improvement of Operations and Maintenance Techniques (IOMT) research program which is sponsored by the Office, Chief of Engineers (OCE), and conducted at the U. S. Army Engineer Waterways Experiment Station (WES). This report contains guidance for the planning of a jet pump remedial sand bypassing system and also contains specific instructions for preparing the basic hydraulic design for such a system.

A companion report will be issued at a later date describing techniques and equipment for building, operating, and monitoring a jet pump bypassing system. This companion report will also include example designs illustrating the procedures and recommendations from both reports. Both reports are based on testing conducted by WES investigators in both laboratory and field installations.

The IOMT work unit was entitled "Eductor Systems for Sandtrap Bypassing" and was performed during the period 1973-1979. The study was performed under the direction of Messrs. H. B. Simmons, Chief of the Hydraulics Laboratory, F. A. Herrmann, Jr., Assistant Chief of the Hydraulics Laboratory, and R. A. Sager, Chief of the Estuaries Division. The work was performed by Messrs. W. B. Fenwick, T. W. Richardson, P. L. Chandler, J. C. Roberge, S. R. Bredthauer, and E. W. Flowers under the supervision of Mr. E. C. McNair, Jr., Chief of the Research Projects Group. This report was prepared by Messrs. Richardson and McNair. This report was reviewed in draft form by several CE Division offices, by the U. S. Army Coastal Engineering Research Center, by the Engineering and Operations Divisions of OCE, and by Dr. D. R. Basco of E_2O Consultants, Inc., as a consultant to WES.

Commanders and Directors of Wes during the conduct of this work unit and the preparation and publication of this report were COL G. H. Hilt, CE, COL John L. Cannon, CE, COL Nelson P. Conover, CE, and COL Tilford C. Creel, CE. Technical Director was Mr. F. R. Brown.

CONTENTS

Page

PREFACE 1

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI) UNITS OF MEASUREMENT 3

PART I: INTRODUCTION 4

The Bypassing Problem 5
Site Study and Problem Formulation 8
Consideration of Bypassing Alternatives 10
Site Conditions Affecting Feasibility of Shore-Based Jet Pump Bypassing System 13
Description and Configurations of Jet Pump Bypassing Systems 15

PART II: INITIAL SYSTEM LAYOUT 23

System Purpose 24
Mode of Operation 25
Interaction with Structures 27
Location of Shore-Based Equipment 30
Location of Individual Jet Pumps 31
Site to Which Bypassed Material Is Pumped 34
Effective Operating Time 35
System Capacity 39
Considerations for Interception Type of System 43
Distribution of System Capacity 44
Backflushing 46
System Pipe Sizes and Materials 49
Other Considerations 52
System Schematic Drawings 53
Equivalent Lengths 53

PART III: HYDRAULIC DESIGN 57

Iteration Design Procedure 58
Graphical Design Procedure 84
Additional Considerations for Multiple Jet or Booster Pumps 93

PART IV: SUMMARY 98

REFERENCES 99

PLATES 1-14

APPENDIX A: NOTATION A1

APPENDIX B: ADDITIONAL EQUATIONS B1

Colebrook-White Equation B1
Equivalent Lengths B2

APPENDIX C: DERIVATION OF GRAPHICAL DESIGN CURVES C1

CONVERSION FACTORS, U. S. CUSTOMARY TO METRIC (SI)
UNITS OF MEASUREMENT

U. S. customary units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	By	To Obtain
cubic yards	0.7645549	cubic metres
Fahrenheit degrees	5/9	Celsuis degrees or Kelvins*
feet	0.3048	metres
feet of water	2988.98	kilograms per square centimetre
feet per second per second	0.3048	metres per second per second
gallons per minute	0.06308	litres per second
inches	25.4	millimetres
square feet	0.0929	square metres

* To obtain Celsius (C) temperature readings from Fahrenheit (F) readings, use the following formula: $C = (5/9)(F - 32)$. To obtain Kelvin (K) readings, use: $K = (5/9)(F - 32) + 273.15$.

A GUIDE TO THE PLANNING AND HYDRAULIC DESIGN OF JET PUMP REMEDIAL SAND BYPASSING SYSTEMS

PART I: INTRODUCTION

1. Sand bypassing is a term used to denote the transfer of cohesionless sediments past man-made or natural barriers that trap, divert, or otherwise interfere with the natural process of coastal sediment transport. This bypassing can be accomplished by natural forces, as is the case in most uncontrolled and unimproved tidal inlets, or bypassing can make use of pumps or other means for excavating and transporting littoral materials.

2. This report provides specific guidance in the design of remedial bypassing systems that employ jet pumps for initial solids handling. The term "remedial" refers to bypassing for the purpose of alleviating an existing problem, as opposed to preventing a possible future problem. However, many of the techniques and approaches used can be applied to either situation. Although jet pumps have been used as suction boosters on hydraulic dredges for many years, their use in sand bypassing was developed as new technology in a research program sponsored by the Office, Chief of Engineers (OCE). Work under this program was performed by the Hydraulics Laboratory of the U. S. Army Engineer Waterways Experiment Station (WES).

3. This report also provides some general guidance in the coastal engineering approach to sand bypassing problems. The approach presented in this report is oriented toward the requirements of jet pump systems, but useful information will result regardless of the type of bypass system finally selected.

4. PART I of this report is devoted to evaluating a site and defining the parameters on which the bypassing system can be designed. Characteristics of jet pump bypassing systems and potential jet pump system configurations are also presented. PART II of this report deals with preparing a preliminary system layout. Methods are presented for

preliminary selection of portions of a jet pump system based on site requirements and characteristics. Specific design procedures and calculations are presented in PART III of this report. A subsequent report will contain instructions and suggestions for building, operating, and monitoring a jet pump bypassing system, as well as example designs.

The Bypassing Problem

5. Any activity in the coastal zone that impounds or diverts littoral sediments implies the need for sand bypassing. The earliest planning stages of such an activity should include consideration of ways to accomplish sand bypassing. When consideration for bypassing was not made prior to construction, the need for such a capability must be determined and remedial action taken if necessary.

6. There are several indicators of the need for a sand bypassing system of some type. Navigational problems caused by channel shoals and downdrift beach erosion coupled with updrift beach accretion (Figures 1 and 2) are by far the most common indicators that natural processes are being altered and that mechanical bypassing of some type may be needed. In many of these circumstances, complaints of local citizens and navigation interests will be heard.

7. Confirmation that a situation does exist which may be alleviated with a bypassing system can be made by personnel versed in coastal engineering who perform the following steps:

a. Site visits and inspections. First-hand, visual inspections of a site will usually provide evidence of updrift accretion/downdrift erosion, indicative of littoral interruption. Visual inspection may even show evidence of channel shoal or offshore bar formation by unusual breaking wave patterns in or near channel areas.

b. Review of site history. A review of photographs, charts, and maps will provide an excellent indication of the behavior of the site. General beach recession or aggradation, both updrift and downdrift, can often be diagnosed. Such studies are not only helpful in diagnosing problems, but may later prove invaluable in establishing magnitudes. For instance, comparisons of high-water marks in aerial photographs of a jetty accretion fillet may help identify the

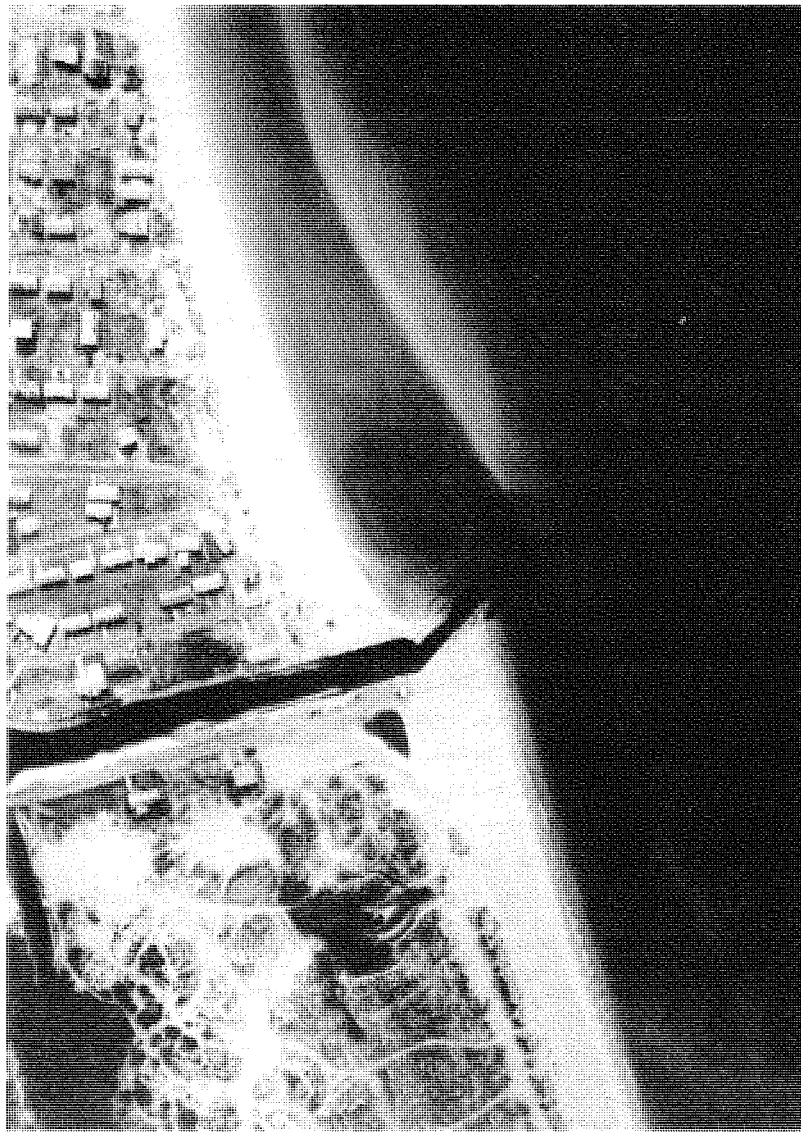

Figure 1. Aerial view of Mexico Beach, Florida, showing updrift accretion, downdrift erosion, and channel shoaling

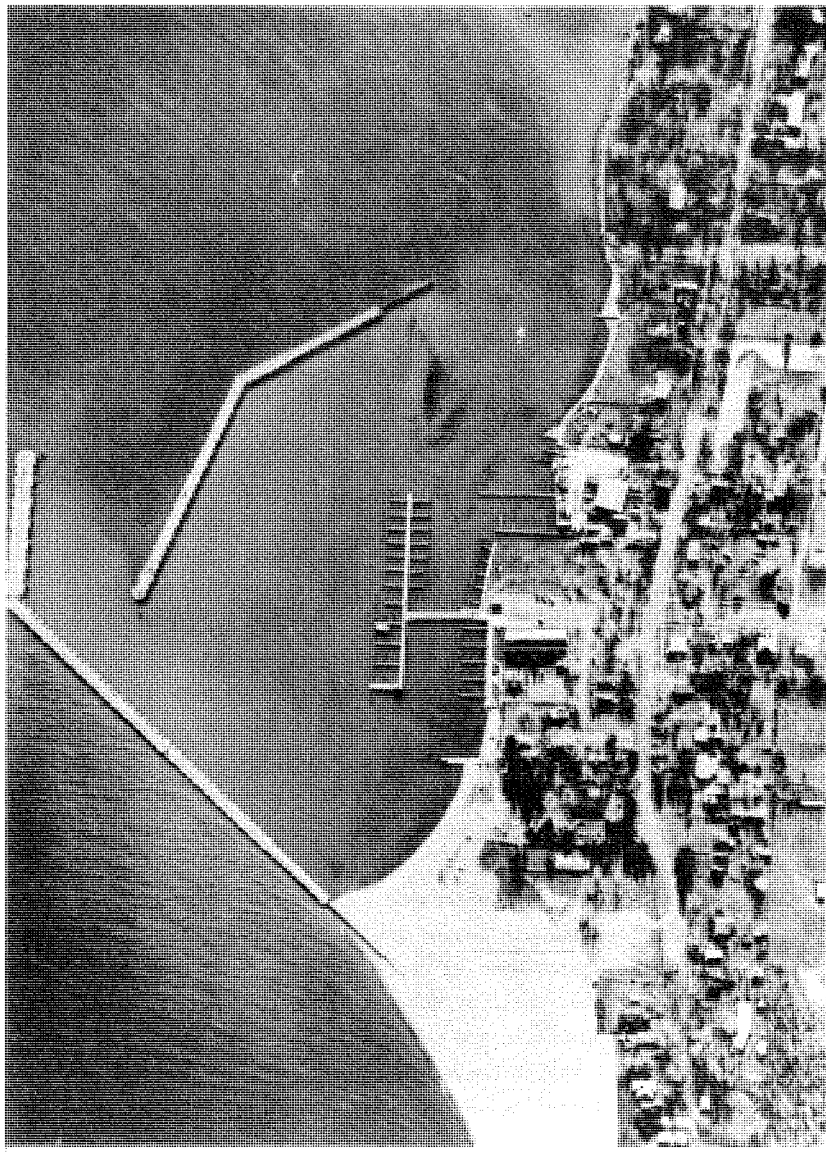

Figure 2. Aerial view of Port Sanilac, Michigan, showing accretion fillet and downdrift erosion

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rate of accretion of littoral drift for a particular period of history.

c. Hearings and interviews - Dialogue with local citizens who have observed the site over an extended period is helpful in establishing behavioral patterns. Such discussions may define events that occur during and immediately following severe storms. Extent of wave runup or overtopping, extent of beach damage, rate of beach rebuilding following storms, areas of concentrated wave attack, etc., are examples of site characteristics that might be identified by this method. Reports of wind speeds, wave heights, and water levels should be used judiciously since these parameters are extremely difficult to quantify by casual observation.

These steps should provide sufficient information to decide whether a problem exists that might require further site study and investigation.

Site Study and Problem Formulation

8. Design and employment of a sand bypassing system require a specialized coastal processes study of the site. Results of such a study provide the basis on which to select the most appropriate sand bypassing approach. If a field data collection program is needed, the cyclic nature of many coastal phenomena requires that the collection period be at least one year. Periods exceeding one year usually give more complete results. Because of this relatively long observation period, the coastal processes study should be implemented as soon as possible following the decision to investigate a mechanical bypassing solution.

9. Coastal processes studies are complex and the methods for carrying out such studies are beyond the scope of this report. Engineer Manual 1110-2-3300, "Beach Erosion Control and Shore Protection Studies," published by the Office, Chief of Engineers, in 1966 and the Shore Protection Manual (SPM) prepared and published in 1977 by the U. S. Army Coastal Engineering Research Center (CERC) may be consulted for guidance in designing and implementing such a study. However, to provide additional explanation, some of the important items of a coastal processes study for a jet pump bypass system are listed in approximate order of

importance, together with explanatory remarks:

a. Littoral transport. Transport vectors (rates and directions) as a function of time should be determined. The smaller the time increment for which transport vectors can be quantified, the better. Especially important are vectors for storm events, when large transport rates may be expected. In addition, an attempt should be made to establish the confidence limits of these vectors, taking into account such factors as data accuracy and effects of any simplifying assumptions used in processing the data.

b. Movement paths and deposition patterns. Of equal importance to identifying transport vectors is the determination of paths along which the transport is moving and the patterns in which it is depositing. This is especially important in the vicinity of structures, for two reasons:

(1) Structures have complicated and often unpredictable effects on littoral transport. The only reliable way of determining movement paths and deposition patterns near structures is to collect and analyze field data on them. Model test results may be used to supplement such data, but should not be considered a substitute.

(2) A jet pump bypassing system is usually used near structures to take advantage of the channelization of sand movement and the concentrated deposition that often occurs there. Also, the structures can provide protection and a foundation for the land-based portion of such a system.

c. Waves. Waves have direct effects on a jet pump sand bypassing system mainly in the restrictions they place on jet pump deployment and in their effect on pumphouse location and characteristics. The wave climate has many indirect effects, however, such as being a prime cause of littoral transport and causing alterations in water levels due to setup. A frequency distribution of significant wave heights at the site, the representative wave periods, and possibly yearly directional roses of significant height and period usually provide information for the direct effects which waves have on a bypassing system. For determining indirect effects, however, a much more detailed description of the wave climate at the site may be required.

d. Sediment characteristics. A description of the sediment to be bypassed is essential to design of the bypass system. Characteristics that must be determined include but are not limited to:

(1) Grain size distribution.

(2) In situ porosity.

(3) Specific gravity of sediment solids.

(4) Presence of cohesive material or cementing agents.

(5) Presence of large objects such as cobbles, shells, or debris.

(6) Subsurface profiles in areas where jet pump system may operate, preferably obtained from core samples.

e. Water-level fluctuations. The magnitude and frequency of water-level fluctuations due to tides, wave setup, surges, seiches, and other causes should be determined. Of special importance is identifying what combinations of these fluctuations might be expected over different time periods.

f. Morphology. Detailed surveys should be made to determine nearshore bathymetry at and adjacent to the bypassing site. Yearly morphologic cycles as well as longer term trends should be identified using these surveys, previous ones, and other data. An attempt should be made to predict future morphological trends.

g. Currents. The only direct effect which currents might have on a jet pump bypassing system would be on jet pump deployment. Maximum expected currents, their location, and direction should be identified. Indirect effects of currents include the potential to transport sediment to jet pump locations or even past these locations in suspension if strong enough.

10. Other information that is needed for preliminary design of the jet pump system but would not necessarily result from a coastal processes study includes:

a. Above-water layout of bypassing site, to include plan views and cross sections of structures, topographic features, rights of way, locations of utilities, etc.

b. Physical description of areas to which bypassed material will be pumped, and identification of possible routes for pipelines.

c. Design characteristics of structures in the vicinity of the bypassing system (design parameters and criteria, armor unit sizes, etc.).

Consideration of Bypassing Alternatives

11. A number of bypassing methods and approaches should be considered for any given bypassing problem. Very rarely will a problem

be so well defined and limited in scope that it can be alleviated only by one type of system. The designer then has the task of selecting the system which most nearly satisfies the bypassing requirements of that site. The following is a brief discussion of some aspects of the spectrum of bypassing systems.

Classification

12. Many ways of classifying sand bypassing systems are possible. However, aside from capacity, the single characteristic of any system that most affects its suitability for a particular project is the degree of mobility which it possesses. Mobility in this sense is defined as the ease with which the system can reach various areas of the project site. Accordingly, the following classifications are suggested:

a. Fixed systems, in which the entire physical plant is fixed as to location. Examples could be dredge pump systems operating from a house or platform or jet pump systems using fixed jet pumps. Such systems require a high degree of predictability of littoral transport vectors, movement paths, and deposition patterns.

b. Mobile systems, in which the entire physical plant can be relocated readily to reach various areas of the bypassing site or other sites. Examples could be floating dredges or jet pump systems mounted on trailers. Such systems may be more vulnerable to the physical environment than other types. Dredges, for instance, may be affected by wave action.

c. Semimobile systems, in which mobility is restricted to a single, well-defined area of the project site, the scope of which can be a determining factor in system design. Examples could be dredge pump systems mounted on tracks or rails, or jet pump systems using mobile jet pumps.

13. An important aspect of the classification system described in paragraph 12 is that particular equipment may fit more than one category, depending on site conditions and how it is used. For instance, a land-based clamshell crane might be used in one location only, making it essentially fixed. If a suitable roadway exists on a jetty, the clamshell might be moved back and forth along the jetty's length, in which case it could be termed a semimobile system. Driven onto a barge, the clamshell crane could become the major part of a mobile system. While this situation may appear confusing at first, in fact a

mobility-type classification is useful to the designer. Since it is based not just on system characteristics but on the interrelationship between these characteristics and project conditions and requirements, it deals directly with the problem at hand: choosing the best system for a particular situation.

Equipment

14. The list of equipment that can be used to form a bypass system is extensive. Anything from a hand shovel to a hopper dredge could conceivably be employed. The following list, not at all complete, gives items of equipment that exist at present and that have been or could easily be used in a bypass system:

a. Floating dredges.
   (1) Trailing suction hopper.
   (2) Cutter suction.
   (3) Plain suction.
   (4) Bucket ladder.
   (5) Clamshell.
   (6) Dipper.
   (7) Backhoe.

b. Land-based mechanical equipment.
   (1) Dragline.
   (2) Clamshell.
   (3) Backhoe.

c. Hydraulic equipment.
   (1) Dredge pump.
   (2) Jet pump.
   (3) Other types of solids-handling pumps.

Structures

15. The role of structures as part of a total sand bypassing system should never be underestimated. Structures can perform the following important functions, among others:

a. Direct and channelize movement of littoral drift.

b. Cause deposition of littoral drift at predetermined locations.

c. Provide access to areas of project site seaward of shoreline.

d. Provide foundation for part or all of bypass system.

e. Shelter bypass system from wave action.

Any bypass system design should try to make maximum use of the benefits that existing structures can offer. In addition, serious consideration should be given to structural changes or additions that might help in operation or design of a bypass system. Such additions might include the creation of deposition areas for littoral drift by means of breakwaters or weir sections in jetties.

16. The engineer responsible for the solution of a bypassing problem will undoubtedly study a number of possible methods in detail and will develop several potential solutions that will be studied even further. If a jet pump bypassing system is identified as a possible alternative, the remainder of this report will serve as a guide in developing designs for such a system.

Site Conditions Affecting Feasibility of Shore-Based Jet Pump Bypassing System

17. Certain site characteristics and bypassing requirements could make a jet pump bypassing system viable at a given site. Assuming that such a system would be deployed from shore (as opposed to a floating base), these characteristics and requirements are:

a. Need for continuous bypassing. Such a requirement definitely indicates that a jet pump system should be considered. Jet pump systems operate at a relatively low pumping rate compared with a large hydraulic dredge. Bypassing performed by a jet pump system can be made to proceed at a rate of the same order of magnitude as the average littoral drift rate.

b. Littoral transport near shore or structures. Littoral transport moving close to shore or to structures at the site can usually be handled by a shore-based jet pump system. At most sites, at least one location can be identified where this occurs. More specific criteria will be given later.

c. Moderate peak transport rates. Although not an absolute

requirement, the less littoral transport rates at a site vary with time over a yearly cycle, the better suited the site is for jet pump bypassing. Those sites with significant variation can be dealt with using concepts that will be explained later.

d. Littoral drift impoundment area. An existing sheltered impoundment area, such as that created by a detached breakwater or a weir section in a jetty, is of great benefit in making a jet pump system viable. An exposed impoundment area, such as a jetty accretion fillet, may be helpful depending on other factors in the system design.

18. Many other, more site-specific factors will have to be considered in determining the viability of jet pump bypassing at a particular site. In addition, not all of the above factors are necessary in order for a site to be suitable for a jet pump system. However, a site that possesses all of these factors can be considered a prime possibility for jet pump bypassing unless one or more conditions exist that preclude use of a jet pump system.

19. Some site conditions will probably preclude the use of a jet pump bypassing system. These are:

a. Presence of cohesive or cemented materials. Cohesive clays and cemented sands cannot be effectively dislodged by the jet pump using presently available cutting techniques. Even relatively thin layers of such material may cause problems.

b. Transport and/or accretion over a broad area. If littoral transport and/or accretion of such transport occurs over broad or poorly defined areas at the site, it may be difficult to design a reasonable jet pump bypassing system. In many ways, this situation would be the converse of the factors described in paragraphs 17 b and d.

c. Absence of suitable location for clear water intake. This will be discussed fully in later parts of this report, but a relatively sheltered, accretion-free location must be available from which clear water can be drawn to drive the jet pump.

Other considerations may impact upon the feasibility of a bypass system, such as property ownership, aesthetics, and local attitudes. Such items must be dealt with but are beyond the scope of this report.

Description and Configurations of Jet Pump Bypassing Systems

20. The center-drive* jet pump, the primary component of the jet pump bypassing system, is different from other pumps in that it contains no moving parts and is powered by a jet of water. The jet pump operates completely submerged, resting on the bottom with its suction tube buried in the material to be pumped. The basic principle behind the operation of the jet pump is the exchange of momentum within the pump. Clear water, normally supplied by a centrifugal pump, enters the jet pump through a nozzle as a turbulent jet (Figure 3). In the mixing chamber, turbulent

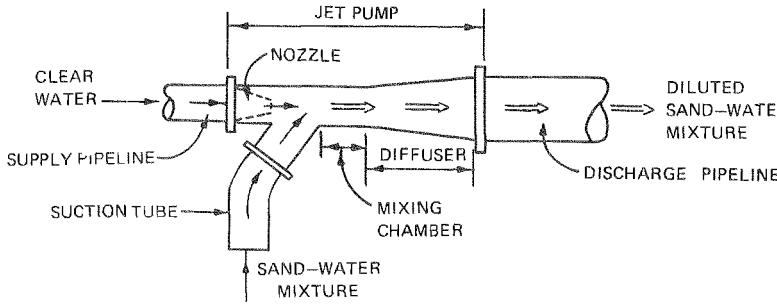


Figure 3. Jet pump principles of operation

mixing occurs between the water jet and a sand-water mixture drawn into the suction tube. This mixing causes a transfer of momentum from the jet to the sand-water mixture. At the same time, the sand-water mixture is diluted by the jet water. The diluted mixture then passes into the diffuser section of the jet pump, causing more sand-water mixture to be drawn into the suction tube in a continuous process. In the diffuser, a gradual expansion of the jet pump walls results in some flow energy changing from velocity to pressure. After exiting the diffuser, the diluted mixture moves through a discharge pipeline, usually to a

* The term "center-drive" refers to a jet pump with a nozzle located on the center line of the main pump body. "Side-drive" or "peripheral-drive" jet pumps, on the other hand, have one or more nozzles located on the periphery of the main pump body.

conventional dredge pump acting as a discharge booster.

21. The performance of the center-drive jet pump in a given medium can be defined in terms of three dimensionless parameters. These parameters are: (a) head ratio, N ; (b) flow ratio, M ; and (c) area ratio, R . The head ratio, N , is defined as

$$N = \frac{HDIS - HSUC}{HSUP - HDIS} \tag{1}$$

where

HDIS = total energy head in the discharge pipeline at the jet pump

HSUC = total energy head in the jet pump suction tube at the jet pump

HSUP = total energy head in the supply pipeline at the jet pump

The flow ratio, M , is defined as

$$M = \frac{QSUC}{QSUP} \tag{2}$$

where

QSUC = volumetric flow rate into the jet pump suction

QSUP = volumetric flow rate through the jet pump nozzle

The area ratio, R , is defined as

$$R = \frac{ANOZ}{AMIX} \tag{3}$$

where

ANOZ = area of the opening at the tip of the jet pump nozzle

AMIX = inside area of the mixing chamber of the jet pump

Locations of these parameters on a center-drive jet pump are shown in Figure 4.

22. Gosline and O'Brien (1934), Mueller (1964), Reddy and Kar (1968), and others have worked on defining the relationships between M , N , and R for various jet pump configurations pumping water. Several investigators, such as Fish (1970), Zandi and Govatos (1970), and Silvester and Vongvisessomjai (1970), have worked on comprehensive theories for jet pumps pumping solids. However, experimentation with a

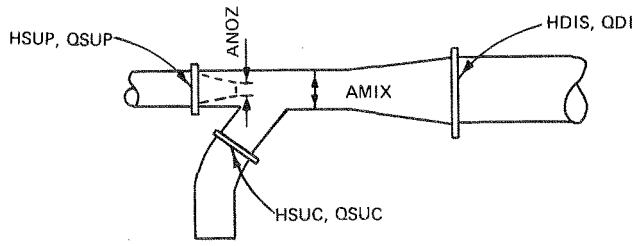


Figure 4. Location of jet pump parameters

particular jet pump is usually required for best results. Experimental data from the WES research program were used to define the relationships for a specific jet pump type pumping both clear water and medium sand. Relationships for pumping sand are presented in a later portion of this report.

23. Figures 5-7 illustrate the basic components of a simple jet pump bypassing system. More complex configurations are possible and

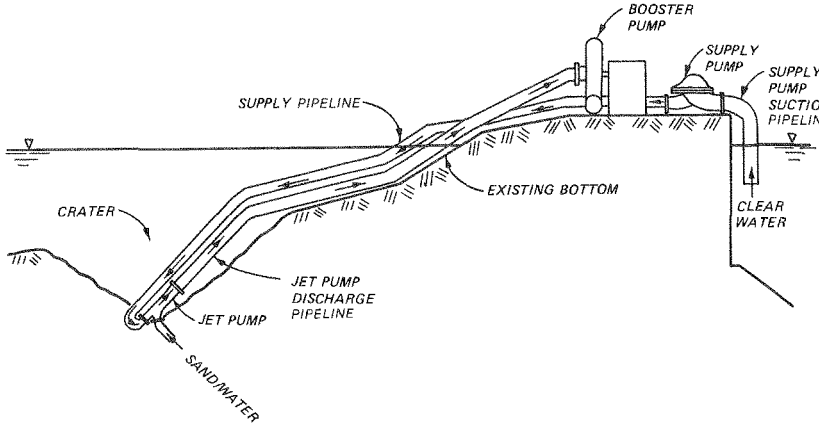


Figure 5. Elevation view of simple jet pump system

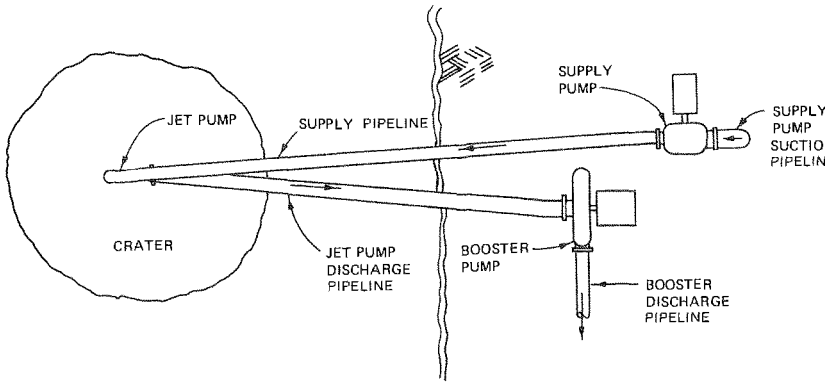


Figure 6. Plan view of simple jet pump system

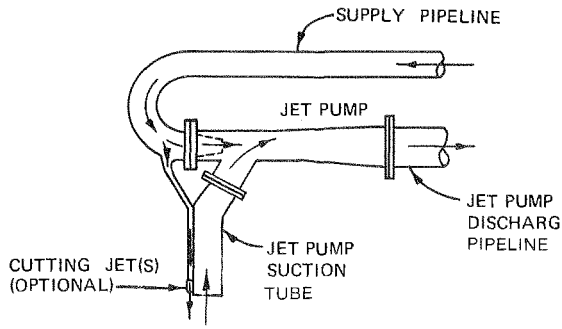


Figure 7. Elevation view of jet pump

are frequently required, but the operating principles remain the same. Figures 5-7 are especially important because the terminology shown for various system components will be used throughout this report.

24. The component parts of the simple jet pump system shown in Figures 5-7 and their purposes are as follows:

a. Supply pump. Provides clear water to drive the jet pump. Also supplies water for jet pump cutting jets, if such are used, and may supply flushing water for the booster pump. Supply pump suction pipeline must be located in an area relatively free of shoaling or large amounts of suspended sediment or small debris. The supply pump is

usually an ordinary centrifugal pump.

b. Supply pipeline. Carries clear water from supply pump to jet pump. May be made of rigid pipe, flexible hose, or a combination of both. Also carries water for cutting jets.

c. Jet pump. Dredges sand/water mixture and provides head to move it through jet pump discharge pipeline to booster pump. Jet pump suction tube is used to ensure burial of jet pump suction opening and consequent intake of high solids content sand/water mixture. Cutting jet(s) aid in burial of suction tube and in excavation of consolidated material.

d. Crater. One of the most important parts of any jet pump system. The crater is formed on the sea or lake bottom and is maintained by virtue of the jet pump dredging below the level of the surrounding bottom. If the jet pump supply and discharge pipelines are flexible, a jet pump resting on an undisturbed bottom will excavate a crater by simply following the bottom of the crater downward as it removes sand. This process is illustrated in Figure 8. A jet pump buried below the undisturbed bottom, on the other hand, with rigid supply and discharge pipelines will excavate a crater above itself by removing sand from underneath. Figure 9 illustrates the formation of such a crater. The crater acts as a trap for littoral drift that would otherwise pass by. Without a crater or an array of craters, the jet pump has no chance of intercepting moving littoral drift. Crater size and shape are functions of many factors, such as depth of the jet pump below surrounding bottom, characteristics of in situ sediment, and rate of dredging by jet pump relative to rates of littoral material influx and slumping of crater sides.

e. Jet pump discharge pipeline. Conveys jet pump discharge mixture from jet pump to booster pump. May be of same construction as supply pipeline.

f. Booster pump. Provides energy to move jet pump discharge mixture to selected discharge area. Several booster pumps may be required along length of booster discharge pipeline, depending on distance mixture is to be pumped. The booster pump is usually an ordinary dredge pump.

g. Booster discharge pipeline. Carries discharge mixture from booster pump to discharge area. Usually of rigid construction.

25. One characteristic of a jet pump bypassing system is that many variations on the simple system shown in Figures 5-7 are possible in order to adapt the system to specific requirements. Some of these variations are:

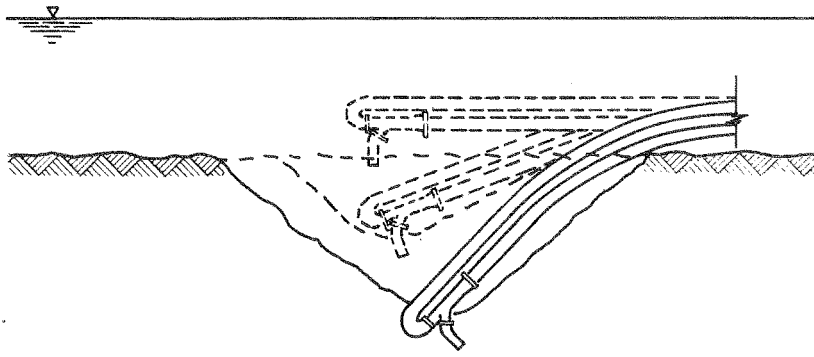


Figure 8. Excavation of crater by jet pump resting on bottom

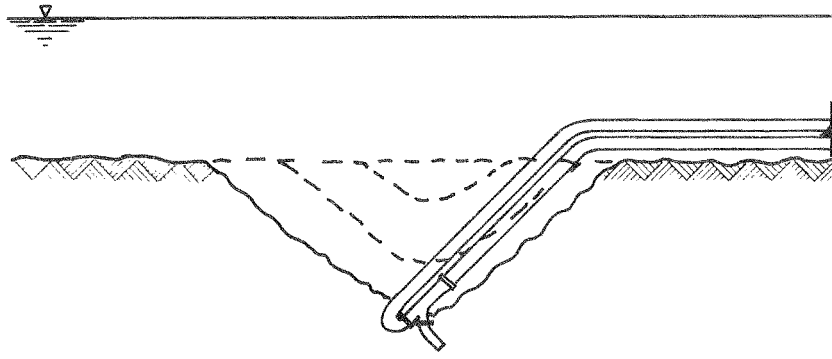


Figure 9. Excavation of crater by jet pump buried below bottom

a. Mobility of on-shore components.

(1) Permanent. Onshore system components, such as the supply and booster pumps, are located on fixed foundations onshore or on a structure such as a jetty. Usually, they are protected from the elements by an enclosure.

(2) Portable. Onshore components are mounted on a movable platform, such as a truck or trailer, and operate from parking locations onshore or on a structure. These components can then be used at several locations within a site or at different sites.

b. Mobility of jet pump(s).

(1) Fixed. Jet pump is installed permanently at a certain elevation, below the existing bottom. In such a configuration, the jet pump is virtually immune to wave action or the effects of currents. Multiple fixed jet pumps can be installed to create craters which cover a certain area.

(2) Mobile. Jet pump is equipped with a variable buoyancy float and flexible hoses, allowing it to be raised from its crater, moved a certain distance, and sunk to create another crater. This configuration of jet pump is best employed in areas sheltered from severe wave action.

c. Flexibility of jet pump pipelines.

(1) Rigid. Jet pump supply and discharge pipelines are constructed of steel pipe or other rigid material. Usually, this type of piping is used in conjunction with fixed jet pumps and can, in fact, be the means by which the jet pump is fixed in place.

(2) Flexible. Flexible hose, such as rubber dredging hose, is used for jet pump pipelines. This hose is normally used with a mobile jet pump to allow easy relocation of the jet pump. In such a use, the hose would be equipped with floats of fixed buoyancy to prevent it from being buried in the existing bottom or in the jet pump crater.

(3) Combination. Lengths of rigid pipe are connected by lengths of flexible hose to form the supply and discharge pipelines. Such a configuration provides a certain degree of flexibility at less cost than an all-flexible system. With floats attached, this type of pipeline can be used with mobile jet pumps in areas subject to very mild wave action. Without floats, such piping could be used with fixed jet pumps, provided that the jet pumps are supported by some means independent of the pipelines.

d. Number of jet pumps operating simultaneously.

(1) Single. System in which only one jet pump operates at a time. Such a system is the simplest to design and operate. A number of jet pumps may be installed at a site and operated individually, although the complications of piping and valving arrangements will increase rapidly as the number of jet pumps increases. In general, however, a single-type installation is preferable to a multiple one.

(2) Multiple. System in which two or more jet pumps operate at a time. This type of system should be considered only where the requirements of the bypassing project cannot be met by a single-type system, or where an excessive number of independent jet pumps are required for a single-type system. If a multiple system is necessary, the number of jet pumps operated simultaneously should be kept to a minimum.

Except as noted, any of the system variations discussed above can be used in conjunction with any of the others.

26. It should be noted that all discussion in this report deals with shore-based bypassing systems. However, there is no reason why a jet pump system designed using the techniques presented in this guide could not be placed on a floating platform. Such deployment would place the system philosophically in the category of dredges; therefore, no discussion of that deployment technique is presented in this report.

PART II: INITIAL SYSTEM LAYOUT

27. The aim of this part of the report is to provide guidance for the designer in arriving at general system configurations for which more detailed designs can be made. Although subsequent discussions will be in terms of a single system layout, in reality the designer should consider several alternative layouts simultaneously. All the alternatives should be treated equally until economics or other factors influence the choice of a final design.

28. Two points regarding this part of the report should be understood at the outset:

a. A series of topics are discussed that relate to the initial system layout. These topics are not presented in sequential order; in fact, no such order can be applied to them. Most of the topics interact with one or more of the others, the degree of interaction sometimes depending upon other factors as well. The designer must develop a grasp of the concepts being presented rather than trying to follow the presentation in a step-by-step fashion.

b. The success of the initial system layout in meeting the actual bypassing requirements of the site will depend primarily upon the quality of the coastal processes study. THE IMPORTANCE OF THE COASTAL PROCESSES STUDY CANNOT BE OVEREMPHASIZED. It is the foundation upon which the bypassing system is designed. Designing a jet pump bypassing system without detailed information on items such as littoral transport vectors is not advised.

29. The principal purpose of the initial system layout is to provide an approximation of a bypassing system that can be refined and altered using the design procedures presented in PART III. A secondary purpose of the initial system layout is to identify problem areas at the site that may be independent of coastal processes or system pumping performance.

30. Certain guidelines are presented relating to the initial layout. These guidelines pertain to selecting the mode of operation, location, operating time, capacity, sizing of various elements, and certain other system features. It should be remembered that the guidelines are only aids and that significant modifications may be needed after

more detailed calculations are performed. In general, however, use of the guidelines should result in reasonable selections of components for the system.

System Purpose

31. There are two basic purposes for which any bypassing system can be designed:

a. Reduction of navigation shoaling caused by littoral drift.

b. Alleviation of undesirable beach changes caused by interruption of littoral drift.

The purpose that the system is to serve should be specifically identified so that requirements pertaining to that purpose can be satisfied. For example, a bypassing system whose purpose is to reduce channel maintenance will be designed, installed, and operated so as to bypass material causing shoals in the navigation channel. On the other hand, a system whose purpose is to provide periodic nourishment for a downdrift beach may be installed and operated quite differently.

32. The designer should be especially wary of attempting to design a "dual-purpose" bypass system; i.e., one that tries to reduce navigation shoaling and alleviate beach changes at the same time. Although the problems of shoaling and beach changes are often interrelated at a particular site, attempting to solve both simultaneously with one bypass system can be difficult for the following reasons:

a. The interrelationship between the two problems is often far more complex than it appears.

b. The optimum approach to solving one of the two problems with a bypass system can be very different from the optimum approach to solving the other problem.

The end result of such a compromise design will often be a bypass system that solves neither problem very well. A better approach is to design the system to help solve one problem only. Then, at the end of the design process, review the projected effects of the system on the other problem. Many times it will be found that a system designed for one problem will have significant beneficial effects on the other as well.

The review may also suggest some modifications to the system design that would aid in solving the other problem without affecting performance on the primary problem.

Mode of Operation

33. A jet pump bypassing system has two possible modes of operation:

a. Removal of littoral materials from a deposition area.

b. Interception of moving littoral drift.

In making the initial system layout, one of these two modes should be selected as the primary mode of operation and the system designed accordingly. Generally speaking, mode a is preferable to mode b, all other factors at a site being equal. A system designed for mode a will probably be of smaller capacity and consequently cost less. The deposition area will provide a trap for littoral drift moving at high rates, allowing the accumulated drift to be bypassed later during times of lower drift rates. This fact in turn implies a more regular operating schedule for the system. A system designed for interception, however, must be operated when drift is moving, whether day or night. The dependence of system configuration on mode of operation is illustrated in Figure 10, where the choice of interception as the primary mode indicated the use of fixed jet pumps located in the path of active transport movement. Sand moving along this path will (hopefully) fall into the jet pump craters and be bypassed by the system. An existing sheltered impoundment basin at the site, on the other hand, might be well suited to mobile jet pumps digging craters at different locations to maintain the basin as a trap for littoral drift. Figure 11 shows a system of this type. The possible negative effects of interception should be considered at this stage, also. If the system is effective in intercepting drift at a certain point, it may cause erosion immediately downdrift of that point. Serious stability problems with adjacent structures could be caused by such erosion.

34. The preceding two examples should not be taken as firm guidance. For instance, there is no reason why mobile jet pumps cannot

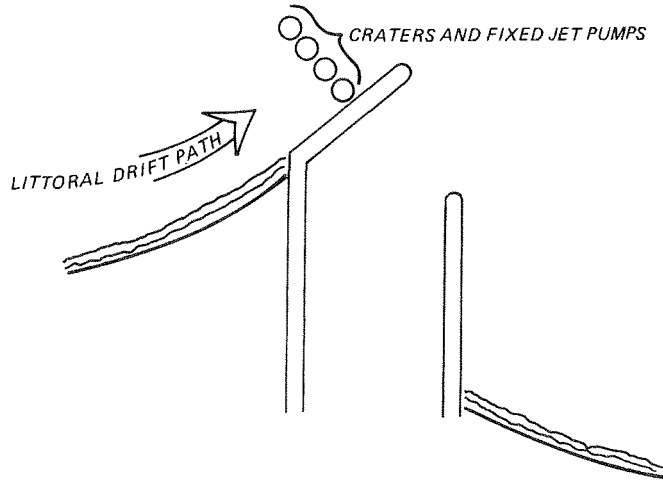


Figure 10. Fixed jet pumps in interception mode

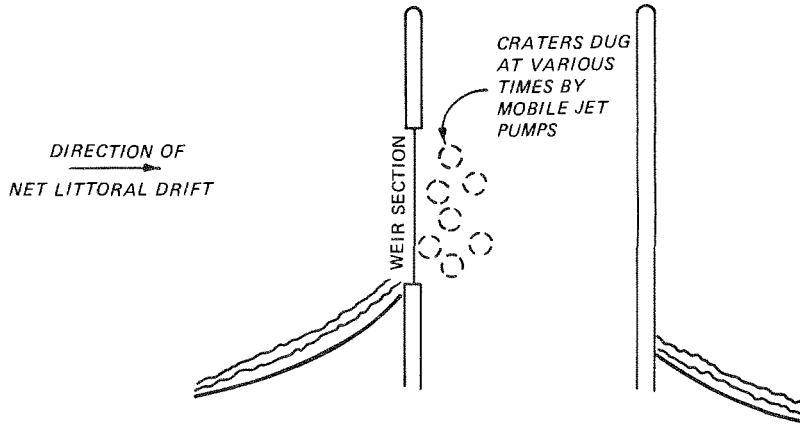


Figure 11. Maintenance of impoundment basin by mobile jet pump(s)

operate in an interception mode or why a field of fixed jet pumps cannot be placed in an impoundment basin. The final choice of mode/system combination must be dictated by the requirements and restrictions of each individual site.

Interaction with Structures

35. A number of general areas are possible for placement of the jet pumps, depending upon the purpose of the bypass system, results of the coastal processes study, and arrangement of structures at the site. The first two items have already been discussed. Some types of structures that may be found at a site and that pertain directly to bypassing are:

a. Jetty.

b. Offshore breakwater.

c. Shore-connected breakwater.

d. Weir section.

36. Figures 12-15 show some possible configurations of these structures at a site and possible locations for system jet pumps. THESE FIGURES ARE BY NO MEANS DEFINITIVE. Initial selection of jet pump locations should be based on consideration of a number of factors, including the following:

a. Littoral transport vectors.

b. Transport movement paths and deposition patterns.

c. Mode of operation.

d. Proximity to shore-based equipment.

However, Figures 12-15 indicate some locations that might prove feasible and that present themselves as a direct result of structural configurations. Hatched areas in the figures indicate regions within which jet pumps might be located.

37. An implied assumption in Figures 12-15 is the existence of a strongly predominant net drift direction. At many potential bypassing sites, however, the littoral drift may be approximately equal from both directions. In such cases it may be necessary to utilize jet pumps on

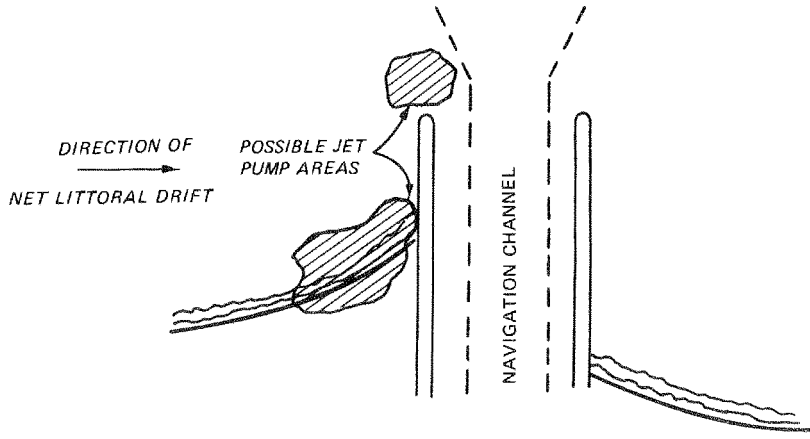


Figure 12. Jettied navigation channel

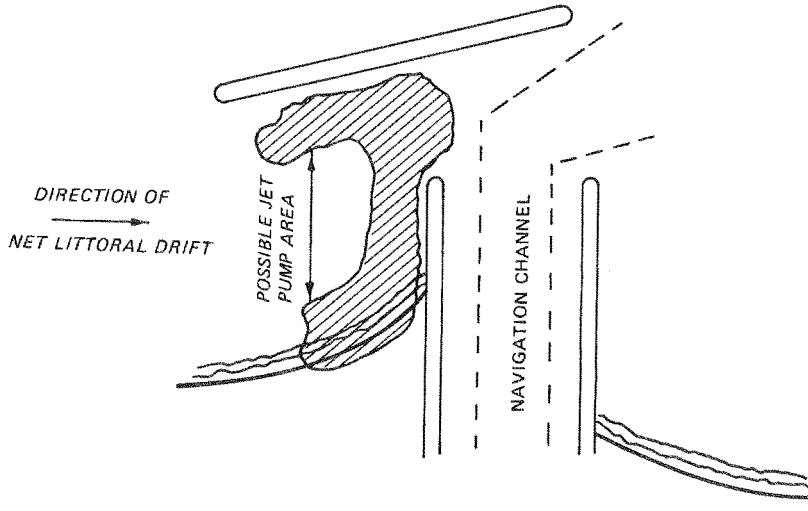


Figure 13. Offshore breakwater and jetties

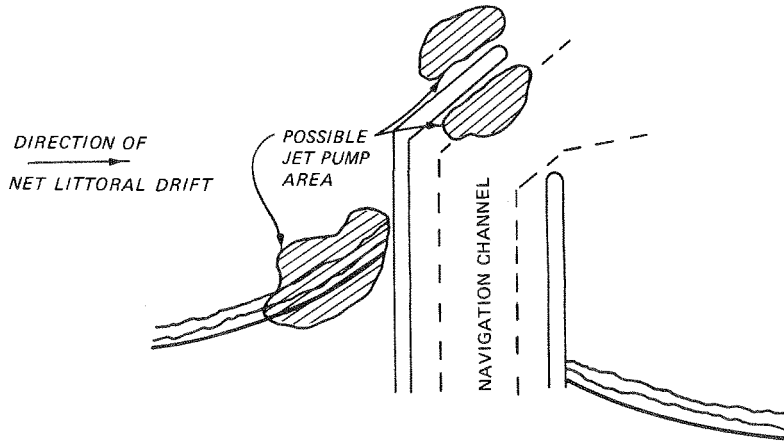


Figure 14. Shore-connected breakwater and jetties

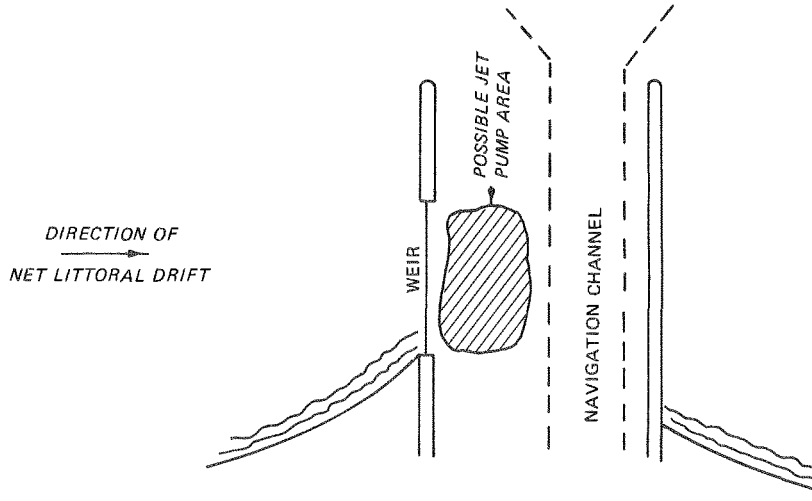


Figure 15. Jetties with weir section

both sides of the site to bypass littoral drift approaching from either direction.

Location of Shore-Based Equipment

38. Tentative location(s) for shore-based equipment should be selected for the initial layout. However, the choice of location for the shore-based portion of a jet pump system is interactive with location of the jet pump(s). Therefore, considerations of this section must be meshed with those of the following section on locating the jet pumps to assure a sound approach. On one hand, shore-based equipment must be as close as possible to the jet pumps. On the other hand, jet pumps cannot be used in areas without a suitable nearby location for the shore-based equipment. The following factors must be considered in evaluating potential sites for shore-based equipment. The factors pertaining to shore-based equipment are listed in approximate order of importance, although this will vary somewhat from site to site:

a. Proximity to jet pump location(s). Distance along potential pipeline routes from the shore based equipment to the farthest jet pump should be less than about 600 to 700 ft*. This requirement is not rigid and will be discussed later in more detail.

b. Supply pump location. The supply pump must be located as close as possible, both vertically and horizontally, to a suitable location from which it can draw clear water through the supply pump suction pipeline. THIS LOCATION MUST ALWAYS BE FREE OF SIGNIFICANT SHOALING. If the location is subject to shoaling under existing conditions, then measures must be taken to change the shoaling pattern preferably by passive means such as structural alterations or additions. For the initial layout, try to place the supply pump such that the following relation is satisfied:

$$ELSUP + 0.03(LSUPSA) \leq 15.0 \qquad (4)$$

---

* A table of factors for converting U. S. customary units of measurement to metric (SI) units is presented on page 4.

where

ELSUP = elevation of supply pump center line above mean low water, ft

LSUPSA = approximate length of supply pump suction pipeline, ft

If this relation cannot be satisfied, choose the location that comes closest and proceed with the system layout. It may be necessary later to make some significant changes in the system configuration, depending upon values calculated in PART III of this report.

c. Access. Preferably, the area where the shore-based equipment is located should be accessible by land vehicle. This is especially important during system construction and is a major convenience for system operation. Access by other means such as by boat is possible but much less desirable.

d. Exposure. The shore-based equipment should be located in an area as sheltered from wave action as possible. The more exposed the location, the more expensive the non-functioning portions of the system will be (pump houses, pipe anchors, etc.).

e. Fuel or power. Consideration should be given to the ease of fuel delivery or power hookup when choosing a site for shore-based equipment, although this is usually not a controlling factor.

Location of Individual Jet Pumps

39. The main intent of locating individual jet pumps in the initial design layout is to establish approximate values for the following items:

a. Total number of jet pumps in system.

b. Length(s) of jet pump supply and discharge pipeline(s).

c. Size, location, and number of craters.

Items a and c are interdependent to a certain extent. Obviously, the number of craters in the system will be related to the number of jet pumps. However, the number of jet pumps will also be a function of the size of the craters; for instance, when fixed jet pumps are being used to cover a certain area with craters. In such case, the larger the craters, the fewer jet pumps are needed. For the initial layout, craters

can be assumed to be conical in shape, with relative dimensions as shown in Figure 16.

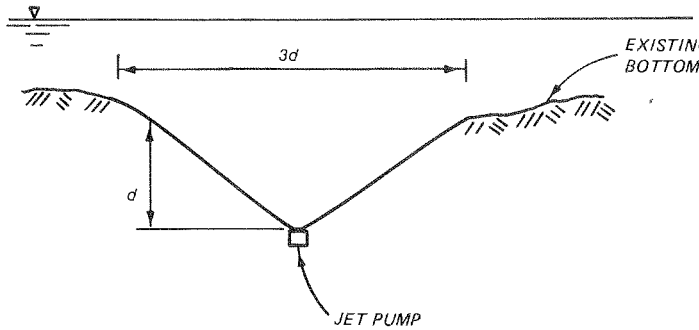


Figure 16. Suggested design crater dimensions

40. The depth, d , of the jet pump below the existing bottom is limited by several factors. A practical maximum is approximately 25 ft, although theoretically no real limit exists. The presence of hard or cohesive strata will limit d to the depth at which they begin. If such strata occur within 5 or 6 ft of the existing bottom, the applicability of jet pumps at that location is doubtful. Also, the proximity of a particular jet pump to rubble-mound structures such as jetties or breakwaters imposes an indirect limit on d at that location. In such a case, placement of the jet pump too close to the structure may result in localized undermining of the structure foundation. Conversely, if the jet pump is placed too far away, a significant portion of the littoral transport may move past the system next to the structure face. A rule of thumb to use for initial jet pump location adjacent to a structure is shown in Figure 17. This rule is based on an isolated jet pump adjacent to a structure. A group of such jet pumps might pose a greater threat to structural stability. The possible stability effects of such a group should be investigated thoroughly on a case-by-case basis.

41. For mobile jet pumps, the term "location" implies determining the area in which each jet pump will operate. The following guidelines

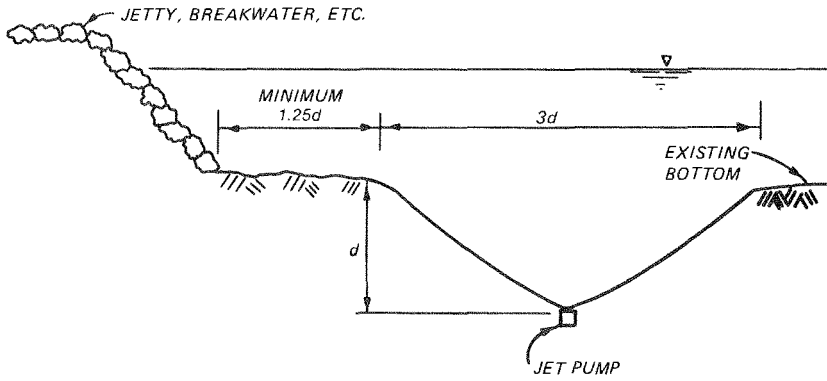


Figure 17. Suggested design dimensions for jet pump location adjacent to structure

should be kept in mind in mobile pump layout:

a. Mobile jet pumps are moved much more easily along an arc than back and forth along a radius (Figure 18). The latter type of movement usually involves lengthening or shortening the supply and discharge pipelines.

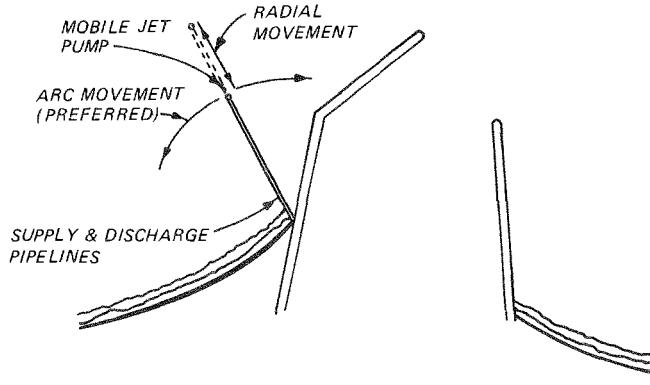


Figure 18. Movement of mobile jet pump

b. Supply and discharge pipelines in the water should be arranged so as to be approximately perpendicular to approaching waves wherever possible (Figure 19).

c. The maximum length of supply and discharge pipelines in the water should be less than 400 ft. This is a practical limitation based on the difficulty of handling long floating pipelines. Ideally, the shorter these pipelines are, the better.

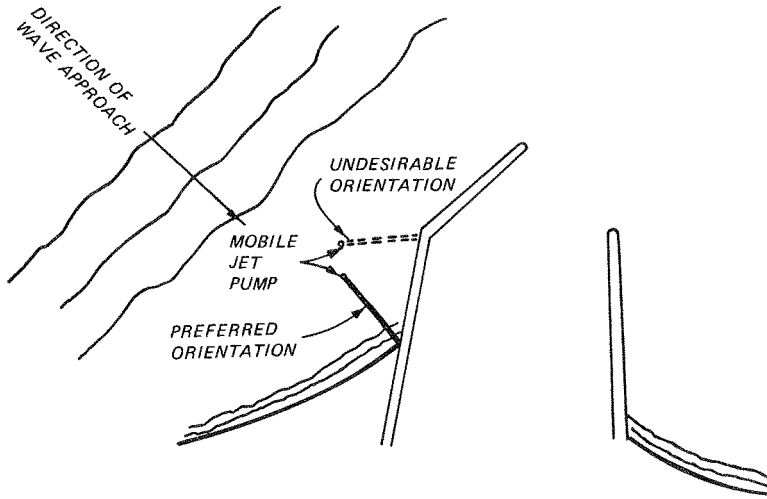


Figure 19. Orientation of mobile jet pump

Site to Which Bypassed Material Is Pumped

42. The initial system layout should include an approximate location or locations to which the material picked up by the system will be pumped. The purpose of selecting such a location at this time is to allow determination of the required booster discharge pipeline length, as well as the approximate number of booster pumps that will be needed. Selection of the discharge location(s) will be determined largely by the information gathered in the coastal processes study, the purpose of the bypassing system, and special requirements and restrictions of the

site. The discharge point(s) should be no farther away from the bypass site than necessary but should not be so close that the discharged material is returned to the bypass site by local littoral processes. In addition, the discharge point(s) should not be located in areas of little or no littoral movement where the bypassed material might stagnate.

43. A rough estimate of the required number of booster pumps can be made by assuming an equal initial spacing between the pumps along the booster discharge pipeline. This initial spacing may have to be adjusted later based on PART III calculations. Figure 20 shows a suggested range of values to use for the initial estimate of booster spacing as a function of the median size, or d_{50}, of the sediment to be bypassed. The designer should choose a value from this figure that falls in the shaded area for the applicable sediment size, then use this value in laying out the booster system. For example, suppose the sediment to be bypassed has a d_{50} of 0.20 mm. Based upon the physical layout of the site, the designer might then choose an initial booster spacing of, say, 3000 ft. If the total discharge line length is 9000 ft, the inital system layout will then include three booster pumps. The first would be located as close as possible to the jet pump(s) (usually at the same location as the supply pump). The second would be at the 3000-ft point on the discharge line, and the third at the 6000-ft point (Figure 21).

Effective Operating Time

44. The concept of an "effective" as opposed to a total time of system operation will now be introduced. Definition of effective time of operation is necessary for computation of the required system capacity. This step requires that a schedule of operation to accomplish the bypassing be selected. The schedule of operation depends on many factors including availability of manpower, local restrictions on operation of the system, availability of material to be bypassed, and other factors that may be peculiar to the site such as ice during parts of the year.

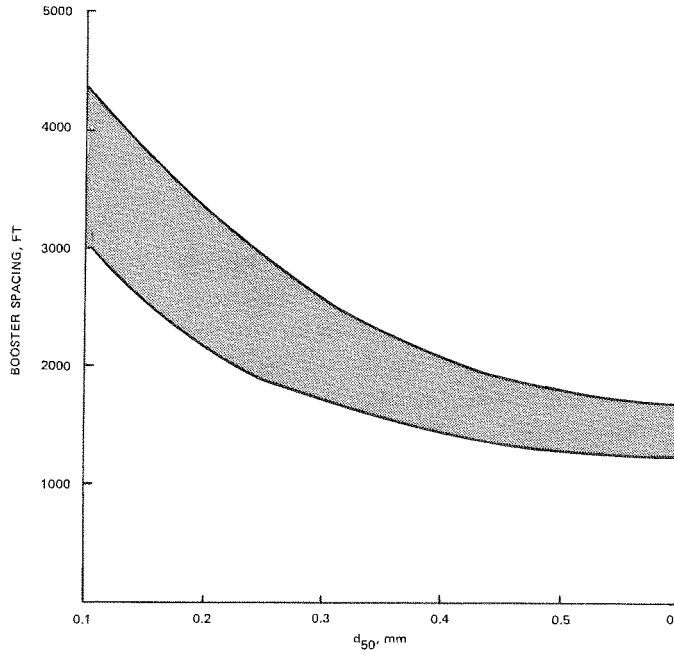


Figure 20. Initial estimate of booster station spacing as a function of sediment size

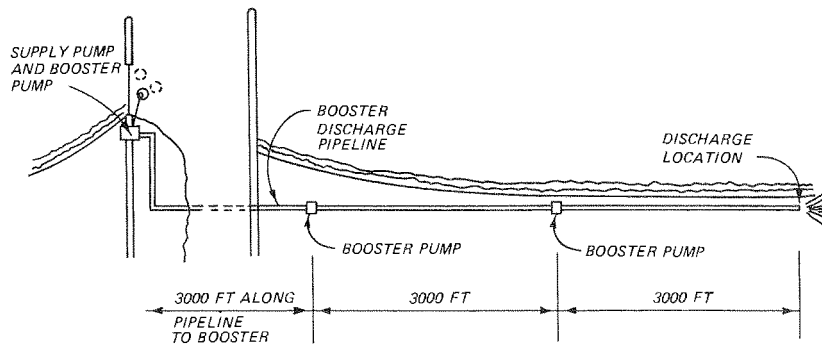


Figure 21. Example arrangement of multiple boosters on 9000-ft-long discharge line for 0.20-mm sand

The basic schedules that should be considered are:

> Daily: Operation for a regular period each day on a 5- or 6-day-per-week basis.
>
> Intermittent: Operation only when conditions are such that bypassing is needed. This means that the system may be idle for days at a time and may be operated 24 hours a day during other periods.

Either of the above two schedules can be employed year-round, or only on a seasonal basis, or as a mixture of the two. For instance, it might be decided to operate a system on a daily basis during times of the year when drift rates are high, and on an intermittent basis at other times.

45. The total operating time is the number of hours per year when personnel are present and the system could be in operation. The effective operating time is defined as the number of hours per year that the bypassing system is actually pumping sand. The effective time of operation can be approximated by estimating the number of working days per year, multiplying by the operating hours per day to get the total operating hours per year, and correcting this value for work or operational interruptions. A system of correction factors is presented below to assist in determining an effective operating time.

46. The correction factor for interruptions due to system repair and replacement is applicable to both daily and intermittent operation but should be less for the latter. Intermittent operation should allow a higher level of preventive maintenance to be performed, reducing the frequency of repairs. No standard correction factor is available to apply to jet pump bypassing systems, but a reduction in total operating time of 10 to 15 percent was observed during the WES research program and appears to be a reasonable long-term average for daily operation. The system should perform with less downtime during early life, but may have more during later years.

47. Other work interruptions take many forms, but the most prevalent are jet pump suction blockages, temporary lack of littoral materials, and need to relocate mobile jet pumps. The reduction factor for suction blockages should be greater for sites with a high number of

shell fragments or cobbles or where sea grasses or debris are present. Mobile jet pumps also call for a higher correction factor than do fixed pumps. Factors for pump blockages should range from 5 percent for fixed pumps in relatively clean sandy shoals to 10 percent for mobile pump assemblies in clean sandy shoals to 20 percent for pumps in areas that have a high shell or cobble content or other debris. In general, fixed pumps are more susceptible to blockage by moving causes (seaweed, debris, etc.) while mobile pumps are affected by in situ causes (cobbles, for instance) and to a lesser degree by moving causes. A high incidence of blockages from in situ and moving causes may make frequent relocation of a mobile pump necessary.

48. Temporary lack of littoral materials is a situation that primarily affects fixed jet pump assemblies. In theory, a properly planned bypassing system will have littoral materials available for pumping at one location or another in the bypassing area throughout the period constituting the total operating time. However, there may be occasions when transport and deposition patterns and rates change enough to "starve" the system of littoral material. There is no set way of estimating this effect, but a factor of 5 percent might be applied to areas with known transport and deposition anomalies.

49. Relocation of mobile pump assemblies for reasons exclusive of suction blockages is a variable dependent on pumping rate, depth to which craters are dug, and rate of littoral material influx. When the pumping rate and the littoral influx rate to the crater are similar, the pump may require only occasional repositioning. When the influx rate is low and crater depth shallow, however, frequent movement of the pump may be necessary. Obviously, this is a highly variable situation, but a factor of 10 percent might be applied to mobile assemblies under average conditions as a first guess. A high anticipated incidence of pump movement might increase this factor to 15 or 20 percent.

50. The Effective Operating Time, EOT , in hours per year for the bypassing system can be determined from the relationship:

$$EOT = (NOD \times HD) \left[1.00 - (RR + PB + ALM + RMP)\right] \qquad (5)$$

where

NOD = number of operating days per year

HD = number of working hours in an operating day

RR = correction factor for system repair and replacement ÷ 100

PB = correction factor for pump blockages ÷ 100

ALM = correction factor for absence of littoral materials ÷ 100

RMP = correction factor for relocation of mobile pump assemblies ÷ 100

51. Proper application of the factors presented here should result in a realistic estimate of the effective operating time for the bypassing system. This analysis shows that the effective operating time could be as little as 50 percent or less of the total operating time. If the effective operating time seems to be relatively low, it should be remembered that many dredging systems have similar characteristics. Hopper dredges may spend a large amount of time in transit to and from the discharge site, while cutter suction dredges have to cease operation to periodically move swing wire anchors or to allow vessels to pass in a navigation channel. If the dredging site is subject to significant wave action, floating dredge downtime may be further increased.

System Capacity

52. The short term relationship between the rate of littoral influx, the production capacity of the bypassing system, and the available storage volume at a site is given by the expression

$$Q_L(\Delta t) - STORE_{\Delta t} = EXC(EOT_{\Delta t}) \qquad (6)$$

where

Q_L = average rate of net littoral influx to storage area(s) during interval Δt , cu yd/hr

Δt = a time interval of the bypassing season, hr; should be as short as possible consistent with available data

$STORE_{\Delta t}$ = storage volume available during interval Δt , cu yd

EXC = required capacity of bypassing system, cu yd/hr

$EOT_{\Delta t}$ = system effective operating time over interval Δt , hr

53. $STORE_{\Delta t}$ is not a fixed quantity, but is dependent upon factors such as the condition of the storage area at the start of Δt . Storage of littoral material in one form or another takes place at all littoral barriers. Often, it is this very storage or a portion of it that makes bypassing necessary. Evaluation of storage for bypassing purposes is complicated by the fact that only a part of the total storage at a site may be available for transfer by a bypassing system. Material stored in locations not reachable by the system cannot be included in the system analysis. Also, because of the variation of littoral rates during the year, the system may temporarily remove all the material within the effective storage area. This temporary removal may result in deepening of the adjacent bottom and localized slumping into pumping areas. This readjustment of the adjacent area must occur without endangering nearby structures.

54. For purposes of the initial layout, areas that are potentially within reach of a bypassing system should be identified as storage areas. As a rule of thumb, all areas below mean high water and located such that the total length of the jet pump discharge line will not exceed 600 to 700 ft can be considered to be potentially within reach of a jet pump bypassing system. The figure of 600 to 700 ft is given here for initial estimating purposes, not as an absolute limit. The range of mobile jet pumps will be determined more by the practical limitations of handling long reaches of floating pipelines and may therefore be less unless special measures are taken. For fixed jet pumps, where floating components are not a problem, the range of the system is a function of hydraulic and power considerations only. In most cases, however, the designer will find rapidly increasing power requirements if the jet pump discharge lines become too long. Areas such as jetty fillets, offshore bars, shoals, and prepared impoundment areas should be considered for use as potential storage areas. Past surveys of these areas together with estimates from the coastal processes study of transport vectors should be analyzed to determine: (a) that littoral transport does in

fact enter each area, and (b) what deposition patterns occur and how these patterns change with time. Only after this sort of analysis has been performed can a reasonable value of storage capacity (the amount of material that the area is capable of retaining at any one time) be determined.

55. Q_L as used in Equation 6 is an average net influx from all directions. In other words, it is the average rate at which littoral material moves into the storage area and remains there during Δt. The maximum value for Q_L is the average gross transport rate from all directions into (but not out of) the storage area during Δt. Use of this value would be based on the assumption that the storage area "traps" all littoral material which moves into it. In some instances, total trapping may not be the case, and a portion of the gross influx will continue on through the storage area. This might occur during periods of high wave activity or strong currents. The portion that moves through would not be available for bypassing; consequently, less storage and/or a smaller system production capacity would be indicated. Operation of the bypass system in the storage area will affect the value chosen for Q_L. Usually, the trapping capability of the storage area will be increased due to the craters formed by the system jet pumps. The amount of this increase will depend on variables such as the number, size, location, and condition of the craters.

56. An earlier section of this report (paragraph 50) outlined how to determine EOT, the Effective Operating Time per year. The same techniques can be applied to determining $EOT_{\Delta t}$ for a particular time interval.

57. Once $STORE_{\Delta t}$, Q_L, and $EOT_{\Delta t}$ have been determined, Equation 6 can be used in a rearranged form to determine various values of EXC, the system production capacity:

$$EXC = \frac{Q_L(\Delta t) - STORE_{\Delta t}}{EOT_{\Delta t}} \qquad (7)$$

Equation 7 can be incorporated into many possible schemes for arriving

at a final design value of EXC . The following approach is given only as an example of such a scheme:

a. For a Δt corresponding to a particular time interval of the year, a value or possible range of values for Q_L is determined from the coastal processes study, keeping in mind the discussion in paragraph 53.

b. $EOT_{\Delta t}$ is calculated, using the considerations described in paragraphs 44-51. Several values may be possible.

c. The storage capacity of the storage area(s) is determined (see paragraphs 53 and 54). If the storage capacity varies during the year, this effect should also be taken into account, since this calculation is for a particular time of the year.

d. Reasonable estimates are made of what range of initial conditions might exist in the storage area(s) at the beginning of the Δt interval. The bounds of this range are that the storage area is either completely full or completely empty. However, the actual condition or range of conditions will probably lie in between these bounds.

e. A range of $STORE_{\Delta t}$ values is calculated, based upon the range of initial conditions determined in paragraph d. For any particular initial condition,

$$STORE_{\Delta t} = STCAP - STIN \tag{8}$$

where

STCAP = storage capacity of storage area, cu yd

STIN = initial condition of storage area; i.e., volume of material already there at beginning of interval Δt , cu yd

f. Reasonable combinations of Q_L , $EOT_{\Delta t}$, and $STORE_{\Delta t}$ are determined. Although a range of values for each variable may have been identified, it does not necessarily follow that each value within the range of a particular variable can occur in combination with all values of the other two variables. Also, some combinations of the three variables may be more likely to occur than others.

g. Equation 7 is solved using the combinations determined in paragraph f. The values of EXC thus calculated are recorded.

h. Steps a through g are repeated for other Δt intervals occurring at other times of the year. The result is a number of possible values for EXC . From these, a

design value or set of values is chosen to use in sizing the system components. The criteria for choosing a value or values for EXC will have to be determined by the designer. One criterion, and possibly a wasteful one in terms of system construction costs, would be simply to use the largest value of EXC . Another method might involve constructing a frequency distribution graph of EXC , plotting the relative frequencies of occurrence of classes of EXC values based on data from the above calculations. Then, from this graph, some value or values of EXC would be chosen corresponding to predetermined frequency criteria. Inherent in such a method is the understanding that on occasion, the storage capacity of the system will be exceeded.

58. Again, it is emphasized that the preceding approach is given only as an example. The important aspect of this section of the report is to understand the basic concepts of effective operating time and storage, and how their interaction with littoral drift rates should determine the design capacity of the system.

Considerations for Interception Type of System

59. Occasionally, the designer may find that little or no storage capacity is available at the site, and that the bypass system must function by intercepting sand which is in continuous motion. In this situation, of course, the concept of storage does not apply in determining a design value of EXC . The relationship expressed in Equation 6 then becomes simply:

$$Q_L(\Delta t) = EXC(EOT_{\Delta t}) \tag{9}$$

60. Q_L as used in Equation 9 takes on a somewhat different character than for Equation 6. None of the littoral material remains in the vicinity of the system; it is either all caught by the jet pump(s) or else moves past the system and is gone, presumably forever. Therefore, Q_L is now simply the rate at which littoral material approaches the system during Δt . It is imperative that Q_L values be determined for Δt intervals which are as small as possible. The ideal

situation would be to have estimates of hourly rates of Q_L . The major concept here, however, is that the bypass system capacity is a direct function of the littoral drift rate for an interception type of system.

Distribution of System Capacity

61. The number of jet pumps to be operated simultaneously should be decided in the initial system layout. Factors such as the system mode of operation, littoral transport vectors, and required system capacity must be considered. The size of jet pumps employed in the system will have an influence as well. WES experience thus far with jet pump bypassing systems has indicated that two sizes of the Pekor center-drive jet pump* have pumping capacities which match the requirements of many bypassing situations. The manufacturer's designation of these sizes, the 4 × 4 × 6 and the 6 × 6 × 8, describes the nominal inside diameters of the suction, mixing chamber, and discharge, respectively. For each pump, the approximate range of pumping capacity suggested for use in this report is shown below.

Jet Pump	Pumping Capacity, cu yd/hr
4 × 4 × 6	Up to 100
6 × 6 × 8	Up to 200

62. The tabulated values given are intended only as guidelines and not guarantees. The actual pumping capacity depends on a number of site-specific conditions. Simply because a pump is capable of moving, say, 100 cu yd/hr, does not mean that it will be able to pump at that rate in a given situation. Final determination of jet pump size based on site conditions will be made in PART III of this report. However, the tabulated values will allow the designer at this stage of design to identify available options in the number of simultaneously operating jet pumps. For example, if a design value for EXC of 140 cu yd/hr has been selected, the designer might choose to operate one 6 × 6 × 8 jet pump at

* Manufactured by Pekor Iron Works, Columbus, Georgia.

a time with a capacity of 140 cu yd/hr. Or, he might elect to operate two 4 × 4 × 6 jet pumps simultaneously, each pumping 70 cu yd/hr. Depending on circumstances at the site, he might even investigate using three or more 4 × 4 × 6 jet pumps at a time, each with the appropriate pumping rate. KEEP IN MIND, HOWEVER, THAT THE BETTER SYSTEM WILL USUALLY HAVE THE LEAST NUMBER OF JET PUMPS OPERATING AT ONE TIME. IF THE JOB CAN BE DONE WITH FEWER JET PUMPS, DON'T USE MORE.

63. Once the number of simultaneously operating jet pumps has been determined, the required capacity of a single jet pump, EXC1 , should be estimated. This is actually a complex task if done rigorously, involving a series of iterative calculations for a pipeline network. One of the characteristics of a multiple jet pump system is that all other variables being equal, the capacity of each jet pump relative to the others will vary inversely with jet pump discharge pipeline length. For example, in Figure 22, jet pump #1 would have a greater capacity

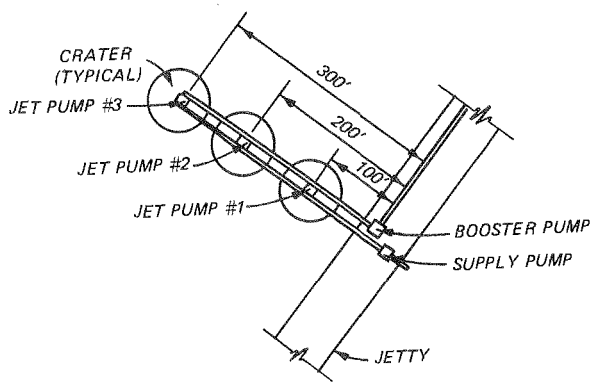


Figure 22. Example jet pump discharge pipeline lengths, multiple jet pump system

than #2, which in turn would pump more than #3. EXC1 can be approximated from the following simple relation:

$$EXC1 = \frac{EXC}{NUM} \tag{10}$$

where NUM is the number of jet pumps operated simultaneously. However, the designer must remember that in a multiple system with different jet pump discharge pipeline lengths, it is extremely difficult to obtain exactly the same output from each jet pump. Also, it may be necessary, due to local transport vectors, for one jet pump to have a capacity in excess of EXC1 as calculated above. The point of all this is that a value for EXC1 should be chosen not calculated for a multiple jet pump situation, taking local conditions and requirements into account. In PART III of this report, the designer will be shown how this chosen value is used to arrive at a design for the complete multiple system.

Backflushing

64. Backflushing, an operational technique peculiar to jet pumps, must be discussed in the initial layout phase of system design, since it influences the layout and selection of discharge pipelines in systems with more than one jet pump. For a jet pump operating with a certain supply flow rate QSUP , if the flow resistance in the jet pump discharge pipeline is increased, the suction flow rate QSUC will decrease. If the discharge pipeline flow resistance is increased enough, QSUC will become zero. If an "infinite" discharge flow resistance is created by closing a valve in the jet pump discharge pipeline, the jet pump supply water will flow out the suction of the jet pump (Figure 23). This property of a jet pump can be useful in clearing the suction of blockages due to shells, debris, etc. Operationally, such a technique is called "backflushing," and the valve in the jet pump discharge pipeline is called the "backflush valve."

65. The influence of backflushing requirements on discharge pipeline layout is illustrated by Figures 24 and 25. Each figure shows a system with two jet pumps operated simultaneously. In Figure 24, the jet pumps share a common discharge pipeline, while in Figure 25 they have separate pipelines that join just before the booster pump. The common discharge pipeline in Figure 24 has one backflush valve, while each pipeline in Figure 25 has its own.

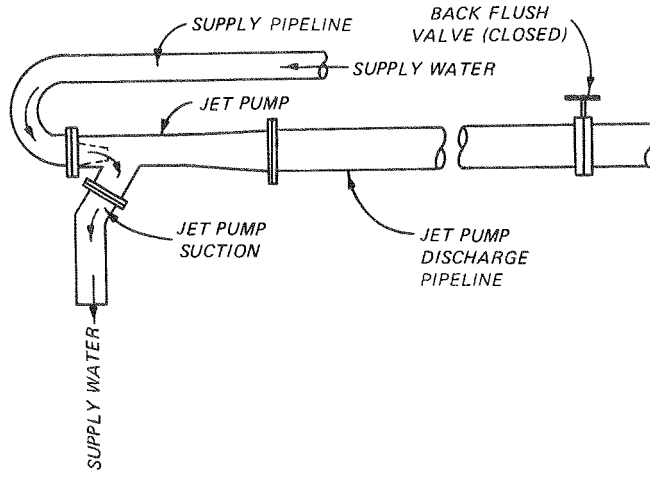


Figure 23. Jet pump backflushing

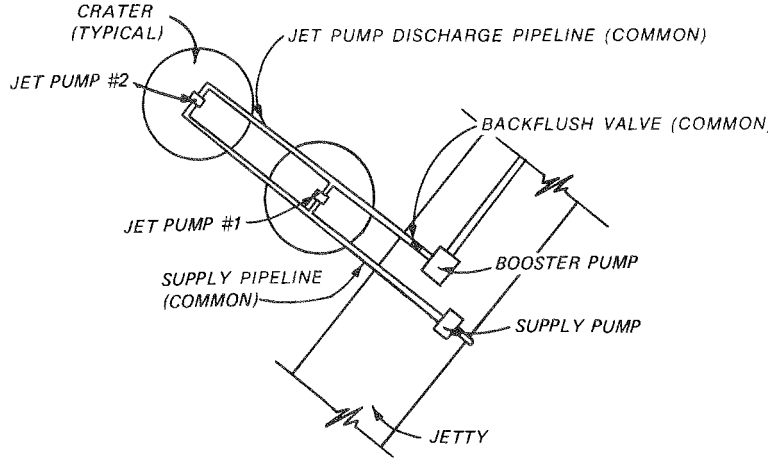


Figure 24. Two jet pumps with common discharge pipelines

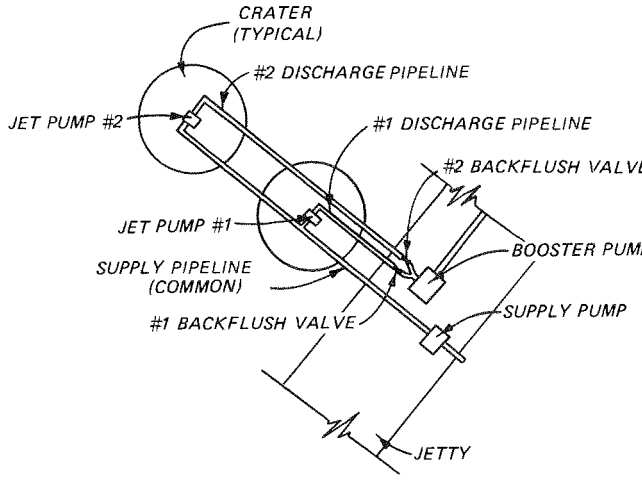


Figure 25. Two jet pumps with separate discharge pipelines

66. In the Figure 24 system, closure of the backflush valve will cause both jet pumps to backflush, even if only one has a suction blockage. There may also be a tendency for more flow to be directed outward through the unblocked suction since the hydraulic resistance there is less. In the Figure 25 system, each jet pump can be backflushed independently. However, more discharge piping and backflush valves are required and system installation may be more difficult.

67. A backflushing capability is necessary for all mobile jet pumps, since they often develop suction blockages when excavating new craters. Fixed jet pumps, on the other hand, are subject to blockage mainly by objects falling into their craters. Backflushing will remove these objects from the jet pump suction, but may not remove them from the crater. If they remain in the crater, they will eventually reenter the jet pump suction. It is usually necessary, therefore, to provide some type of coarse screen around the suction of a fixed jet pump to prevent large objects from entering. Then, the question of how to provide a backflushing capability will be answered by the degree of

discharge pipeline complexity the designer is willing to introduce.

System Pipe Sizes and Materials

68. The initial system layout must include a "first guess" at the size and material for the following pipelines:

a. Jet pump supply.

b. Supply pump suction.

c. Jet pump discharge.

d. Booster pump discharge.

Actually, several alternates should be developed at this stage for each of the above pipelines. These alternates should be carried through the design procedure in PART III as parallel calculations. Then, the relative effects of each will be apparent, and the most suitable combinations of size and material can be chosen.

69. The following general guidelines may be followed in choosing initial pipe sizes for single jet pump systems. These guidelines apply only to pipe with inside dimensions corresponding to Schedule 40 specifications. For other types of pipe, the nominal sizes given below may not be acceptable. The pipe sizes given are for initial estimating purposes only and may be changed in the final design, based on the results of PART III calculations:

a. Jet pump supply pipeline.

(1) 4 × 4 × 6 jet pump - 6 in. for line lengths up to 500 ft; 8 in. for greater lengths.

(2) 6 × 6 × 8 jet pump - 8 in. for line lengths up to 500 ft; 10 in. for greater lengths.

b. Supply pump suction pipeline. At least one pipe size larger than the jet pump supply pipeline.

c. Jet pump discharge pipeline.

(1) The best that can be done at this stage in the design process is to choose a jet pump discharge pipeline size which falls in the middle of a range of design possibilities. The approach used consists of choosing a pipe size based on the calculated value of EXC1 , then adjusting the jet pump discharge pipeline length so that the combination of EXC1 ,

pipe size, and pipeline length fall within a predetermined range of values. The designer may later have to revise his initial layout following more detailed calculations in PART III.

(2) The designer should enter Figure 26 using the value of EXC1 from paragraph 63 and move vertically to the first line encountered corresponding to a particular pipe size, which then becomes the "first guess" at the jet pump discharge pipeline size. Then, the approximate center of the range of pipeline lengths possible for EXC1 and that pipe size can be found from the vertical axis. If the value from Figure 26 is greater than 700 ft, the designer may lengthen the pipeline to the new value, if necessary. If the Figure 26 value is substantially less than the value used up to now, the designer must shorten the jet pump discharge pipeline to the new value. If the discharge pipeline cannot be shortened to the new value, the designer may move upward on Figure 26 to the line corresponding to the next larger pipe size. This pipe

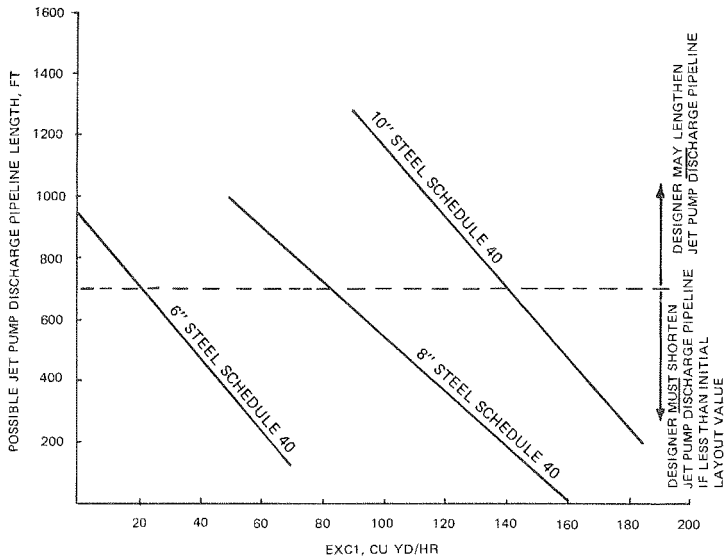


Figure 26. Possible jet pump discharge pipeline lengths versus EXC1 for various pipe sizes

size then becomes the "first guess" in subsequent calculations. The designer should resist the urge to use longer or larger pipelines than necessary, since the system will be more expensive to build and operate. Also, the designer should not use 6-in. pipe with a 6 × 6 × 8 jet pump or 10-in. pipe with a 4 × 4 × 6. If the discharge pipeline length is changed, the designer should review all aspects of the initial layout to see whether other changes are necessary. In particular, if the area of influence of the jet pump(s) is altered, a new system capacity will have to be calculated.

d. Booster pump discharge pipeline. Same size as jet pump discharge pipeline, or possibly one pipe size larger if flow in the jet pump discharge pipeline is near maximum for that pipe size.

For multiple jet pump systems that use common supply and discharge pipelines to serve all simultaneously operating jet pumps, pipe sizes for items a and c should be chosen such that their inside areas are roughly the appropriate multiple of the areas for the sizes shown above for single systems. For instance, if a 6-in. supply pipeline would be chosen for a certain single jet pump system, then an 8-in. pipeline is indicated for a two-jet pump system with the same pipeline lengths (the inside area of an 8-in. pipe is slightly less than twice that of a 6-in. pipe). The instructions given above for items b and d apply to multiple jet pump systems as well.

70. An initial selection of pipe materials should be made at this stage, so that the complete hydraulic characteristics of the pipelines will be known for PART III. Although different materials will have different hydraulic characteristics, no adjustments for pipe material (such as changing pipeline lengths) should be made to the initial system layout at this stage. Some options that may be considered and that have performed satisfactorily in WES field tests are:

a. Jet pump supply pipeline.

(1) Steel - For fixed jet pumps.

(2) Flexible rubber hose - For mobile jet pumps.

(3) High density polyethylene (HDPE) - For fixed jet pumps where the pipe will not have to support any external load, such as the weight of the jet pump.

b. Supply pump suction pipeline.

(1) Steel.

(2) HDPE.

c. Jet pump discharge pipeline. Same as jet pump supply pipeline.

d. Booster pump discharge pipeline.

(1) Steel.

(2) HDPE.

Other Considerations

71. Two other items must be considered by the designer before proceeding with the system hydraulic design: (a) booster pump flushing water and (b) jet pump cutting jets. Flushing water is clear water (i.e. no solids) which is continually provided to the booster pump stuffing box to prevent solid particles from entering. The flushing water must be at a pressure greater than the discharge pressure of the booster pump. The system supply pump may be able to provide flushing water to a nearby booster pump if the supply pump discharge pressure is sufficiently greater than that of the booster pump. If this arrangement is used, the supply pump will have to be sized to provide this additional flow.

72. As described previously, cutting jets are often used around the jet pump suction to aid in suction burial and in excavating consolidated material. Mobile jet pumps should always be provided with cutting jets, due to the range of conditions they often encounter. For fixed jet pumps, cutting jets may or may not be needed depending on the size and characteristics of the material that enters the jet pump crater. Fine sand that tends to pack quickly may require some cutting action to loosen it. Coarse, well-graded sand, on the other hand, may flow easily under the influence of suction alone. The point is that for fixed jet pumps, the question of whether to provide cutting jets should be answered by sediment information gathered in the coastal processes study. The water for cutting jets has to be provided by the supply pump (Figure 7), imposing an additional flow requirement on it.

System Schematic Drawings

73. The final aspect of initial system layout is the preparation of system schematic drawings in both plan and elevation. Schematic drawings should show the following information as a minimum:

a. Major system components (jet, supply, and booster pumps and structures).
   (1) Location.
   (2) Elevation.

b. Pipelines.
   (1) Routing.
   (2) Length.
   (3) Size.
   (4) Material.

c. Valves and pipe fittings (bends, reducers, etc.).
   (1) Location.
   (2) Size.
   (3) Type.

d. Craters.
   (1) Location.
   (2) Dimensions.

e. Jet pump excavation rate(s).

74. A set of example schematic drawings for a mobile jet pump system with two jet pumps, one of which operates at a time, is shown in Figures 27-31.

Equivalent Lengths

75. A convenient method to account for hydraulic energy losses caused by bends, valves, or other fittings in a pipeline is to replace these fittings in the calculations with lengths of straight pipe which give the same energy losses as the fittings. These "equivalent lengths" of straight pipe are added to the actual length of the pipeline. Then, a calculated loss factor is applied to the total equivalent pipeline

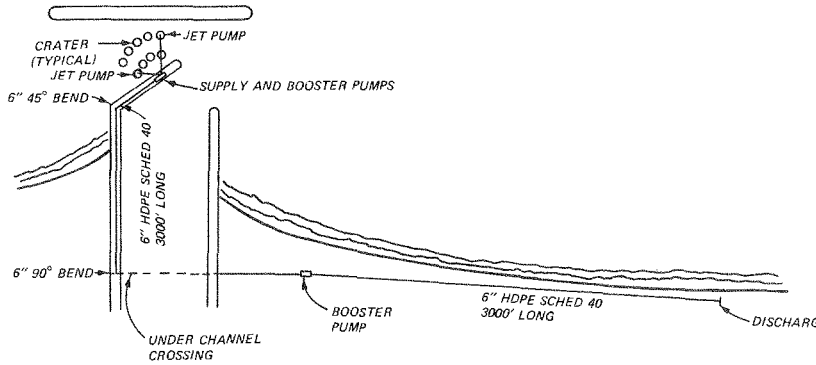


Figure 27. Overall system schematic

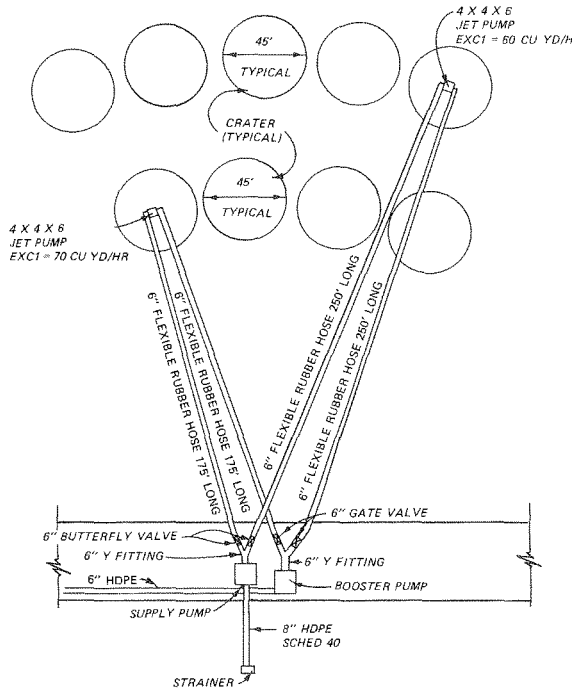


Figure 28. Detailed schematic - jet, supply, and booster pumps (plan view)

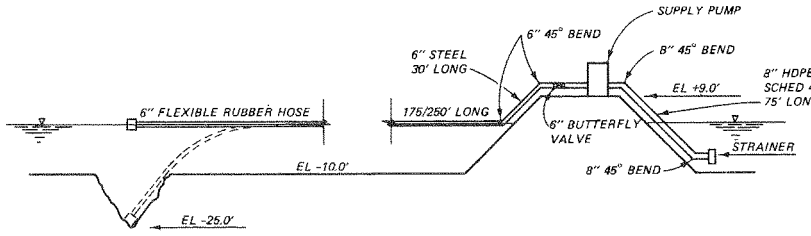


Figure 29. Jet pump supply system (elevation view)

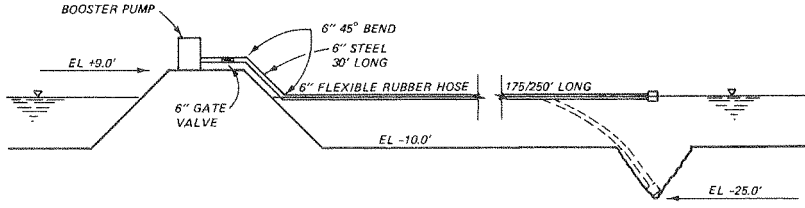


Figure 30. Jet pump discharge system (elevation view)

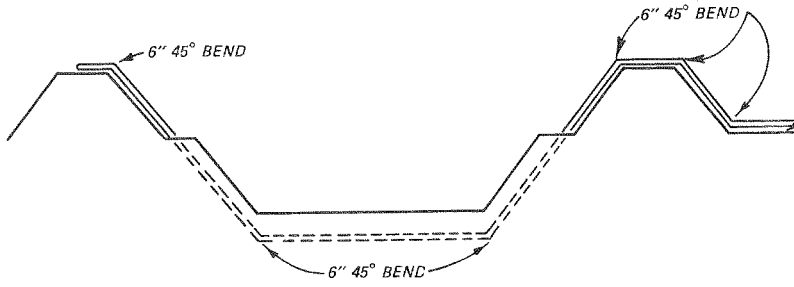


Figure 31. Booster discharge pipeline underchannel crossing (elevation view)

length (actual plus fitting equivalents), giving the total system energy loss in one computation.

76. Tables giving equivalent lengths of steel or cast iron pipe for different types and sizes of fittings are in many hydraulic handbooks (see Hydraulic Institute Standards, 1965, p E(I)-7). For fittings and pipe materials not included in such tables, Appendix B suggests some approaches to be used. The tabulation below shows an example of equivalent length calculations for the supply pump suction pipeline shown in Figures 28 and 29.

Type of Fitting	Number of Fittings	Equivalent Length per Fitting, ft	Total ft
Strainer	1	35.6	35.6
45-deg bend	2	7.7	15.4
Straight pipe	--	--	75.0
		Total equivalent length	126.0

PART III: HYDRAULIC DESIGN

77. Two separate procedures are described in this section that can be followed in designing jet pump systems for pumping sand. These procedures are presented in step-by-step fashion. In some steps, it is necessary that judgment be applied, and explanatory text is included to guide the designer. The knowledge or information that is necessary to perform the calculations or to make the decisions required by each step is specified where possible. A simplified flow chart is included so that the logical structure of the hydraulic design process can be followed.

78. The first procedure consists of a series of well-defined calculation steps. Included in the procedure is an iteration loop to determine values of the jet pump operating parameters. This procedure can be partially adapted to a programmable desk calculator or a computer. Such adaptations are not included in this report.

79. The second procedure utilizes graphs of jet pump performance together with discharge head curves generated by the designer to arrive at values of the operating parameters. The major advantage of this procedure is that it allows the designer to consider the entire range of jet pump possibilities at once, without having to recalculate design values. Also, jet pump cavitation limits are built into the graphs and values of efficiencies are shown.

80. The basic jet pump system for pumping sand consists of a centrifugal pump to provide supply water, a jet pump, a booster pump, and the interconnecting pipelines with valves and fittings. Either of the design procedures that follow will result in the following information:

a. Values of operating parameters for:
   (1) Jet pump.
   (2) Supply pump.
   (3) Booster pump.

b. Flow rates and velocities at all points in system.

c. Values of energy losses in all pipelines.

d. Percent solids pumped at design operating point.

e. Methods for selecting:

(1) Supply pump.

(2) Booster pump.

81. The given procedures are for the basic single jet pump system with one booster pump. Procedures for systems with multiple jet and/or booster pumps are similar except for some additional hydraulic considerations. These will be discussed at the end of PART III.

82. The design calculations make use of the initial layout and schematics of the bypassing system generated in PART II. If the design calculations show that a system element is inadequate or produces inefficient operation, a more reasonable selection should be inserted into the layout together with other associated corrections. By this method, the designer is assured of considering the bypassing system as an entity rather than as a group of components.

83. In both design procedures described in this part of the report, the total system design develops as a function of the jet pump design operating point. A major consideration in choosing the jet pump design operating point is efficiency of the jet pump at that point. Since the other demands on the jet pump at that point (excavation rate, pumping distance, etc.) resulted directly from project considerations discussed in PART II, such an approach will usually produce a well-designed system. However, the designer must remember that overall system efficiency, i.e., accomplishing the required bypassing with the least amount of total energy, is what really matters. Jet pump efficiency is a major factor in overall system efficiency, but the supply and booster pump operating characteristics play a role as well. Therefore, the designer should consider several alternative designs and compare the projected energy consumptions for each.

Iteration Design Procedure

84. The following design calculations are presented as a number of discrete steps. At the beginning of each step the information necessary to perform the calculations is given. The necessary relationships and equations are either presented in the step or are specifically

referenced. Some steps are check points and may show that reselection of system components and recalculation of new system values are necessary. These steps are specifically identified. A detailed flow chart showing relationships between steps as well as decision points in the design procedure is presented in Plate 1.

Step 1: Objective - Determine the minimum discharge pipeline velocity, often called critical velocity, necessary to maintain solids in suspension for all pipelines with solids flow. Also, determine the representative settling velocity of the sediment particles to be bypassed. This calculation should be done for each size of pipe used in the sediment-carrying portion of the system.

Information required - (a) Pipe inside diameter, D, ft; (b) median diameter of sediment to be bypassed, d_{50}, mm; and (c) specific gravity of the sediment solids, SGSOL (for quartz sand, SGSOL = 2.65).

Method - The first sediment parameter that will be determined is the settling velocity, W, of the d_{50} sediment particle. W can be determined from the curves in Figure 32, which shows plots of both empirical data and equations from several investigators for quartz particles settling in water at 68°F. For $d_{50} < 0.6$ mm, the center of the plots may be used. For $d_{50} > 0.6$ mm, the plots diverge rapidly, indicating that variables such as the particle shape become more important. In this range of particle sizes, it is suggested that plot 9 be used, since it is based on data using naturally occurring particle shapes. It should be noted that d_{50} is expressed in millimetres and W in millimetres per second in Figure 32. The value of W from Figure 32 should be multiplied by 0.00328 to convert it to feet per second for use in subsequent calculations.

The following empirical relationship from Durand (1953) is suggested as a means of determining the minimum discharge pipeline velocity, VCRIT :

$$VCRIT = F_L \sqrt{[2gD(SGSOL - 1)]} \qquad (11)$$

F_L, a proportionality coefficient, can be determined from Figure 33. C_v in Figure 33 is the expected volumetric concentration of solids in the discharge pipeline. It is suggested at this stage in the calculations to use the curve marked $C_v = 15\%$ as a conservative value.

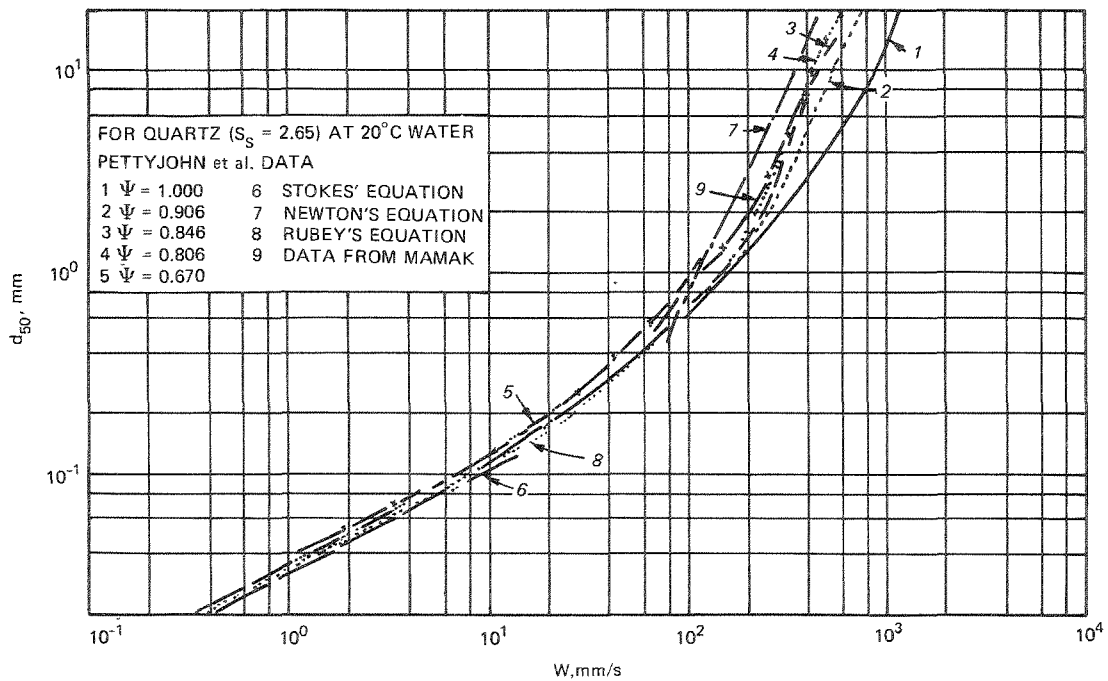


Figure 32. Settling velocity of quartz particles (from Hydraulics of Sediment Transport by Graf (1971). ©1971 by McGraw-Hill Inc. Used with permission of McGraw-Hill Book Company)

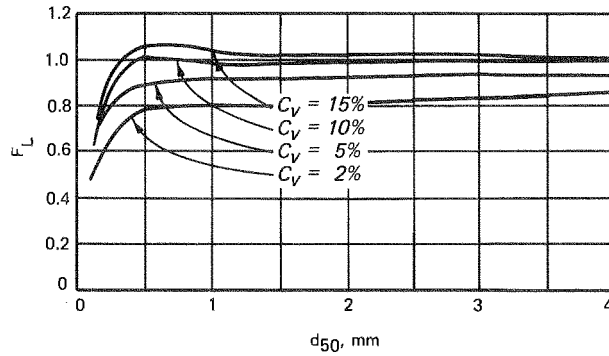


Figure 33. F_L versus d_{50} for Durand relationship (from Hydraulics of Sediment Transport by Graf (1971). ©1971 by McGraw-Hill Inc. Used with permission of McGraw-Hill Book Company)

Step 2: Objective - Determine the minimum required volumetric flow rate, $QSUP_{min}$, in the system discharge pipelines to assure conveyance of solids in suspension.

Information required - (a) VCRIT from Step 1, fps; (b) discharge pipe maximum inside area, ADIS, ft^2. ADIS should be the inside area of the largest pipe in the sediment-carrying portion of the system.

Rationale - The flow rate calculated in this step is the minimum clear water flow rate that should be supplied to the jet pump nozzle. Such a minimum flow rate will help ensure that sediment in the discharge pipelines can still be carried in suspension even if the jet pump intake plugs completely.

Method - Perform the following calculation to obtain $QSUP_{min}$ in gallons per minute (gpm):

$$QSUP_{min} = (448.831)(ADIS)(VCRIT) \qquad (12)$$

Step 3: Objective - Determine the jet pump suction flow necessary to produce the required project site bypassing rate.

Information required - (a) Individual jet pump required bypassing rate, EXC1, cu yd/hr; (b) in situ porosity, n, of sediment to be bypassed; (c) specific gravity, SGSOL, of solids.

Rationale - The mixture entering the jet pump suction is called suction flow, and the volumetric rate of entry is termed QSUC . This mixture is composed partly of fluid and partly of solid sand particles. By determining the specific gravity of the in situ material at the site and making certain assumptions as to the specific gravity of the entering mixture, the value of QSUC can be determined.

Method - The required jet pump suction flow, QSUC , in gallons per minute, can be calculated from

$$QSUC = EXC1\ (3.37) \left(\frac{SGIN - SGWAT}{SGSUC - SGWAT}\right) \qquad (13)$$

where

SGIN = in situ material specific gravity = SGSOL(1 - n) + n(SGWAT)

SGWAT = specific gravity of ambient water (1.00 for fresh water, 1.025 for seawater)

SGSUC = assumed average specific gravity of mixture entering jet pump suction

In WES field tests, SGSUC varied between about 1.40 and 1.85 depending on pumping conditions. It is suggested that a value of SGSUC = 1.70 be used for preliminary estimation.

Step 4: Objective - Select a jet pump size to use in subsequent calculations.

Information required - Value of QSUC , gpm, from Step 3.

Rationale - Two sizes of the Pekor center-drive jet pump, the 4 × 4 × 6 and the 6 × 6 × 8, have pumping capacities that match the requirements of many bypassing situations. The same dimensionless performance characteristics are assumed for each, but flow rates in the larger pump are higher. It is therefore necessary to know which pump is being considered for steps later in this procedure.

Method - Compare the value of QSUC with those given below:

QSUC Range, gpm	Jet Pump
200 to 500	4 × 4 × 6
500 to 700	Transition
700 to 1500	6 × 6 × 8

Select the jet pump corresponding to the correct range of QSUC . For values of QSUC in the transition range either jet pump may prove the most feasible, depending on other system requirements. It is suggested that both types be considered simultaneously.

If QSUC from Step 3 is less than 200 gpm, the designer should consider at this point whether such a small capacity is correct, and if so, why. Since QSUC is a direct function of EXC1 (Equation 13), and the value of EXC1 for a given EXC depends only on NUM , the number of jet pumps operated simultaneously (Equation 10), it may be that QSUC is too small because NUM is too large. Or, EXC may be too small. The designer should return to the initial layout to check these possibilities. If such is not the case, the designer should reevaluate the entire situation to make sure the problem is of sufficient magnitude to warrant a sand bypassing system.

If QSUC is larger than 1500 gpm, the designer should also recheck his determination of EXC , NUM , and EXC1. If the value chosen for EXC still appears reasonable, the only option left is to increase NUM , the number of jet pumps operated simultaneously. As a general guideline, if adding more than one additional jet pump to NUM is required to make QSUC less than 1500 gpm, the designer should at this point reconsider the entire system layout. If the layout still looks sound, then there is a good possibility that the bypassing problem is beyond the feasible range of a jet pump solution. THE DESIGNER MUST RESIST THE TEMPTATION OF FORCING A JET PUMP SYSTEM TO FIT THE PROBLEM. For many situations, a jet pump system is not practical. Results of this step may be indicating just that.

Step 5: Objective - Determine the flow ratio M , the head ratio N , and the area ratio R , of the jet pump.

Information required - (a) $QSUP_{min}$, gpm, from Step 2, (b) QSUC , gpm, from Step 3, (c) jet pump dimensionless performance curves, Plate 2.

Rationale - As discussed earlier (paragraphs 20-22), the behavior of jet pumps of a given design when pumping a given medium can be described by three dimensionless ratios. These are:

$$\text{Head Ratio } N = \frac{HDIS - HSUC}{HSUP - HDIS} \qquad (1 \text{ bis})$$

$$\text{Flow Ratio } M = \frac{QSUC}{QSUP} \qquad (2 \text{ bis})$$

$$\text{Area Ratio } R = \frac{ANOZ}{AMIX} \qquad (3 \text{ bis})$$

As part of the WES research program "Eductor Systems for Sandtrap Bypassing," the relationships between these ratios were defined for a Pekor center-drive jet pump under the condition of pumping medium sized sand (d_{50} = 0.5 mm). These relationships are shown graphically in Plate 2. It is evident from the plots shown in Plate 2 that if two of the ratios are selected, the third is uniquely defined. Since the effects of different grain sizes on M vs N relationships have not been measured, it is suggested that the plots in Plate 2 be used only for naturally occurring beach sands (d_{50} = 0.1 to 1.0 mm). More detailed performance data for a particular beach sand or data for coarser or finer sediments should be obtained by pump testing.

The operating efficiency, E , of the jet pump can be defined at any point from the relationship

$$E = M \times N \tag{14}$$

Peak operating efficiency is a goal of any design procedure and is a consideration in the accomplishment of this step.

Method - The optimum* flow ratio, M_{op} , can be found from the previous calculations of drive water flow rate requirements and jet pump suction flow rate requirements. Therefore

$$M_{op} = \frac{QSUC}{QSUP_{min}} \tag{15}$$

Enter Plate 2 at M_{op} and trace vertically to the jet pump dimensionless performance curve which gives the largest possible value of head ratio, N_{max} . Note the area ratio, R , associated with this curve. Determine the operating efficiency, E , of the jet pump at that point from the relation

$$E = M_{op} \times N_{max} \tag{16}$$

If E is approximately 0.20 or greater, the jet pump operating ratios have been selected. If E is between 0.14 and 0.20, the designer must choose whether to use

---

* This flow ratio is "optimum" in the sense that it derives directly from bypassing requirements and the minimum flow rate in the discharge line. "Optimum" in this context does not necessarily imply a degree of efficiency.

the M and N values just calculated, or try for a higher E value.

If E is less than 0.14, compare the value of M_{op} with values of M in the following tabulation corresponding to the proper R . If M_{op} is greater than the value from the tabulation, the value of $QSUP_{min}$ should be increased and the operating ratios recalculated. If M_{op} is less than the tabulated value, QSUC should be increased for recalculating the operating ratios. Once new ratios are calculated, use them to recalculate E . Continue this process until an acceptable value of E is found.

R	M
0.096	1.063
0.138	0.745
0.175	0.614
0.202	0.537
0.246	0.463
0.311	0.205

Step 6: Objective - Calculate the discharge flow from the jet pump, QDIS .

Information required - Jet pump suction flow, QSUC , and supply flow, QSUP , gpm, used in the final determination of M in Step 5.

Rationale - Flow rates in various segments of the discharge system must be calculated in determining the system design operating point. The input to the calculations of this step should be the rate of flow of the mixture entering the jet pump through the suction tube, QSUC , and the dimensionless flow ratio, M . These values must reflect any adjustments made in Step 5.

Method - The volumetric discharge flow rate from the jet pump, QDIS , can be calculated from the relationship

$$QDIS = QSUC + QSUP \tag{17}$$

Step 7: Objective - Calculate the expected maximum volumetric concentration of solids, CVMAX , in the jet pump discharge pipeline.

Information required - (a) Jet pump flow ratio, M , from Step 5; (b) specific gravity of sediment solids, SGSOL;

(c) in situ specific gravity, SGIN , of sediment to be bypassed (from Step 3); (d) jet pump discharge, QDIS , gpm, from Step 6; (e) porosity, n , of in situ sediment to be bypassed; (f) specific gravity of ambient water, SGWAT , from Step 3.

Rationale - Head loss calculations should be based on the maximum slurry concentration conditions that are reasonably expected to occur. The WES research program indicated certain relations that could be used for different jet pump configurations to estimate what the maximum sustained specific gravity of the mixture entering the jet pump might be. These relations are used in the following calculations.

Method - CVMAX can be determined from the relationship

$$CVMAX = \left(\frac{M}{1 + M}\right)\left(\frac{SGSUCM - SGWAT}{SGSOL - SGWAT}\right) \tag{18}$$

where SGSUCM is the assumed maximum sustained specific gravity of the slurry entering the jet pump suction. Experiments at WES developed the following relationships between SGSUCM and SGIN :

For fixed jet pumps with no cutting assists:

$$SGSUCM = SGIN \tag{19}$$

For fixed jet pumps with cutting assists:

$$SGSUCM = 0.85(SGIN) + 0.15 \tag{20}$$

For floating jet pumps, which almost always require cutting assists:

$$SGSUCM = 0.80(SGIN) + 0.20 \tag{21}$$

Note - The solids concentration determined in this step is to be used for subsequent calculation of energy losses and booster pump requirements only. No attempt should be made to return to previous steps with this value since the bypassing system will not consistently attain solids concentrations as high as those calculated in this step.

The expected maximum specific gravity of slurry in the

jet pump discharge pipeline, SGDISJ , can be computed from:

$$SGDISJ = CVMAX(SGSOL) + (1 - CVMAX)SGWAT \qquad (22)$$

The maximum excavation rate of in situ material by one jet pump, EXCMAX , cu yd/hr, can be calculated by the expression

$$EXCMAX = \frac{0.297(CVMAX)}{1 - n}(QDIS) \qquad (23)$$

EXCMAX as given by this expression should exceed EXC1 as used in Step 3. If it does not, a mistake was made somewhere in Steps 3 through 7. Calculations in these steps should be checked.

Step 8: Objective - Calculate the required jet pump discharge head, HDIS .

Information required - (a) Description of jet pump discharge pipeline including inside diameter and length (D and LDISJ), both in feet, with adjustments for valves, fittings, and bends; (b) hydraulic characteristics of jet pump discharge pipe; (c) total flow rate delivered by jet pump, QDIS , gpm, from Step 6; (d) settling velocity, W , of d_{50} particle diameter, fps (see Step 1); (e) maximum concentration of solids, CVMAX , in jet pump discharge pipeline; (f) specific gravity of sediment solids, SGSOL ; (g) elevation of booster pump center line, ZBOO , ft, relative to water surface datum; (h) maximum specific gravity of slurry in jet pump discharge pipeline, SGDISJ , from Step 7; (i) expected maximum water depth over jet pump while operating, DEPMAX , ft; (j) design pressure or vacuum head at the booster pump suction flange, PHSUCB , in feet of water. Suggestions for selecting a value of PHSUCB are given in this step.

Rationale - The jet pump discharge head represents the total energy output of the jet pump. It is composed of the energy required to overcome friction losses in the discharge pipeline, of velocity head energy, of energy required to raise the mixture to the level of the booster pump, and of the pressure or vacuum at the booster pump. Friction losses in pipelines carrying fluids and solids are calculated in two steps. First, losses attributable to the fluid flow alone are calculated. Then, these losses are adjusted to account for the presence of the solids. Equivalent lengths of pipeline should be used in the calculations.

Fluid energy losses: the Darcy-Weisbach formula is often used to calculate the rate of head loss per unit length of pipeline for fluid flow, $(\Delta h/\Delta L)_w$:

$$\left(\frac{\Delta h}{\Delta L}\right)_w = \frac{f}{D}\frac{V^2}{2g} \tag{24}$$

where

f = dimensionless friction factor; a function of pipe relative roughness and Reynolds number

D = pipe inside diameter, ft

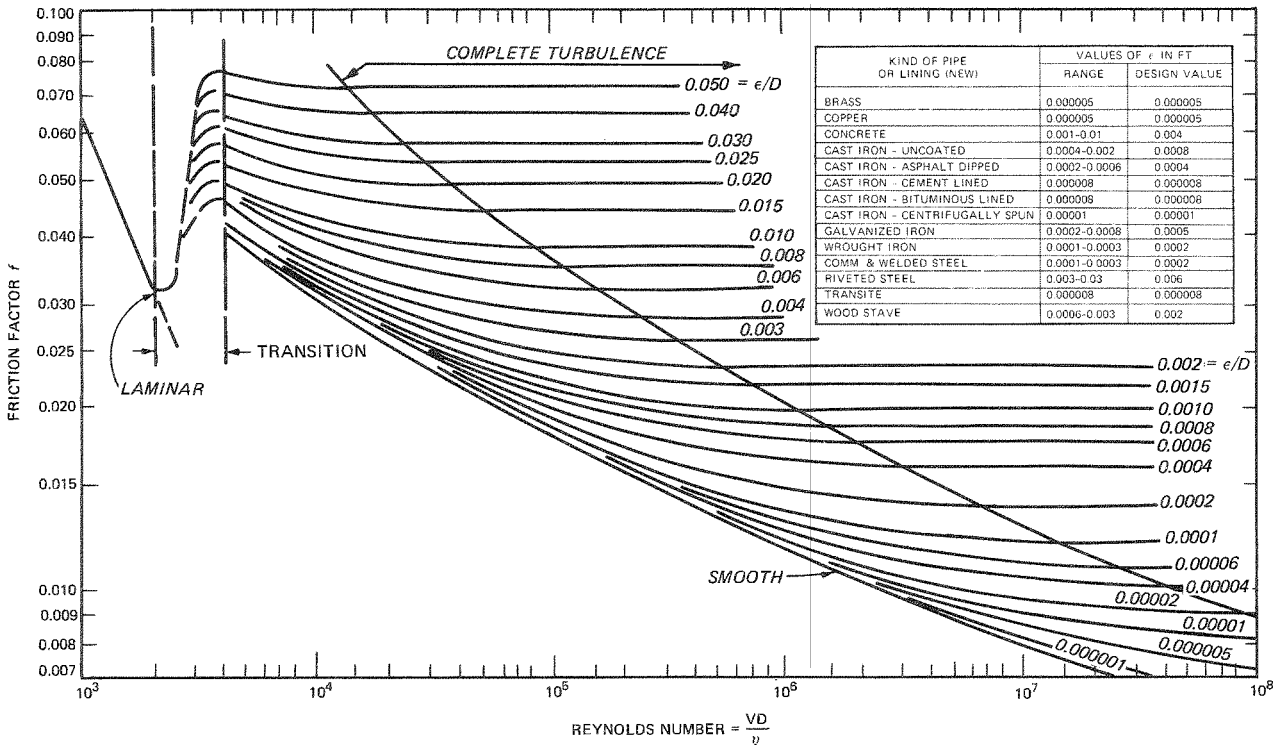
V = flow velocity in the pipe, fps

g = acceleration due to gravity, ft/sec^2

The friction factor, f , can be found from a Moody diagram such as that shown in Figure 34 (Moody 1944). f can also be found directly by an iterative solution of the Colebrook-White equation (Colebrook 1939). This method is described in Appendix B. Other relationships such as the Hazen-Williams formula are available to define fluid head loss rates, and the appropriate one should be selected by the designer on the basis of what information is available on the hydraulic characteristics of the pipe being used.

A word of caution is necessary at this point against using so-called "rules of thumb" for estimating head loss rates or any other hydraulic parameter. While such methods may indeed give answers approximating those of more complex formulas, their range of validity is often not known. At the very least, their use can result in wasteful overpowering of a system. In the worst case, they may give results which underestimate head losses, causing the system to be inadequate.

Mixture energy losses: the flow regime existing in the booster discharge pipeline must be determined before adjustments are made to fluid-only head loss rates to account for the presence of solids. The piping system has been designed to carry the mixture in a nonsettling mode, so the only test necessary is whether the mixture is a heterogeneous or homogeneous slurry. A heterogeneous slurry has a vertical concentration gradient in the pipe; i.e., more solid material is carried at the bottom of the pipe than at the top. In a homogeneous slurry, velocities in the pipe are high enough that solids are distributed



KIND OF PIPE OR LINING (NEW)	VALUES OF ε IN FT	
	RANGE	DESIGN VALUE
BRASS	0.000005	0.000005
COPPER	0.000005	0.000005
CONCRETE	0.001-0.01	0.004
CAST IRON - UNCOATED	0.0004-0.002	0.0008
CAST IRON - ASPHALT DIPPED	0.0002-0.0006	0.0004
CAST IRON - CEMENT LINED	0.000008	0.000008
CAST IRON - BITUMINOUS LINED	0.000006	0.000006
CAST IRON - CENTRIFUGALLY SPUN	0.00001	0.00001
GALVANIZED IRON	0.0002-0.0008	0.0005
WROUGHT IRON	0.0001-0.0003	0.0002
COMM & WELDED STEEL	0.0001-0.0003	0.0002
RIVETED STEEL	0.003-0.03	0.006
TRANSITE	0.000008	0.000008
WOOD STAVE	0.0006-0.003	0.002

Figure 34. Moody diagram (after Moody 1944)

more or less evenly over the pipe cross section. Head loss rates are much greater in the homogeneous flow range. Therefore, it is more efficient to size the discharge piping system to produce heterogeneous flow. The transition velocity between heterogeneous and homogeneous flow, VHOM , fps, can be found from:

$$VHOM = \sqrt[3]{1800\ gWD} \tag{25}$$

where D is the pipe inside diameter, ft, and W is the settling velocity of the sediment particles, fps.

Now, the mixture head loss per unit length, $(\Delta h/\Delta L)_m$, can be determined. For the situation

$V \geqq VHOM$ (homogeneous regime):

$$\left(\frac{\Delta h}{\Delta L}\right)_m = \left(\frac{\Delta h}{\Delta L}\right)_w [C_v(SGSOL - 1) + 1] \tag{26}$$

where the subscripts m and w refer to mixture and water, respectively, and C_v is the volumetric solids concentration in the mixture.

For the situation

$VCRIT < V < VHOM$ (heterogeneous regime):

$$\left(\frac{\Delta h}{\Delta L}\right)_m = \left(\frac{\Delta h}{\Delta L}\right)_w \left\{\frac{C_v}{(V)^3} [1100(SGSOL - 1)WgD] + 1\right\} \tag{27}$$

Equations 25 and 27 are attributable to Newitt et al. (1955). Equation 26 is from Graf and Acaroglu (1967).

Method - To apply the above calculation procedure to the jet pump discharge pipeline, substitute VDIS for V . VDIS is the velocity in the jet pump discharge pipeline, fps:

$$VDIS = \frac{QDIS}{(448.831)(ADIS)} \tag{28}$$

where ADIS is equal to the jet pump discharge pipe cross-sectional area, ft^2.

Also, substitute the jet pump discharge pipeline inside diameter, ft, for D and CVMAX from Step 7 for C_v in order to determine the unit mixture head loss from either Equation 26 or 27. Then, the total head loss in the jet pump discharge pipeline, HMJ , in feet of water, is calculated by the expression:

$$HMJ = \frac{\Delta h}{\Delta L_m} \; LDISJ \tag{29}$$

where LDISJ is the total equivalent length of the jet pump discharge pipeline, ft.

Consideration should be given at this point to the choice of PHSUCB , the estimated design pressure or vacuum at the booster pump suction flange. Choosing PHSUCB to be a vacuum will result in a smaller required HDIS from the jet pump, which will significantly decrease the jet pump supply water requirements. However, such a choice will increase the possibility of cavitation and water hammer at the booster pump when the jet pump suction becomes plugged or if the system as installed has different hydraulic characteristics from the design. A vacuum may also cause air to be drawn into the system through pipe joints or other openings, creating a loss in booster pump efficiency and adding to cavitation and water hammer problems. A compromise might be to choose PHSUCB as a mild pressure, say +10 ft, for the initial design and then recheck the design later for the effects of different flow possibilities.

The required jet pump discharge head, HDIS , in feet of water, can now be calculated from the expression

$$HDIS = HMJ + \frac{VDIS^2}{2g} + DEPMAX(SGDISJ - SGWAT) + SGDISJ(ZBOO) + PHSUCB \tag{30}$$

Step 9: Objective - Calculate the jet pump suction head, HSUC .

Information required - (a) Jet pump suction flow, QSUC , gpm, as used in Step 6; (b) length of jet pump suction tube, LSUC , ft; (c) inside area of jet pump suction, ASUC , ft^2.

Rationale - The jet pump suction head represents the

total energy available at the jet pump suction. This value is composed of the velocity head of the suction fluid minus the head losses of the sediment/water mixture as it enters and flows through the suction tube.

Method - The jet pump suction head, HSUC , in feet of water, can be calculated from the expression

$$HSUC = \frac{VSUC^2}{2g} - \left[2(LSUC) + 4\left(\frac{VSUC^2}{2g}\right)\right] \qquad (31)$$

where

$$VSUC = QSUC/(ASUC \times 448.831) \text{ , in fps}$$

The expression in brackets in Equation 31, developed from laboratory observations, is an estimate of the total mixture head loss in the suction tube. Detailed information on design of the suction tube will be given in a subsequent report. A value of LSUC = 2.0 ft is suggested for the present design purpose.

Step 10: Objective - Calculate the required jet pump supply head, HSUP .

Information required - (a) Jet pump head ratio, N (see Step 5); (b) required jet pump discharge head, HDIS (see Step 8), in feet of water; (c) jet pump suction head, HSUC (see Step 9), in feet of water.

Rationale - The dimensionless jet pump head ratio, N , is a function of the jet pump supply head, the jet pump discharge head, and the jet pump suction head (Equation 1). Therefore, definition of any three of these parameters uniquely defines the fourth.

Method - The required jet pump supply head, HSUP , in feet of water, can be calculated from the expression

$$HSUP = \frac{HDIS - HSUC}{N} + HDIS \qquad (32)$$

Step 11: Objective - Calculate QSUP from the standpoint of nozzle hydraulics, to determine whether the value of $QSUP_{min}$ calculated in Step 2 is realistic.

Information required - (a) Jet pump supply head, HSUP , in feet of water; (b) area ratio, R , from Step 5; (c) jet pump suction head, HSUC , from Step 9, in feet of water.

Rationale - This step is the "closing" step of an

iterative calculation procedure, the objective of which is to determine the operating parameters of the jet pump. The jet pump operates by means of supply water entering through a nozzle. Therefore, its behavior on the supply side can be characterized by a form of the basic nozzle equation. When the results of calculations from the nozzle equation are approximately the same as those arrived at via Steps 1 through 10, then the values of operating parameters determined in Steps 1 through 10 can be considered valid.

Method - Calculate QSUP , gpm, by means of the following equation, which is conservatively based on the results of laboratory tests of jet pumps:

$$QSUP = B(ANOZ)\sqrt{(HSUP - HSUC)} \qquad (33)$$

ANOZ can be calculated from the following relation:

$$ANOZ = R \times AMIX \qquad (34)$$

The tabulation below gives values of AMIX for Pekor 4 × 4 × 6 and 6 × 6 × 8 jet pumps:

Jet Pump	AMIX, ft^2
4 × 4 × 6	0.0873
6 × 6 × 8	0.1963

B is a coefficient which varies with the value of R . The following tabulation gives values of B to use with corresponding R values.

R	B, $gpm/ft^{5/2}$
0.096	3533.4
0.138	3429.7
0.175	3633.9
0.202	3776.5
0.246	3682.5
0.311	4544.8

Compare this value of QSUP with the value of QSUP used in the final determination of M in Step 5. If they are not within approximately 5% of each other (and

they probably will not be), the iterative calculation procedure must be worked again. Replace the Step 5 QSUP with the value of QSUP calculated in this step, return to Step 5, and work through to this point again. Several runs through Steps 5-11 may be necessary until the two values of QSUP agree. After the first iteration, the value of QSUP calculated in this step is no longer compared with the original Step 5 QSUP, but with the value of QSUP calculated in the previous iteration. Caution: if at any time the value of QSUP calculated in this step is less than the Step 5 QSUP, the iteration must be carried out differently. Either the excavation rate, EXC, or the jet pump discharge pipe diameter can be reduced. The first adjustment will have the effect of reducing QSUC; the second will cause a reduction in QSUP. In either case, the designer must return to the system initial layout.

Step 12: Objective - Check for possible cavitation in jet pump.

Information required - (a) jet pump supply head, HSUP (see Step 10), in feet of water; (b) jet pump suction head, HSUC (see Step 9), in feet of water; (c) jet pump suction velocity, VSUC (see Step 9), fps; (d) jet pump area ratio, R (see Step 5); (e) jet pump flow ratio, M (see Step 5); (f) minimum anticipated water depth over jet pump while operating, DEPMIN, ft; (g) atmospheric pressure, ATMOS, in feet of water; (h) vapor pressure of water, VAP, in feet of water; (i) jet pump supply flow rate, QSUP, gpm, as finally determined in the Step 2 through 11 iteration process; (j) area of opening at jet pump nozzle tip, ANOZ, from Step 11, in ft^2.

Rationale - The exact prediction of cavitation in the Pekor jet pump, especially when pumping solids, has not been experimentally determined at this time. For this reason, it is recommended that the designer check the jet pump operating point as determined in Steps 5-11 against cavitation criteria taken from Silvester and Mueller (1968) and Wakefield (1972). Although those criteria do not apply directly to the Pekor pump, they will serve to indicate whether the operating point is near a "danger zone" of possible cavitation.

Method - The criterion from Silvester and Mueller is expressed in the terminology of this report as:

$$\frac{\text{HSUP} + \text{DEPMIN}}{\text{ATMOS} - \text{VAP} + \text{HSUC} - \left(\frac{\text{VSUC}^2}{2g}\right) + \text{DEPMIN}} \leq \left[\frac{0.95(1 - R)}{M \times R}\right]^2 \qquad (35)$$

Cavitation is assumed not to occur if this inequality is satisfied.

The criterion as given in Wakefield's publication involves use of a graph. For purposes of this manual, the graph is eliminated and the following expression used:

$$\frac{\left(HSUC - \frac{VSUC^2}{2g} + DEPMIN + ATMOS\right)2g}{VNOZ^2} > 0.046 - 0.126X + 1.44X^2 + 4.44X^3 - 9.18X^4 \quad (36)$$

where

X = VSUC/VNOZ

VNOZ = velocity of water jet at tip of nozzle, fps

Again, cavitation is assumed not to occur if the inequality is satisfied. VNOZ may be calculated from the following expression:

$$VNOZ = \frac{QSUP}{(448.831)(ANOZ)} \quad (37)$$

If cavitation is indicated by either of these criteria, the designer has two alternatives: (a) decrease QSUC or (b) select a larger size jet pump. From Equations 13 and 10, it is seen that QSUC is a direct function of EXC1 , and that EXC1 depends solely on EXC and NUM . Therefore, choosing alternative (a) means returning to the initial system layout to see what can be altered to reduce EXC1 and thereby decrease QSUC . Alternative (b) is feasible only if QSUC falls in the transition zone defined in the tabulation in Step 4, p 62. If alternative (b) is chosen, the designer should also return to the initial system layout to determine if changes in pipe sizes are necessary.

Step 13: Objective - Calculate all expected energy losses in the booster pump discharge pipeline.

Information required - (a) Description of booster discharge pipeline, including inside diameter and length, both in feet, with equivalent length adjustments for

valves, fittings, and bends; (b) hydraulic characteristics of booster discharge pipe; (c) total flow rate delivered by jet pump to booster pump, QDIS (see Step 6), gpm, (d) settling velocity, W , of d_{50} sediment particle (see Step 1); (e) maximum concentration of solids, CVMAX , in jet pump discharge pipeline (see Step 7); (f) specific gravity of sediment solids, SGSOL .

Rationale - The methodology for calculating friction losses in pipelines conveying sand/water slurries was presented in Step 8 and will not be repeated here.

Method - The velocity in the booster pump discharge pipeline, VDISB , fps, should be calculated on the basis of the total discharge of the jet pump plus the quantity of flushing water introduced into the booster pump. Therefore

$$\text{VDISB} = \frac{\text{QDIS} + \text{QFL}}{\text{ADISB}(448.831)} \tag{38}$$

where

QFL = flushing water volumetric flow rate into booster, gpm

ADISB = inside area of booster pump discharge pipe, ft^2

Recommended values of QFL vary from pump to pump, but QFL may usually be assumed as 100 to 150 gpm. The expected maximum volumetric concentration of solids in the booster discharge pipeline, CVMAXB , may be calculated from:

$$\text{CVMAXB} = \text{CVMAX}\left(\frac{\text{QDIS}}{\text{QDIS} + \text{QFL}}\right) \tag{39}$$

Using the relations from Step 8, and by substituting VDISB for V , the booster discharge pipe inside diameter, ft, for D , and CVMAXB for C_v , the head loss per unit length of pipeline, $(\Delta h/\Delta L)_m$, can be calculated.

Total head loss in the booster discharge pipeline, HMB , in feet of water, is calculated by the expression

$$\text{HMB} = \left(\frac{\Delta h}{\Delta L}\right)_m \text{LDISB} \tag{40}$$

where LDISB is the total equivalent length, ft, of the booster discharge pipeline.

Step 14: Objective - Calculate the operating requirements to be placed on the booster pump. These requirements include the total dynamic head of the booster pump, TDHB , the flow rate of the booster pump, QDISB , and the specific gravity of the booster pump discharge, SGDISB .

Information required - (a) Total frictional head loss in booster discharge pipeline, HMB , in feet of water (see Step 13); (b) estimated design pressure or vacuum at the booster pump suction flange, PHSUCB , in feet of water (see Step 8); (c) elevation of the end of the booster discharge pipeline, ZDIS , relative to water-surface datum, ft; (d) elevation of booster pump center line relative to water surface, ZBOO , ft; (e) maximum concentration of solids in the booster discharge pipeline, CVMAXB (see Step 13); (f) jet pump discharge flow rate, QDIS , gpm (see Step 6); (g) flushing water flow into booster pump, QFL , gpm (see Step 13); (h) specific gravity of sediment solids, SGSOL ; (i) manufacturers literature describing booster pumps.

Method - The total dynamic head required of the booster pump, TDHB , is composed of the total head loss in the booster discharge pipeline, HMB , in feet of water; a design pressure or vacuum at the booster pump suction flange, HSUCB , in feet of water; and the difference in elevation between the center line of the pump and the discharge pipe end at the disposal site, ft. TDHB may be calculated in feet of water from:*

$$TDHB = HMB - PHSUCB + (ZDIS - ZBOO) \qquad (41)$$

Note - Kinetic (velocity) energy terms are not included in this calculation because their only contribution to TDHB is the negligible difference between velocity heads at the pump suction and pump discharge.

At this point, the designer should review the manufacturers' literature and make a preliminary selection of a class of booster pumps so that the reasonableness of the flushing water flow rate estimates, QFL , can be

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* Equation 41 must be modified for systems with multiple booster pumps. See paragraph 91 for details.

verified. If possible, a more accurate value of QFL should be selected for subsequent use. The volumetric discharge flow rate of the booster pump, QDISB , gpm, can be determined from the expression:

$$QDISB = QDIS + QFL \tag{42}$$

The maximum specific gravity of the booster pump discharge slurry, SGDISB , is calculated from the expression

$$SGDISB = CVMAXB(SGSOL) + (1 - CVMAXB) \tag{43}$$

Step 15: Objective - Calculate the required production flow rate of the clear water supply pump.

Information required - (a) Jet pump supply water flow rate, QSUP , gpm, as determined in Step 5; (b) flushing water flow rate required by booster pump, QFL , gpm (Step 13).

Rationale - The production flow rate of the clear water supply pump is determined principally by the jet pump supply water requirements. Added to this will be the total flow rate requirement for jet pump cutting jets, QJET , if such jets are used. Finally, it may be possible in some cases to provide flushing water for the booster pump from the clear water supply pump. In such cases, this flow rate must also be added to the required clear water supply pump flow rate. Before finalizing a design using such a flushing water system, however, it would be advisable to contact the booster pump supplier about his specific requirements.

Method - The value of QJET has not been determined, but as a general rule, the relationship

$$QJET = 0.2(QSUC) \tag{44}$$

will provide a realistic estimate.

The required total volumetric flow rate of the supply pump, QSUPT , is given by the expression

$$QSUPT = QSUP + QJET + QFL \tag{45}$$

Note - QJET and QFL should be included in this calculation only if they are to be provided by the supply pump. The ultimate feasibility of providing QFL with the supply pump will not be known until the supply pump discharge head is calculated and compared with the booster pump discharge head.

It should be noted that in most cases the quantity QFL will be included in the pump suction water, but will be removed and introduced into the booster pump very near the supply pump discharge flange. Therefore, for the purpose of calculation, QFL is included in supply pump suction flow but not in the flow between supply pump and jet pump.

Step 16: Objective - Calculate the required total dynamic head of the clear water supply pump.

Information required - (a) Inside areas of supply pump suction and jet pump supply pipes, ASUPS and ASUPD , ft^2; (b) inside diameters of supply pump suction and discharge pipes, ft; (c) equivalent lengths of supply pump suction and jet pump supply pipelines, LSUPS and LSUPD , ft; (d) description of hydraulic characteristics of supply pump suction and discharge pipes; (e) required total production flow rate of clear water supply pump, QSUPT , gpm (Step 15); (f) elevation of supply pump, ZSUP , above water-surface datum, ft; (g) jet pump supply head, HSUP (Step 10), in feet of water; (h) supply flow to the jet pump, QSUP , gpm (Step 11); (i) supply flow to jet cutting assists, QJET , gpm (Step 15); (j) expected flushing water requirement, QFL , gpm (Step 13).

Rationale - The total dynamic head, or total head as it may be called, of the clear water supply pump represents the energy imparted by the supply pump to the liquid. This energy can take the form of a change in elevation, velocity, or pressure of the liquid being pumped. The sum of these changes expressed in feet of water is, by definition, the total dynamic head of the pump. For a centrifugal pump supplying water to a submerged jet pump, the change in elevation of water passing through the centrifugal pump is zero. The change in velocity may be approximated by the velocity head in the centrifugal pump discharge pipe. The change in pressure is due to two factors: (a) the required supply head HSUP at the jet pump and (b) the total frictional losses in the centrifugal pump suction and discharge pipelines.

Method - Use the method described in Step 8 for calculating the rate of head loss per unit length of pipeline for fluid flow (the Darcy-Weisbach formula). This method

should be applied separately to the centrifugal pump suction and discharge pipelines. Velocity in the suction pipeline, VSUPS , fps, can be calculated by:

$$VSUPS = \frac{QSUP + QJET + QFL}{(448.831)(ASUPS)} \tag{46}$$

Velocity in the jet pump supply pipeline, VSUPD , fps, can be obtained from:

$$VSUPD = \frac{QSUP + QJET}{(448.831)(ASUPD)} \tag{47}$$

As in Step 15, QJET and QFL should be included in these calculations only when they are to be provided by the supply pump. QFL is not included in VSUPD calculations since it is normally removed from the discharge pipeline shortly after leaving the supply pump.

Using the appropriate values of velocity, inside diameter, and hydraulic characteristics, head loss rates per unit length should be calculated for the suction pipeline $(\Delta h/\Delta L)_{WSS}$ and jet pump supply pipeline $(\Delta h/\Delta L)_{WSD}$. Then, the total head loss in the supply pump suction pipeline, HWSS , in feet of water, can be calculated by:

$$HWSS = \left(\frac{\Delta h}{\Delta L}\right)_{WSS} \times LSUPS \tag{48}$$

An important adjustment to include in LSUPS is an allowance for entrance losses into the suction pipe.

The total head loss in the jet pump supply pipeline, HWSD , can be obtained in feet of water from:

$$HWSD = \left(\frac{\Delta h}{\Delta L}\right)_{WSD} \times LSUPD \tag{49}$$

The required total dynamic head of the supply pump, TDHS , in feet of water, is then:

$$TDHS = HSUP + HWSS + HWSD \tag{50}$$

Step 17: Objective - Calculate the available net positive suction head, NPSHA , at the supply pump suction flange.

Information required - (a) Head loss in supply pump suction pipeline, HWSS (Step 16), in feet of water; (b) atmospheric pressure, ATMOS , in feet of water; (c) water vapor pressure, VAP , in feet of water; (d) maximum expected elevation of supply pump suction center line above free water surface, ZSUPM , ft; (e) velocity in supply pump suction pipeline, VSUPS , fps (Step 16).

Rationale - The available net positive suction head represents the absolute pressure in the liquid at the supply pump suction flange above its vapor pressure. Different types of centrifugal pumps require different values of NPSHA at a given operating point in order to avoid cavitation within the pump itself. This required value is often denoted NPSHR . NPSHR varies for a given pump with the operating point.

Method - ZSUPM should take into account low tide, low lake levels, seiches, surges, and the change in water surface due to waves propagating past the suction pipe. In other words, ZSUPM should be the elevation, ft, of the supply pump suction center line above the lowest water level, transient or otherwise, that could reasonably occur during regular pumping operations. The net positive suction head available, NPSHA , of the supply pump can be calculated in feet of water from the expression:

$$NPSHA = ATMOS - VAP - HWSS - ZSUPM - \frac{VSUPS^2}{2g} \qquad (51)$$

Step 18: Objective - Select supply pump to drive jet pump system.

Information required - (a) The required total dynamic head of the supply pump, TDHS (see Step 16), in feet of water; (b) the required total flow of the supply pump, QSUPT , gpm (see Step 15); (c) the net positive suction head available at the supply pump suction flange, NPSHA (see Step 17), in feet of water; (d) manufacturers' literature for centrifugal water pumps.

Method - The required operating point of the supply pump has been defined through calculation of TDHS , QSUPT , and NPSHA . Various pump curves from several manufacturers should be examined to locate a pump that can produce the desired operating point for the least shaft

horsepower input, and that has a required net positive suction head, NPSHR , at the operating point equal to or less than the value of NPSHA .

Selecting a centrifugal pump inherently involves selecting a particular impeller diameter for that pump. The electric motor or diesel engine used to drive the pump should have a continuous horsepower rating not less than the maximum horsepower that the pump with the selected size of impeller will draw at "runout," or the maximum flow rate shown on the pump curve for that size impeller. For pumps that will be primed by a vacuum method, consideration should be given to specifying mechanical stuffing box seals instead of packing to reduce air leakage into the pump during priming. A horizontally split-case type of pump should be specified wherever possible to facilitate access to the impeller for repair or replacement. Corrosion-resistant materials should be specified for use in saltwater environments.

Step 19: Objective - Select booster pump to deliver slurry to discharge site.

Information required - (a) Required total dynamic head of the booster pump, TDHB (see Step 14), in feet of water; (b) required total flow rate of the booster pump, QDISB , gpm (see Step 14); (c) specific gravity of booster pump mixture, SGDISB (see Step 14); (d) sediment d_{50} grain size, mm; (e) maximum concentration of solids in the booster discharge pipeline, CVMAXB (see Step 13); (f) manufacturers' literature on dredge pumps.

Rationale - The terminology "booster pump" has been used to describe the pump that has the responsibility of supplying the majority of energy needed to deliver the mixture of bypassed sand and water to the discharge site. In actuality, the pump selected will probably be a dredge pump, which is a centrifugal pump that is specifically designed with large internal clearances and specially hardened and strengthened parts to allow handling of solids. Selection of the dredge pump is essentially the same as selection of the clear water supply pump in Step 18. The difference is that the presence of solids in the dredge pump has the combined effects of reducing the efficiency of the pump while increasing the horsepower required to convey a certain flow rate at a certain discharge pressure. Dredge pump performance curves are usually given for clear water pumping. Therefore, the information available from these curves must be corrected to account for the effects of solids.

Method - The first step is to convert the total dynamic head of the booster pump, TDHB , which is in feet of

water, into feet of mixture, TDHBM . This is done by using the relationship:

$$TDHBM = \frac{TDHB}{SGDISB} \tag{52}$$

Next, the ratio of efficiency when pumping slurry, EMIX , to efficiency when pumping water, EW , is determined by entering Figure 35 with the sediment d_{50} grain size and determining the ratio of EMIX/EW that corresponds to CVMAXB . The total dynamic head is then corrected for this decrease of efficiency by the relationship:

$$TDHBME = \frac{TDHBM}{\frac{EMIX}{EW}} \tag{53}$$

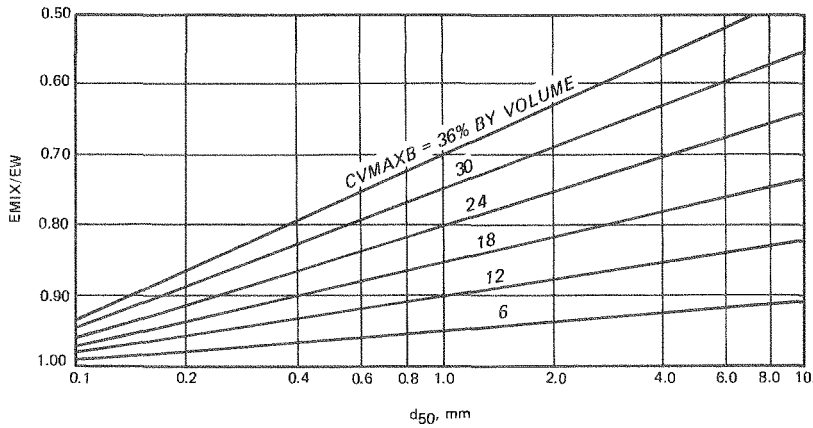

Figure 35. Ratio of efficiency mixture/efficiency water versus grain size (after Stepanoff 1969)

Select a pump by entering the manufacturer's pump performance curves for water with the required total dynamic head corrected for specific gravity and efficiency, TDHBME , and with the total flow required of the booster, QDISB .

The input shaft horsepower indicated at this point on the manufacturer's curves for water will represent the

power required to pump water, BHPW . This must also be corrected to account for the heavier mixture being pumped. Assuming that the dredge pump will be operating near its point of peak efficiency, the required horsepower to pump the mixture, BHPM , is given by the relationship

$$BHPM = BHPW(SGDISB) \tag{54}$$

Graphical Design Procedure

85. This design procedure incorporates portions of the iteration design procedure. Such portions will not be repeated here but simply referred to. Therefore, familiarity with the iteration design procedure is a prerequisite to use of this procedure. Appendix C describes the derivation of the graphical design procedure and its relation to the iteration procedure.

Steps 1 through 3: Perform Steps 1 through 3 as described in the iteration design procedure.

Step 4: Objective - Generate a set of curves giving the required jet pump discharge head, HDIS , for a given value of jet pump suction flow, QSUC , and supply flow, QSUP .

Information required - (a) Minimum jet pump supply flow, $QSUP_{min}$ (see Step 2); (b) required jet pump suction flow, QSUC (see Step 3); (c) description of jet pump discharge pipeline, including length and adjustments for valves, fittings, and bends (several pipe sizes may be considered at this point); (d) hydraulic characteristics of jet pump discharge pipe; (e) settling velocity, W , of sediment d_{50} particle diameter (see Step 1); (f) specific gravity of solids, SGSOL ; (g) elevation of booster pump suction flange relative to water surface, ZBOO ; (h) estimated design pressure or vacuum at the booster pump suction flange, HSUCB (see discussion of this subject in Step 8 of the iteration design); (i) assumed maximum specific gravity of suction mixture, SGSUC , as discussed in Step 7 of the iteration design procedure.

Rationale - The required discharge head at the jet pump discharge is a function of the discharge flow rate, solids concentration, pipeline characteristics, and conditions at the booster pump suction. By assuming various values for some or all of these parameters, required discharge heads

can be calculated for a variety of discharge conditions. Doing this in a systematic manner will result in a table of values that can be used to generate sets of required discharge head curves.

Method - If more than one diameter or material is being considered for the jet pump discharge pipeline, choose a size and type of pipe to begin calculations. Next, choose a starting value of jet pump supply flow, QSUP , equal to or somewhat less than $QSUP_{min}$. Also, choose a starting value of jet pump suction flow, QSUC , which is several hundred gallons per minute less than the QSUC value determined in Step 3.

Using these starting values, perform the following calculations:

$$QDIS = QSUP + QSUC \tag{55}$$

$$VDIS = \frac{QDIS}{(448.831)(ADIS)} \tag{28 bis}$$

$$CVMAX = \left(\frac{QSUC}{QDIS} \; \frac{SGSUC - SGWAT}{SGSOL - SGWAT}\right) \tag{56}$$

Apply these calculated values to the procedure outlined in Step 8 of the iteration design procedure for calculating the energy loss gradient in pipelines conveying sand/water slurries. The result will be a value of $(\Delta h/\Delta L)_m$. Continue with the remainder of Step 8 of the iteration design procedure to obtain a value of the required jet pump discharge head, HDIS . Record this value together with the corresponding values of QSUP and QSUC .

Keeping the same value of QSUP , increase the value of QSUC by an increment of 100 gpm or less and repeat the above procedure. Continue this process until QSUC is several hundred gallons per minute greater than the Step 3 value, recording each time the corresponding values of HDIS , QSUP , and QSUC .

Next, increase QSUP by an increment of 100 gpm or less and begin the calculation procedure again with the value of QSUC used initially. Execute this entire procedure several times until QSUP is several hundred gallons per minute greater than $QSUP_{min}$. The result will be a set of values of required HDIS corresponding to particular values of QSUC and QSUP for a certain size

and type of discharge pipe. This information can be summarized in tabular form. Table 1 shows the hypothetical results of a set of such calculations for the same system layout but with two different sizes of discharge pipe.

The final task in this step is to use the tabulated information to generate a set of curves of QSUC versus HDIS . Figure 36 shows a set of such curves drawn using the information for the 6-in. discharge line in Table 1. Each curve represents a row from Table 1. To be compatible with the scale of the jet pump performance curves discussed in the next step, these curves should be drawn using axes with the following scales:

Horizontal (QSUC): 1 in. = 200 gpm

Vertical (HDIS): 1 in. = 20 feet of water

The curves should be drawn on or transferred to a transparent medium such as tracing paper so they can be used as overlays in the next step.

Table 1

Example: Required HDIS , ft

QSUP gpm	QSUC , gpm 300	400	500*	600	700	800
			6-in. Discharge Pipe			
500	35.6	39.3	43.1	47.1	51.4	62.1
600 ($QSUP_{min}$)	37.4	41.6	45.9	50.4	60.4	68.3
700	40.0	44.6	49.3	58.8	66.5	74.9
800	43.3	48.2	57.1	64.8	73.0	81.9
Heterogeneous flow ←|→ Homogeneous flow						
			8-in. Discharge Pipe			
1100	29.0	31.0	33.0	34.9	36.8	38.7
1200 ($QSUP_{min}$)	29.9	32.0	34.0	36.0	38.0	40.1
1300	31.0	33.1	35.3	37.3	39.5	41.6
1400	32.3	34.5	36.6	38.8	41.0	43.3

* QSUC from Step 3.

Step 5: Objective - Correlate the curves of required HDIS from Step 4 with curves of actual jet pump performance.

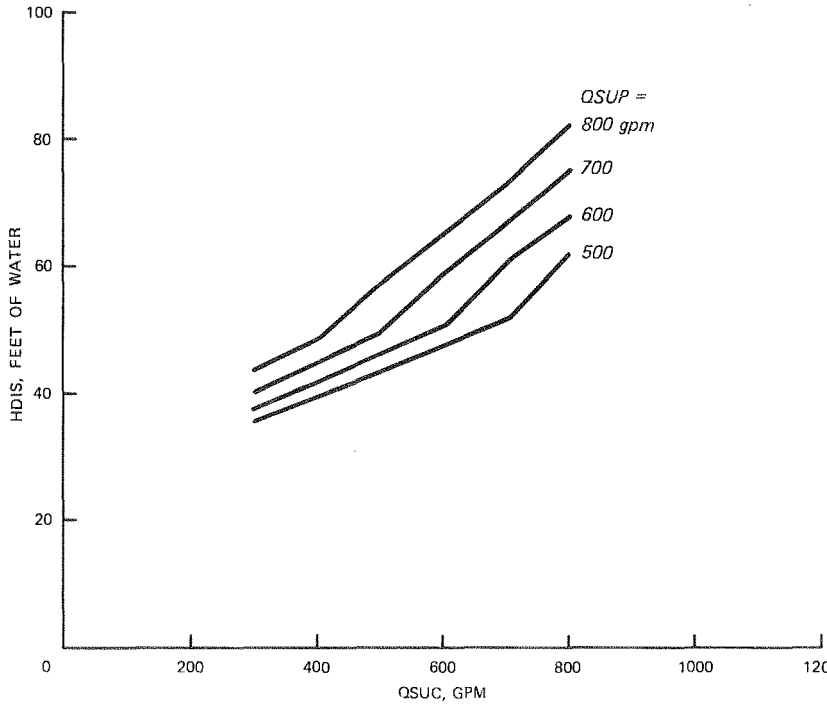

Figure 36. Example jet pump discharge pipeline curves for 6-in. pipe

Information required - Curves from Step 4 drawn on transparent paper.

Rationale - The information calculated in Step 4 is based solely on conditions in the jet pump discharge pipeline. The physics of operation of a jet pump are such that the values of three of its other operating parameters (HSUC , QDIS , and QSUC) also depend in part on conditions in the discharge pipeline. The purpose of this step, therefore, is to match what is required by the discharge piping system with what a particular jet pump is capable of producing under such conditions. The result of this step will be a number of possible operating points for the jet pump.

Method - Plates 3-14 give curves of actual jet pump performance pumping a sand/water slurry. Plates 3-8 apply to a 4 × 4 × 6 jet pump, while Plates 9-14 are for a 6 × 6 × 8 jet pump. Experience has shown that the characteristics of these two sizes of jet pumps will match the requirements of most sand bypassing situations.

Each plate shows curves of QSUC versus HDIS for particular values of QSUP . Each plate gives a complete set of curves for one nozzle size in a certain jet pump. THE CURVES SHOULD NOT BE EXTENDED UNDER ANY CIRCUMSTANCES. The limits as given are based on considerations which include cavitation, and operation outside of those limits entails the very real possibility of impaired system performance due to jet pump cavitation. Also, Plates 3-14 apply only when pumping a sand/water slurry. They are not valid for pumping water or materials other than sand. In addition to the value of QSUP for each curve, the recommended design value of HSUP is also given. Lines of equal efficiency values are also shown to aid the designer in selecting the most efficient jet pump configuration for a particular operating situation.

The technique in this step is simply to place the curves from Step 4 over Plates 3-14. The intersection of a curve from Step 4 that has a particular QSUP value with the curve on the plate that has the same QSUP value gives a potential operating point in terms of HDIS , HSUP , QSUC , and QSUP for the jet pump system. Figure 37 shows the example curves from Figure 36 superimposed on Plate 4. It is seen that two potential operating points have been identified by curve intersections. These operating points are as follows:

a. QSUP = 700 gpm
   HSUP = 271 feet of water
   QSUC = 350 gpm
   HDIS = 42.5 feet of water
   Efficiency = 14%

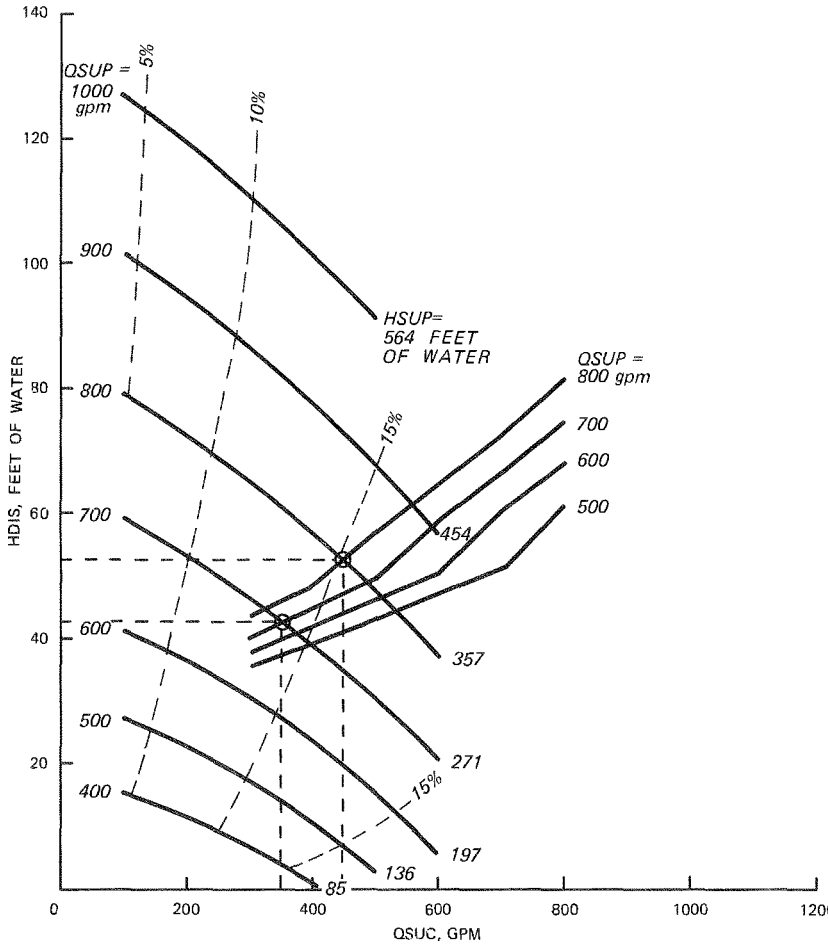

Figure 37. Example jet pump discharge pipeline curves for 6-in. pipe superimposed on Plate 4

b. QSUP = 800 gpm
HSUP = 357 feet of water
QSUC = 450 gpm
HDIS = 52.5 feet of water
Efficiency = 15%

Superimposing the Step 4 curves on other plates will generate more potential operating points. In some cases, few or none of the curves on a plate will coincide with the Step 4 curves. This situation indicates, of course, that such a nozzle size in that particular jet pump is unsuitable for the bypass system operating requirements. In other cases, the intersections may occur near the limits of the curves shown on a plate. While the operating points thus defined are valid, the designer should make sure that his predictions of system operating requirements are correct before using such operating points in designing an actual bypass system. Small variations from the predicted values may force the jet pump into cavitation.

The information for the operating points defined by this procedure can be summarized in tabular form. Table 2 shows the results of superimposing the example curves of Figure 36 on Plates 3-14.

Table 2

Example: Potential Operating Points, 6-in. Discharge Pipe

Jet Pump	Nozzle Size in.	QSUP gpm	HSUP ft	QSUC gpm	HDIS ft	Approximate Efficiency %
4 × 4 × 6	1.25	600	391	420	42.5	13
4 × 4 × 6	1.50	700	271	350	42.5	14
4 × 4 × 6	1.50	800	357	450	52.5	15
6 × 6 × 8			None			

The figures in Table 2 show that the example system design options with a 6-in. discharge pipe are limited in number and of poor efficiency. None of the possible operating points in Table 2 will give a QSUC value of 500 gpm, which as noted in Table 1, was the assumed design value from Step 3.

Figure 38 shows the curves of QSUC versus HDIS from Table 1 for an 8-in. discharge pipe for the same example system. Table 3 gives the results of superimposing these example curves on Plates 3-14.

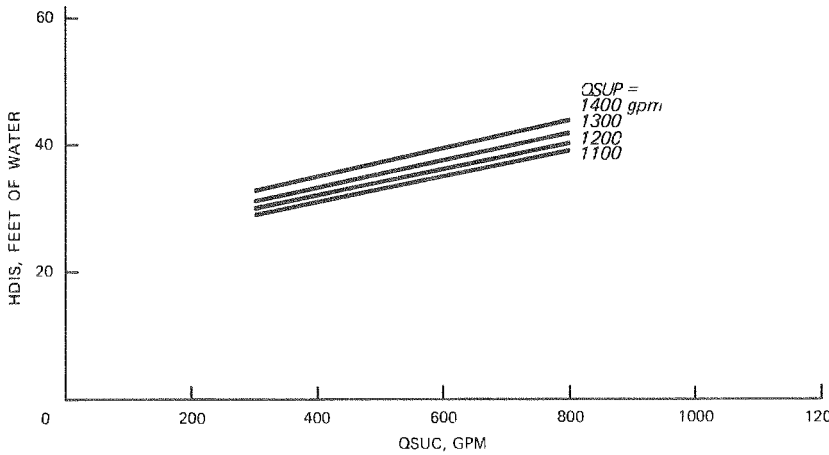

Figure 38. Example jet pump discharge pipeline curves for 8-in. pipe

Table 3

Example: Potential Operating Points, 8-in. Discharge Pipe

Jet Pump	Nozzle Size in.	QSUP gpm	HSUP ft	QSUC gpm	HDIS ft	Approximate Efficiency %
4 × 4 × 6	2.00	1100	180	580	34.5	25
4 × 4 × 6	2.25	1200	86	320	30.5	27
4 × 4 × 6	2.25	1300	101	375	33.0	24
4 × 4 × 6	2.25	1400	118	420	35.0	23
6 × 6 × 8	1.88	1200	299	660	37.0	12
6 × 6 × 8	1.88	1300	354	800	42.0	12
6 × 6 × 8	2.25	1400	207	500	36.5	12

Step 6: Objective - Select a jet pump design operating point.

Information required - (a) Potential operating points from Step 5, (b) assumed maximum specific gravity of suction mixture, SGSUCM , as discussed in Step 7 of the iteration design procedure.

Rationale - A number of potential jet pump operating points were determined in Step 5. This step requires a decision as to which of these points, if any, should

be used in further calculations. If further calculations show the chosen point to be unfeasible, then another can be selected based on the Step 5 results.

Method - The first step is to look at the QSUC values of all the potential operating points. Those points with values of QSUC close to the value determined in Step 3 should be noted for further consideration.

The next step is to look at the remaining operating points to see whether some additional calculations with different values of QSUP would generate other operating points with QSUC values close to the Step 3 value. For instance, for the example being demonstrated, recall that QSUC from Step 3 was 500 gpm. Then, looking at Table 3, other possibilities for additional calculations are:

a. 4 × 4 × 6 jet pump -

(1) 2.00-in. nozzle, QSUP = 1000 gpm.

(2) 2.25-in. nozzle, QSUP = 1600 gpm.

b. 6 × 6 × 8 jet pump - Efficiencies shown are relatively low; additional calculations would probably not be worthwhile.

The designer should now return to Step 4 and perform the additional calculations indicated by this review. The resulting points together with the ones first noted constitute the group of potential design operating points.

If the potential design operating points identified in this step have uniformly low efficiencies, or if the points with acceptable efficiencies lie near the limits of the applicable jet pump performance curves, the designer may want to reconsider certain aspects of his system layout before proceeding any further. It is important at this point to carry on only with what appears to be a feasible design. Step 5, if performed properly, will show a range of possibilities for a particular design.

If the operating points within this range are inefficient or marginal, then the basic system layout may be at fault.

Once the design point has been selected, the design values of QSUP , HSUP , QSUC , and HDIS are automatically determined. Values of QDIS and CVMAX needed for subsequent calculations can be determined from Equations 55 and 56.

Remaining calculations - The remainder of the graphical design procedure can be accomplished by performing Steps 13 through 19 of the iteration design procedure. In effect, Steps 4, 5, and 6 of the graphical procedure have

replaced Steps 5 through 12 of the iteration design procedure.

Additional Considerations for Multiple Jet or Booster Pumps

Multiple jet pumps

86. The steps in the two design procedures can be followed for systems in which more than one jet pump operates at a time, provided that certain hydraulic requirements are met. These requirements stem from two basic principles of pipeline flow at junctions:

a. At a pipe junction, the total head in all branches of the junction must be equal. Thus, from Figure 39,

$$H_1 + \frac{V_1^2}{2g} = H_2 + \frac{V_2^2}{2g} = H_3 + \frac{V_3^2}{2g} \tag{57}$$

b. Total flow away from the junction must equal total flow into the junction. Again, from Figure 39,

$$Q_1 + Q_2 = Q_3 \tag{58}$$

87. Figure 40 shows these two principles as applied to a system of two jet pumps without cutting assists operating simultaneously. The hydraulic requirements that would have to be met are as follows:

a. Supply pipeline

$$HSUP = HSUP1 = HSUPA$$

$$HSUP2 = HSUPA - HWSD_{1-2}$$

$$QSUP = QSUP1 + QSUP2$$

where

HSUP , HSUP1 , HSUPA , and HSUP2 are the total heads at the following respective locations:

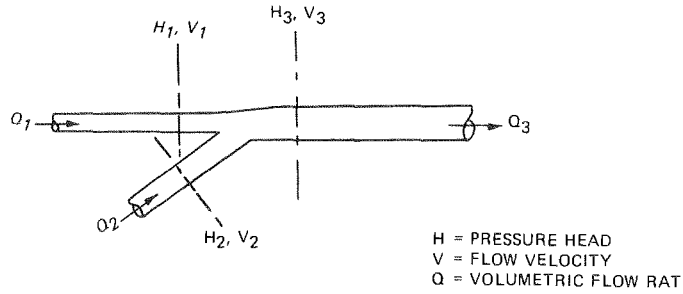

Figure 39. Junction of three pipes

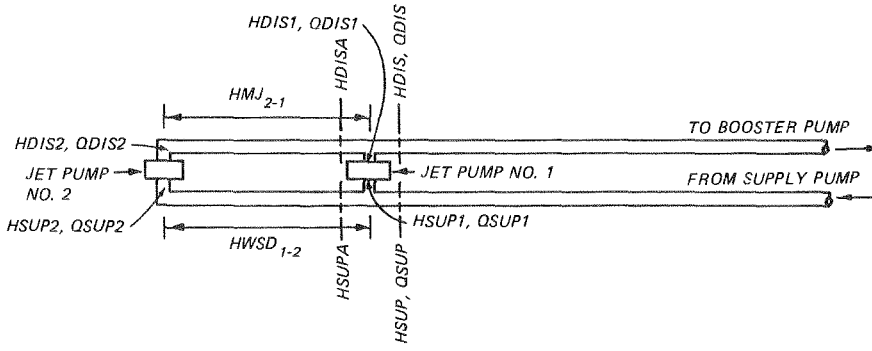

Figure 40. Dual jet pump system

(1) In the supply pipeline immediately before the junction of jet pump #1

(2) At jet pump #1 (on the supply side)

(3) In the supply pipeline immediately after the junction of jet pump #1

(4) At jet pump #2 (on the supply side).

$HWSD_{1-2}$ is the head loss in the supply pipeline between jet pumps #1 and #2

QSUP , QSUP1 , and QSUPA are the volumetric flow rates at the same locations as the respective total heads.

b. Discharge pipeline

$$HDIS = HDIS1 = HDISA$$

$$HDIS2 = HDISA + HMJ_{2-1}$$

$$QDIS = QDIS1 + QDIS2$$

where

HDIS , HDIS1 , HDISA , and HDIS2 are the total heads at the following respective locations:

(1) In the discharge pipeline immediately after the junction of jet pump #1.

(2) At jet pump #1 (on the discharge side).

(3) In the discharge pipeline immediately before the junction of jet pump #1.

(4) At jet pump #2 (on the discharge side).

HMJ_{2-1} is the head loss in the discharge pipeline between the junctions of jet pumps #2 and #1.

QDIS , QDIS1 , and QDIS2 are the volumetric flow rates at the same locations as the respective total heads.

88. The end result of these requirements is to increase the complexity of iterative calculations to determine values of the jet pump operating parameters. The number of iterations can be reduced if as

many system variables as possible are made into constants. Some ways of doing this are:

a. Use the same size jet pump for all jet pumps.

b. Use the same nozzle size in all jet pumps.

c. Space jet pumps equal distances apart where possible.

d. Choose pipe sizes to give similar flow velocities in all branches of a junction.

89. The number of iterations can be reduced further by choosing values of EXC1 for each jet pump that decrease with increasing distance to the booster pump. For instance, in Figure 40, jet pump #2 should have a smaller value of EXC1 than jet pump #1.

Multiple booster pumps

90. Multiple booster pumps located at intervals along the discharge pipeline require additional considerations not needed for a single-booster system. Monitoring, control, and sequencing of booster operation become very important to prevent cavitation or water hammer, either of which can ruin an expensive pump. Designing for a positive pressure head, PHSUCB , at each booster suction will aid in preventing such problems as well as helping keep air out of the discharge system. Booster pumps should be spaced at intervals along the discharge pipeline such that their operating points are roughly the same. Each pump must be provided clear flushing water at a pressure greater than the booster discharge pressure. After the initial hydraulic design, the entire bypass system should be analyzed for the effects of different possibilities, such as plugging a jet pump suction or stopping a booster pump unexpectedly.

91. Two adjustments must be made to the hydraulic design procedure to allow for multiple booster pumps. First, total flow in the discharge pipeline will increase at each booster due to the addition of flushing water. This must be accounted for in determining flow rates, velocities, and solids concentrations at each booster. Second, the total dynamic head required of a booster pump will depend on conditions somewhat different from those considered in Equation 41 of the iteration design procedure. For example, if the first and second boosters in a pipeline are

numbered 1 and 2, Equation 41 becomes:

$$TDHB_1 = HMB_{1-2} - PHSUCB_1 + (ZBOO_2 - ZBOO_1) + PHSUCB_2 \qquad (59)$$

where HMB_{1-2} is the total frictional head loss in the discharge pipeline between boosters 1 and 2. Equation 59 should be used for all boosters in a multiple booster system except the final one, where Equation 41 applies.

PART IV: SUMMARY

92. This report is designed to be used by an engineer or group of engineers with a basic knowledge of coastal processes and a rudimentary knowledge of centrifugal pumping systems. Using this report, such a person or group will be able to perform the following tasks:

a. Determine the general feasibility of a jet pump remedial sand bypassing system for a specific problem.

b. Develop the initial layout(s) for a jet pump sand bypassing system.

c. Perform the basic hydraulic design for such a system.

93. A set of factors relative to tasks a and b are discussed. Detailed instructions are given for aspects of the initial layout such as determining the system effective operating time and capacity. A format consisting of schematic drawings is suggested for presenting the results of the initial layout. Examples of such drawings are shown.

94. The designer is provided with two step-by-step procedures for performing task c. The first procedure, called the iteration procedure, consists of calculating in an iterative manner an operating point for the jet pump portion of the system. Then, the hydraulic characteristics of the total system are calculated linearly. The jet pump operating point reflects the results of the initial layout and is based upon the premises of having a minimum total flow in the system and of achieving a high jet pump efficiency. The second procedure utilizes a set of graphs to replace the iterative part of the first procedure. Use of these graphs gives a number of potential operating points for the jet pump portion of the system. One or more of these operating points is chosen by the designer to use in further calculations.

95. The specialized information resulting from use of this report, together with more routine design data, should allow the designer to estimate the approximate cost of a jet pump sand bypassing system relative to other solutions for a given problem. A subsequent report will provide information about the detailed design, construction, operation, and monitoring of a jet pump system, as well as design examples.

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APPENDIX A: NOTATION

The following notation is used in a general sense in this report:

C_v	Volumetric concentration of solids in a slurry
D	Inside diameter of a pipe
H	Pressure head
h_f	Energy loss due to a pipe fitting
L	Length of straight pipe
Q	Volumetric flow rate
V	Flow velocity

The following notation identifies specific quantities or parameters:

ADIS	Discharge pipe maximum inside area, ft^2
ADISB	Inside area of booster pump discharge pipe, ft^2
ALM	Correction factor for absence of littoral materials
AMIX	Inside area of mixing chamber of jet pump, ft^2
ANOZ	Area of opening at tip of jet pump nozzle, ft^2
ASUC	Inside area of jet pump suction, ft^2
ASUPD	Inside area of jet pump supply pipe, ft^2
ASUPS	Inside area of supply pump suction pipe, ft^2
ATMOS	Atmospheric pressure, feet of water
B	Coefficient in nozzle equation for QSUP , $gpm/ft^{5/2}$
BHPM	Horsepower required by dredge pump pumping slurry
BHPW	Horsepower required by dredge pump pumping water
CVMAX	Expected maximum volumetric concentration of solids in jet pump discharge pipeline
CVMAXB	Expected maximum volumetric concentration of solids in booster pump discharge pipeline
d_{50}	Median diameter of sediment to be bypassed, mm
DEPMAX	Maximum anticipated water depth over jet pump while operating, ft
DEPMIN	Minimum anticipated water depth over jet pump while operating, ft
E	Operating efficiency of jet pump
EMIX	Efficiency of dredge pump pumping slurry

EOT	Effective operating time of jet pump bypassing system over one-year operating period
$EOT_{\Delta t}$	Effective operating time of jet pump bypassing system over interval Δt operating period
EW	Efficiency of dredge pump pumping water
EXC	Required capacity of jet pump bypassing system, cu yd/hr
EXC1	Required capacity of one jet pump in bypassing system, cu yd/hr
EXCMAX	Maximum excavation rate of in situ material by one jet pump, cu yd/hr
f	Dimensionless friction factor used in Darcy-Weisbach formula
F_L	Dimensionless parameter in Durand relationship for critical velocity
g	Acceleration due to gravity, ft/sec^2
HD	Number of working hours in an operating day
HDIS	Total energy head in the discharge pipeline at the jet pump, feet of water
HMB	Total head loss in booster pump discharge pipeline, feet of water
HMJ	Total head loss in jet pump discharge pipeline, feet of water
HSUC	Total energy head in the jet pump suction tube at the jet pump, feet of water
HSUP	Total energy head in the supply pipeline at the jet pump, feet of water
HWSD	Total head loss in jet pump supply pipeline, feet of water
HWSS	Total head loss in supply pump suction pipeline, feet of water
K	Pipe fitting resistance coefficient
LDISB	Total equivalent length of booster discharge pipeline, ft
LDISJ	Total equivalent length of jet pump discharge pipeline, ft
LSUC	Length of jet pump suction tube, ft
LSUPD	Total equivalent length of jet pump supply pipeline, ft
LSUPS	Total equivalent length of supply pump suction pipeline, ft
LSUPSA	Approximate length of supply pump suction pipeline, ft
M	Jet pump flow ratio

M_{op}	Optimum jet pump flow ratio
n	In situ porosity of sediment to be bypassed
N	Jet pump head ratio
N_{max}	Largest possible value of N corresponding to a particular value of M
NOD	Number of operating days per year for jet pump bypassing system
NPSHA	Available net positive suction head at supply pump suction flange, feet of water
NPSHR	Required net positive suction head at supply pump suction flange, feet of water
NUM	The number of jet pumps operated simultaneously in a jet pump bypassing system
PB	Correction factor for pump blockages
PHSUCB	Design pressure or vacuum head at booster pump suction flange, feet of water
Q_L	Average rate of net littoral influx to storage area(s) during interval Δt operating period, cu yd/hr
QDIS	Jet pump volumetric discharge flow rate, gpm
QDISB	Booster pump volumetric discharge flow rate, gpm
QFL	Flushing water volumetric flow rate into booster pump, gpm
QJET	Volumetric flow rate through jet pump cutting jets, gpm
QSUC	Volumetric flow rate into jet pump suction, gpm
QSUP	Volumetric flow rate through jet pump nozzle, gpm
$QSUP_{min}$	Minimum required volumetric flow rate in discharge pipelines of jet pump bypassing system, gpm
QSUPT	Supply pump required total volumetric flow rate, gpm
R	Jet pump area ratio
Re	Reynolds number
RMP	Correction factor for relocation of mobile jet pumps
RR	Correction factor for system repair and replacement
SGDISB	Maximum specific gravity of booster pump discharge slurry
SGDISJ	Maximum specific gravity of jet pump discharge slurry
SGIN	In situ specific gravity of sediment to be bypassed
SGSOL	Specific gravity of sediment solids
SGSUC	Assumed average specific gravity of slurry entering jet pump suction

SGSUCM	Assumed maximum sustained specific gravity of slurry entering jet pump suction
SGWAT	Specific gravity of ambient water
STCAP	Storage capacity of storage area, cu yd
STIN	Initial condition of storage area, cu yd
$STORE_{\Delta t}$	Storage volume available during interval Δt , cu yd
TDHB	Total dynamic head required of booster pump, feet of water
TDHBM	Total dynamic head required of booster pump in terms of mixture being pumped, feet of mixture
TDHBME	Total dynamic head of booster pump corrected for decrease in pump efficiency due to presence of solids, feet of mixture
TDHS	Total dynamic head required of supply pump, feet of water
VAP	Vapor pressure of water, feet of water
VCRIT	Minimum velocity necessary to maintain solids in suspension in discharge pipelines, fps
VDIS	Velocity in jet pump discharge pipeline, fps
VDISB	Velocity in booster pump discharge pipeline, fps
VHOM	Velocity of transition between heterogeneous and homogeneous flow regimes, fps
VNOZ	Velocity of water jet at tip of jet pump nozzle, fps
VSUC	Velocity of mixture in jet pump suction tube, fps
VSUPD	Velocity in jet pump supply pipeline, fps
VSUPS	Velocity in supply pump suction pipeline, fps
W	Settling velocity of the d_{50} particle of sediment to be bypassed, fps
X	Ratio of VSUC to VNOZ as used in cavitation calculations
ZBOO	Elevation of booster pump center line relative to water surface datum, ft
ZDIS	Elevation of end of booster discharge pipeline relative to water surface datum, ft
ZSUP	Elevation of supply pump center line relative to water surface datum, ft
ZSUPM	Maximum expected elevation of supply pump suction center line above free water surface, ft
$(\Delta h/\Delta L)_m$	Head loss per unit length of pipeline for slurry flow
$(\Delta h/\Delta L)_w$	Head loss per unit length of pipeline for fluid flow

$(\Delta h/\Delta L)_{WSD}$	Head loss per unit length of pipeline for jet pump supply pipeline
$(\Delta h/\Delta L)_{WSS}$	Head loss per unit length of pipeline for supply pump suction pipeline
Δt	Time interval of the bypassing season, hr
ε	Equivalent roughness of pipe wall (Nikuradse roughness), ft
ν	Kinematic viscosity of fluid, ft^2/sec

APPENDIX B: ADDITIONAL EQUATIONS

Colebrook-White Equation

1. For the range of conditions covered by this report, the friction factor, f, used in the Darcy-Weisbach formula for energy loss in pipe flow can be found via an iterative solution to the Colebrook-White equation:

$$\frac{1}{\sqrt{f}} = -2 \log\left(\frac{2.51}{Re\sqrt{f}} + \frac{\varepsilon}{3.71D}\right) \tag{B1}$$

where

$Re = VD/\nu$, the Reynolds number

V = average flow velocity in pipe, fps

D = inside diameter of pipe, ft

ν = kinematic viscosity of fluid, ft^2/sec

ε = equivalent roughness of pipe wall, sometimes called "Nikuradse roughness," ft

2. Values of ε for different pipe materials can be found in standard references on fluid flow in pipes. Values of ν can be found in hydraulic handbooks or similar references.

3. To solve Equation B1 by iteration, begin with an assumed value for f, say 0.007. Using this assumed value, solve the right-hand side of the equation. The result will be of the form:

$$\frac{1}{\sqrt{f}} = C \tag{B2}$$

where C is the value of the right-hand side of Equation B1 using the assumed value of f and the appropriate pipe characteristics and flow conditions.

4. Next, solve Equation B2 for f. If this value of f and the assumed one are reasonably similar (say within 0.0005 of each other), f has been determined. If not, repeat the iteration process using f from Equation B2 as the assumed value. The iteration should converge

to an acceptable degree of accuracy in a few such calculations.

5. Obviously, this process is easily adapted to a computer, eliminating the need for a Moody diagram.

Equivalent Lengths

6. For pipe fittings not included in tables of equivalent lengths, the energy loss h_f is often given by an equation of the form:

$$h_f = K \frac{V^2}{2g} \tag{B3}$$

where K is a resistance coefficient for a particular fitting type and size.

7. For straight pipe, an equation in common use for calculating energy losses is the Darcy-Weisbach equation in the form:

$$h_L = f \frac{L}{D} \frac{V^2}{2g} \tag{B4}$$

where

h_L = energy loss in straight pipe
f = friction factor
L = length of straight pipe
D = pipe inside diameter

8. Equating Equations B3 and B4, an expression for an equivalent length can be obtained:

$$L = \frac{K \cdot D}{F} \tag{B5}$$

where L now represents the length of straight pipe of inside diameter D equivalent to a fitting with resistance coefficient K and the same nominal pipe size.

9. For steel pipe and the range of flow velocities and pipe sizes commonly encountered in jet pump bypassing systems, Equation B5 can be approximated by:

$$L = \frac{K \cdot D}{0.014} \tag{B6}$$

10. Equation B6 will give an estimated equivalent length of steel pipe of inside diameter D for a fitting of the same nominal pipe size with resistance coefficient K .

11. For pipelines made of material other than steel, the method of equivalent lengths is more difficult to apply. In such cases, it is suggested that losses for fittings be calculated by Equation B3. These losses can then be added to the losses for straight pipe calculated by the Darcy-Weisbach equation to obtain the total pipeline energy loss.

APPENDIX C: DERIVATION OF GRAPHICAL DESIGN CURVES

1. The purpose of this appendix is to show, briefly, how the design curves of Plates 3 through 14 (main text) were derived from equations outlined in the iteration design procedure.

2. The dimensionless parameters describing the performance of a jet pump with a certain area ratio R are given by Equations 1 and 2:

$$N = \frac{HDIS - HSUC}{HSUP - HDIS} \qquad \text{(1 bis)}$$

$$M = \frac{QSUC}{QSUP} \qquad \text{(2 bis)}$$

3. The relationship between these parameters is assumed to be of the form:

$$N = a \cdot M + b \qquad \text{(C1)}$$

which is the equation for a straight line where a and b are constants. The values of these constants can be obtained from the M versus N relations shown in Plate 2.

4. Substituting Equations 1 and 2 into Equation C1,

$$\frac{HDIS - HSUC}{HSUP - HDIS} = a\left(\frac{QSUC}{QSUP}\right) + b \qquad \text{(C2)}$$

5. The relationship between QSUP , HSUP , and HSUC must satisfy Equation 33:

$$QSUP = B(ANOZ)\sqrt{(HSUP - HSUC)} \qquad \text{(33 bis)}$$

From Equation 34,

$$ANOZ = f(R\ ,\ AMIX) \qquad \text{(C3)}$$

For a given jet pump size, AMIX is constant. For a given R value, B is constant (see tabulation on p 73 of main text). Therefore, for a given jet pump size and R value,

$$QSUP = f(HSUP\ ,\ HSUC) \tag{C4}$$

6. Equation 31 gives a suggested expression for calculating HSUC :

$$HSUC = \frac{VSUC^2}{2g} - \left[2LSUC + 4\left(\frac{VSUC^2}{2g}\right)\right] \tag{31 bis}$$

For a given jet pump size,

$$VSUC = f(QSUC) \tag{C5}$$

7. Therefore, for a given jet pump size and assumed LSUC value,

$$HSUC = f(QSUC) \tag{C6}$$

Equation C4 can now be rewritten:

$$QSUP = f(HSUP\ ,\ QSUC) \tag{C7}$$

or

$$HSUP = f(QSUP\ ,\ QSUC) \tag{C8}$$

8. Substituting Equations C6 and C8 into Equation C2,

$$\frac{HDIS - f(QSUC)}{f(QSUP\ ,\ QSUC) - HDIS} = a\left(\frac{QSUC}{QSUP}\right) + b \tag{C9}$$

9. Equation C9 is the basis for the design curves of Plates 3-14. It contains three variables (HDIS , QSUC , and QSUP) and two known constants (a and b). By holding one variable constant, a unique relationship is defined between the other two variables. The

graphical design curves were generated by holding QSUP constant and solving for HDIS for different values of QSUC . Then, the value of QSUP was changed, and the process repeated. The only departure from the iteration design procedure was in assuming a certain LSUC value. However, this assumption can be shown to have a minimal effect on the calculated value of HDIS .

10. The values of HSUP shown on the graphical design curves were calculated using a rearranged form of Equation 33:

$$HSUP = \left[\frac{QSUP}{B(ANOZ)}\right]^2 + HSUC \qquad (C10)$$

11. For a given jet pump size and R value, if HSUC is held constant in Equation C10, then HSUP depends only on the value of QSUP . For each design curve shown in Plates 3-14, the value of HSUC at the curve midpoint was used as a constant in calculating HSUP from Equation C10. Therefore, the value of HSUP given for each curve is exactly correct at the curve midpoint, with an increasing error toward either end of the curve. The magnitude of this error at the curve ends, in most cases, is in the range of 5 percent. For any design operating point, therefore, the error involved in using an HSUP value from the graphical design curves instead of one rigorously calculated from the iteration procedure will be much less than the error envelope of the entire design process.

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111 p. in various pagings : ill. ; 27 cm. -- (Instruction report / U.S. Army Engineer Waterways Experiment Station ; HL-81-1)
Cover title.
"September 1981."
"Prepared for Office, Chief of Engineers, U.S. Army."
Bibliography: p. 99-100.

1. Hydraulic engineering. 2. Hydraulic machinery. 3. Jet pumps. 4. Sand. I. McNair, Ernest C., Jr. II. United States. Army. Corps of Engineers. Office of the Chief of Engineers. III. U.S. Army Engineer Waterways Experiment Station. Hydraulics Laboratory.

Richardson, Thomas W.
A guide to the planning and hydraulic design : ... 1981.
(Card 2)

IV. Title V. Series: Instruction report (U.S. Army Engineer Waterways Experiment Station) ; HL-81-1.
TA7.W34i no.HL-81-1

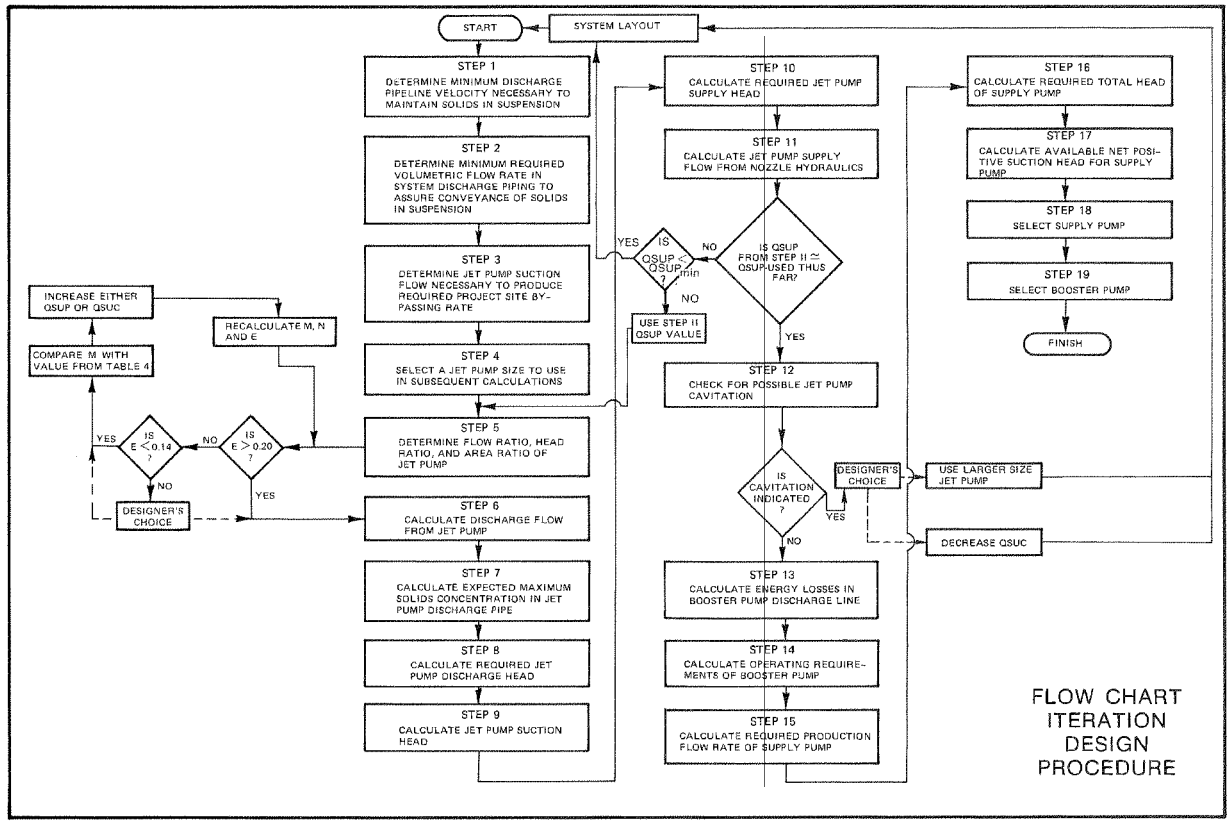

START
SYSTEM LAYOUT
STEP 1
DETERMINE MINIMUM DISCHARGE PIPELINE VELOCITY NECESSARY TO MAINTAIN SOLIDS IN SUSPENSION
STEP 2
DETERMINE MINIMUM REQUIRED VOLUMETRIC FLOW RATE IN SYSTEM DISCHARGE PIPING TO ASSURE CONVEYANCE OF SOLIDS IN SUSPENSION
STEP 3
DETERMINE JET PUMP SUCTION FLOW NECESSARY TO PRODUCE REQUIRED PROJECT SITE BY-PASSING RATE
STEP 4
SELECT A JET PUMP SIZE TO USE IN SUBSEQUENT CALCULATIONS
STEP 5
DETERMINE FLOW RATIO, HEAD RATIO, AND AREA RATIO OF JET PUMP
STEP 6
CALCULATE DISCHARGE FLOW FROM JET PUMP
STEP 7
CALCULATE EXPECTED MAXIMUM SOLIDS CONCENTRATION IN JET PUMP DISCHARGE PIPE
STEP 8
CALCULATE REQUIRED JET PUMP DISCHARGE HEAD
STEP 9
CALCULATE JET PUMP SUCTION HEAD
STEP 10
CALCULATE REQUIRED JET PUMP SUPPLY HEAD
STEP 11
CALCULATE JET PUMP SUPPLY FLOW FROM NOZZLE HYDRAULICS
IS QSUP FROM STEP II ≈ QSUP USED THUS FAR?
NO
YES
IS QSUP < QSUP min ?
YES
NO
USE STEP II QSUP VALUE
STEP 12
CHECK FOR POSSIBLE JET PUMP CAVITATION
IS CAVITATION INDICATED ?
YES
NO
DESIGNER'S CHOICE
USE LARGER SIZE JET PUMP
DECREASE QSUC
STEP 13
CALCULATE ENERGY LOSSES IN BOOSTER PUMP DISCHARGE LINE
STEP 14
CALCULATE OPERATING REQUIREMENTS OF BOOSTER PUMP
STEP 15
CALCULATE REQUIRED PRODUCTION FLOW RATE OF SUPPLY PUMP
STEP 16
CALCULATE REQUIRED TOTAL HEAD OF SUPPLY PUMP
STEP 17
CALCULATE AVAILABLE NET POSITIVE SUCTION HEAD FOR SUPPLY PUMP
STEP 18
SELECT SUPPLY PUMP
STEP 19
SELECT BOOSTER PUMP
FINISH
INCREASE EITHER QSUP OR QSUC
RECALCULATE M, N AND E
COMPARE M WITH VALUE FROM TABLE 4
IS E < 0.14 ?
YES
NO
IS E > 0.20 ?
NO
YES
DESIGNER'S CHOICE
FLOW CHART ITERATION DESIGN PROCEDURE

PLATE 1

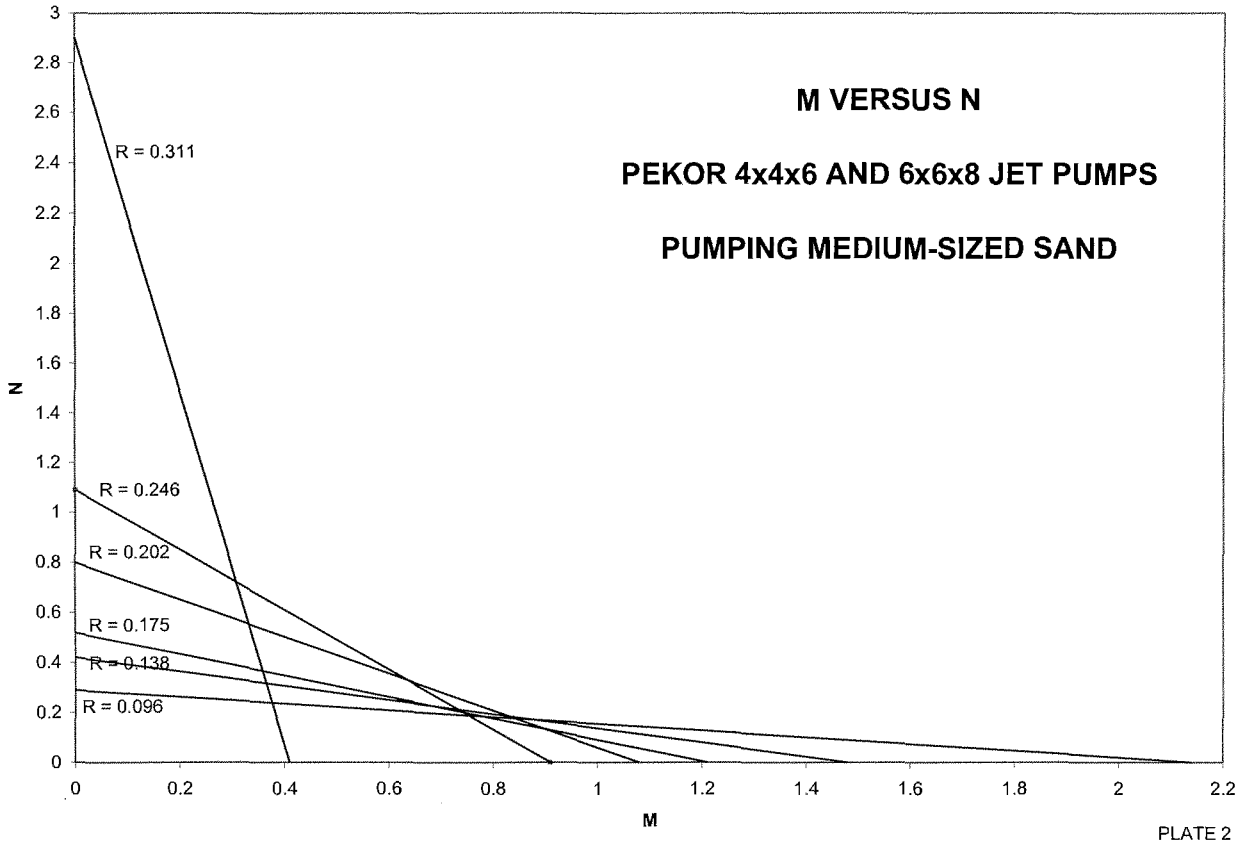
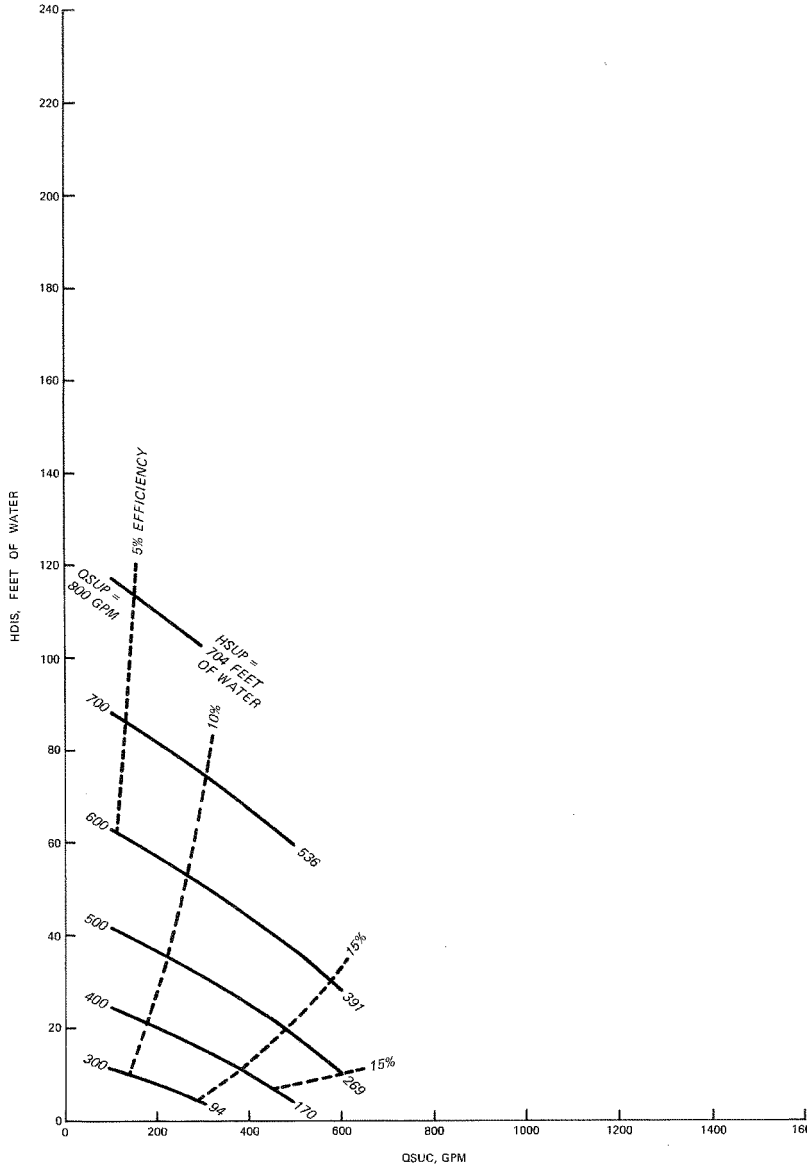

M VERSUS N
PEKOR 4x4x6 AND 6x6x8 JET PUMPS
PUMPING MEDIUM-SIZED SAND
R = 0.311
R = 0.246
R = 0.202
R = 0.175
R = 0.138
R = 0.096
N
M
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
2.2
2.4
2.6
2.8
3

PLATE 2

774

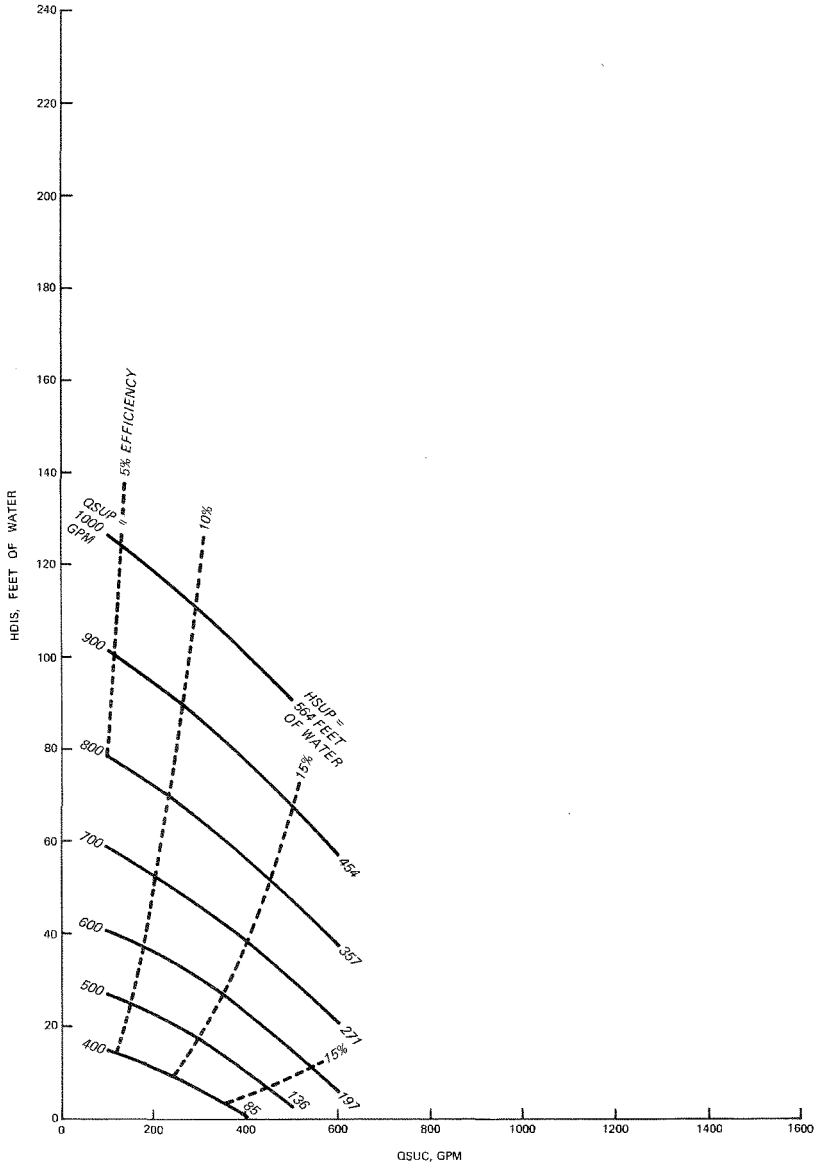


HDIS VERSUS QSUC

4×4×6 PEKOR JET PUMP PUMPING SAND

R = 0.096

PLATE 3



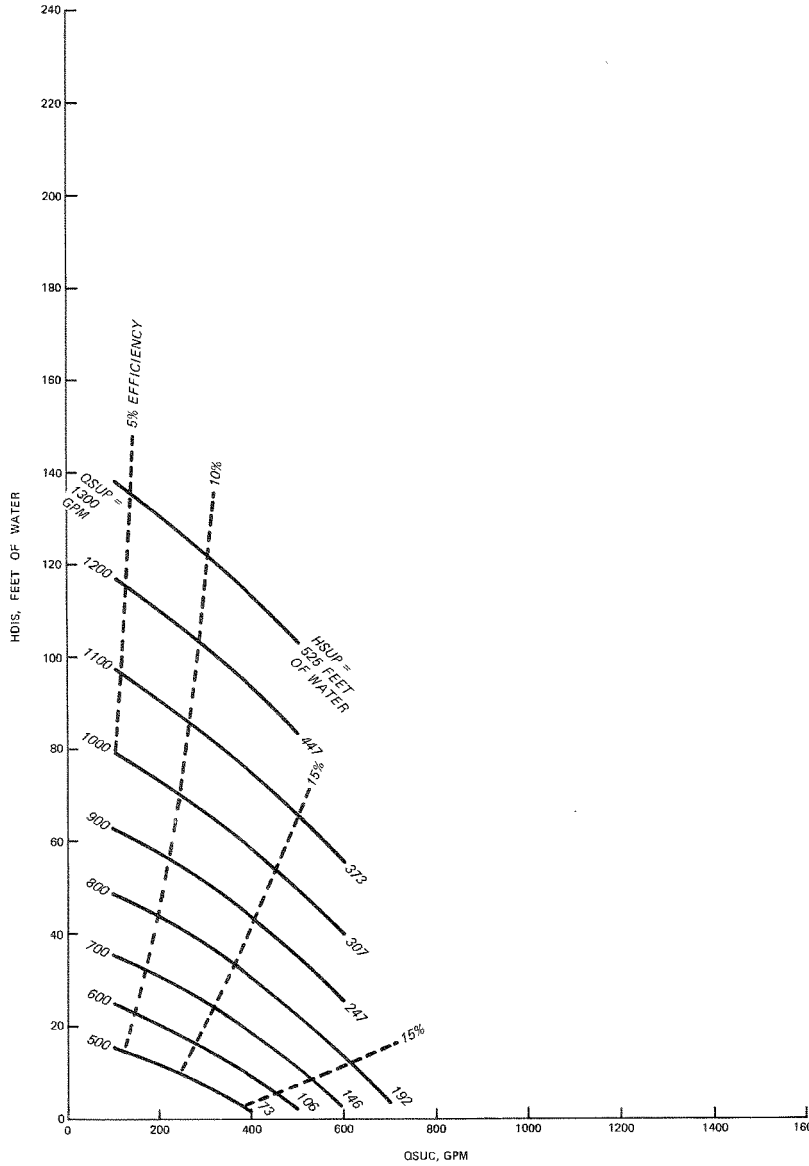
HDIS VERSUS QSUC

4×4×6 PEKOR JET PUMP

PUMPING SAND

R = 0.138

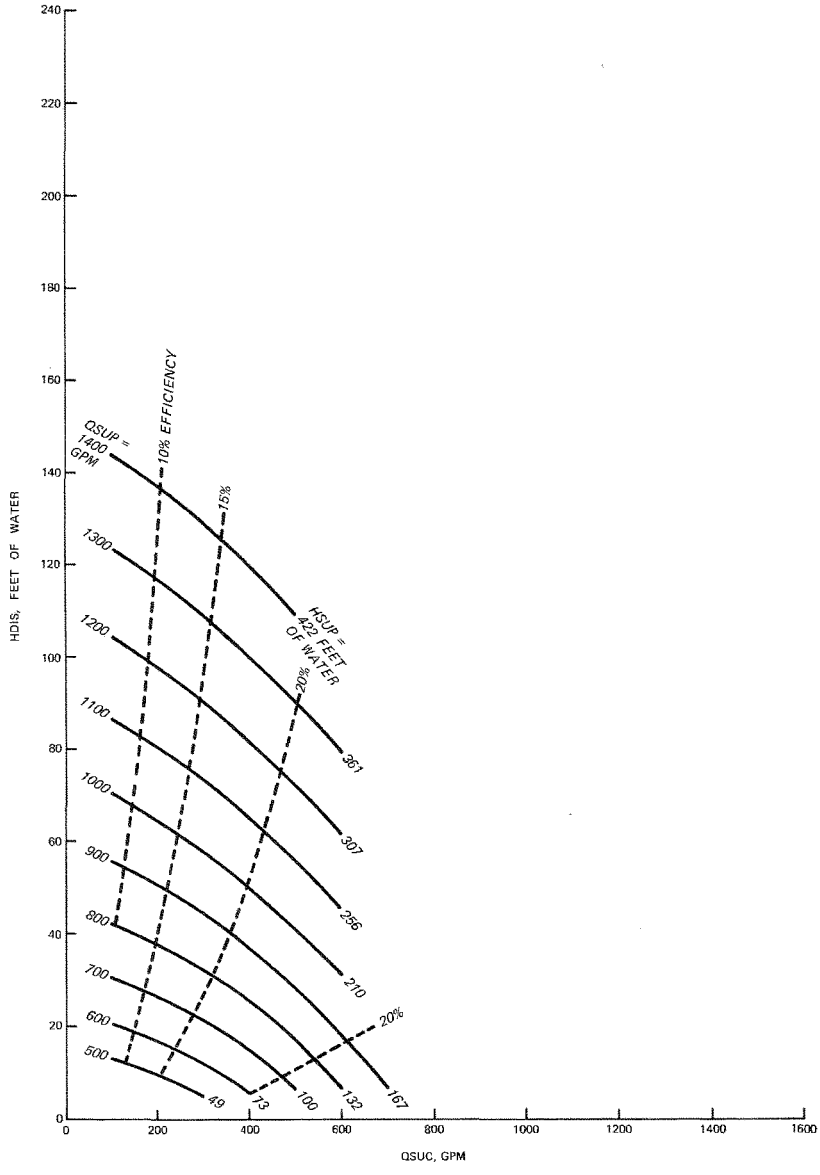
PLATE 4



HDIS VERSUS QSUC

4×4×6 PEKOR JET PUMP
PUMPING SAND
R = 0.175

PLATE 5



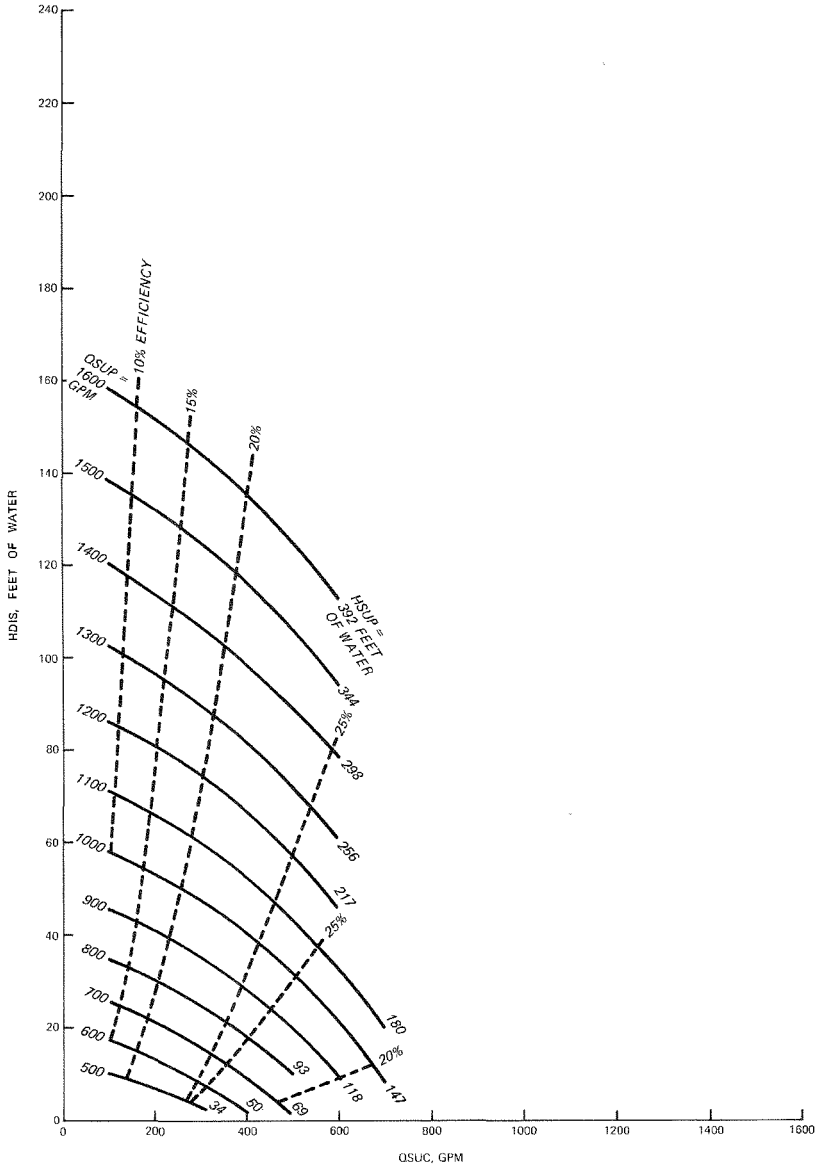
HDIS VERSUS QSUC

4×4×6 PEKOR JET PUMP

PUMPING SAND

R = 0.202

PLATE 6



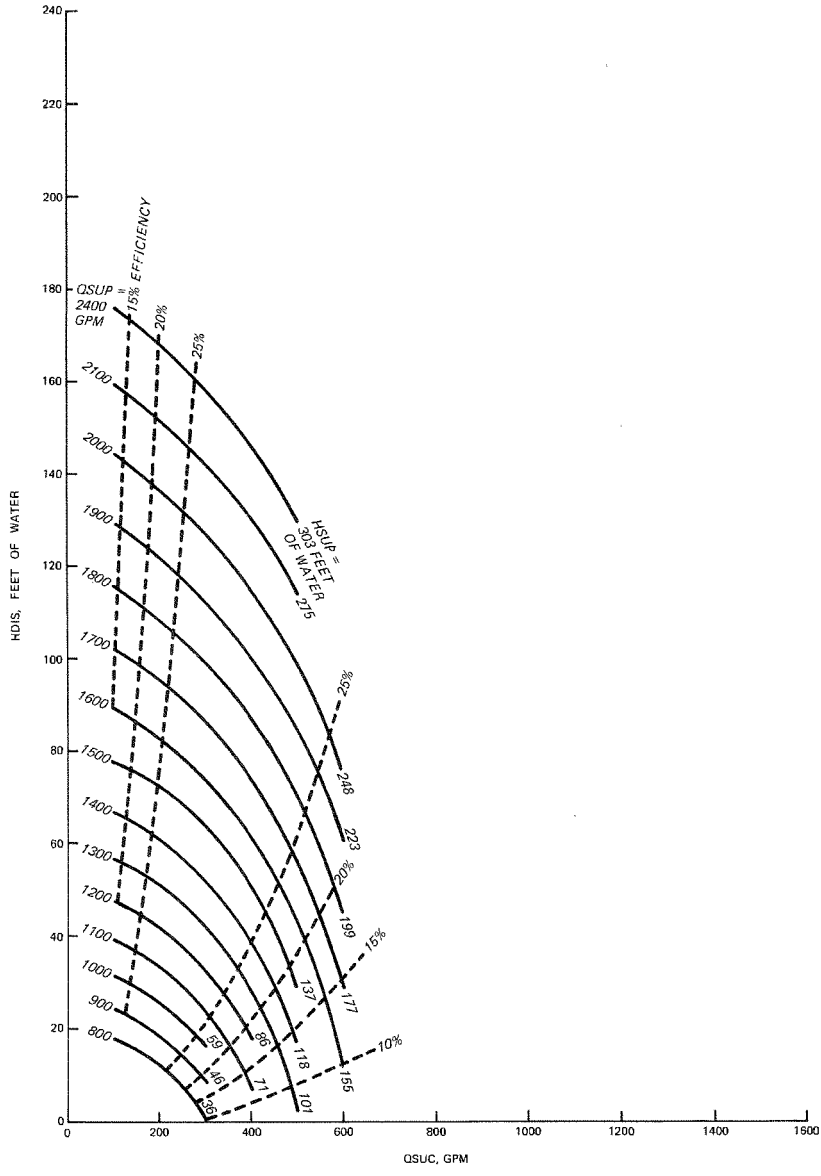
HDIS VERSUS QSUC

4×4×6 PEKOR JET PUMP

PUMPING SAND

R = 0.246

PLATE 7



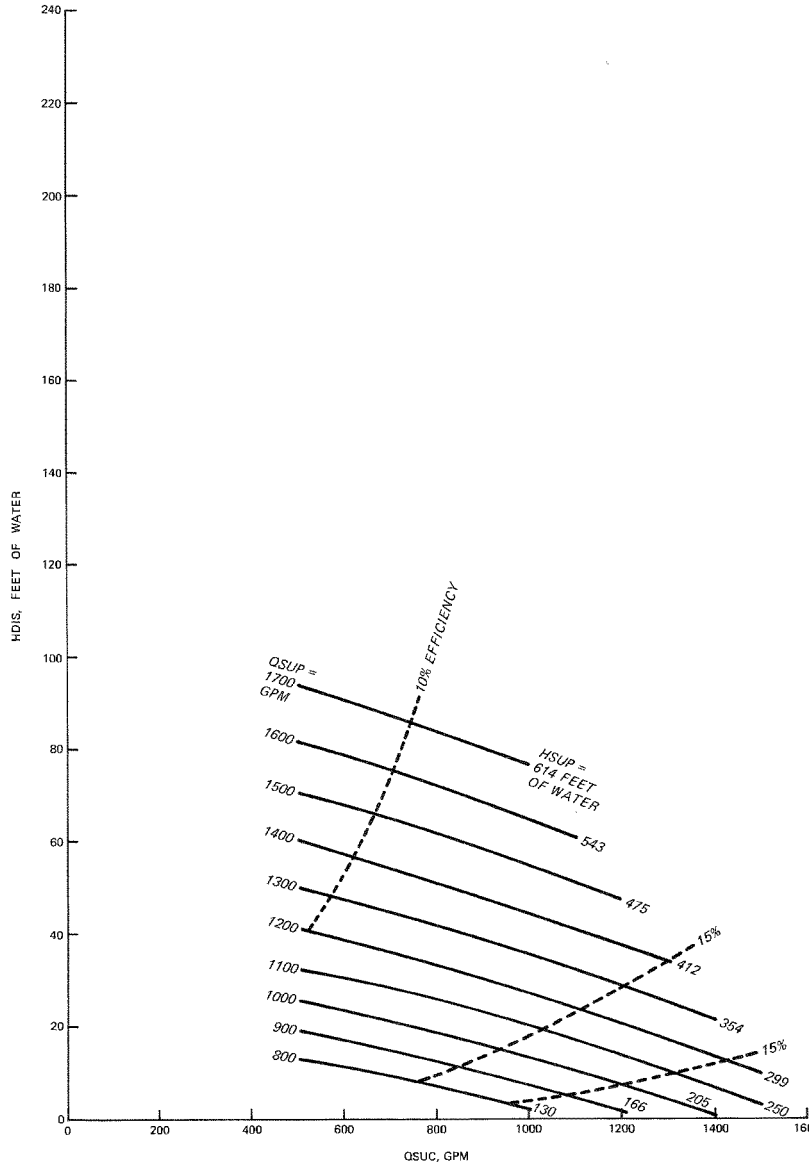
HDIS VERSUS QSUC

4×4×6 PEKOR JET PUMP

PUMPING SAND

R = 0.311

PLATE 8

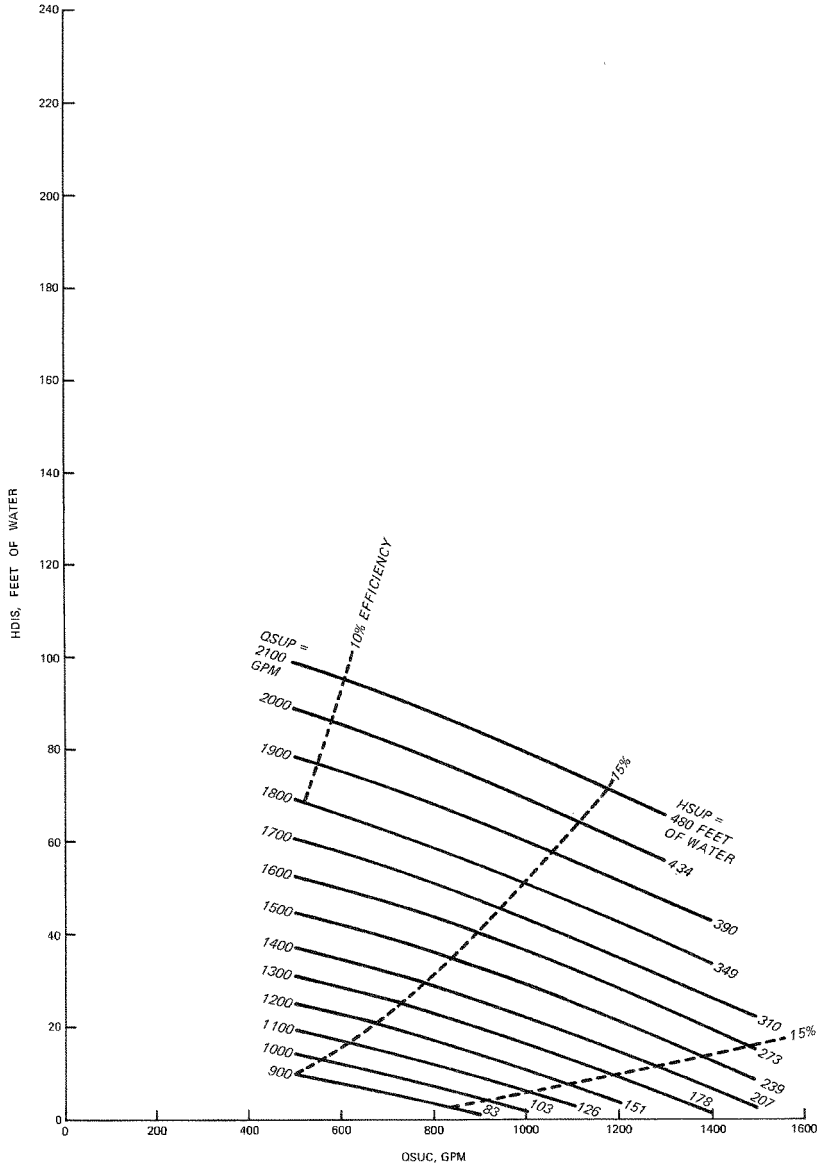


HDIS VERSUS QSUC

6×6×8 PEKOR JET PUMP PUMPING SAND

R = 0.096

PLATE 9



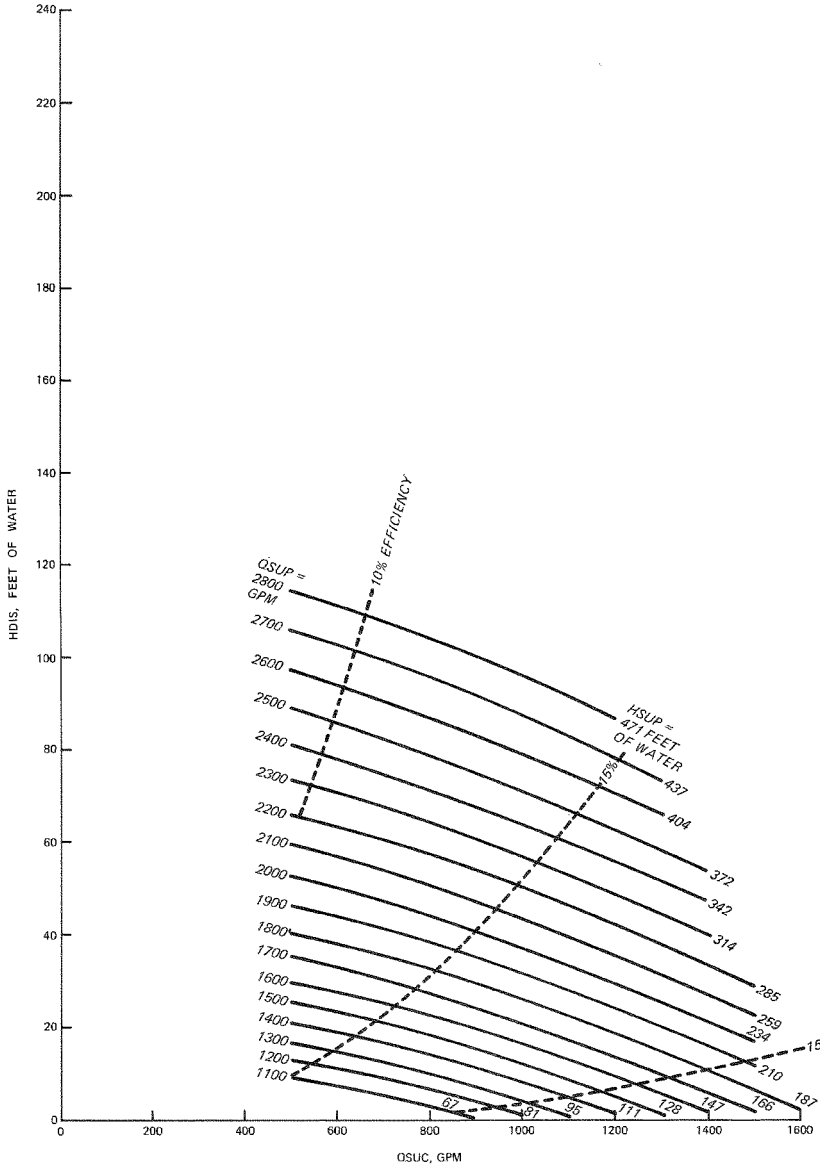
HDIS VERSUS QSUC

6×6×8 PEKOR JET PUMP

PUMPING SAND

R = 0.138

PLATE 10



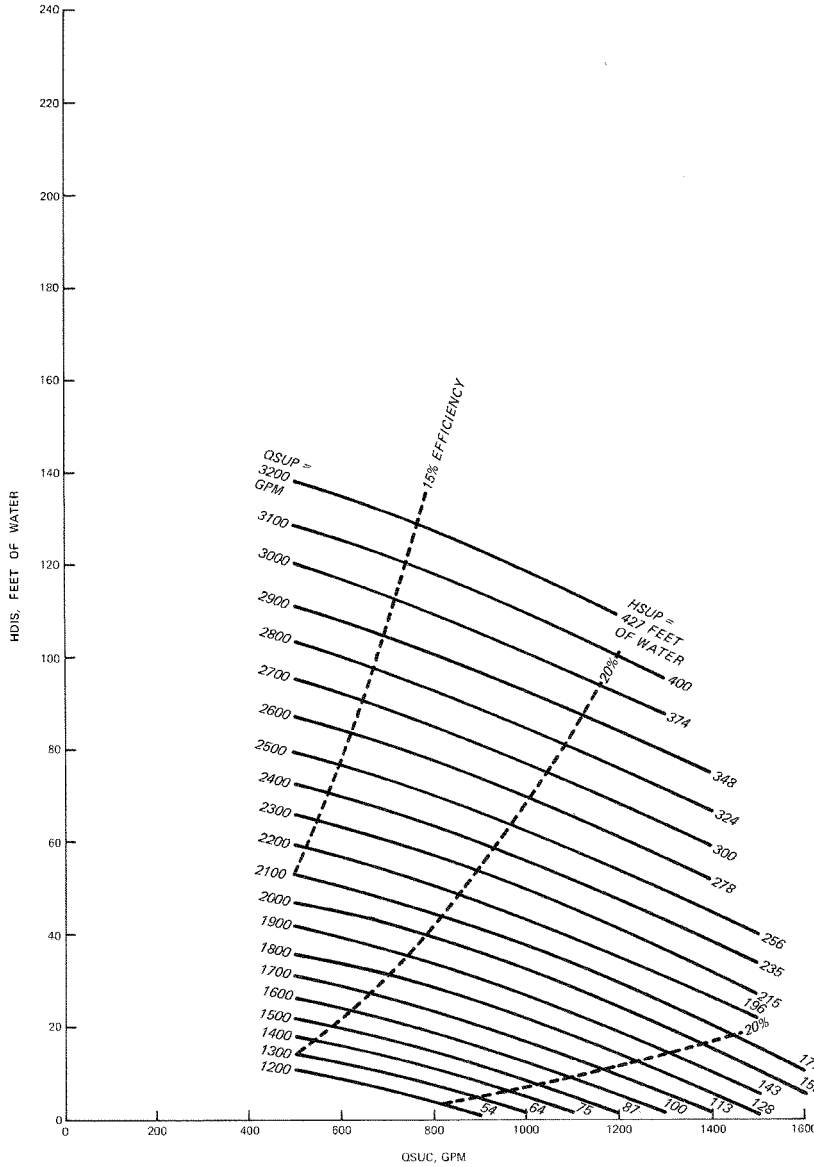
HDIS VERSUS QSUC

6×6×8 PEKOR JET PUMP

PUMPING SAND

R = 0.175

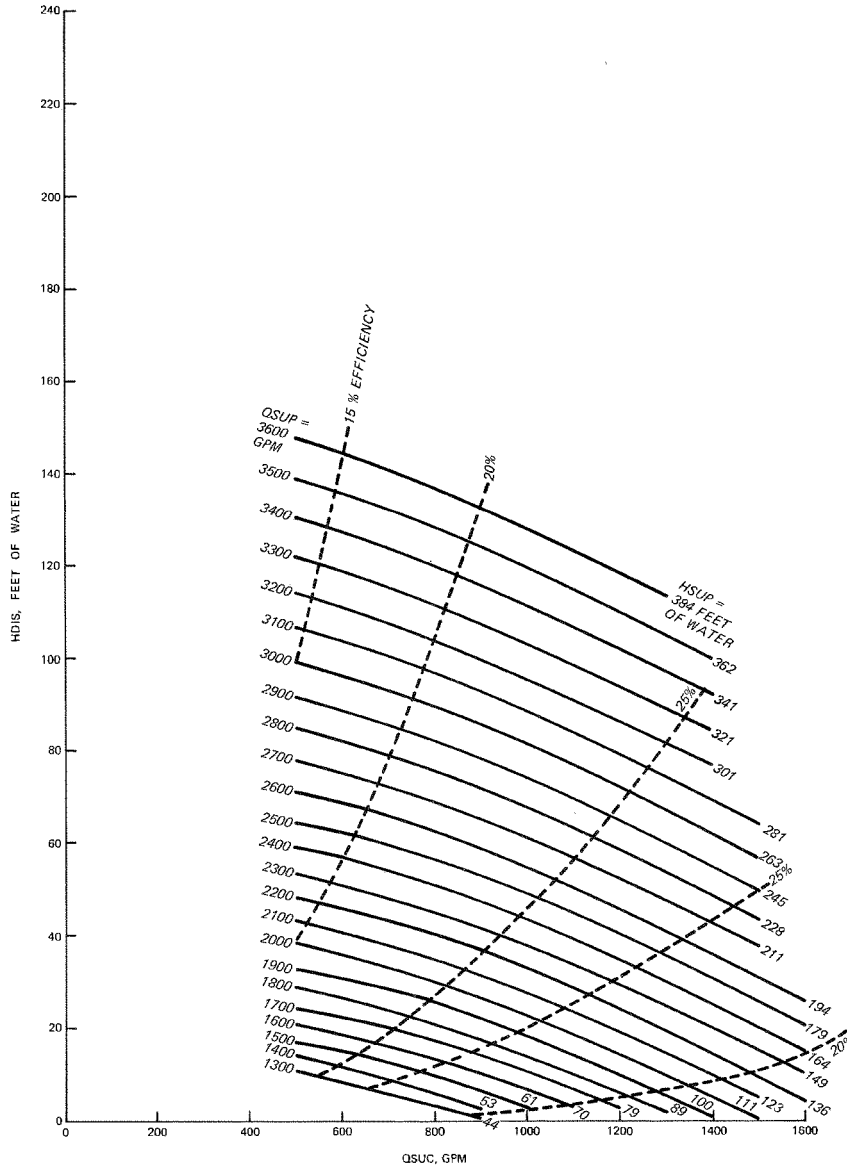
PLATE 11



HDIS VERSUS QSUC

6×6×8 PEKOR JET PUMP
PUMPING SAND
R = 0.202

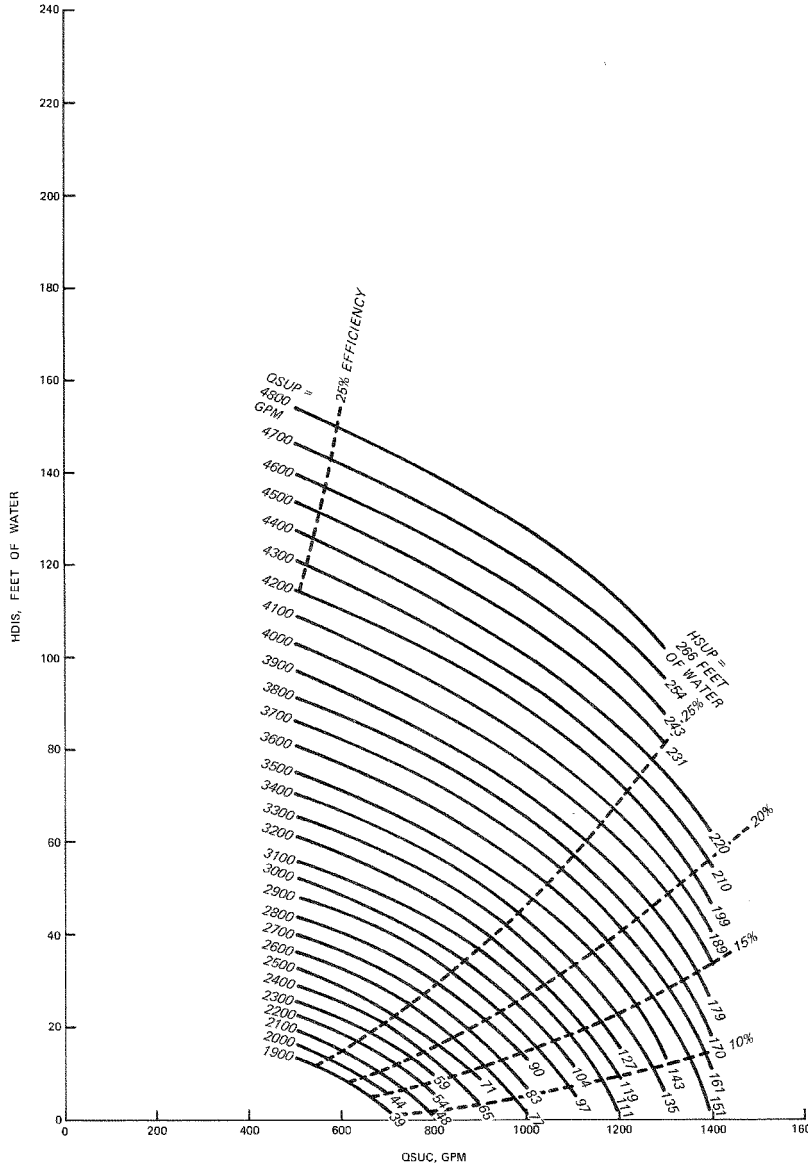
PLATE 12



HDIS VERSUS QSUC

6×6×8 PEKOR JET PUMP
PUMPING SAND
R = 0.246

PLATE 13



HDIS VERSUS QSUC

6×6×8 PEKOR JET PUMP

PUMPING SAND

R = 0.311

PLATE 14

World-wide sand bypassing systems: data report

P.K. Boswood and R.J. Murray

Queensland Government
Environmental Protection Agency

Conservation technical report No. 15 (R20)

ISSN 1037-4701 August 2001

World-wide Sand Bypassing Systems: Data Report
(Compiled 1997)

PK Boswood and RJ Murray
Coastal Services technical report R20
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Preface

This report has been prepared by Mr Paul Boswood, Coastal Services Branch, Environmental and Technical Services, Environmental Protection Agency, and Mr Russell Murray, formerly Project Director, Tweed River Entrance Sand Bypassing Project.

This report was prepared in 1996/97 as background information for the assessment of bypassing systems for the Tweed River Entrance Sand Bypassing Project. The information contained within this report has been obtained from a number of sources. The authors wish to thank all those who have provided assistance. In particular, the advice and feedback from project personnel within the Queensland Environmental Protection Agency, NSW Department of Land and Water Conservation, and Brown and Root as well as Queensland Transport, was greatly appreciated.

Contents

i. List of symbols 3
ii. Dimensions and units 3
1. Introduction 4
2. Terminology 4
3. Sand bypassing: general description 4
4. World-wide sand bypassing systems 5
5. Selected sand bypassing systems 5
6. Bibliography 5

Appendices

Appendix A List of sand bypassing systems (as of 1997) 19
Appendix B Data sheet: Nerang River Sand Bypassing System, Queensland, Australia 23
Appendix C Data sheet: Boca Raton Inlet Sand Bypassing System, Florida, U.S.A. 31
Appendix D Data sheet: Channel Islands Harbour Sand Bypassing System, California, U.S.A. 35
Appendix E Data sheet: Dawesville and Mandurah Inlets Sand Bypassing System, Western Australia 39
Appendix F Data sheet: Indian River Inlet Sand Bypassing System, Delaware, U.S.A. 45
Appendix G Data sheet: Oceanside Harbour Sand Bypassing System, California, U.S.A. 50
Appendix H Data sheet: South Lake Worth Inlet Sand Bypassing System, Florida, U.S.A. 56

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List of Figures

Figure A1: Locality of world-wide sand bypassing systems. 22
Figure B1: Nerang River Entrance Sand Bypassing System, Locality plan (Munday, 1995). 29
Figure B2: Nerang River Entrance Sand Bypassing System, System layout (Witt and Hill, 1987). 30
Figure B3: Schematic of Nerang River Entrance Sand Bypassing System (Witt and Hill, 1987). 30
Figure C1: Boca Raton Inlet Sand Bypassing System, Locality plan (Coastal Planning and Engineering, 1996) 33
Figure C2: Boca Raton Inlet Sand Bypassing System (Dombrowski and Mehta, 1993) 34
Figure D1: Channel Islands Harbour Sand Bypassing System (Walker, 1991). 38
Figure E1: Dawesville and Mandurah Inlets Sand Bypassing System, Locality plan (Moloney et al, 1999). 42
Figure E2: Layout of Dawesville Sand Bypassing System (Moloney et al, 1999). 43
Figure E3: Layout of Mandurah Sand Bypassing System (Moloney et al, 1999). 43
Figure E4: General arrangement of the Slurrytrak 300-65 HH used for sand bypassing at Dawesville and Mandurah Inlets (Moloney et al, 1999). 44
Figure F1: Indian River Inlet Sand Bypassing System (Rambo et al, 1991). 48
Figure F2: Indian River Inlet Sand Bypassing System, Locality plan (Rambo et al, 1991). 49
Figure G1: Oceanside Harbour Sand Bypassing System locations (Patterson et al, 1991). 54
Figure G2: Oceanside Harbour Sand Bypassing System, Locality plan (Weisman et al, 1996). 55
Figure G3: Oceanside Harbour Sand Bypassing System, Fluidiser locations (not to scale) (Weisman et al, 1996). 55
Figure H1: South Lake Worth Inlet Sand Bypassing System, Locality plan (Olsen Associates, 1996). 59
Figure H2: South Lake Worth Inlet Sand Bypassing System (Yeend and Hatheway, 1988) 59

List of Tables

Table 1. List of selected bypassing systems 5

i. List of symbols

AC = asbestos cement.
CD = Chart Datum.
cyl. = cylinder.
D_{50} = median sediment particle size.
dia. = diameter.
dir = wave direction.
HDPE SDR-9 = high density polyethylene standard density rating.
H_{max} = maximum wave height.
Hrs Op = hours operation.
Hs = significant wave height.
Hs(10%) = significant wave height exceeded 10% of the time.
Hs(50%) = significant wave height exceeded 50% of the time.
Hs,o = deep water significant wave height.
ID = inside diameter.
LWD = low water datum.
MDPE = medium density polyethylene.
MHHW = mean higher high water.
MLLW = mean lower low water.
MLW = mean low water.
MSL = mean sea level.
NW = north-west.
pa. = per annum.
PVC = polyvinyl chloride.
S = south.
SE = south-east.
std dev. = standard deviation.
SW = south-west.
T = wave period.
T_{ave} = average wave period.
T_p = spectral peak wave period.
typ. = typical or typically.
WNW = west of north-west.

ii. Dimensions and units

cy = cubic yard.
ft = feet.
gpm = gallons per minute.
hp = horse power.
hr = hour.
km = kilometre.
kV = kilovolt.
kW = kilowatt.
kWh = kilowatt hour.
lps = litres per second.
m = metre.
m^3 = cubic metre.
m^3 pa = cubic metres per annum.
m^3/yr = cubic metres per year.
mm = millimetre.
s = second.
yr = year.

1. Introduction

The Tweed River Entrance Sand Bypassing Project is a joint project undertaken by the State Governments of Queensland and New South Wales in conjunction with the Gold Coast City Council and Tweed Shire Council. The main aims are to establish and maintain a navigable entrance to the Tweed River and to enhance and maintain the amenity of the southern Gold Coast beaches.

The project involves two inter-related components, namely:

- initial dredging of the Tweed River bar and entrance area and nourishment of the southern Gold Coast beaches between Snapper Rocks and North Kirra (Stage 1).
- an artificial sand bypassing system, to operate in perpetuity (Stage 2).

To aid project delivery, world-wide experience operating various sand bypassing systems has been examined for their potential application to this project, and to expand knowledge on existing bypass technology and problems encountered.

This data report provides:

- a non-exhaustive reference list as of 1997;
- a short description of world-wide bypassing systems; and
- a set of data sheets providing a detailed brief description of selected bypassing systems.

It provides a reference source for the project team, consultants engaged for the project, potential contractors, regulating authorities, advisory bodies, the community and others with an interest in sand bypassing.

2. Terminology

This report summarises sand bypassing works undertaken around the world, with international references to these systems. Terminology used to describe key coastal works components will vary according to geographic location. This report uses the following terms for some of these key components:

Training wall: coastal structure aligned along the inlet sides and extending seawards to stabilise an inlet entrance and maintain a channel. Sometimes referred to as a jetty or breakwater.

Trestle: a structure extending seawards from the shore used for recreational rather than protective measures. Sometimes referred to as a jetty, pier, or wharf.

Breakwater: a coastal structure used to protect open coast regions from waves. Extensively used in harbours or mariners.

Weir Training Wall: a training wall with a depressed section of the wall usually near the beach to allow movement of sand into a controlled section of the channel. Usually associated with a sand trap to allow dredging in sheltered conditions.

Revetment: A protective layer usually of rock or concrete placed over a bank, scarp or in front of foreshore development to protect it from wave attack and currents.

3. Sand bypassing: general description

Natural sand bypassing is the process where the longshore sand transport (littoral drift) along an open coast travels across inlets in the direction of the net sediment transport. For inlets where the tidal prism of the inlet is small compared to the transport rate along the coast, a bar will form across the entrance of the inlet to convey sand to the other side. Such bars can be hazardous to navigation. Breakwaters or training walls may be erected along the entrance banks and seawards to stabilise movement of the inlet, to produce new inlets or harbours, and to improve navigation. While the result may be an improved entrance channel in the short term, the training walls trap the littoral drift such that the updrift beach accumulates against the training wall, whilst the downdrift beach erodes due to a lack of sand supply. In

the long term, this process may continue until the sand can once again naturally bypasses around the entrance, creating another entrance bar.

To maintain a navigable entrance and neighbouring beach amenity, sand bypassing systems have been created to artificially bypass the littoral drift. A number of different systems have been developed and employed around the world. Most systems fall under one or a combination of the following generic types:
1. water based mobile systems including maintenance dredging either of the channel or sand trap;
2. land based mobile systems; and
3. fixed systems such as a trestle- or breakwater-mounted.

4. World-wide sand bypassing systems

A reference list has been prepared from a wide number of sources of information and is presented in section 8 below. Appendix A lists the world-wide sand bypassing systems found from a non-exhaustive search of the cited references. The locality of these systems are shown in figure A1.

No list of sand bypassing systems (including this one) can be regarded as fully complete because different definitions of bypassing are used in different jurisdictions and by different investigators. The list covers major systems in operation, other systems trialed or operated for a limited time, and some systems in development phase as of 1997.

5. Selected sand bypassing systems

Based on this list, the available references, and the knowledge of project staff, a selection of sand bypassing systems was chosen for a more detailed summary to cover a range of various types of systems in operation. The list of selected bypassing systems considered for a more detailed summary is given in table 1.

Table 1. List of selected bypassing systems.

Plant location	Country	Type of bypass system
Nerang River Entrance, Queensland	Australia	Trestle and jet pump system (fixed).
Boca Raton, Florida	USA	Weir training wall and trap with conventional dredging.
Channel Islands Harbour, California	USA	Detached breakwater and sand trap with biannual dredging and pumping down coast of Port Hueneme.
Dawesville, Western Australia	Australia	Crawler excavator (mobile) and crawler mounted pump system.
Indian River Inlet, Delaware	USA	Jet pump and crane (mobile system).
Oceanside Harbour, California	USA	Jet pumps and fluidisers (experimental fixed system).
South Lake Worth Inlet, Palm Beach County, Florida	USA	Fixed hydraulic suction dredge with a rotating boom (fixed).

A data sheet on each of these systems is given in appendices B to H. These data sheets provide a systematic description of key environmental and system parameters, a site description, and a specific reference list with some additional references not given in the bibliography. The measuring units provided in these appendices depends on the source of information and varies between metric and imperial. A description of unit abbreviations is provided in section 2.

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Appendix A

List of sand bypassing systems (as of 1997).

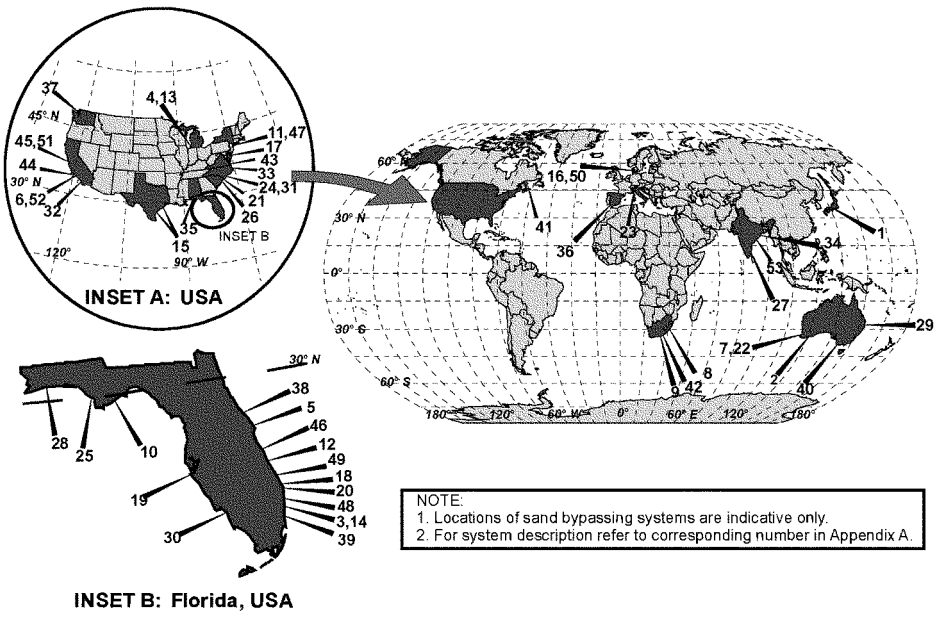
	Plant location	Country	Type of bypassing system [and reference]
1.	Amanohashidate coast	Japan	Investigation and trial only [54,258].
2.	Bandy Creek Harbour, Esperance, Western Australia	Australia	Natural bypassing around entrance with offshore breakwater to prevent sediment returning (constructed 1989) [24].
3.	Boca Raton, Florida	USA	Weir training wall and trap with conventional dredging [71,81].
4.	Bridgman, Michigan (Lake Michigan)	USA	Small quantities by hydraulic bypassing from accretion fillet with remainder of nourishment from mined sand from dunes (1971-1973) [120].
5.	Canaveral Harbour, Florida	USA	Conventional dredging from nearshore borrow area (recommended plan as of 1995) [108].
6.	Channel Islands Harbour, California	USA	Detached breakwater and sand trap with biannual dredging and pumping down coast of Port Hueneme [106,211,226].
7.	Dawesville, Western Australia	Australia	Crawler excavator (mobile) and crawler mounted pump system [22,50,111].
8.	Durban	South Africa	Maintenance dredging of entrance and trap updrift of breakwater (installed 1982). Considering fixed system of jet pumps as of 1996 [10,129,191].
9.	East London Port	South Africa	Maintenance dredging of trap [129].
10.	East Pass, Florida	USA	Weir training wall and trap with conventional dredging (1969-1985) [207].
11.	Fire Island, New York	USA	Maintenance dredging of bay shoals [41].
12.	Ft. Pierce, Florida	USA	Maintenance dredging of bay shoals [41].
13.	Great Lakes	USA	Mobile system consisting 200 mm jet pump with cutting assists, flotation buoy, and two propulsion jets connected by flexible hose to two land-based trailers supporting pumping and control equipment to travel between harbours (constructed in 1978) [189].
14.	Hillsboro Inlet, Florida	USA	Weir training wall and trap with 36 cm floating hydraulic dredge (mobile) [81,109].
15.	Houston, Corpus Christie, Texas	USA	Dredging of bay and ocean shoals with disposal offshore [41].
16.	Hvide Sande	Denmark	Maintenance dredging of entrance, as well as nourishment from offshore borrow site. Booster station in entrance for pumping during summer [115].

	Plant location	Country	Type of bypassing system [and reference]
17.	Indian River Inlet, Delaware	USA	Single jet pump and crane (mobile system) [1,6,56,61,65,67,69,96,131,181,182,183,234,240].
18.	Jupiter Inlet, Florida	USA	Conventional dredging of trap (constructed 1966) in Inlet [81].
19.	Lake LaVista Channel, Anna Maria Island, Florida.	USA	Demonstration of sand fluidisation system in 1986 [72].
20.	Lake Worth Inlet, Florida	USA	Electrically driven moveable suction head suspended from a boom (1960-1990); and maintenance dredging of entrance [150,191,203,211,227,261].
21.	Little River Inlet, South Carolina	USA	Weir in both training walls for bypassing. Weirs covered, to be opened when required [174].
22.	Mandurah Inlet, Western Australia	Australia	Crawler excavator (mobile) and crawler mounted pump system [22,50,111].
23.	Marina di Carrara	Italy	A 250mm suction pipe dredge mounted and swivels on a fixed circular concrete trestle off the updrift side of the harbour breakwater (installed 1972) [188,191].
24.	Masonboro Inlet, North Carolina	USA	Weir training wall and trap with conventional dredging (commenced 1966) [141,201,211].
25.	Mexico Beach, Florida	USA	Two fixed jet pumps operating from crater (constructed 1976). Replaced by floating dredge in 1978 [167].
26.	Murrells Inlet, South Carolina	USA	Weir training wall and trap with conventional dredging (mobile) [12,172].
27.	Nagapattinam (Bay of Bengal)	India	Pump on trestle pier with shutters [41].
28.	Navarre Beach, Florida	USA	Considering moveable dredge plant as of 1989 [23].
29.	Nerang, Queensland (Gold Coast Seaway)	Australia	Ten jet pumps along a trestle (fixed) (commenced 1986) [58,59,60,137,140,173,175,176,180,191,206, 216,256,257].
30.	New Pass, Florida	USA	Maintenance dredging of ocean shoal [41].
31.	New River Inlet, North Carolina	USA	Sidecasting dredge with split hull barge for deposition within 2m depth (experiment, 1976) [199,200].
32.	Oceanside Harbour, California	USA	Jet pumps and fluidisers (experimental fixed system, 1989 to 1996) [11,14,18,21,80,152,153,166,226,228, 246].
33.	Oregon Inlet, North Carolina	USA	Cutter-suction pipeline dredge operating in openings in proposed entrance walls (in consideration, 1985) [53,116,117].

	Plant location	Country	Type of bypassing system [and reference]
34.	Paradip, Orissa (Bay of Bengal)	India	Moveable plant on trestle with additional maintenance dredging [41].
35.	Perdido Pass, Alabama	USA	Weir training wall and trap with conventional dredging (construction commenced in 1968) [207].
36.	Playa de Castilla beach (Huelva Spain)	Spain	Trailing suction hopper dredge dredging shoals trapped by updrift dike, and pumping via 2 km long steel submerged pipeline to downdrift beaches [86].
37.	Point Roberts Marina, Strait of Georgia (northern Puget Sound), Washington	USA/ Canada border	Small-scale land based equipment bypassing beach sand by truck (mobile) [132,133].
38.	Ponce de Leon Inlet, Florida	USA	Weir training wall and trap with conventional dredging [201].
39.	Port Everglades, Florida	USA	Nourishment from offshore borrow site, and maintenance dredging [41].
40.	Portland, Victoria	Australia	Sand shifter system operated from breakwater or from barge [129].
41.	Prince Edward Island	Canada	Trailer-mounted jet pump and telescoping hydraulic crane (mobile, commenced 1982) [191].
42.	Richards Bay	South Africa	Maintenance dredging of trap [129].
43.	Rudee Inlet, Virginia Beach, Virginia	USA	Weir training wall and trap with conventional dredging (1968-1972). Two jet pumps on flexible hose (semi-mobile) installed in 1972 at trap, supplemented by maintenance dredging [188].
44.	Santa Barbara, California	USA	Maintenance dredging of harbour [211,226,248].
45.	Santa Cruz, California	USA	Annual maintenance dredging of entrance channel (commenced 1965 with floating pipeline dredge) [126,188].
46.	Sebastian Inlet, Florida	USA	Maintenance dredging of channel sand trap with periodic transfer to downdrift beaches (commenced in 1989) [229].
47.	Shinnecock Inlet, New York	USA	Design/construct of inlet including bypass system in process as of 1992 [156].
48.	South Lake Worth inlet, Palm Beach County, Florida	USA	Fixed hydraulic suction dredge with a rotating boom (fixed) [8,51,158,191,260].
49.	St. Lucie, Florida	USA	Weir training wall and trap with conventional dredging (proposed as of 1987) [41].
50.	Torsminde	Denmark	Maintenance dredging of entrance, as well as nourishment from offshore borrow site [115].

	Plant location	Country	Type of bypassing system [and reference]
51.	Twin Lakes Harbour, Santa Cruz, California	USA	Fixed plant (commenced 1972) [41].
52.	Ventura, California	USA	Detached breakwater (constructed 1972) and sand trap with annual dredging (bypassing and some backpassing) [226].
53.	Visakhapatnam (Bay of Bengal)	India	Detached breakwater trap and transfer by pipeline across entrance to harbour [41,79,185].

***Figure A1**: Locality of world-wide sand bypassing systems.*



Appendix B

Data sheet: Nerang River Sand Bypassing System, Queensland, Australia.

Location: The Nerang River flows to the sea through a broad shallow tidal estuary called the Broadwater, meeting the Pacific Ocean between the southern end of South Stradbroke Island and the Southport Spit. The entrance is located at the northern end of the City of Gold Coast, south-east Queensland, Australia.

Problem: The progressive movement of the entrance northwards at a rate of 20 - 40 m per year has involved accretion of the Southport Spit and erosion of the southern tip of South Stradbroke Island. Hazardous navigation through the changing entrance shoals, and the possible threat of breakthrough at the South Stradbroke Island township of Currigee in the future, lead the Queensland Government to train and stabilise the river mouth between September 1984 to May 1986. The construction included revetments and breakwaters, opening of a new entrance and closure of the old entrance, creation of Wavebreak Island and Broadwater channels, and installation of a fixed bypass system.

Wave climate: Based on recorded wave data offshore from Southport in approx. 40 m depth for 1987 - 1994:
modal Hs(50%) = ~1 m
H_{max} = 9.98 m during Tropical Cyclone Roger
The majority of the waves range in height of Hs = 0.25 - 3.0 m (99 %) with 65 % of the data occurring within Hs = 0.5 - 1.25 m. The wave period (spectral peak) ranges typically between 3 and 15 s (99 %) with 65 % of the data within Tp = 7 - 11 s.

The wave climate is influenced by the predominant south-easterly swells with intense storms associated with low pressure systems and tropical cyclones approaching from the north.

Inlet characteristics: Nerang River: catchment = 480 km^2; semidiurnal mean spring tide range = 1.3 m extending to a limit of 21 km upstream from the mouth.

Inlet usage: Recreational boating, fishing, and commercial vessels (for recreational hire).

Sediment characteristics: D_{50} = 0.27 mm for the intertidal sands on adjacent beaches (ranges from 0.2 to 0.3 mm along the profile).

Drift rate: Net northerly transport = 500,000 m^3/yr (~654,000 cy/yr) (Beach Protection Authority, 1981).
Gross transport = 655,000 m^3/yr (~857,000 cy/yr).
Northerly transport = 575,000 m^3/yr (~752,000 cy/yr).
Southerly transport = 80,000 m^3/yr (~105,000 cy/yr).

Beach erosion rate: The bypass system was constructed in conjunction with the training of the entrance and so there was no erosion as a result of the entrance. Before training of the inlet, there was a progressive movement of the entrance northwards at a rate of 20 - 40 m per year.

Type of bypass: Ten jet pumps along a trestle (fixed).

Bypass system components:

Clear water intake from Broadwater through a 4 ft (~1.2 m) dia. concrete pipe; low pressure pump station with two 150 kW (200 hp) turbines (total 780 lps, 10,300 gpm); 24 inch (600 mm) dia. AC pipeline 2,300 ft (~700 m) long to the control building; high pressure jet water supply pumps housed in control station consisting of two 560 kW (750 hp) Centrifugal pumps (total 770 lps, 10,200 gpm); 14 inch (450 mm) coal tar epoxy lined water supply pipeline; 6 inch (150 mm) feed pipelines to jet pumps; ten 3.5 inch (90 mm) Genflo sandbug jet pumps with rate of 135 cy/hr (~100 m^3/hr) spaced 30 m apart along a 490 m long trestle; an elevated 23 inch (600 mm) dia. slurry pipe flume (1,214 ft or approx. 370 m long), on a 2.5 % slope to gravity feed into a density adjusting slurry pit which is a conical 189 cy (145 m^3) hopper; discharge pump housed in control station consisting of a 710 kW (950 hp) Centrifugal pump (total 489 lps, 6,500 gpm).

The jet pumps are lowered up to 11 m below mean sea level and create a trap of length 270 m. The trestle consists of a timber deck supported on steel piles. The jet pumps run on rails attached to the steel support piles to allow for installation and removal for maintenance work.

The operations are controlled by an automatic programmable logic controller. A nuclear density meter and electromagnetic flow meter are installed in the discharge line for the control of the flow rate and slurry solids concentration by the automatic system, and for operation monitoring records.

The system is powered by an 11 kV underground cable.

Outlet type:

406 mm (16 inch) dia. polyurethane lined steel pipe discharging at approximately the high water level, approx. 400 m north of the northern breakwater. Three outlet locations were considered in the design of the system, the further most discharge point being approx. 1,710 ft (~520 m) north of the northern training wall. The discharge pipe passes through steel sleeve tubes in the rock training walls for protection, and passes beneath the channel with pile supports.

Bypass rate:

Design Parameters:
Average rate = 500,000 m^3/yr; peak annual rate = 750,000 m^3; nominal transport capacity = 300 m^3/hr; maximum 5 day transport = 100,000 m^3; maximum monthly transport = 200,000 m^3; maximum sand trap capacity = 40,000 m^3.

The system was designed for the operation of 4 to 7 jet pumps with nominal capacities of 335 to 580 m^3/hr and an operating performance of 3.15 kWh/m^3. Operational experience has indicated the use of 3 to 5 jet pumps to be more effective.

Degree of bypassing: (e.g. all, 50%, etc.)

Designed for 100 % bypassing, however an unknown quantity of sand bypasses the trestle. No dredging of the entrance channel has been required.

Costs: Construction of bypass system and ancillary works (Jan 1985 - June 1986): $8,134,000 (AUD).

Operating expenses since commencement of bypassing: (July to June)

ITEM	89/90	90/91	91/92	92/93	93/94
Electricity	183,400	152,100	167,600	140,200	241,000
Salaries and Wages	90,700	93,400	95,000	102,800	95,700
Repair and Maintenance	111,900	100,100	184,000	318,800	266,200
TOTAL ($)	386,000	345,600	446,600	516,800	602,900

ITEM	94/95	95/96	96/97
Electricity	221,847	154,421	163920
Salaries and Wages	104,054	119,573	112,204
Repair and Maintenance	360,544	397,438	459,165
TOTAL ($)	686,445	671,432	735,289

Funding: State Government.

Contract type: Contract to design and construct. Operations and maintenance conducted by owner. A contract was let for the management of the structure as a fishing platform by the general public. In 1992, a painting contract was let for the complete painting requirements for the offshore structure.

Owner: State Government, Queensland Department of Transport.

Operator: State Government, Queensland Department of Transport.

Supervisor of operations: State Government, Queensland Department of Transport, Marine Services Section.

Staffing: Total of 3 people: an operator, assistant operator, and labourer working a normal daytime shift.

Operating cycle: The system runs automatically overnight, and sometimes weekends, to take advantage of cheaper electricity rates. The operator selects the appropriate jet pumps (depending on sand supply in each crater and the presence of debris) and commences pumping in the afternoon to run through the night. The system automatically performs an initial warm up and flushing of the lines, before the valves to the jet pumps are opened and bypassing commences.

Environmental constraints: No known constraints. Bypassing takes place at night and the discharge point is on an undeveloped part of an island, therefore having no direct effect on beach users.

Environmental management issues: A monitoring programme is undertaken to examine the performance and impacts of the entire project. This includes undertaking hydrographic surveys, aerial photography, sand bypassing records, visual observation of beach and surf zone conditions, wave recording, and the recording of water levels in the Nerang River and the Broadwater.

Commencement date of bypassing: May, 1986.

Performance: (include any leakage to inlet, formation of entrance bar, etc.)

Summary of Sand Bypassing Statistics (July to June)

ITEM	89/90	90/91	91/92	92/93	93/94
m^3 Pumped	378,756	440,287	376,841	286,974	569,013
kWhrs	2,077,111	2,101,010	1,859,789	1,608,946	2,434,098
kWhr/m^3	5.48	4.77	4.93	5.61	4.28
Hrs Op	1839	1568	1433	1210	1642
m^3/hr	206	281	263	237	347
\$/m^3	1.02	0.78	1.18	1.95	1.06

Summary of Sand Bypassing Statistics (Continued)

ITEM	94/95	95/96	96/97
m^3 Pumped	570,293	408,917	563,831
kWhrs	2,250,130	1,566,335	2,146,236
kWhr/m^3	3.95	3.83	3.81
Hrs Op	1518	1117	1539
m^3/hr	376	366	366
\$/m^3	1.20	1.64	1.30

For the financial years (July to June) up to 1989/90, the system had delivered 138,236 m^3 (85/86), 544,002 m^3 (86/87), 464,435 m^3 (87/88), and 392,821 m^3 (88/89). For the 1997/98 financial year the system pumped a total of 587,869 m^3. The system operates with 3 to 5 jet pumps achieving capacities in the range of 330 to 540 m^3/hr depending on factors such as weather, blockages, density of sand and slurry, and sand supply to the traps. As of September 1998, a bypassing rate of approx. 420 m^3/hr has been able to be maintained owing to continual improvements to the efficiency of the system.

The system was originally designed to create a long continuous sand trap of 270m length under the trestle. However, in practice, individual steep slope craters (typically 1:1 to 1:1.5) have formed around each jet pump.

There has been an unknown quantity of sand bypassing the trestle and building a bar formation, but no maintenance dredging of the channel between or seaward of the walls has been required. There has been some build-up of sand requiring dredging at the Broadwater end of the entrance.

There has been some significant scouring of the channel from strong ebb currents which has exposed the discharge pipe. The pipe has subsequently been supported by piles. The ebb tidal bar is forming further offshore then prior to the works but is not a problem for navigation. Some occasional growth of the sand spit around the southern training wall and into the entrance occurs and there is a progressive sand build-up in the nearshore areas to the north of the entrance.

The jet pumps are subject to clogging from debris especially during and after storm events. This has resulted in the plant not being operational during storms as originally envisaged. Key components of the jet pumps have undergone severe wear and have been through a series of improvements to reduce the problem. Difficulties are also encountered in retrieving the jet pumps for maintenance works owing to the limited working area for the crane.

Present plant status: (as of 1996)

Successful. Still in operation.

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***Figure B1**: Nerang River Entrance Sand Bypassing System, Locality plan (Munday, 1995).*

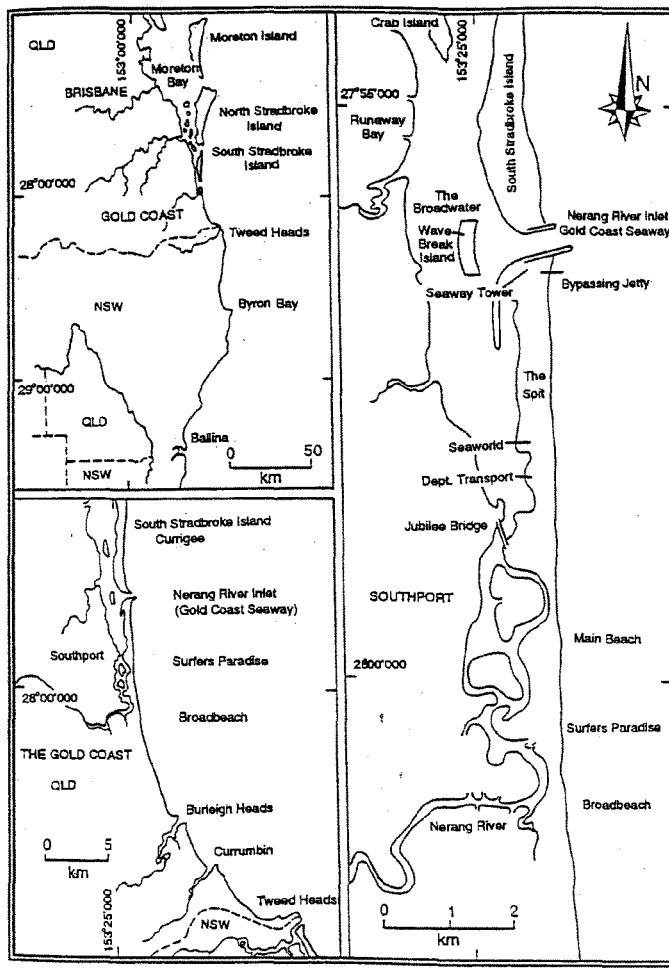


***Figure B2**: Nerang River Entrance Sand Bypassing System, System layout (Witt and Hill, 1987).*

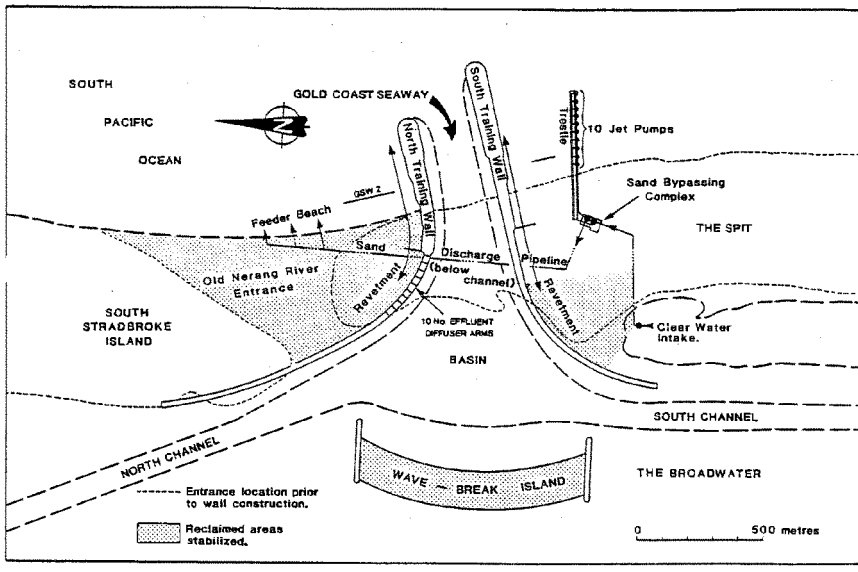
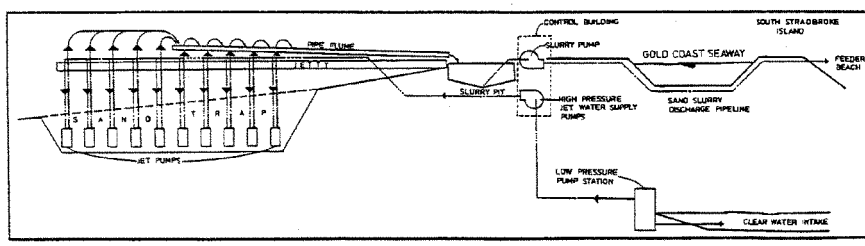


***Figure B3**: Schematic of Nerang River Entrance Sand Bypassing System (Witt and Hill, 1987).*



Appendix C

Data sheet: Boca Raton Inlet Sand Bypassing System, Florida, U.S.A.

Location:	Boca Raton Inlet is a natural entrance connecting Lake Boca Raton to the Atlantic Ocean. The inlet is situated within the City of Boca Raton in the south-eastern region of Palm Beach County, Florida, USA, between South Lake Worth Inlet (23 km to the south) and Hillsboro Inlet (9 km to the north).
Problem:	Erosion of the southern beaches and the creation of an ebb shoal at the entrance becoming a hazard to navigation.
Wave climate:	No published information available for this site, however refer to the Data Sheet for South Lake Worth Inlet (Appendix H) which is 23 km to the north of this site, for some general idea of conditions.
Inlet characteristics:	Tide range = approx. 2.5 ft (~0.75 m).
Inlet usage:	Small craft from southern Palm Beach and northern Broward counties.
Sediment characteristics:	Not known.
Drift rate:	Net southerly drift = 93,000 m^3/yr (~122,000 cy/yr). Transport is to the north for nine months and to the south for three months of the year during winter.
Beach erosion rate:	1975 - 1979: following extension of the training walls, the beach immediately south of the inlet receded by 187 ft (~57 m). August 1985 - August 1995: following the 1985 nourishment which widened the southern beach (3,400 ft or 1036 m length) on average 75 ft (~23 m), the same beach had receded approx. 138 ft (~42 m) by August 1995. (Coastal Planning & Engineering, 1996)
Type of bypass:	Weir training wall and channel trap with conventional dredging (mobile).
Bypass system components:	1972: 335 hp, 8 inch (~200 mm) hydraulic pipeline dredge and small tugboat. 1975: northern training wall extended seawards 180 ft (~55 m). 1980: construction of a 65 ft (~20 m) long weir section in the northern training wall at 180 ft (~55 m) in from the seaward end of the wall; added a second engine to the tug; modifications to the dredge and spoil pipelines to facilitate the dredging of the inshore portions of the ebb tidal shoal. 1985: South Boca Raton Ebb Shoal Dredging/Feeder Beach Project placed 221,000 cy (~169,000 m^3) of sand from the ebb tidal shoal to a 3,400 ft (~1,036 m) length of beach south of the inlet. 1996: A second replenishment project is planned. The Boca Raton Inlet Ebb Tidal Shoal Sand Transfer Project provides for the dredging of another 252,000 cy (~193,000 m^3) of sand from the ebb tidal shoal to be placed on a 3,960 ft (~1.2 km) length of beach south of the inlet.
Outlet type:	Pipe discharge from dredge directly on to southern beach via approx. 200 mm PVC pipe.
Bypass rate:	Average bypass rate = 32,000 m^3/yr (~41,850 cy/yr).
Degree of bypassing: (e.g. all, 50%, etc.)	34 % artificial bypassing; 47 % natural (Dombrowski and Mehta, 1990).
Costs:	1972: purchase cost = $140,000 (US) for dredge and tugboat (Coastal Planning & Engineering, 1996).

Funding:	1972: City of Boca Raton All inlet/beach maintenance projects and monitoring activities are funded jointly by the Florida Department of Environmental Protection (75 %) and the City of Boca Raton (25 %) (Coastal Planning & Engineering, 1996).
Contract type:	Operated by the City of Boca Raton.
Owner:	Prior 1972: private ownership. After 1972: City of Boca Raton.
Operator:	City of Boca Raton.
Supervisor of operations:	Experienced dredge master, employed by the City of Boca Raton.
Staffing:	3 people.
Operating cycle:	The dredge is not certified for ocean operations and so cannot proceed past the end of the walls. Works within the entrance proceed with, and are governed by, the sand, wave, and current conditions. Operates during winter and intermittently during summer.
Environmental constraints:	Not known.
Environmental management issues:	Narrow inlet with heavy usage by recreational vessels. Heavy beach usage.
Commencement date of bypassing:	Dredge and tug commenced in 1972.
Performance: (include any leakage to inlet, formation of entrance bar, etc.)	The plant only bypasses 34 % of the southerly drift with 47 % naturally bypassing around the ebb tidal shoal. A further 18 % is retained by the northern training wall, and 1 % is deposited on the flood shoal. Strong currents exist within the narrow inlet and a bar offshore from the entrance requires dredging by other equipment occasionally. The amount of artificial bypassing did not stop erosion of the southern beach, while the natural bypassing had made navigation of the ebb shoal hazardous. The beach nourishment project of 1985 using sand from the ebb shoal, provided on average 30 % (28,000 m^3/yr based on a 6 year return period for nourishment works) of the annual littoral drift to the southern beach, resulting in a total of 111 % (103,000 m^3/yr) of the net southerly drift being bypassed both artificially and naturally. (Dombrowski and Mehta, 1993)
Present plant status: (as of 1996)	Still in operation.
References:	Coastal Planning & Engineering, Inc., 1996. *The Boca Raton Inlet Ebb Tidal Shoal Sand Transfer Project and Ongoing Interior Sand Transfer Program*, Brochure, 25th International Conference on Coastal Engineering, Orlando, Florida, USA. Dombrowski, M.R., Mehta, A.J., 1993. Inlets and Management Practices: Southeast Coast of Florida, *Journal Coastal Research*, Special Issue No. 18, Fort Lauderdale, Florida, pp29-57.

***Figure C1**: Boca Raton Inlet Sand Bypassing System, Locality plan (Coastal Planning and Engineering, 1996)*

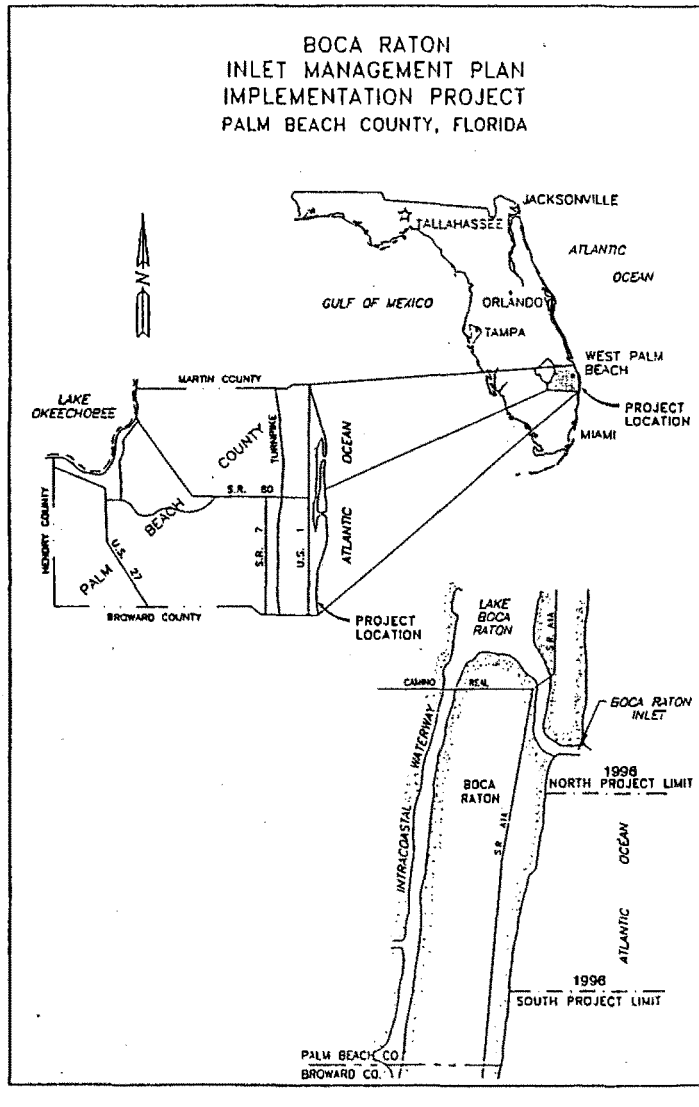
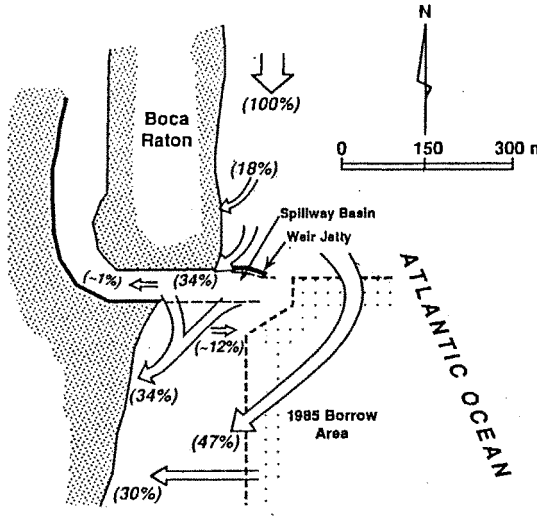


***Figure C2**: Boca Raton Inlet Sand Bypassing System (Dombrowski and Mehta, 1993)*



Appendix D

Data sheet: Channel Islands Harbour Sand Bypassing System, California, U.S.A.

Location: The artificial Channel Islands Harbour was constructed in 1960 and is situated 1.6 km to the north-west of Port Hueneme (pronounced "Why-nee-mee") in the City of Oxnard in Ventura County, California, USA. The harbour is approx. 60 miles (~96 km) Northwest of Los Angeles facing the Santa Barbara Channel. The area is the coastal edge of the Oxnard Plain, an abandoned flood plain of Santa Clara River which is bound by the Sulphur mountains to the south and the Santa Monica mountains to the north. The Ventura and Santa Clara Rivers are to the north.

Problem: With the construction of the artificial Port Hueneme in 1938, the southerly drift was halted causing accretion behind the upcoast breakwater and severe erosion downcoast at Ormond Beach threatening Federal, industrial, and residential property. The sand which began to naturally bypass the harbour was lost from the littoral system to Hueneme submarine canyon. Channel Islands harbour was constructed to trap sand which was being diverted offshore into the Hueneme submarine canyon, and to supply sand by mechanical bypassing to Ormond Beach and other downdrift beaches.

Wave climate: Both the sea and swell are predominantly from the west and north-west owing to restrictions caused by Point Conception and offshore islands. The breaking wave heights common to this shoreline range from 3 - 8 ft (~0.9 - 2.4 m). Some local short duration winter storms and limited amount of summer swell from the South Pacific, produce short periods of northward transport. Wave periods of 14 s or greater often occur in this region (Herron and Harris, 1966).

The significant wave conditions used as a basis for design of the offshore breakwater using hindcast data from 1936 - 1938 were :
dir = 280° (WNW); T = 6 - 13 s; Hs = 9.4 - 15.7 ft (~2.8 - 4.8 m) at the structure.
dir = 215° (SW); T = 7 s; Hs = 10.3 ft (~3.1 m) at the structure.
dir = 175° (S); T = 7 s; Hs = 8.1 ft (~2.5 m) at the structure.
(Herron and Harris, 1966)

Inlet characteristics: The man-made harbour has a width of approx. 500 ft (~150 m) and an entrance depth of 20 ft (~6 m) (MLLW).

Inlet usage: Channel Islands: small-craft (serves up to 1,100 small craft). The harbour is an access point for the islands offshore (i.e. Anacapa, Santa Cruz, Santa Rosa, and San Miguel Islands).
(Port Hueneme: deep water US Navy and commercial facility.)

Sediment characteristics: The Oxnard Plain consists of alluvial deposits of sand, silt and clay.

Drift rate: Net southerly drift = ~1,000,000 m^3/yr (Walker, 1991) or 1,200,000 cy/yr (Herron, and Harris, 1966)
Sources: Santa Clara River = 800, 000 cy/yr (~612,000 m^3/yr); Ventura River = 100,000 cy/yr (~76,500 m^3/yr); littoral drift = 270,000 cy/yr (~206,000 m^3/yr) (Herron, and Harris, 1966)

Beach erosion rate:

Between 1940 (completion of Port Hueneme) and 1961 (establishment of permanent bypass system) approx. 1,000 ft (~765 m) beach recession occurred in the vicinity of the City of Port Hueneme (south of the Port), tapering to no shoreline retreat approx. 7, 000 ft (~2.1 km) downcoast. During this period almost 4,000,000 cy (~3,058,000 m^3) of sand was placed on this stretch of beach between 1940 and 1954. Approximately 500 acres of industrial, residential and agricultural land was lost of a total volume of 21,000,000 cy (~16,100,000 m^3).
(Herron, and Harris, 1966)

Type of bypass:

Updrift offshore breakwater sheltered trap with conventional hydraulic pipeline dredging using floating plant moored in and near the entrance, behind the breakwater.

Bypass system components:

1953 -1954: dredged 4,000,000 cy (~3,058,000 m^3) from the fillet upcoast of Port Hueneme Harbour northern breakwater, and pumped under the harbour to southern beach. Project cancelled after only 2,000,000 cy (~1,500,000 m^3) was bypassed owing to difficulties in dredging in the surf.
Dec 1958 - Oct 1960: construction of Channel Islands Harbour entrance training walls (finished Sep 1959), and the offshore breakwater (finished Oct 1960). The offshore breakwater is situated in 30 ft (~9 m) depth (MLLW) and is 2,300 ft (~700 m) long with the southern end in line with the southern training wall.
Feb 1960 - Jun 1961: initial dredging of Channel Islands Harbour (3,708,500 cy or ~2,835,400 m^3) and sand trap (2,627,000 cy or ~2,000,000 m^3) was bypassed to Ormond Beach by pipeline beneath both Channel Islands and Port Hueneme Harbours.
Jun 1963 - Sep 1963: first biennial dredging of the trap, bypassing 1,986,000 cy (~1,520,000 m^3).
Apr 1965 - Sep 1965: biennial dredging and bypassing of 3,527,000 cy (~2,697,000 m^3). The larger quantity was dredged to increase the capacity of the trap owing to overfilling and leakage into the entrance since the first dredging project.
Apr 1967 - Sep 1967: biennial dredging and bypassing of approx. 3,000,000 cy (~2,300,000 m^3). Again, the large quantity was to increase the trap capacity.

It was intended that future biennial bypassing would be reduced to between 2.0 and 2.5 million cy (~1,500,000 - 1,900,000 m^3).
(Herron, and Harris, 1966)

Walker (1991) reports that the annual bypassing rate has been about 1,000,000 m^3 (~1,300,000 cy) with the majority of the sand going to Ormond Beach and a minor amount going to the beach between the two harbours and backpassed to the updrift beach.

Outlet type:

Pipeline underneath both the Channel Islands and Port Hueneme Harbours to discharge on Ormond Beach.

Bypass rate:

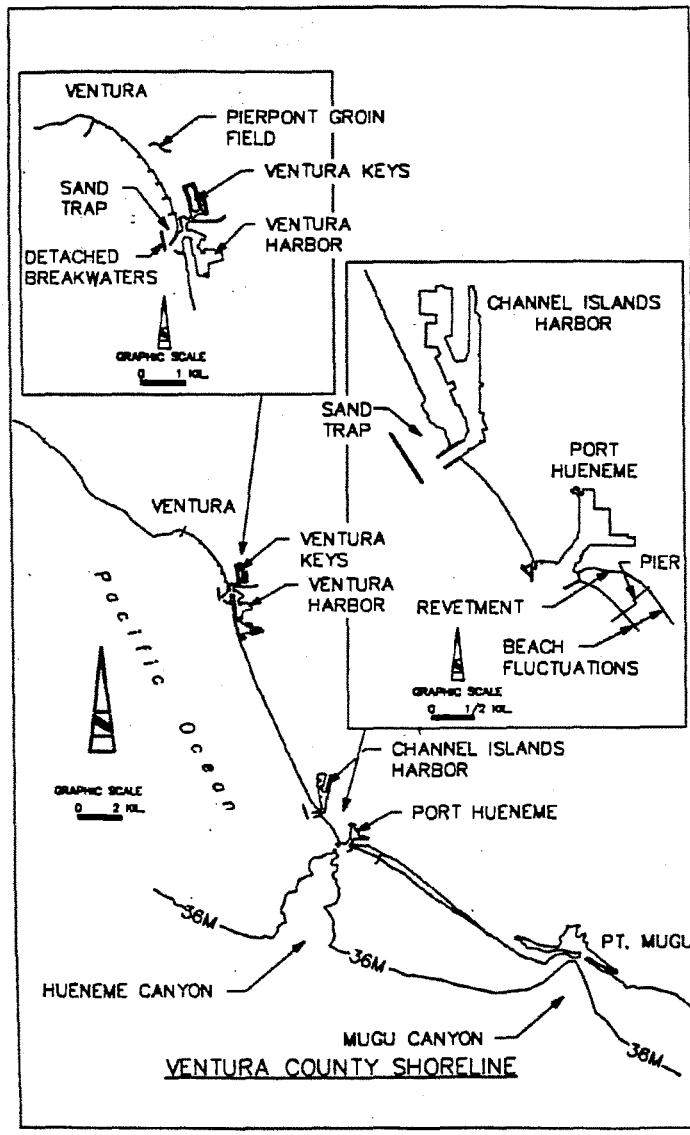
Average bypass rate = 1,000,000 m^3/yr (~1,300,000 cy). Approximately 14,500,000 m^3 (~19,000,000 cy) was bypassed over the first 14 years of operation (Walker, 1991).

Degree of bypassing: (e.g. all, 50%, etc.)

The majority of the sand reaching the Channel Islands Harbour has been bypassed. Walker (1991) suggests that a annual loss of 600,000 m^3 to the Mugu Canyon is occurring.

Costs:	1953 -1954: $1,837,865 (US) for total 4,000,000 cy. Dec 1958 - Oct 1960: $669,000 (US) for training wall construction; $3,351,000 (US) for offshore breakwater construction Feb 1960 - Jun 1961:$1,250,000 (US) for bypassing from sand trap. Jun 1963 - Sep 1963: $951,000 (US) for bypassing. Apr 1965 - Sep 1965: $1,092,000 (US) for bypassing. Apr 1967 - Sep 1967: $500,000 (US) for bypassing. The estimated average annual cost of sand bypassing only, including depreciation and maintenance, was $0.38 (US) /cy. (Herron, and Harris, 1966)
Funding:	US Army Corps of Engineers.
Contract type:	A contract is let for each biennial project.
Owner:	US Army Corps of Engineers.
Operator:	Contract dredger.
Supervisor of operations:	US Army Corps of Engineers.
Staffing:	Dredge crew.
Operating cycle:	Biennial during summer months.
Environmental constraints:	Not known.
Environmental management issues:	Entrance is heavily used for navigation. Beaches are heavily used and backed by beachfront houses and apartments.
Commencement date of bypassing:	February, 1960 with the initial dredging of the harbour and sand trap.
Performance: (include any leakage to inlet, formation of entrance bar, etc.)	The bypass system has performed well with all sand reaching the trap being bypassed (Herron and Harris, 1966).
Present plant status: (as of 1996)	Still in operation.
References:	Herron, W.J., Harris, R.L., 1966. Littoral Bypassing and Beach Restoration in the Vicinity of Port Hueneme California, *Proceedings of Tenth Conference on Coastal Engineering*, ASCE, pp651-675. Walker, J.R., 1991. Downdrift Effects of Navigation Structures on the California Coast, *Coastal Zone '91: Proceedings of the 7th Symposium on Coastal and Ocean Management*, Vol. 1, ASCE, Long Beach, California, USA, July 8-12, pp1889-1903.

***Figure D1**: Channel Islands Harbour Sand Bypassing System (Walker, 1991).*



Appendix E

Data sheet: Dawesville and Mandurah Inlets Sand Bypassing System, Western Australia.

Location:	The Dawesville and Mandurah inlets connect the Peel-Harvey inlet system to the Indian Ocean. Mandurah is approx. 65 km south of Perth, Western Australia. Dawesville is approximately 15 km south west of Mandurah.
Problem:	Severe algae pollution was caused by poor circulation and increased phosphate levels from agricultural land run-off exacerbated by the low ocean tide range and shoaling single entrance at Mandurah. The construction of the new Dawesville inlet was implemented to increase the flushing and salinity of the Peel-Harvey Inlet system.
Wave climate:	Predominantly south-westerly swell.
Inlet characteristics:	a. Dawesville: Inlet width = 200 m; depth = 4.5 - 6.5 m below mean sea level at seaward end; water exchange / tidal cycle = 16.5 x 10^6 m^3 (summer) and 17.1 x 10^6 m^3 (winter); diurnal tides. b. Mandurah: Inlet width = 90 m; depth limited by rock sill to 3 m below CD. Design navigation channel is 30 m wide by 2.5 m deep.
Inlet usage:	a. Dawesville: fishing industry and recreational boating. b. Mandurah: fishing industry and recreational boating.
Sediment characteristics:	Clean marine sand.
Drift rate:	a. Dawesville: net northerly rate = 85,000 m^3/yr. b. Mandurah: The littoral drift is understood to vary between 100,000 and 200,000 m^3/yr from west to east without significant reversals in direction. Most of the drift occurs in quantities of 10,000 to 30,000 m^3 during the winter storm events.
Beach erosion rate:	a. Dawesville: In 1992, 107,000 m^3 of sand excavated from the channel was placed north of the channel. Between 1992 and 1993 there was a net loss of 90,000 m^3. Since 1993 the volume of sand north of the channel has fluctuated between 100,000 m^3 and 150,000 m^3 less than in 1992. b. Mandurah:
Type of bypass:	Mobile land based system consisting of a crawler excavator feeding a crawler mounted screen and pump system called the "Slurrytrak" (system operates both Dawesville and Mandurah).
Bypass system components:	1. Cat 245 Excavator with 3m^3 bucket digging on beach and feeding "Slurrytrak" inlet hopper. 2. "Slurrytrak" consists of inlet hopper with sieves, gravity feeding to a reciprocating tray feeder on to a inclined cleated conveyor with belt weighometer. Conveyor feeds to a linear motion scalping screen on top of agitation hopper which is fed with water (middle and lower). Centrifugal slurry pump fed from bottom of hopper pumps a slurry with approx. 45% sand content by weight through discharge pipe (MDPE and some flexible sections). System is self propelled with diesel motor. 3. Clear water supplied by separate pump via a 315 mm OD Class 12 MDPE pipe from inlet. At the Mandurah Inlet, a 75 m groyne was constructed in 1986 - 87 approx. 300 - 350 m west of the western entrance training wall to allow for the dredging of a large trap between the groyne and breakwater without affecting the public beach to the west of the groyne.

At the Dawesville Inlet, a spur groyne was constructed projecting updrift (approx. south) off the southern training wall to create a sand trap behind it.

Outlet type: A 315 mm OD Class 12 MDPE discharge pipe to downdrift beaches for both inlets.
a. Dawesville: channel crossing by 2 fixed pipes trenched in bottom; 0.5km to discharge.
b. Mandurah: channel crossing by HDPE line weighted; 1km to discharge.

Design bypass rate: a. Dawesville: up to 85,000 m^3 pa.
b. Mandurah: up to 110,000 m^3 pa.

Degree of bypassing: (e.g. all, 50%, etc) Desired to be 100%. At Mandurah a bar still exists seawards of the entrance and there is some channel infill during winter storm events. At Dawesville, the trap is not capturing 100% of the sand with accumulation offshore of the trap in depths of -5 m to -8 m CD (approx. 150,000 m^3).

Costs: In general, bypass operation costs about \$3/m^3 and monitoring and management costs approx. \$1/m^3.

a. Dawesville:
Bypassing costs (July to June):

Year	Volume (m^3)	Cost (\$)
1995/96	22,000	68,000
1996/97	39,000	103,000
1997/98	85,000	280,000
TOTAL	146,000	451,000
AVERAGE	49,000	150,000

b. Mandurah:
Bypassing costs (July to June):

Year	Volume (m^3)	Cost (\$)
1995/96	55,000	179,000
1996/97	156,000	426,000
1997/98	86,000	262,000
TOTAL	296,000	868,000
AVERAGE	99,000	289,000

Funding: West Australian State Government Department of Transport.

Contract type: 5 year design, construct and operate. Paid per cubic metre (weighed); plus payment per re-establishment; plus guarantee of minimum quantity for each establishment (15,000 m^3 from Dawesville; 20,000 m^3 from Mandurah).

Owner: Contractor.

Operator: Local contractor for 5 years.

Supervisor of operations: Department of Transport.

Staffing: 2 full-time.

Operating cycle: Up to approx. 48 weeks/year (including maintenance periods) with plant alternating between Dawesville and Mandurah. System is envisaged to operate at each location 2 to 3 times per annum with re-establishments directed by supervisor. System has actually operated 1 to 2 times per year at each site. Minimum quantity for each session as to be 15,000 m^3 (Dawesville) and 20,000 m^3 (Mandurah). Periods of higher sediment inflow at each site are generally not synchronous.

Environmental constraints:	Rock lobster fishing requirement demands a navigation depth of 2.5m LWD from 1 November; main sand infill occurs in winter.
Environmental management issues:	Not known.
Commencement date of bypassing:	December 1995.
Performance: (include any leakage to inlet, formation of entrance bar, etc)	a. Dawesville: trap is not collecting design quantity and is not filling to expected volume; it is believed that there is leakage. Channel has remained relatively stable. Between 1994 and 1996 accretion occurred offshore from the sand trap in depths of -5 m to -8 m CD (approx. 150,000 m^3), reducing sand accumulation in the trap. Offshore bathymetry has since stabilised. b. Mandurah: bar decreasing in volume. The target depth of 2.5 m CD has not been achieved continuously, but access has been provided to most vessels most of the time. Problems stem from insufficient trap capacity during winter storm events. Sand trap has been extended.
Present plant status: (as of 1999)	Still in operation.
References:	Black, R.E., Hearn, C.J., 1987. Management of a Eutrophic Estuary: Modelling the Effects of a New Outlet to the Sea, *Proceedings of Eighth Australasian Conference on Coastal and Ocean Engineering*, Institution of Engineers Australia, Launceston, 30 November - 4 December, pp284-287. Bruun, P., 1993. Final Report on possible Sand Bypassing Arrangements and Other Improvements for Maritime Facilities in Western Australia. Byrne, A.P., Rogers, M.P., Byrne, G., 1987. Dawesville Channel, Western Australia - Coastal Process Studies, *Proceedings of Eighth Australasian Conference on Coastal and Ocean Engineering*, Institution of Engineers Australia, Launceston, 30 November - 4 December, pp303-306. Clough Engineering Group, 1989. *Peel Inlet and Harvey Estuary Management Strategy: Dawesville Channel Mechanical Sand Bypassing System, Preliminary Investigation*, report, Perth, Australia. Clough Engineering Group, Slurry Systems, 1989. *Peel Inlet and Harvey Estuary Management Strategy: Dawesville Channel Mechanical Sand Bypassing System, Feasibility Study*, report, Perth, Australia. Department of Marine and Harbours - Western Australia, 1987. *Peel Inlet and Harvey Estuary Management Strategy: Dawesville Channel Engineering Investigations*, Report no. DMH 5/88, Perth, Australia. Department of Transport - Western Australia, 1994. Expressions of Interest for Design, Provision and Operation of a Mechanical Sand Bypass Dredging System at the Dawesville and Mandurah Channel Ocean Entrances, September. Department of Transport - Western Australia, 1998. *Dawesville Channel - Hydrographic Monitoring 1998*, Transport Report 394, November. Foster, D.N., Nittim, R., 1985. Sedimentation Aspects of the Proposed Harvey Estuary to Ocean Channel - Stage 1, University of New South Wales, Water Research Laboratory, Technical Report No. 85/01, Australia. Hutton, I.M., 1987. Dawesville Channel - Ocean Entrance, *Proceedings of Eighth Australasian Conference on Coastal and Ocean Engineering*, Institution of Engineers Australia, Launceston, 30 November - 4 December, pp330-334. Moloney, B., Shand, S., Paul, M.J., 1999. Dawesville Channel and

Mandurah Ocean Entrance Sand Bypassing and Monitoring, *14th Australasian Coastal and Ocean Engineering Conference and 7th Australasian Port and Harbour Conference*, Institution of Engineers Australia, Perth, 14 - 16 April, pp444-449.

Riedel and Byrne, 1987. *Dawesville Channel: Coastal Engineering Studies*, Report no. R149, Perth, Australia.

Schwartz, R.A., 1986. *Physical Modelling of the Proposed Dawesville Channel Ocean Entrance*, Environmental Dynamics Working Paper WP-86-031, University of Western Australia, Centre for Water Research, Nedlands, Western Australia.

Winders, Barlow & Morrison, 1989. *Dawesville Channel Sand Bypassing Breakwater Option*, Report no. 3989, Spring Hill, Victoria, Australia.

***Figure E1**: Dawesville and Mandurah Inlets Sand Bypassing System, Locality plan (Moloney et al, 1999).*

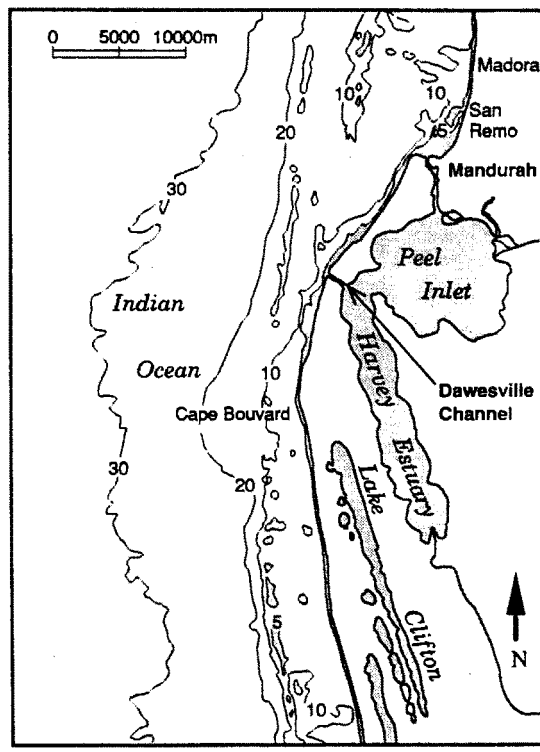


***Figure E2**: Layout of Dawesville Sand Bypassing System (Moloney et al, 1999).*

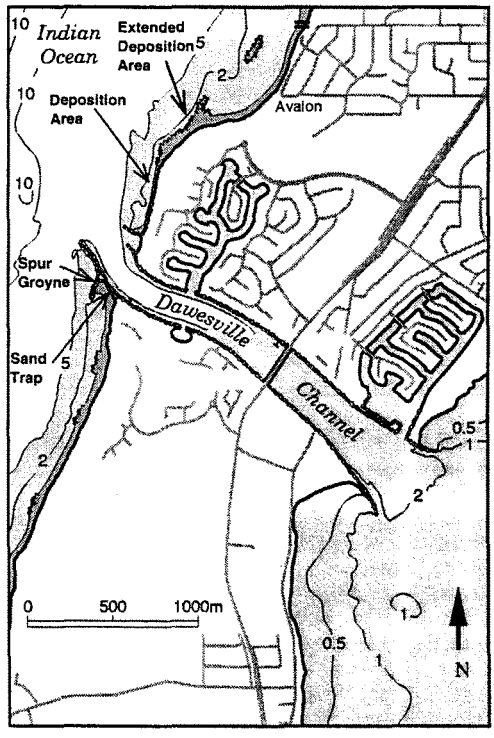


***Figure E3**: Layout of Mandurah Sand Bypassing System (Moloney et al, 1999).*

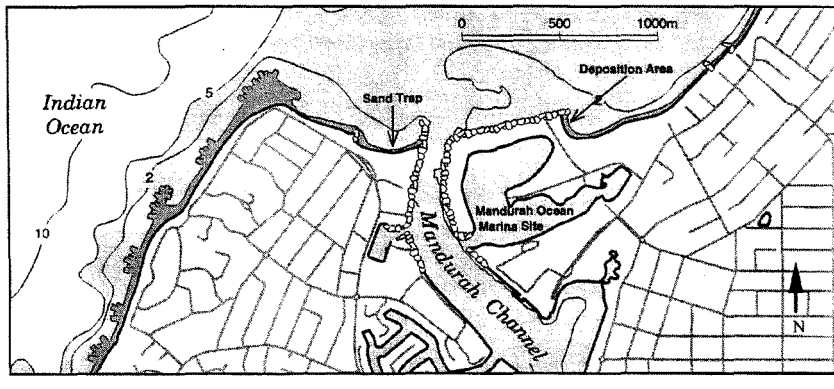
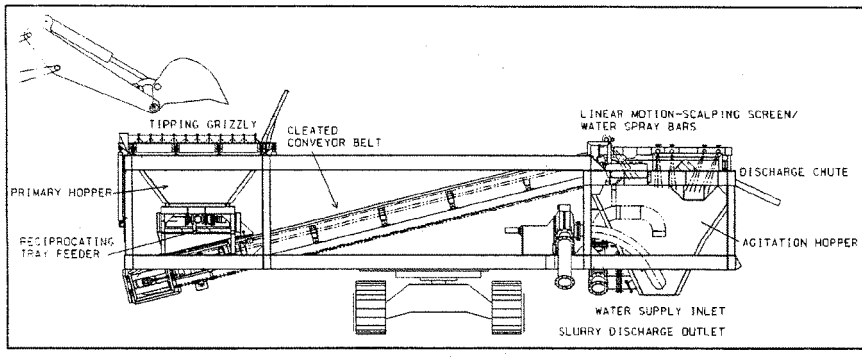


***Figure E4**: General arrangement of the Slurrytrak 300-65 HH used for sand bypassing at Dawesville and Mandurah Inlets (Moloney et al, 1999).*



Appendix F

Data sheet: Indian River Inlet Sand Bypassing System, Delaware, U.S.A.

Location: Indian River Inlet, Delaware situated on the Atlantic coast approx. 10 miles (~16km) north of Ocean City, Maryland, USA, connects Indian River Bay and Rehoboth Bay to the Atlantic Ocean.

Problem: Construction and training of the 500 ft (~150 m) wide inlet in 1938-1940 to stabilise the existing channel (which was prone to migrating within a 2 mile (~3.5 km) region, as well as closing occasionally) has resulted in the gradual erosion of the beach adjacent the northern training wall, threatening the Route 1 state highway which runs parallel to the coast line.

Wave climate: Not known. Calculation of the annual longshore sediment transport rate was based on the use of Phase III WIS (Wave Information Study nearshore hindcast wave data) statistics utilising data from WIS Atlantic Coast Station 65 (Gebert et al, 1992).

Inlet characteristics: Wall centre line to wall centre line spacing = 500 ft (~150 m); semidiurnal tide; mean tide range = ~4 ft (~1.2 m); spring tide range = ~5 ft (~1.5 m); design channel depth = 15 ft (~4.5 m) MLW; channel dredged to 14 ft (~4.2 m) MLW in 1938 (Anders et al, 1990); existing channel depth = typ. 40 - 90 ft (12 - 27 m) MLW . Channel currents in excess of 9 ft/s (~2.7 m/s) (Anders et al, 1990).

Indian River Bay and Rehoboth Bay: mean tide ranges = 2.1 ft (~0.64 m) and 1.0 ft (~0.3 m) respectively; combined surface area = 29 square miles (~75 km^2); total tributary area = 250 square miles (~647 km^2).
(Gebert et al, 1992)

Inlet usage: Small commercial and recreational vessels (Gebert et al, 1992, p506).

Sediment characteristics: Medium sand (Gebert et al, 1992). Typical grain size of the order of 0.4 mm (Anders et al, 1990).

Drift rate: Net northerly drift of 110,000 cy/yr (~84,000 m^3/yr) based on WIS data, analysis of historic beach profile and hydrographic survey data, and beach erosion data (Clausner et al, 1992).
From WIS study: 160,000 cy/yr (~122,000 m^3/yr); std dev. = 90,000 cy/yr (69,000 m^3/yr)
(Gebert et al, 1992).

Beach erosion rate: In the region 200 ft (~60 m) to 1800 ft (~550 m) north of the training wall the shore position has receded 150 - 194 ft (~45 - 59 m) from November 1984 to October 1989 (Gebert et al, 1992, table 1).

Type of bypass: Single jet pump mounted 135 ton capacity rated crawler crane with 120 ft (~37 m) boom (mobile system) operating from southern beach.

Bypass system components: Clear water 12 inch (~305 mm) HDPE SDR-9 (9.9 inch or ~250 mm ID) supply line from inlet (approx. 20 m from pump house); water supply pump (8 cyl. motor, 400 hp) in pump house on southern side; Genflo eductor with 2.5 inch (63 mm) nozzle and 6 inch (150 mm) mixing chamber with rate of 200 cy/hr (~153 m^3/hr) positioned in swash zone using Crawler crane; 12 inch (305 mm) HDPE SDR-13.5 (10.8 inch or ~274 mm ID) discharge line; discharge booster pump (12 cyl. motor, 600 hp but running typ. at 400 hp) in pump house; HDPE pipe across Route 1 bridge extending up to a maximum distance of 1,500 ft (457 m) north of the inlet.

The jet pump creates an 18 ft (~5.5 m) deep and 48 ft (~14.6 m) diameter crater. The crane can create a trench of three crater diameters length

before requiring repositioning. Collection occurs over a stretch of the southern beach from 100 - 400 ft (30 - 120 m) south of the inlet.

Outlet type: 12 inch (305 mm) HDPE SDR-13.5 (10.8 inch or ~274 mm ID) pipe discharging directly onto the beach within 1,500 ft (457 m) north of the inlet.

Bypass rate: Design rate = 200 cy/hr (~153 m^3/hr); 100,000 - 110,000 cy/yr (76,000 - 84,000 m^3/yr). Following experience and system operating enhancements, approx. 330 cy/hr (~250 m^3/hr) can be achieved. The suggested maximum capacity is 552 cy/hr (~422 m^3/hr). Pumping concentration of approx. 40% by weight.

Suitable for sites where maximum bypass rate < 150,000 m^3/yr (Watson et al, 1993).

Degree of bypassing: (e.g. all, 50%, etc.) Proposed to bypass all the northwards transport. However, the system is limited by the quantity of sand reaching the collection area. Strong flow conditions maintains (and are in fact scouring) the inlet depth.

Costs: Final cost of plant construction: $1.7 million (US)
Estimated operating and maintenance: $290,000 (US) (includes annualised replacement costs). The actual operating costs for 1990 to 1996 are given in *Performance* below.

Funding: Shared between the State of Delaware and the Federal Government of USA. Federal Government contributes 40.755%.

Contract type: State performs work for Federal Government.

Owner: State of Delaware.

Operator: State of Delaware, which has a state dredging program.

Supervisor of operations: State of Delaware; oversight by US Army Corps of Engineers.

Staffing: Total of 3 people: a primary operator, operator's assistant, and crane operator. The staff are supervised by an experienced dredge master (off site) who covers several projects.

Operating cycle: 5 day (7.5 hr day) week (37.5 hr week) with a 2 day weekend shutoff, operating 9 months per year.
1 hr (min) to 7 hr (max.) operation per day. The system operates only 40 % of available days owing to limitations of the amount of littoral material transported and trapped within reach of the system (Watson et al, 1993).

Environmental constraints: Social: the beach north and south of the inlet is a state park and used by tourists during the summer season. Bypassing is not allowed in summer between Memorial Day (late May) and Labour Day (early September). However, State park service have allowed bypassing during summer months within 100 - 200 ft (30 - 60 m) south of the training wall provided that the area is fenced off and marked with warning signs and buoys.

Cold weather conditions and location mean that week day beach usage during the operational window in winter is low; but anglers use the training wall. Surfers also surf adjacent to both breakwaters during the operating season.

Environmental management issues:

The northern beach is a nesting spot for the piping plover, an endangered species of bird, during March through August. Guidelines follow that if a nest is sighted, the discharge operation will stay several hundred feet away, and walkovers will be built to allow young birds to cross the discharge pipe (Rambo et al, 1991).

Commencement date of bypassing:

January, 1990.

Performance: (include any leakage to inlet, formation of entrance bar, etc.)

Summary of sand bypassing statistics (Watson et al, 1993)

	1990	1991	1992	Total (90-92)
m^3 bypassed	86,000	63,000	51,700	200,700
[cy]	[112,700]	[82,335]	[67,670]	[262,700]
No. Days Bypassing	71	55	60	186
No. Mths Bypassing	11	9	9	29
Avg Production (m^3/day)	1,225	1,150	850	1075
[cy/day]	[1,600]	[1,500]	[1,100]	[1,400]
Avg Days/Month Bypassing	6.45	6.11	6.7	6.41

Short term rate remains about 200 m^3/hr. The higher bypassed amount for 1990 was a result of the initial large volume of trapped sand, and bypassing during summer. As stated by Watson et al (1993), "apparently the system is only able to capture about 60 to 80% of the estimated net northerly drift, though the variable nature of littoral transport in this area makes this conclusion very preliminary".

The rates and operating costs from Feb 1990 to May 1996 for each calendar year (Jan - Dec) as detailed in the additional data for operating expenses were:

Year	cy Pumped	m^3 Pumped	cost/cy	cost/m^3
1990	112,700	86,000	$1.00	$1.30
1991	82,330	63,000	$1.70	$2.20
1992	67,670	51,700	$1.85	$2.40
1993	67,800	51,800	$2.50	$3.25
1994	84,570	64,660	$1.65	$2.15
1995	68,750	52,560	$2.30	$3.00
1996 (partial)	31,550	24,100	$3.00	$3.90

Present plant status: (as of 1996)

Still in operation.

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Other data:

Indian River Inlet Sand Bypass Plant operating expenses from February, 1990 to May, 1996.

Sand Bypass Plant capital replacement schedule for 1996.

Sand Bypass Plant standard operating procedures.

***Figure F1**: Indian River Inlet Sand Bypassing System (Rambo et al, 1991).*

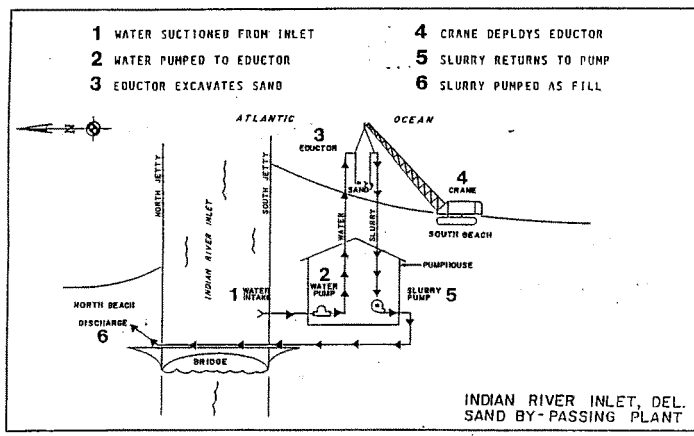
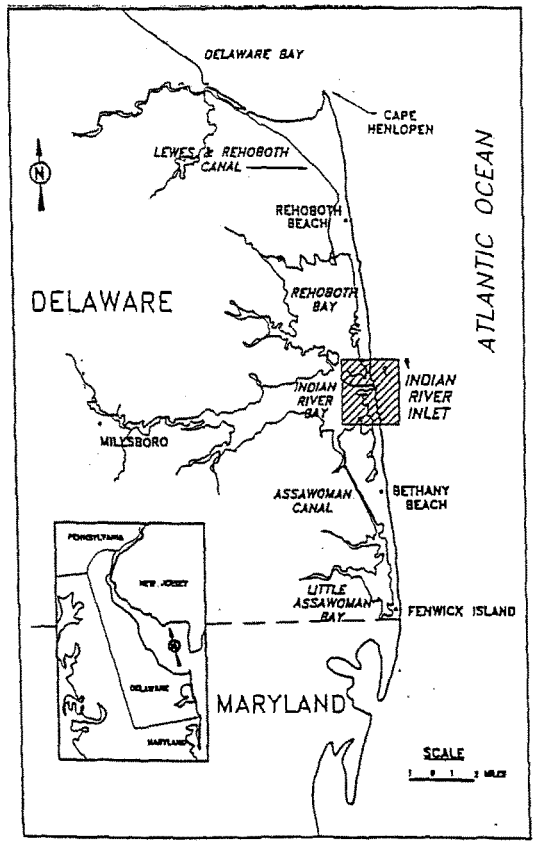


***Figure F2**: Indian River Inlet Sand Bypassing System, Locality plan (Rambo et al, 1991).*



Appendix G

Data sheet: Oceanside Harbour Sand Bypassing System, California, U.S.A.

Location:

Oceanside Harbour is situated on the west coast of California, USA, approx. 80 miles (~130 km) south-east of Los Angeles and 30 miles (~48 km) north of San Diego. The harbour is bordered by Santa Margarita River 6,600 ft (~2 km) to the north, and San Luis Rey River 2,400 ft (~730 m) to the south. The City of Oceanside is located to the south of the harbour, and the US Naval Base of Camp Pendelton is located immediately north of the harbour.

The harbour services both the U.S. Navy Del Mar boat basin, constructed in 1942, and the City of Oceanside Small-Craft Harbour, constructed in 1963 (with sand dredged from the harbour used to nourish Oceanside Beach).

Problem:

The construction of the harbour complex has interrupted the littoral transport which has resulted in accretion along the northern breakwater, shoals developing in the entrance, and erosion to the beaches to the south (specifically Oceanside beach). The region is also affected by a large gross transport resulting in shoals entering the harbour from both the north and south.

Wave climate:

Camp Pendleton surf and weather station (depth = 32 ft or 9.75 m MLLW):
highest measured Hs = 10.8 ft (~3.3 m) with T = 17.8 s
Hs(50%) = 3.5 ft (~1.1 m); Hs(10%) = 5 ft (~1.5 m) based on 7 years of data.
California coastal data collection program, near Oceanside Pier (depth = 32 ft or 9.75 m MLLW):
highest measured Hs = 8.3 ft (~2.5 m) with T = 14 to 16 s
Hs(50%) = ~2.0 ft (~0.6 m); Hs(10%) = ~4.0 ft (~1.2 m) based on 3 years of data.

Typically, the Oceanside wave climate consists of:
Northern hemisphere swell: Hs,o < 10 ft (~3 m); T = 12 - 18 s; Dir = 260° to 270° (November to April).
Southern hemisphere swell: Hs,o < 4 ft (~1.2 m); T = 18- 21 s; Dir = S to SE (May to October).
Local sea: Hs = 2 - 5 ft (~0.6 - 1.5 m); T_{ave} = 7 s; Dir = predominantly NW (all year).
Eastern North Pacific tropical cyclones approaching from the south to south-west (May to November) seldom produce large waves that reach the site. Largest waves at Oceanside occurred in 1939 producing a significant breaking wave height = 24 ft (~7.3 m) (> 100 - 200 yr recurrence interval). (Moffatt & Nichol, Engineers, 1983)

Inlet characteristics:

Tide range: 5.6 ft (~1.7 m) from MHHW to MLLW, or 3.78 ft (~1.15 m) from MHW to MLW (Moffatt & Nichol, Engineers, 1983).

Inlet usage:

U.S. Navy and public small-craft.

Sediment characteristics:

North fillet: D_{50} = 0.21 mm
Entrance channel: D_{50} = 0.18 mm

Drift rate:

Net southerly drift = 100,000 - 250,000 cy/yr (~75,000 - 190,000 m^3/yr)
Gross transport rate = 1,200,000 cy/yr (~917,000 m^3/yr)
(Weisman, 1996)
Based on predicted longshore transport rates by three different studies, Dolan et al (1987) presented the following averages:
Gross northerly transport = 546,000 cy/yr (~417,000 m^3/yr)
Gross southerly transport = 740,000 cy/yr (~565,000 m^3/yr)
Net southerly transport = 194,000 cy/yr (~150,000 m^3/yr)

Beach erosion rate: Camp Pendleton to the north of the harbour continues to accrete, while Oceanside to the south is eroding.

Type of bypass: Experimental system of jet pumps and fluidisers to be constructed in phases (fixed). Main system location in harbour entrance; secondary capture location at northern breakwater.

Bypass system components: Phase I: single jet pump (Pekor 6x6x8 inch or 150x150x200 mm, capacity of 330 cy/hr (~250 m^3/hr)) and crane at north breakwater for bypassing sand from the north fillet; two jet pumps (Pekor 4x4x6 inch or 100x100x150 mm, capacity of 230 cy/hr (~175 m^3/hr)) in the entrance adjacent the south breakwater with deployment fluidisers attached to jet pump support beams; mobile hoist barge with pumps (supply pump of 750 hp and main booster pump of 1,050 hp) and controls moving between the north and south jetty riser structures; undersea pipelines to riser structures; cross harbour pipeline; shore booster station (pump of 1,050 hp) used during bypassing of north fillet; discharge line. The hoist barge was a contractor modification due to earthquake/stability concerns regarding jack-up (as designed).

Phase II: Addition of 150 ft (~45 m) fluidiser oriented shoreward and parallel to the south breakwater at entrance to feed shoreward entrance jet pump, and 200 ft (~60 m) fluidiser oriented seaward and parallel to the south breakwater at entrance to feed seaward entrance jet pump. The fluidisers are supported on 25 - 30 ft (~7.6 - 9.1 m) spaced steel 12 inch (~305 mm) dia. piles driven in 20 - 22 ft (~6.1 - 6.7 m). The fluidisers are SDR 11 HDPE pipes with 1/8 inch (~3 mm) holes every 2 inches (~50 mm) aligned horizontally, with flanged connections at 50 ft (~15 m) lengths. A valve was introduced into the system to supply firstly to the fluidisers, and then the jets (the supply pump could not support the operation of both the fluidisers and jets at the same time). To improve jet recovery problems, the jets were attached to a 63 ft long (~19 m) strongback (I section) pivoted at a support pile. A fluidiser was attached to this to ease deployment/recovery problems. Phase II contract included operation and maintenance.

Phase III (cancelled): Addition of two 200 ft (~60 m) fluidisers to feed sand from the tip of the southern breakwater to both entrance jet pumps; lengthen existing shoreward fluidiser another 145 ft (~44 m); increase entrance jet pumps to 6x6x8 inch (150x150x200 mm); add separate pump to power fluidisers.
(Weisman et al, 1996, and Clausner et al, 1990).

Outlet type: 14 inch (~355 mm) HDPE discharge pipe extending 11,000 ft (~3.3 km) to the south along the beach with 3 discharge points along the length.

Bypass rate: Ultimately, the system was expected to bypass 250,000 cy/yr (~190,000 m^3/yr) at the entrance and 150,000 cy/yr (~115,000 m^3/yr) from the north fillet (Clausner et al, 1990).
Design rate = 200 cy/hr (~153 m^3/hr) (Weisman et al, 1996)

Degree of bypassing: (e.g. all, 50%, etc.) Only in experimental stages, full bypassing not achieved. It was not designed to achieve full bypassing.

Costs: Estimated first construction cost of $5,000,000 (US) with a planned project life of 5 years. Actual costs = $15,000,000 (US) approx.

Funding: Phase I: Federal Government of USA.
Phase II: Federal Government of USA.
Phase III: Federal with contributions from State and Local Governments.

Contract type:	Phase I: designed by consultant for the owner; fixed price construction contract. Phase II: contractor C & W Diver Services Inc. under contract with payments for maintenance of owners equipment and hire rate for pumping.
Owner:	U.S. Army Corps of Engineers (capital equipment, excluding barge owned by contractor).
Operator:	Contracted out. Phase II contractor C & W Diver Services Inc. under contract with payments for maintenance of owners equipment and hire rate for pumping.
Supervisor of operations:	US Army Corps of Engineers (LA District).
Staffing:	Total of 4 people: main operator to control the SCADA system (Supervisory Control and Data Acquisition); a mechanic overseeing component operations and manual operation of pumps in case of SCADA failure; a shore booster pump operator; and observer at the discharge point (Clausner et al, 1990).
Operating cycle:	Design Plan: 5 days a week, for up to 10 hours per day. Summer months (April - September): bypass from entrance jet pumps Winter months (October - March): bypass from northern fillet. (Clausner et al, 1990) Actual: bypassing only carried out for one year, with approx. 2 weeks only from northern fillet.
Environmental constraints:	No mining allowed of the north fillet on Camp Pendelton U.S. Marine Corps Base Property (rejected by the local base commander) and no mining of the fillet between the south breakwater and San Luis Rey River Groin (rejected by the City of Oceanside) (Weisman, 1996). North breakwater bypass system was placed on the breakwater beyond the intertidal zone without permanent structures as required by Marine Corps restrictions (Walker et al, 1987). Concerns regarding the nesting of the Lesser Tern restricted the operational window to the winter months.
Environmental management issues:	Required to carefully monitor the effects of the system on fauna, fish, plankton, grunion, and other marine species (Walker et al, 1987). Beach outlet required supervision during operation due to 'quick' sand and public usage. Outlet pipes were required to traverse rock walls seaward of beachfront condominiums and lifeguard station at pier, exposing them to wave action.
Commencement date of bypassing:	Phase I: June, 1989 (to August, 1990) Phase II: November, 1991 Phase III: Cancelled (insufficient funds)
Performance: (include any leakage to inlet, formation of entrance bar, etc.)	Phase I (June 1989 to August 1990 excluding January 1990 to April 1990): Total bypassed = 18,300 cy (~13,990 m^3); overall average = 63 cy/hr (~48 m^3/hr); total operational hours = 744; pumping sand hours = 305; minimum monthly pumping hours = 2; maximum monthly pumping hours = 55. Phase II (December 1991 to December 1992 inclusive): Total bypassed = 106,000 cy (~81,000 m^3); overall average = 95 cy/hr (~73 m^3/hr) (58% increase from Phase I); pumping sand hours = 1,128; total system downtime and maintenance hours = 607; minimum monthly pumping hours = 35; maximum monthly pumping hours = 126.

The major problems were associated with clogging and plugging of the fluidisers with sand, and the covering of the craters with kelp which reduced the amount of sand being pumped by the jets. The key problem with this project was that the shoals were forming from transport from both the south and the north, covering a large area to bypass.
(Weisman et al, 1996)

Other significant problems:
(a) difficult conditions for maintenance divers due to long period swell producing a surge in entrance;
(b) inability to access equipment except by using divers;
(c) system was in the entrance adjacent to the navigation channel, providing some constriction to navigation;
(d) funding was not guaranteed for multiple-year operations;
(e) funding was not available (budgets not confirmed) until 1 to 2 months after start of operational window;
(f) equipment was designed to operate at two sites;
(g) expensive booster station.

Present plant status: (as of 1996)

Entrance of harbour had been dredged for many years by conventional suction dredge. Owing to insufficient funding to continue with phase III, the system was closed in 1996 pending removal. At September 1996, documentation was being finalised to call for tenders to remove all of the system. The barge had been removed, and capital equipment on it sold.

Tenders closed 6 November 1996 for the approx. $3 million (US) removal of the bypass system including pipes on breakwaters and to jet pumps, cross channel discharge pipe, support piles, pipe rack, south and north riser structures for jack-up barge, fluidisers, jet pumps. Optional items for removal included the discharge pipe line from the beach south of San Luis Rey River Groin. Items to remain include the booster pump station, discharge pipe between the southern breakwater and San Luis Rey River Groin, and pipes under the southern breakwater spur.

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Figure G1: *Oceanside Harbour Sand Bypassing System locations (Patterson et al, 1991).*

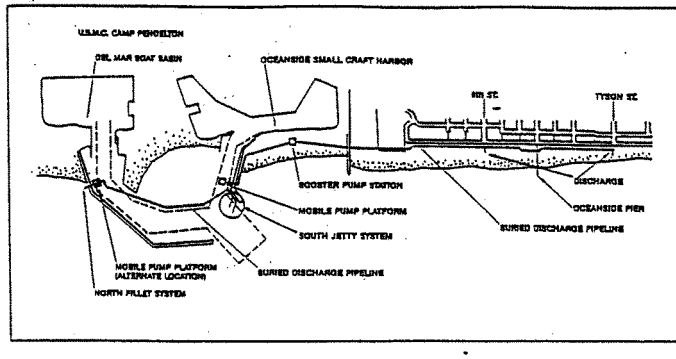


Figure G2: *Oceanside Harbour Sand Bypassing System, Locality plan (Weisman et al, 1996).*

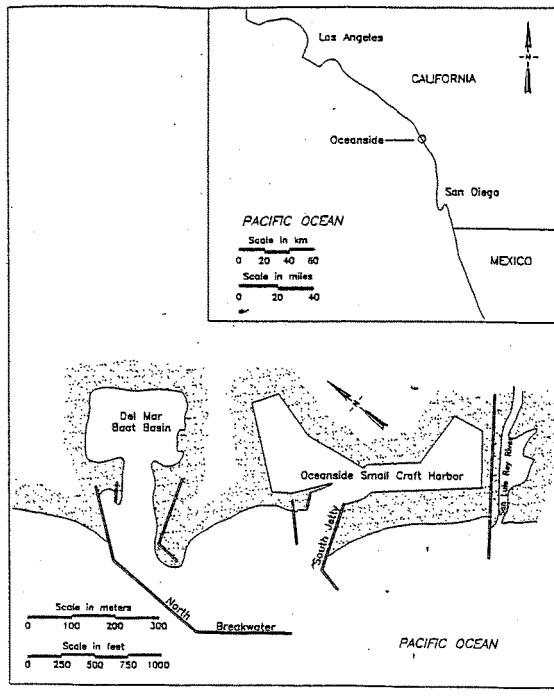
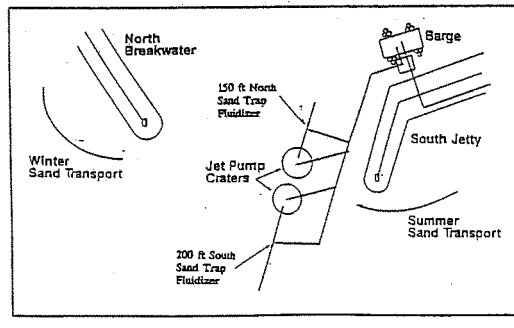


Figure G3: *Oceanside Harbour Sand Bypassing System, Fluidiser locations (not to scale) (Weisman et al, 1996).*



Appendix H

Data sheet: South Lake Worth Inlet Sand Bypassing System, Florida, U.S.A.

Location:	South Lake Worth (Boynton) Inlet is an artificial entrance located in Palm Beach County, Florida, USA, connecting Lake Worth to the Atlantic Ocean. The two adjacent inlets are Boca Raton Inlet 23 km to the south, and Lake Worth Inlet 25 km to the north.
Problem:	The inlet was constructed in 1927 to provide tidal circulation thereby improving the water quality of the Lake. The training walls halted the net southerly transport resulting in erosion of the adjoining southern beach, and also shoaling of the entrance channel from sand moving around the northern training wall. The erosion downdrift threatened upland structures and Highway A1A.
Wave climate:	Varies seasonally; influenced by the sheltering effects of the Bahamas. Strong north-east storms in winter produce the net southerly drift, while more persistent southerly waves generated by local winds occur during summer. Tropical storms and occasionally hurricanes also affect the area (Walker and Dunham, 1977).
Inlet characteristics:	Width varies from 90 m at the entrance to 40 m; depth = 3.0 m (MSL); spring tide range = 3.3 ft (~1.0 m); semidiurnal tides; flood channel flows = 5 ft/s (~1.5 m/s).
Inlet usage:	Small commercial and recreational craft.
Sediment characteristics:	60 % shell; 40 % medium to course sand with significant fractions of quartz and feldspars. Grain size bypassed is slightly in excess of 0.3 mm.
Drift rate:	Net southerly drift = 134,000 - 172,000 m^3/yr (Dombrowski and Mehta, 1990).
Beach erosion rate:	Mean recession rate to approx. 4000 m south of the inlet = 0.9 m/yr with the existing bypass system (Dombrowski and Mehta, 1990).
Type of bypass:	Fixed hydraulic suction dredge with a rotating boom.
Bypass system components:	Initial plant (installed 1937): 8 inch (~200 mm) suction line; 6 inch (~150 mm) diesel centrifugal pump (65 hp); 1200 ft (~365 m) of 6 inch (~150 mm) discharge line crossing the inlet via the highway bridge. An A-frame derrick on the roof of the pump house enabled the intake to be swung in a horizontal arc as well as raising and lowering. The bypass plant was situated on the northern training wall approx. 50 ft (~15 m) from the seaward end. Upgrade, 1948: 10 inch (~250 mm) intake mounted on a swinging boom of 30 ft (~9.1 m) radius with a flexible rubber sleeve at the centre of the turning radius; jet attached to side of intake for agitating sand; 8 inch (~200 mm) diesel centrifugal pump (600 rpm); 1200 ft (~365 m) of 8 inch (~200 mm) discharge line. The bypass plant can create a circular trench of 8 - 10 ft (~2.4 - 3.0 m) depth and 30 ft (~9.1 m) length with a sand fill capacity of ~800 m^3 (~1050 cy). (Caldwell, 1950; Dombrowski and Mehta, 1990). Upgrade, 1967 (present plant): 125 m curved extension to the northern breakwater (curved to the south); 20 m extension to southern breakwater; training wall constructed from the inlet to Lake Worth; plant relocated 36 m seaward of the 1937 position (or approx. 100 ft (~30 m) seaward of the MHW line on the north breakwater); 12 inch (~300 mm) suction intake line; diesel Caterpillar engine pump (400 hp) rated to pump 4,000 gpm with 20% solids in suspension; 10 inch (~250 mm) discharge line. (Yeend and Hatheway, 1988; Dombrowski and Mehta, 1990).

Outlet type:	Discharge pipe on to southern beach to deposit between 60 and 150 m south of the inlet. The pipeline crosses the inlet by the highway bridge.
Bypass rate:	Average bypass rate = 53,500 m^3/yr; pumping capacity = 110 m^3/hr (Dombrowski and Mehta, 1990).
Degree of bypassing: (e.g. all, 50%, etc.)	35 % artificial bypassing; 45 % natural (Dombrowski and Mehta, 1990).
Costs:	Initial plant (installed 1937): installation cost = $15,000 (US). Upgrade, 1948: installation costs = $15,000 - 20,000 (US, 1950 prices). (Caldwell, 1950) Upgrade, 1967 (present plant): not known The unit price for sand bypassing is $8 - 9 /$m^3$ (US) (Bruun, 1993).
Funding:	Initial plant (installed 1937): South Lake Worth Inlet District and a property owner. Upgrade, 1948: Palm Beach County. (Caldwell, 1950)
Contract type:	Not known.
Owner:	Publicly owned.
Operator:	Palm Beach County.
Supervisor of operations:	Not known.
Staffing:	2 people for maintenance and operation (Caldwell, 1950).
Operating cycle:	All year round, the operating period being governed by the rate of infill of the bypassing trap. Peak pumping periods occur during September to March (Yeend and Hatheway, 1988). In Caldwell (1950) the plant operated 2 to 3 hours during calm weather, while during periods of north-east weather, pumping for 18 hours still did not match the transport rate.
Environmental constraints:	Not known.
Environmental management issues:	Beaches on both sides of entrance are heavily used.
Commencement date of bypassing:	Original plant: 1937 (ceased operation 1942 - 1945 during World War 2).
Performance: (include any leakage to inlet, formation of entrance bar, etc.)	The plant only bypasses 35 % of the southerly drift with 45 % naturally bypassing via the inlet ebb tidal shoal and bypass bar which attaches to the beach approx. 600 - 900 m south of the inlet. A further 11 % is retained by the northern training wall, and 7 % is deposited on the flood and ebb shoals (2 % of the material entering the flood shoal is dredged and placed on the southern beach). The limitation of reach and capacity prevent a full 100 % bypassing. On only a fifth of occasions does the crater fill faster than dredged (Olsen, 1996). The original design had been for a system with a large boom mounted on rails to give greater trap capacity. The strong velocities produced by the narrow entrance have scoured the

channel to a hard bottom. A bar exists seaward of the entrance.

Present plant status: (as of 1996) Still in operation.

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***Figure H1**: South Lake Worth Inlet Sand Bypassing System, Locality plan (Olsen Associates, 1996).*

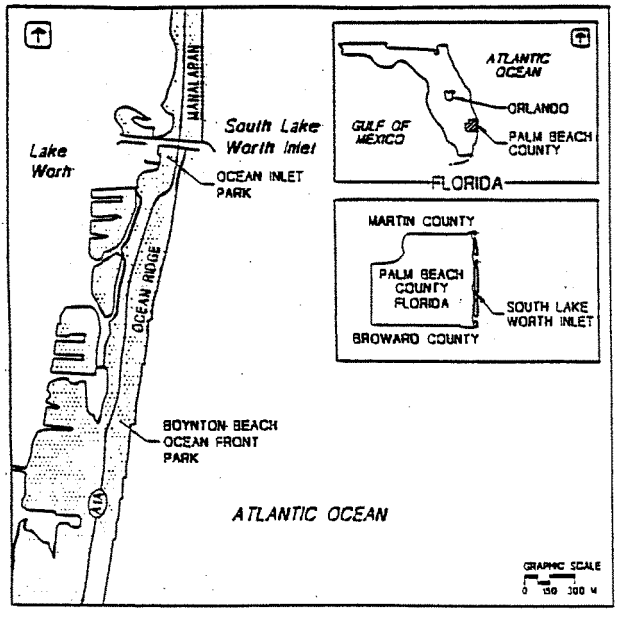
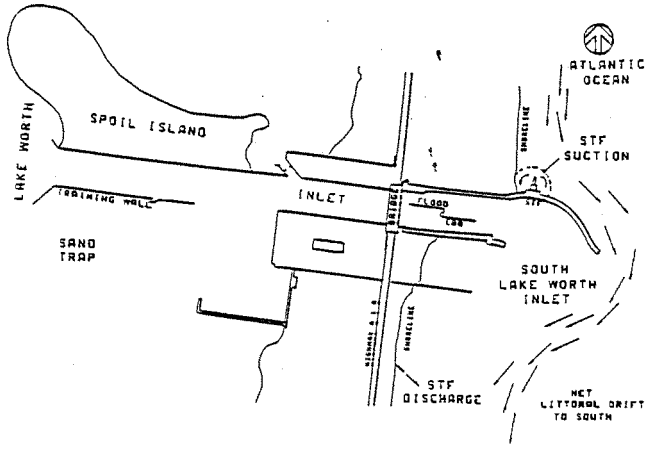


***Figure H2**: South Lake Worth Inlet Sand Bypassing System (Yeend and Hatheway, 1988)*



NEW JERSEY
SHORE PROTECTION STUDY

US Army Corps
of Engineers
Philadelphia District

New Jersey Department
of Environmental
Protection

Hereford Inlet to Cape May Inlet

Volume- 3 Appendix

VOLUME 3

APPENDIX B: ECONOMIC ANALYSIS
APPENDIX C: CLEAN AIR ACT ANALYSIS
APPENDIX D: U.S. FISH AND WILDLIFE SERVICE COORDINATION
APPENDIX E: CULTURAL RESOURCES
APPENDIX F: REAL ESTATE PLAN
APPENDIX G: SECTION -1 PERTINENT CORRESPONDENCE
APPENDIX G: SECTION -2 COMMENTS AND CORPS RESPONSES
APPENDIX H: PUBLIC ACCESS PLAN

Appendix B.

Economic Analysis

APPENDIX B: ECONOMIC ANALYSIS

APPENDIX B – ECONOMIC ANALYSIS
TABLE OF CONTENTS

Title		Page Number
1.0	**Introduction**	1
2.0	**Socioeconomic Resources**	1
	2.1 Population and Land Use	1
	2.2 Employment and Income	4
	2.3 Regional Economy and Development	6
3.0	**Historical Damages**	10
	3.1 Recent Storms	10
4.0	**Economic Analysis**	12
	4.1 Structure Inventory	13
	4.2 Storm Damage Modeling	16
	4.3 Erosion Damage Analysis	17
	4.4 Wave-Inundation Damage Analysis	19
	4.5 Emergency/Clean-Up Costs	20
5.0	**Economic Benefit Evaluation**	20
	5.1 Without Project Conditions – North Wildwood	20
	5.1.1 Damage Zone Structures	20
	5.1.2 Infrastructure and Improved Property Damages	22
	5.1.3 Summary of Damages	23
	5.1.4 Emergency/Clean-Up Costs	23
	5.1.5 Back Bay Impact	23
	5.2 Without Project Conditions – Wildwood, Wildwood Crest & Lower Township	24
	5.2.1 Accreted Area	24
	5.2.2 Damage Zone Structures	24
	5.2.3 Accreted Area Damage Summary	28
	5.2.4 Amusement Pier Damages	29
	5.3 Estimated Total Without Project Damages	29
6.0	**Benefit Analysis**	30
	6.1 With Project Alternatives	30
	6.1.1 Storm Damage Reduction	30
	6.1.2 Local Costs Forgone Benefits	33
	6.2 Optimization	35
	6.3 Incidental Benefits	38
	6.3.1 Recreation Benefits	38
	6.3.2 Benefits During Construction	40

7.0 Selected Plan Combination 41
7.1 Interest During Construction 41
7.2 Average Annual Costs 42
7.3 Benefit-Cost Summary 44

8.0 Risk and Uncertainty Analysis 45

List of Tables

Table	Title	Page Number
Table B-1	Population Density	3
Table B-2	Employment Comparison	4
Table B-3	Unemployment Rate Comparison	5
Table B-4	Study Area Unemployment Rate Comparison	5
Table B-5	Income Comparison	6
Table B-6	Proposed Residential Dwellings	7
Table B-7	Housing Units by Usage Category	7
Table B-8	Significant Residential Development Projects	9
Table B-9	Major Non-Residential Space	9
Table B-10	Cape May Toll Volumes	10
Table B-11	North Wildwood Historical Damage Events	11
Table B-12	Study Area Delineation	12
Table B-13	Physical Characteristics Obtained for Building Inventory	14
Table B-14	Summary of Depreciated Structure Values	14
Table B-15	Excerpt of COSTDAM Model Structure File	16
Table B-16	Excerpt of Depth Damage Curves	17
Table B-17	Expected Annual Damage (EAD) Input File Example	19
Table B-18	Without Project Structures Affected - North Wildwood	21
Table B-19	Without Project Average Annual Structure Damage – North Wildwood	21
Table B-20	Without Project Damages by Structure Type – North Wildwood	22
Table B-21A	Without Project Infrastructure Damage by Storm Frequency - North Wildwood	22
Table B-21B	Total Without Project Average Annual Infrastructure and Improved Property Damage - North Wildwood	22
Table B-22	Without Project Damages – North Wildwood	23
Table B-23	Without Project Emergency Costs – North Wildwood	23
Table B-24	Without Project Structures Affected – Wildwood	25
Table B-25	Without Project Structures Affected – Wildwood Crest	26
Table B-26	Without Project Structures Affected – Lower Township	27
Table B-27	Without Project Damages – Wildwood, Wildwood Crest, and Lower Township	28

Table B-28	Without Project Damages by Structure Type – Wildwood, Wildwood Crest, and Lower Township	28
Table B-29	Without Project Pier Damage – North Wildwood and Wildwood	29
Table B-30	Without Project Damages by Community	29
Table B-31	Storm Damage Reduction Benefits – North Wildwood	30
Table B-32	Storm Damage Reduction Benefits – Wildwood	31
Table B-33	Storm Damage Reduction Benefits – Wildwood Crest	31
Table B-34	Plan Alternative Screening – Wildwood and Wildwood Crest	32
Table B-35	Pier Plan Alternative Screening – North Wildwood and Wildwood	32
Table B-36	Beachfill Local Costs Forgone – North Wildwood	34
Table B-37	Plan Alternatives by Backpass Method – North Wildwood	36
Table B-38	Reduced Maintenance Local Costs Forgone – Wildwood and Wildwood Crest	37
Table B-39	Summary of AAB, AAC, NB, BCR for the Selected Plan	38
Table B-40	Recreation Benefit	39
Table B-41	Benefits During Construction - Selected Plan	40
Table B-42	Interest During Construction - Selected Plan	41
Table B-43	Average Annual Project Construction Cost – Selected Plan	42
Table B-44	Average Annual Monitoring Costs – Selected Plan	43
Table B-45	Benefits and Costs for the Selected Plan	44
Table B-46	Summary of Risk and Uncertainty Analysis HSDR Benefits	49
Table B-47	Summary of Risk and Uncertainty Sensitivity Analysis BCR	50

List of Figures

Figure	Title	Page Number
Figure B-1	Study Area	2
Figure B-2	Winter and Summer Population	3
Figure B-3	Historical Population	4
Figure B-4	Value of Owner-Occupied Housing Units	8
Figure B-5	Inventory Map and Photo Example	15
Figure B-6	Foundation Footprint Compromised Comparison	18
Figure B-7	Wave-Inundation Graphic	20
Figure B-8	Without Project Structures Affected – North Wildwood	21
Figure B-9	Without Project Structures Affected – Wildwood	25
Figure B-10	Without Project Structures Affected – Wildwood Crest	26
Figure B-11	Without Project Structures Affected – Lower Township	27
Figure B-12	North Wildwood Estimated Structure Damage by Plan Alternative	31
Figure B-13	The Wildwoods - Total Structure Damage by Storm Frequency	48

HEREFORD TO CAPE MAY INLET SHORE PROTECTION FEASIBILITY STUDY

ECONOMIC CONDITIONS

1.0 INTRODUCTION

The following sections detail the economic analysis performed to evaluate the damages and potential damage reduction for the developed areas along the oceanfront from Hereford Inlet to Cape May Inlet. North Wildwood, Wildwood, and Wildwood Crest are three of the four municipalities contained within the barrier island located between the Hereford and Cape May Inlets. These three communities along with sound-side West Wildwood form a shore region known as the *Wildwoods' Five Mile Island*, or simply the *Wildwoods*. Figure 1 shows the three communities and a portion of a very small Lower Township community called Diamond Beach which will also be reviewed in this document. Benefit categories to be evaluated include reduction in storm, wave, and inundation damages, and increased recreation value. The basic underlying assumptions used an FY2014 discount rate of 3-½%, June 2007 price level, a 50-year period of analysis, and a base year of 2016. Project benefits for the tentatively selected plan (TSP) were updated to a March 2014 price level by applying a combination of the EM 1110-2-1304 CWCCIS Index and the McGraw Hill Engineering News Record Building Cost and Construction Cost Indices for comparison with the selected plan cost estimate.

2.0 SOCIOECONOMIC RESOURCES

2.1 Population and Land Use

The study area is located in a coastal community in Cape May County, New Jersey along the Atlantic Ocean. Within the USACE – Philadelphia District boundaries, Cape May County is one of the four counties including Atlantic, Ocean, and Monmouth counties located along the New Jersey coast. Cape May County is surrounded by the Atlantic Ocean on the east and south, borders the Delaware Bay on the west, and Atlantic County on the north. The county covers 454 square miles, with almost 60% consisting of usable land area and the remainder being marshes and flood plains. Two main transportation arteries in the county are the Garden State Parkway and US Route 9. Other major nearby roads which allow residents and visitors to access the area include State Routes 47 and 50, the Black and White Horse Pikes, and the Atlantic City Expressway. North Wildwood, Wildwood, and Wildwood Crest with a combined land area of 4.1 square miles cover approximately five linear miles along the coast.

The three municipalities ranked six, seven, and eight respectively on the list of the ten largest municipalities in Cape May County. As shown in Table B-1, Wildwood was the most densely populated of the three communities with 4,096 people per square mile. More vacationers flock to Wildwood and North Wildwood than to Wildwood Crest as indicated by the estimated summer population in Figure 2. The *Wildwoods* is a popular destination for vacationers seeking sunbathing, water sports, amusements, and recreational fishing among other leisure activities.

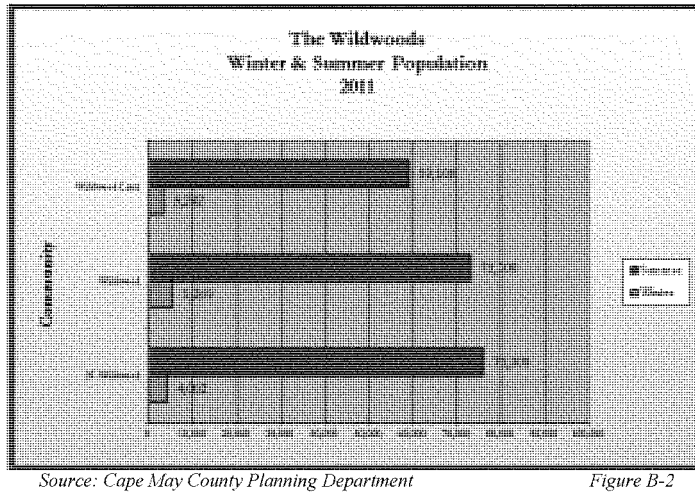
SCALE IN FEET
0
2,500
5,000
Feet
NEW JERSEY SHORE PROTECTION
FEASIBILITY STUDY
HEREFORD INLET TO CAPE MAY INLET
THE WILDWOODS
CAPE MAY COUNTY, NJ

Figure B-1

Table B-1
POPULATION DENSITY - 2010

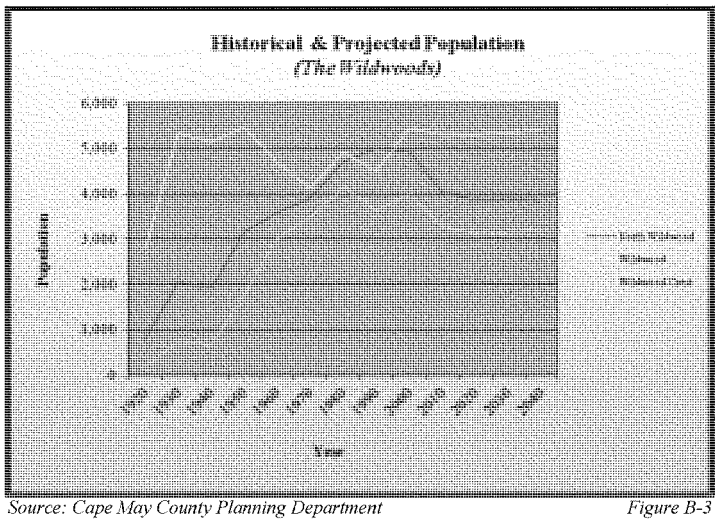
Municipality	Total Square Miles	Population	Persons Per Square Mile
North Wildwood	1.7	4,041	2,377
Wildwood	1.3	5,325	4,096
Wildwood Crest	1.1	3,270	2,973
The Wildwoods	*4.1*	*12,636*	*9,446*

Source: Cape May County Planning Department



Source: Cape May County Planning Department *Figure B-2*

The year-round population of many coastal communities has increased as baby-boomers started to retire and housing development increased. The *Wildwoods* experienced substantial growth in population throughout most of the 20th century. The steepest increase in population for Wildwood occurred in the decade between 1920 and 1930, while the steepest increase for North Wildwood occurred between 1940 and 1950 and occurred for two decades in Wildwood Crest between 1940 and 1960. Wildwood experienced a sharp decline in population over the period from 1950 to1970, population soared back up through 1980, dipped again through 1990 and spiked through 2000 nearly to the level of its peak population in the 1950s. As shown in Figure B-3, Wildwood and Wildwood Crest are two communities that had increased year-round population for the ten years between 1990 and 2000. During this time period North Wildwood population growth remained relatively flat. Year-round population decreased slightly in all three municipalities during the initial years of the 21st century.



Source: Cape May County Planning Department *Figure B-3*

2.2 Employment and Income

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

Table B-2
EMPLOYMENT COMPARISON – 2012

	STATE	COASTAL COUNTY			
Year – 2012	**New Jersey**	**Cape May**	**Atlantic**	**Ocean**	**Monmouth**
Unemployment Rate	9.5	13.4	13.5	10.3	8.9
Unemployed	435,000	7,793	18,377	27,944	29,904
Employed	4,158,000	50,397	136,125	244,125	304,904

Source: U.S. Department of Labor – Bureau of Labor Statistics

Cape May County has consistently experienced higher unemployment rates than state and national levels. A study area may qualify for a national economic development (NED) benefit if it is found to have substantially and persistently unemployed or underemployed labor resources. This condition would exist: (a) if the unemployment rate for the most recent consecutive 12 month period averages 6 percent or more; and (b) if it is 50% above the national rate of unemployment for three of the preceding four calendar years, 75% above the national rate of unemployment for two of the preceding three calendar years, or 100% above the national unemployment rate for one of the preceding two calendar years. A comparison of unemployment rates for the five years beginning 2008 through 2012, as shown in Table B-3, indicates that although the unemployment rate in Cape May County exceeds that of the United States by more than two points for each of the five years in the time series, it does not meet the criteria to qualify for the unemployed or underemployed labor resource benefit.

Table B-3
RECENT UNEMPLOYMENT RATE COMPARISON
UNITED STATES, NEW JERESEY AND CAPE MAY COUNTY
(2008-2012)

Year	United States	New Jersey	Cape May County
2008	5.8	5.5	8.0
2009	9.3	9.0	11.1
2010	9.6	9.6	12.2
2011	8.9	9.4	12.6
2012	8.1	9.5	13.4

Source: U.S. Department of Labor – Bureau of Labor Statistics

The much higher unemployment rate in the study area of the *Wildwoods*, as shown in Table B-4, is indicative of its relative reliance on seasonal employment. The unemployment data updated for the most recent year shows the continued affect of the recession and possibly impacts from the devastating super-storm in 2012. The regional coastal economy had also been enhanced by a healthy construction industry with new development, "tear-downs" and renovations - a trend in which older structures are purchased, demolished, and replaced with much more expensive houses. The continued decline in manufacturing and the recent decrease in financial services employment resulting from the reduction in mortgage applications and the tightened credit market have also resulted in higher unemployment. However, certain subcategories within the service sector such as healthcare and educational services remain strong.

Table B-4
STUDY AREA EMPLOYMENT ESTIMATES COMPARISON – 2012

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

Source: U.S. Department of Labor – Bureau of Labor Statistics

As displayed in Table B-5, per capita income in both the State of New Jersey and Cape May County exceeds that of the United States. New Jersey and Cape May County's per capita incomes are about 25% and 12% more, respectively, than the U.S. per capita income. Per capita income in Wildwood Crest is about 10% more than the U.S. while that of North Wildwood and Wildwood falls below the national level. Per capita income in Wildwood nearly doubled and increased at a faster rate than that of the state over the first decade of this century. Median household income and median home value were lower in Wildwood when compared to the nation, the state and the other communities in the *Wildwoods*. The lower median home value may have existed in Wildwood rather than in the other communities because residents may pay a premium to live in areas away from high traffic volume and commercial activity.

Table B-5
INCOME COMPARISON – 2010

Municipality	Per Capita	Median Household	Median Home Value[1]
United States	$27,334	$51,914	$188,400
New Jersey	34,858	69,811	357,000
Cape May County	33,571	54,292	337,300
North Wildwood	$31,748	$45,041	$384,900
Wildwood	25,118	32,783	288,000
Wildwood Crest	40,032	46,111	398,400

Source: New Jersey Department of Labor & U.S. Census Bureau

2.3 Regional Economy and Development

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

The construction industry has also been important to the regional economy. Construction within some commercial sectors such as healthcare and education facilities has maintained a steady pace. However, residential construction has decreased significantly nationally and in the region since 2006. As shown in Table B-6, the number of proposed residential site plans plummeted by more than half from 2005 to 2006 and dropped more precipitously in 2007. The greatest number of dwellings proposed during the ten year period from 2003 to 2012 was developed in the City of Wildwood. The *Wildwoods* has a relatively limited area for new development and most of the new development occurs in the form of renovations and/or replacements. Historically, cyclical declines in housing starts have experienced several years of reductions. Currently, the slow but

[1] Median home value of owner-occupied housing units (2000 & 2010)

steady upturn in the U.S. economy following the deep 2008-2009 recession provides encouragement for housing starts going forward.

Table B-6
PROPOSED RESIDENTIAL DWELLINGS IN SITE PLANS

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

Source: Cape May County Planning Department

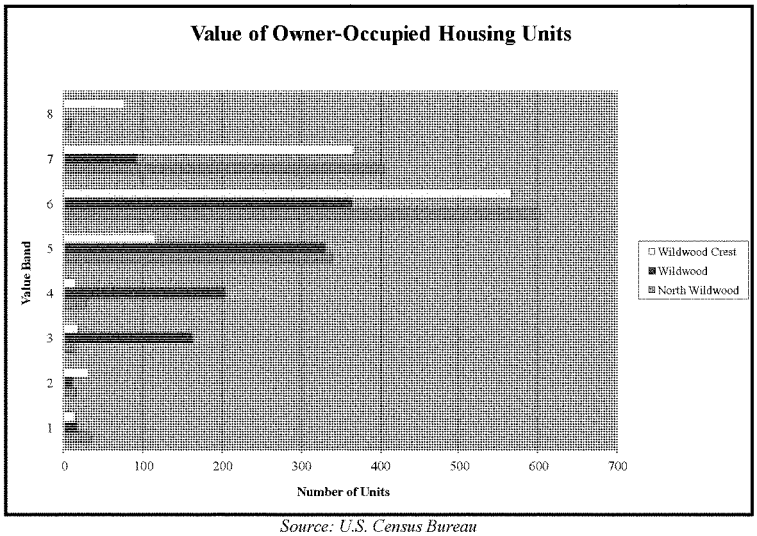
Table B-7 displays the number of housing units by usage category for the three coastal cities of the *Wildwoods*. In 2010, seasonal and/or rental housing units represent a large percentage of housing units in the coastal counties of New Jersey. Almost half of the seasonal and/or rental properties in New Jersey are located in Cape May County and 47% of dwellings in the county are vacation homes. Consistent with other popular summer destinations, the majority of housing units in the *Wildwoods* are vacant and categorized as seasonal, recreational, and occasional use units. Therefore, condominiums, townhouses, and vacation homes dominate the housing stock.

Table B-7
HOUSING UNITS BY USAGE CATEGORY (2010)

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

Source: U.S. Census Bureau

Figure 4, *Value of Owner-Occupied Housing Units*, shows a concentration of more affordable housing located in Wildwood. According to data from the 2008-2012 American Community Survey (ACS) estimates, none of the housing units in Wildwood were valued at or above one million dollars. One third of the owner-occupied units in the City of Wildwood were valued below $200,000. Conversely, approximately 6% of the homes were valued at less than $200,000 in either North Wildwood or Wildwood Crest. House market values skyrocketed for the first five or six years of the new century and have only recently declined slightly in shore communities.



Source: U.S. Census Bureau

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

Figure B-4

Highlights in major commercial development include the completion of a $70 million convention center in Wildwood in 2002. Portions of Wildwood have also been designated as an Urban Enterprise Zone (UEZ). This program encourages business investment and job creation through various incentives. Merchandise can be purchased at a reduced sales tax as a benefit to patronizing shops in these special zones.

Most new development projects in all three communities cater to the tourism industry and are characterized as hotel/motel or multifamily dwellings such as condominiums as shown in the following listings from 2006 and 2012 data. Another new residential development with almost 70 new units located in Diamond Beach (Lower Township) was under construction during the time of this study. Table B-8 lists significant development projects built recently during the study period. These projects are apparently located outside the inventoried ocean block of the study area. No significant non-residential development within the study area occurred in the more recent timeframe of 2012; therefore Table B-9 shows data for 2006 only. Non-residential development of 5,000 square feet or more is reported as significant by the county.

Table B-8
SIGNIFICANT RESIDENTIAL
DEVELOPMENT PROJECTS – 2006 & 2012

Municipality	Project Name	Dwelling Type	# of Units/Lots
Year - 2006			
North Wildwood	Champagne Island Resorts	Hotel/Motel	24
North Wildwood Subtotal			*24*
Wildwood	The Riviera	Hotel/Motel	86
Wildwood	The Riviera	Multi Family	288
Wildwood	Martinique Resorts	Multi Family	254
Wildwood	Anchor Beach Condo	Multi Family	30
Wildwood	Petunia, LLC	Multi Family	22
Wildwood	Westgate Village	Multi Family	13
Wildwood Subtotal			*693*
Wildwood Crest	Sanzone Condos	Multi Family	13
Wildwood Crest Subtotal			*13*
The Wildwoods			***789***
Year - 2012			
North Wildwood	Hawaiian Beach Resort	Multi Family	22
North Wildwood Subtotal			*22*
Wildwood	Grand Wildwoodian	Multi Family	138
Wildwood Subtotal			*138*
The Wildwoods			***160***

Source: Cape May County Planning Department

Table B-9
MAJOR NON-RESIDENTIAL SPACE - 2006

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

Source: Cape May County Planning Department

Each summer tourists flock to Cape May County's beaches, boardwalks, promenades, and amusement piers for day trips and extended vacations. The county is also a popular birding destination for tourists seeking to catch a glimpse of the migratory birds that stop along the shoreline. A two-mile boardwalk with four amusement piers, water parks, roller coasters, arcade and carnival games, and shopping characterizes Wildwood. The *Wildwoods* has received many distinctions and positive ratings from publications and organizations such as "America's Best Beaches", "Top Tourist Town in the Northeast", and "Best Sports Beach". Recently, a survey conducted by the New Jersey Marine Sciences Consortium (NJMSC) to determine New Jersey's top ten beaches ranked Wildwood as the best with approximately 14 percent of the vote. Wildwood won top honor in a field of over 60 beaches from Cape May to Monmouth Counties. Wildwood Crest and North Wildwood ranked second and fourth, respectively. According to the NJMSC, Wildwood Crest was chosen as the best location for a family vacation in a special category of the survey.

This region of the coast is also well known for its "Doo Wop" motels and hotels which feature mid 20th century style architecture. It's a decorative style that incorporates bright colors, boomerang shapes, and angled walls and roofs. The name originated from the popular music enjoyed by many in the 1950s. Many shore communities have increased the number of off-season festivities to entertain a growing population and to draw more tourists throughout the

year. The *Wildwoods* have marketed this seashore location and garnered attention as an increasingly popular destination for conventioneers. The Wildwood Convention Center has been a catalyst for drawing non-seasonal visitors to Five Mile Island and neighboring coastal communities. Table B-10 shows double-digit increases in toll volumes since 1970 in each decade up to 2000 for which round-trip volumes were available.

Table B-10
CAPE MAY TOLL VOLUMES

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

Source: Cape May County Planning Department

3.0 HISTORICAL DAMAGES

3.1 Recent Storms

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

North Wildwood: Local officials were contacted to determine the extent of historical damage. Table B-11 displays an example of the most damaging events for which information was available. In general, the beach in North Wildwood has eroded significantly over the years while the beach in the middle and southern end of the island has accreted. According to emergency management officials in North Wildwood, much of the beach loss has occurred on the oceanfront

between 2nd Avenue and 19th Avenue. No recent structural or content damage to buildings has been recorded from ocean wave or inundation infiltration. A damaging storm occurred in February 2003 in which concrete walkways on Allen Drive at the Anglesea Beach Colony collapsed. One or two houses on Ocean Avenue received some water in the ground floor/basement from the bay (8-foot tide) during this same event. Street flooding from the bay is common in North Wildwood. In 2008, the Mother's Day northeaster from May 12 through 13 caused minor flooding when the ocean extended beyond the beach, below the boardwalk, and over the streets. An amusement pier bulkhead was severely damaged during this storm event. Erosion in front of Surfside Pier was so severe that the pier owner constructed a bulkhead to protect against continued storm damage. In October 2012, the borough experienced beach erosion and damage to shoreline structures such as bulkheads and boardwalks from Superstorm Sandy. Repairs to oceanfront protective structures and replacement of sand and required walkovers are estimated to be approximately $3 million.

Table B-11
NORTH WILDWOOD HISTORICAL DAMAGE EVENTS

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

**Dollar loss in September 2007 dollars*

Wildwood: Damage in Wildwood has mostly affected infrastructure. Outfall pipe damage creates street flooding and vehicle damage. A large beach has been the major problem area from the oceanfront causing outfalls to back up into the community. Some commercial structures have received damage recently. Businesses were inundated by a storm event in August 2012 when there was no time to deploy sandbags. Amusement piers and rides that are on the beach, and unprotected may be vulnerable to oceanfront damage. The west side of town floods from the bay similarly to North Wildwood. The magnitude of Hurricane Sandy affected the entire region including the City of Wildwood. According to published reports, 400 residences were damaged and almost 800 businesses were impacted. Nevertheless, the wide beaches provided a critical buffer to mitigate some of the damage to the oceanfront structures.

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

Superstorm Sandy: The storm left millions of dollars of damage to east coast communities from the Mid-Atlantic to New England when it made landfall north of Atlantic City in late October 2012. The nature of the storm destroyed property in the shore counties north and northeast of the

landfall zone and, to a lesser extent, in the counties south and southwest. In New Jersey from north to south, nine counties were impacted by the hurricane: Bergen, Essex, Hudson, Union, Middlesex, Monmouth, Ocean, Atlantic, and Cape May. Atlantic, Ocean, Monmouth, and Hudson Counties were hardest hit by Superstorm Sandy. Published reports assert that about 1% of the approximately 300,000 residential structures damaged by this significant storm will require elevating.

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

4.0 ECONOMIC ANALYSIS

The study area was delineated based on physical setting, hydraulic characteristics, and economic factors. The oceanfront communities of the *Wildwoods* were analyzed by community from the representative beach profiles as shown in Table B-12. Overall, the study area is less than 6 miles in length. The U.S. Coast Guard base is buffered by hundreds of feet of beach and the surrounding vegetation of the Cape May National Wildlife Refuge. It was, therefore, not further considered in the damage analysis. Damages and benefits in subsequent project formulation tables prior to determination of the tentatively selected plan (TSP) combination are based on a June 2007 price level for comparison to costs which were provided in a June 2007 price level.

Table B-12
STUDY AREA DELINEATION

Community	Cell	Profile	Length (ft)	From	To
North Wildwood	1	WW02	3,549	2nd Street	15th Street
North Wildwood	2	WW03	2,959	15th Street	26th Street
Wildwood	3	WW07	6,965	26th Street	Cresse Street
Wildwood Crest	4	WW10	4,585	Cresse Street	Rambler Road
Wildwood Crest/ Lower Township	5	WW13	5,835	Rambler Road	Memphis Ave
Lower Township	6	WW15	1,090	Memphis Avenue	Madison Avenue
Coast Guard Base	7	WW17	6,267	Madison Avenue	Cape May Inlet

The communities have proactively approached shoreline maintenance to protect residential, commercial, and public property from the impact of storm-related encroachment. Consideration of local and state-sponsored projects to preserve the baseline without project conditions is inherent in the analysis. Provision of beach material in North Wildwood and outfall pipe maintenance and extension in Wildwood and Wildwood Crest along with limited availability of developable land and adherence to floodplain management plans indicate the stability of the barrier island's local and state-sponsored maintenance program.

4.1 Structure Inventory

A structure database was compiled containing information pertinent to the calculation of hurricane and storm damage for the study area. Initially in 2005 and 2007, the inventory focused on North Wildwood, the erosion prone portion of the study area; because field conditions established that the beaches in Wildwood and Wildwood Crest were extremely wide, in excess of 1,500 and 1,100 feet, respectively. The inventory was later expanded in 2010 to include structures in Wildwood and Wildwood Crest to evaluate the extent of potential damage to reaches without dunes and assess the impact of sand backpassing. The inventory of structures has not changed since the fieldwork was conducted in the study area.

Available digital aerial photos, street centerlines, and footprints of structures derived from a geographic information system were reviewed, and unique identification numbers were assigned to each structure. Data collected in the field, listed in Table B-13, included address, quality and construction type, number of stories, and occupancy type. A handheld computer with a digital map of the study area was used to code structure characteristics on electronic forms. Photographs of each inventoried structure were taken for in-office verification. Figure B-5 displays an example of a map and photo. Additional data such as first floor elevations, ground elevations, footprint area, and foundation type (pile or slab) were also obtained for each inventoried structure. Professional surveyors conducted the elevation survey on a structure by structure basis.

The construction characteristics of each building were entered into the Marshall & Swift Valuation Service software to calculate depreciated replacement cost value. Table B-14 displays total and mean residential and non-residential structure values by foundation type for the study area. The inventory consists of approximately 60% commercial and 40% residential structures. The associated content value of each residential structure is assumed to be 25% of the structural replacement cost. This assumption is based on previous studies that established content value to be about 40% of structural value in primary homes and 15 to 20% of structural value in secondary/vacation homes. The study area consists of a combination of rental or vacation homes, and year round residential homes. However, nearly 70% of the residential structures are vacation and rental homes, and typically the contents of structures with these types of occupancies are insured at a much lower percent, therefore, a conservative weighted content-to-structure value of 25% was adopted. Field observations and site-specific interviews with local residents during the conduct of the Townsends Inlet to Cape May Inlet Feasibility Study, which included a portion of the *Wildwoods*, substantiate that the ratio is suitable. Also, information from a local insurer confirmed that personal property in secondary homes is typically insured at a lower percentage than that of primary residences. Typically applied in urban areas, affluence is an inundation reduction benefit defined as an increase in residential content-to-structure value ratio in relation to future increases in residential income. The benefit is based on the prevention of damages to potentially increased content values of residential structures in the future. Affluence is a minor potential benefit which has not been claimed by the District in any coastal studies.

Table B-13
PHYSICAL CHARACTERISTICS OBTAINED FOR BUILDING INVENTORY

1.) Type – Residential, Commercial, etc.
2.) Usage
3.) Town
4.) Structure Size
4.) Number of Stories
5.) Basement/Foundation
6.) Exterior Material
7.) Roof Material
8.) Quality
9.) Condition
10.) Garage/Shed
11.) Ground Elevation
12.) First Floor Elevation
13.) Total Units
14.) Distance from Reference Line

Table B-14
SUMMARY OF DEPRECIATED STRUCTURE VALUES

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

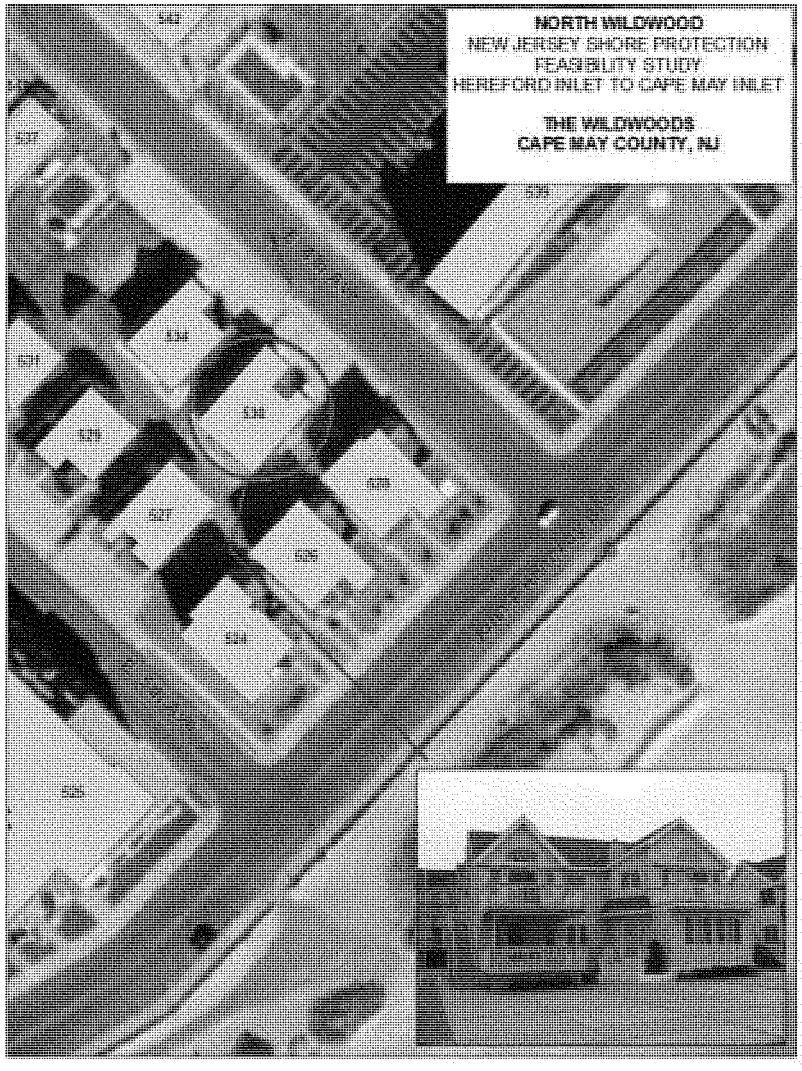

NORTH WILDWOOD
NEW JERSEY SHORE PROTECTION
FEASIBILITY STUDY
HEREFORD INLET TO CAPE MAY INLET
THE WILDWOODS
CAPE MAY COUNTY, NJ

Figure B-5

COSTDAM (**CO**astal **ST**orm **D**amage **A**ssessment **M**odel), developed by Wilmington District, was used to estimate erosion, wave, and inundation damage to the structures in the database. The economic model incorporates pertinent structure characteristics such as location, ground and first floor elevations, structure and content values and foundation type along with coastal storm parameters such as wave zone, erosion zone, and water level by distance from the shore/reference line. The COSTDAM model and methodologies have been applied and approved for six studies conducted previously along the coast of New Jersey. The model has been approved for continued use for this study as discussed in Section 5.5.1 of the main report. A description of the program's damage estimation methodology is provided in the following paragraphs.

4.2 Storm Damage Modeling

Damages (for without and with project conditions) were calculated for seven frequency storm events (5, 10, 20, 50, 100, 200, and 500 year events) for erosion, wave and inundation damage to structures, infrastructure and improved property. The calculations were performed using COSTDAM and EAD. COSTDAM reads an ASCII 'Control' file which contains the storm frequency parameters for each cell and an ASCII 'Structure' file which contains the information database of each structure. An excerpt from the structure file is shown in Table B-15. COSTDAM checks if a structure has been damaged by wave attack, based on the relationship between a structure's first floor elevation and the total water elevation that sustains a wave. Then COSTDAM checks for erosion damage at a structure. Finally, COSTDAM calculates inundation damages if the water elevation is higher than the first floor elevation based on FIA depth-damage curves adjusted for increased salt-water damageability. Examples of these curves are shown in Table B-16. To avoid double counting, if damage occurs by more than one mechanism, COSTDAM takes the maximum damage of any given mechanism (wave, erosion, or inundation) and drops the rest of the damages from the structure's total damages.

Table B-15
EXCERPT OF COSTDAM STRUCTURE FILE

1	1	102.0	152.4	7.4	1.3	1818	454S17MT2 3 1
1	2	228.8	242.8	6.5	1.0	1384	346S03S04 3-1
1	3	276.1	287.3	6.9	2.2	758	190S17MT2 3 1
1	4	271.3	287.0	6.6	2.6	279	70S03S04 3-1

Columns 1-3 contain the Reach ID.
Columns 4-9 contain the Structure ID.
Columns 10-19 are blank.
Columns 20-27 contain the distance to the front of the structure.
Columns 28-35 contain the distance to middle of structure.
Columns 36-40 contain the ground elevation.
Columns 41-44 contain distance between the first floor and ground.
Columns 45-53 contain structure replacement cost value.
Columns 54-62 contain content replacement cost value.
Columns 63-65 contain structure depth damage curves.
Columns 66-68 contain content depth damage curves.
Columns 69-70 contain a code to make the structure "active".
Columns 71-72 contain the damage category

Table B-16
EXCERPT OF DEPTH DAMAGE CURVES

S03 (2 story, no basement, residential structure)
# of Rows (free format)
13
Depth Damage (expressed as a decimal) (free format)

-2	0
-1	.01
0	.10
1	.24
2	.30
3	.36
4	.39
5	.42
6	.47
7	.49
8	.56
9	.64
10	.67

S15 (1 story, masonry, no basement, commercial structure)
# of Rows (free format)
13
Depth Damage (expressed as a decimal) (free format)

-1	0
-1	.01
0	.05
1	.21
2	.29
3	.38
4	.46
5	.48
6	.53
7	.55
8	.59
9	.67
10	.73

4.3 Erosion Damages

The distance between the reference (profile) line and the oceanfront and back walls were measured in ArcGIS using georeferenced mapping of the study area. This technique reduces the amount of human error and photographic distortion. For the structure damage/failure analysis, it was assumed that a structure is destroyed at the point that the land below the structure is eroded halfway through the structure's footprint if the structure is not on a pile foundation. If the structure is on piles, the land below the structure must have eroded through the entire footprint of the structure before total damage is claimed. Prior to this, for both foundation types, the percent damage claimed is equal to the linear proportion of erosion under the structure's footprint relative to the total damage point. Figure 6 graphically depicts the relationship between percent damage and percent of footprint compromised. The damage relationship was developed during the initial assessment of storm erosion damage susceptibility on the Delaware and New Jersey coasts, has been applied regionally, and is considered a reasonable method to estimate aggregate erosion damages to the structure types represented in this coastal environment.

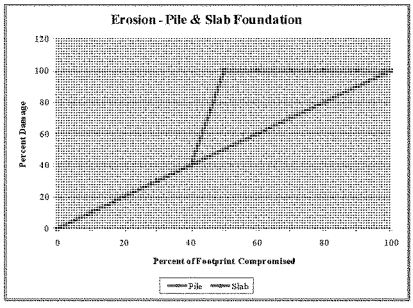


Figure B-6

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

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

Erosion damage to infrastructure was also calculated. An erosion damage curve was developed for damage to infrastructure within the erosion limits. Values for roads, sidewalks, storm drains, electrical lines, and other utilities were estimated using standard engineering criteria. The judgment was made that all infrastructure damaged would be replaced in-kind. The replacement cost does not necessarily relate to the number of structures in the area. Road and utilities replacement costs consisted of fixed and variable costs based on ranges of feet of replacement/repair. In general, the unit replacement cost of roads decreased with greater quantities eroded reflecting economies of scale. Distance from the reference line and feet of erosion per event for each road and associated utilities were used to determine damage susceptibility. Once damages were calculated for infrastructure for the storm events the expected annual damages were calculated by using the Hydrologic Engineering Center's (HEC) Expected Annual Damage (EAD) program. The EAD program determines expected average annual damage by relating the dollar value of damage for different event magnitudes to the percent chance of exceeding those events. A sample EAD input file is shown in Table B-17.

Table B-17
EAD INPUT FILE EXAMPLE

```
TT HEREFORD INLET TO CAPE MAY INLET (THE WILDWOODS) (NAVD88)
TT FEASIBILITY PHASE JUNE 2007 P.L. ($000)
TT EROSION DAMAGE ANALYSIS EXISTING COND. INFRASTRUCTURE DAMAGE 5-500 YR
J1    50    2007    2012 06 2007
J2 3.500
CN     3   INFRA   BDWLK   PIERS
PN     1 WITHOUT PROJECT CONDITIONS (REVISED)
RN 1
FR             7      20      10       5       2       1      .5      .2
DG     1       1   379.6   496.3   559.4   595.2  4126.0  5967.5  7048.0
DG     1       2     0.0     0.0     0.0     0.0     0.0     0.0     0.0
DG     1       3     0.0     0.0     0.0     0.0     0.0     0.0     0.0
ER     1
```

4.4 Wave-Inundation Damages

A structure in the COSTDAM model is considered damaged by a wave when there is sufficient force (from a 3-foot high breaking wave) in the total water elevation to completely destroy a structure. Figure B-7 illustrates the various components of waves. Partial wave damages are not calculated; instead the structure is subjected to inundation damages. Large masonry structures like high-rise condominiums are not expected to experience failure by wave damage. The wave attack damage relationship developed by Wilmington District for Atlantic coast studies was adopted for use in the New Jersey coast hurricane and storm damage reduction analyses of seven projects. Since waves cause similar types of damage as inundation, assessing damage prior to full wave impact on a structure would, in essence, duplicate the inundation damage estimate.

Percentages of total depreciated replacement cost used to calculate damage by the depth-damage function curves for inundation damage reflect various characteristics of a structure. The depth-damage curves display the percent damaged at various stages relative to the first floor. The curves used to estimate inundation damage to structures were derived from well-established FIA (Federal Insurance Administration) depth-damage curves and previous studies of saltwater areas are applicable for this study. The distinguishing characteristics are construction type and the number of stories in a structure. The FIA curves were developed by sampling the various types of structures and contents at New Jersey seashore communities in Cape May and Atlantic counties. Curve percentages were compared to survey data of the additional damage that corrosive saltwater would cause. An example of the frequency at which damage begins and the damage mechanism for the *Wildwoods* is shown below.

	Damage Start	
Community	**Frequency**	**Type**
North Wildwood	5 YR	Flooding
Wildwood	5 YR	Flooding
Wildwood Crest/Lower Township	50 YR	Flooding

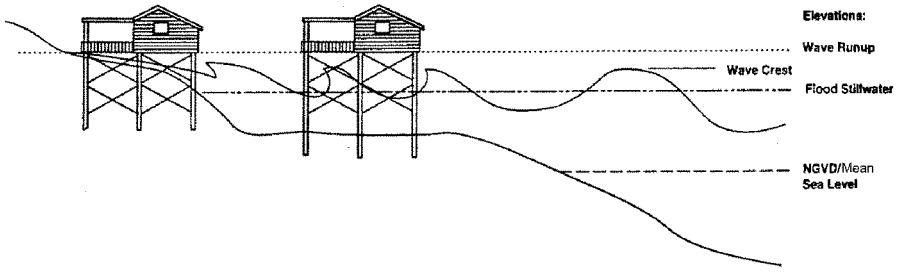


Figure B-7 (Source: FEMA)

4.5 Emergency/Clean-Up Information

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

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

5.0 ECONOMIC BENEFIT EVALUATION

5.1 WITHOUT PROJECT CONDITIONS – NORTH WILDWOOD

5.1.1 Damage Zone Structures

The number of structures affected and total damages by damage zone or damage frequency for structures in North Wildwood is presented in Table B-18. Damage from the different mechanisms (wave, erosion, or inundation) decreases between storm events because structures may be susceptible to more damage from a different mechanism at different storm frequencies. However, overall damage from all damage mechanisms increases with higher intensity storms. Structural damage below the 5-year event is negligible. Storms equivalent to a 2-year event have occurred in which no structural damages were reported.

Table B-18
NORTH WILDWOOD
WITHOUT PROJECT CONDITIONS
STRUCTURES AFFECTED AND
TOTAL DAMAGE BY FREQUENCY
(Dollars in thousands)

North Wildwood	5-YR	10-yr	20-YR	50-YR	100-YR	200-YR	500-YR
Structures	1	1	1	64	148	160	176
Wave Damage	0	0	0	$485	$54,954	$136,861	$180,796
Erosion Damage	0	0	0	0	$3,395	$17,167	$10,175
Inundation Damage	$140	$152	$165	$15,349	$36,774	$6,418	$7,263
Total Damage	$ 140	$ 152	$ 165	$15,834	$95,123	$160,446	$198,234

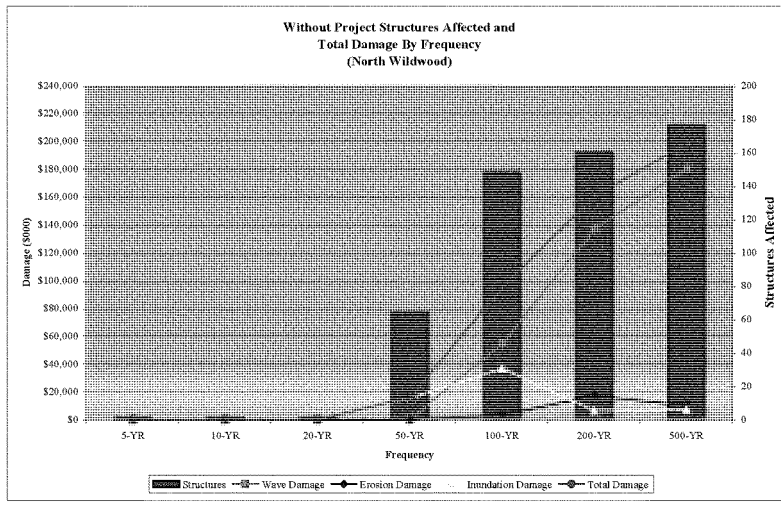


Figure B-8

Table B-19
NORTH WILDWOOD
WITHOUT PROJECT CONDITIONS
AVERAGE ANNUAL STRUCTURE DAMAGE
(Dollars in thousands)

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

Table B-20
NORTH WILDWOOD
WITHOUT PROJECT CONDITIONS
RESIDENTIAL AND COMMERCIAL
AVERAGE ANNUAL STRUCTURE DAMAGE
(Dollars in thousands)

Location	Cell	Residential	Commercial	Average Annual Damage
North Wildwood	1	$316	$895	$1,211
North Wildwood	2	$247	$753	$1,000
Total		$ 563	$1,648	$2,211

5.1.2 Infrastructure and Improved Property Damages

Total infrastructure damages by frequency are shown in Table B-21A. The without project average annual damages (AAD) for the infrastructure such as roads, storm drains, the boardwalk, piers, bulkheads, and improved property are displayed in Table B-21B.

Table B-21A
NORTH WILDWOOD
WITHOUT PROJECT CONDITIONS
TOTAL INFRASTRUCTURE DAMAGES BY FREQUENCY
(Dollars in thousands)

Category	5-YR	10-YR	20-YR	50-YR	100-YR	200-YR	500-YR
Infrastructure	$1,440	$3,350	$3,418	$3,852	$15,089	$18,173	$22,124
Boardwalk	0	0	0	0	5,540	5,540	5,540
Bulkhead	0	0	0	0	1,239	1,239	1,239
Total	$1,440	$3,350	$3,418	$3,852	$21,868	$24,952	$28,903

Table B-21B
NORTH WILDWOOD
WITHOUT PROJECT CONDITIONS
AVERAGE ANNUAL INFRASTRUCTURE AND
IMPROVED PROPERTY DAMAGES
(Dollars in thousands)

Category	Total
Infrastructure	$ 226
Boardwalk	83
Bulkhead	19
Improved Property	28
Total	$ 356

5.1.3 Summary of Damages

Total estimated average annual damages in North Wildwood by location/cell and damage mechanism are $3,070,000 as presented in Table B-22. Average annual damages to structures only are estimated to be $2,211,000.

Table B-22
NORTH WILDWOOD
WITHOUT PROJECT
TOTAL AVERAGE ANNUAL DAMAGE
(Dollars in thousands)

Location	Cell	Structure	Infrastructure	Improved Property	Average Annual Damage
North Wildwood	1	$1,211	$185	$24	$1,420
North Wildwood	2	$1,000	$646	$4	$1,650
Total		$2,211	$ 831	$ 28	$3,070

5.1.4 Emergency/Clean-Up Costs

The number of structures affected and the estimated costs for each storm event are presented in Table B-23 for North Wildwood. Average annual emergency and clean-up costs for all affected individuals and public entities are $103,000, combined. Total expected average annual damage under without project conditions including emergency costs is $3,173,000.

Table B-23
NORTH WILDWOOD
WITHOUT PROJECT CONDITIONS
EMERGENCY/CLEAN-UP COSTS
(Dollars in thousands)

North Wildwood	5-YR	10-YR	20-YR	50-YR	100-YR	200-YR	500-YR
Structures	1	1	1	64	148	160	176
Individual Clean-up Costs	$1	$1	$3	$65	$351	$812	$1,786
Municipal Emergency Costs	$11	$92	$141	$826	$2,410	$4,122	$6,005

5.1.5 Back Bay Flooding

Storm damage resulting from infiltration of waves, beach erosion, and inundation from the ocean shoreline was the focus of the proposed plan recommended by the study. Many barrier islands, including the *Wildwoods*, are traditionally subject to the impacts of bay flooding from any combination of storm events and high tides. This phenomenon was not evaluated as part of this study. As an example, the model was run for the stages associated with the back-bay (stillwater) inundation. The result represents inundation damages specific only to the oceanfront/nearshore structures in the database that would not be eliminated by a project on the oceanfront of North

Wildwood. These back-bay residual damages for these structures total $153,000 in average annual damages.

5.2 WITHOUT PROJECT CONDITIONS – WILDWOOD, WILDWOOD CREST & LOWER TOWNSHIP

5.2.1 Accreted Area

The study area at the *Wildwoods* is a dynamic system, characterized by the movement of sand down-shore from North Wildwood to the beaches in Wildwood and Wildwood Crest. This redistribution of sand from North Wildwood has created an on-shore borrow area of built-up accreted sand in Wildwood and Wildwood Crest which has caused water to pond at clogged outfalls, and increased costs for beach maintenance and outfall pipe extension. At the beginning of the study, initial review of field conditions in Wildwood and Wildwood Crest indicated that beach width was in excess of 1,500 and 1,100 feet, respectively. Therefore, the study focused on the highly eroded oceanfront of North Wildwood.

In addition to the down drift structures south of North Wildwood, property located on the piers seaward of the proposed project may be susceptible to damage from hurricanes and storms. Three piers in North Wildwood and Wildwood have extensions sloping down near beach level and are not uniformly elevated on tall piles as in other shore communities like Atlantic City. Structures located in these areas were reviewed to determine potential damages and the impact of extending various plan alternatives around the piers.

5.2.2 Damage Zone Structures

The number of structures affected and total damages by damage zone or damage frequency for structures in Wildwood, Wildwood Crest, and Lower Township are presented in Tables B-24 through B-26. To avoid double counting, if damage is incurred by more than one of the potential three mechanisms (wave, erosion, or inundation), the COSTDAM program takes the maximum damage of any one given mechanism, and disregards the lower damages estimated by the two other mechanisms. Overall damage from all damage mechanisms increases with higher intensity storms.

The problems of clogged outfall pipes and street flooding are an on-going challenge which has required continuous maintenance by Wildwood. Many of the nearshore structures in Wildwood are commercial activities and several have first floors with elevations at grade or slightly above, that are located within the modeled 5-year inundation profile area in terms of distance from the shoreline and inundation susceptibility. Wildwood has no dune system to impede over-berm flow of floodwaters; therefore the model carries the water elevation inland. The difference between historical observations and modeled results could be caused by a combination of factors. Officials and business owners implement mitigation measures such as sandbag placement and constructing building closures. When there has been no time to deploy protective measures damage has occurred in Wildwood. Businesses experienced with frequent potentially damaging storm events also may have employed storm proofing and modifications to property to reduce the impacts of flooding. Natural landscaping may also act as a barrier to infiltration of water into buildings. These variables are not model parameters.

Table B-24
WILDWOOD
WITHOUT PROJECT CONDITIONS
STRUCTURES AFFECTED AND
TOTAL DAMAGE BY FREQUENCY
(Dollars in thousands)

Wildwood	5-YR	10-yr	20-YR	50-YR	100-YR	200-YR	500-YR
Structures	32	47	54	63	115	125	131
Wave Damage	0	0	0	0	0	$48,306	$51,036
Erosion Damage	0	0	0	0	0	$70	$1,603
Inundation Damage	$1,797	$3,650	$5,543	$9,298	$29,236	$3,933	$3,578
Total Damage	$1,797	$3,650	$5,543	$9,298	$29,236	$52,309	$56,217

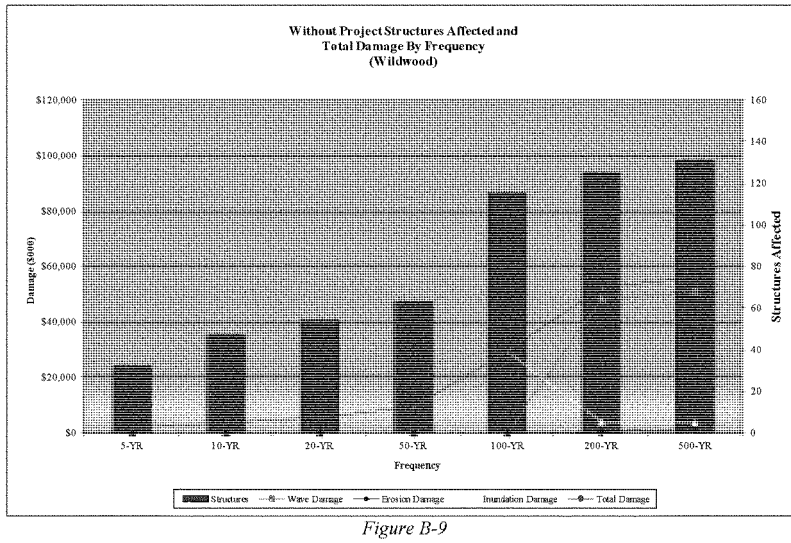


Figure B-9

Table B-25
WILDWOOD CREST
WITHOUT PROJECT CONDITIONS
STRUCTURES AFFECTED AND
TOTAL DAMAGE BY FREQUENCY
(Dollars in thousands)

Wildwood Crest	5-YR	10-yr	20-YR	50-YR	100-YR	200-YR	500-YR
Structures	0	0	0	19	81	100	105
Wave Damage	0	0	0	0	$1,406	$20,881	$41,371
Erosion Damage	0	0	0	0	$29,497	$22,301	$6,071
Inundation Damage	0	0	0	$5,598	$17,299	$53,059	$111,406
Total Damage	$ 0	$ 0	$ 0	$5,598	$48,202	$96,241	$158,848

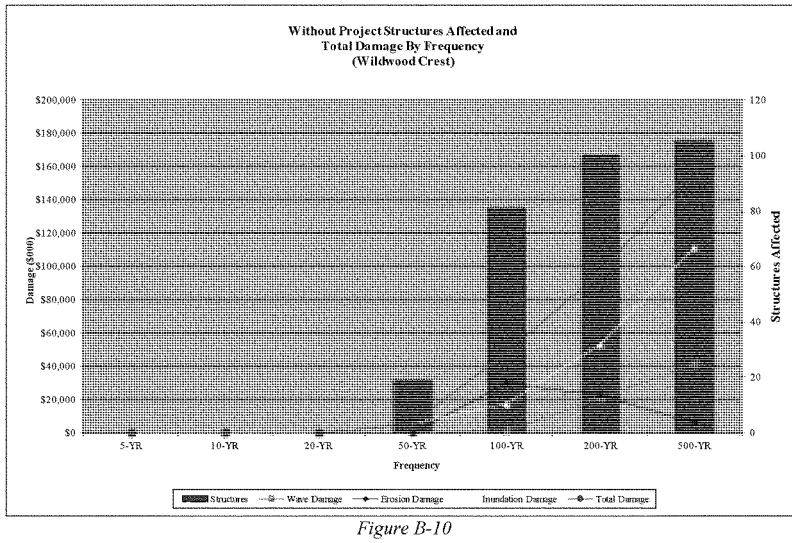
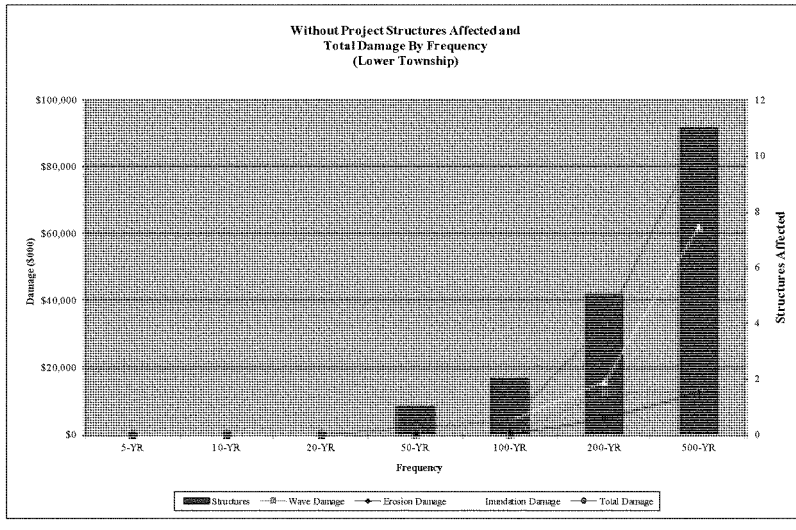


Figure B-10

Table B-26
LOWER TOWNSHIP
WITHOUT PROJECT CONDITIONS
STRUCTURES AFFECTED AND
TOTAL DAMAGE BY FREQUENCY
(Dollars in thousands)

Lower Township	5-YR	10-yr	20-YR	50-YR	100-YR	200-YR	500-YR
Structures	0	0	0	1	2	5	11
Wave Damage	0	0	0	0	$0	$12,605	$12,605
Erosion Damage	0	0	0	0	$0	$4,566	$12,318
Inundation Damage	0	0	0	$2,153	$3,826	$15,675	$62,169
Total Damage	$ 0	$ 0	$ 0	$2,153	$3,826	$32,846	$87,092



5.2.3 Accreted Area Damage Summary

Expected average annual damages by location/cell and damage mechanism for structures and other damage elements in the communities within the potential backpass area are presented in Table B-27. A breakdown of damage by structure type for Wildwood, Wildwood Crest, and Lower Township is shown in Table B-28. Average annual damages to structures only are an estimated $3,081,000 of the $5,124,000.

Table B-27
WILDWOOD, WILDWOOD CREST, LOWER TOWNSHIP
WITHOUT PROJECT
TOTAL AVERAGE ANNUAL DAMAGE
(Dollars in thousands)

Location	Cell	Erosion	Wave	Inundation	Infrastructure	Improved Property	Structure Subtotal	Average Annual Damage
Wildwood	3	$4	$298	$1,192	$1,306	$0	$1,494	$2,800
Wildwood Crest	4	$15	$5	$198	$498	$4	$ 218	$ 720
Wildwood Crest	5	$288	$178	$482	$212	$11	$ 948	$1,171
Lower Township	6	$49	$82	$290	$12	$0	$ 421	$ 433
Total		$ 356	$ 563	$2,162	$2,028	$ 15	$3,081	$5,124

Table B-28
WILDWOOD, WILDWOOD CREST, LOWER TOWNSHIP
WITHOUT PROJECT CONDITIONS
RESIDENTIAL AND COMMERCIAL
AVERAGE ANNUAL STRUCTURE DAMAGE
(Dollars in thousands)

Location	Cell	Residential	Commercial	Average Annual Damage
Wildwood	3	$52	$1,443	$1,495
Wildwood Crest	4	$0	$218	$ 218
Wildwood Crest	5	$518	$429	$ 947
Lower Township	6	$406	$15	$ 421
Total		$ 976	$2,105	$3,081

5.2.4 Amusement Piers Damages

A major attraction of the *Wildwoods* are the amusement piers which offer an assortment of mild to high thrill rides, kids' rides, game booths, and concessions, as well as waterparks. The unique nature of analyzing damage to the amusement piers required a separate database for the pier structures. Amusement pier ride replacement cost values were provided by the pier operator and depreciated using an amusement ride depreciation schedule. Specialized depth damage curves from similar activities were used in the inundation analysis. Estimated average annual damage to the amusement pier rides is $122,000. Table B-28 presents a breakdown of the damage estimate by community/pier and damage category.

Table B-29
NORTH WILDWOOD & WILDWOOD
WITHOUT PROJECT CONDITIONS
AVERAGE ANNUAL PIER DAMAGES
(Dollars in thousands)

Location	Pier	Erosion	Wave	Inundation	Average Annual Damage
North Wildwood	Surfside	$27	$7	$0	$ 34
Wildwood	Mariner's Landing	$44	$1	$0	$ 45
Wildwood	Adventure	$3	$12	$28	$ 43
Total		*$ 74*	*$ 20*	*$ 28*	*$ 122*

5.3 ESTIMATED TOTAL DAMAGES

Total estimated without project average annual damage for all categories in North Wildwood, the eroding portion of the study area, and Wildwood and Wildwood Crest, the down-drift accreting area, is $8,194,000. Table B-30 presents a breakdown of the damage estimate by community.

Table B-30
WITHOUT PROJECT CONDITIONS
TOTAL AVERAGE ANNUAL DAMAGES
(Dollars in thousands)

Community	Total
North Wildwood	$3,070
Wildwood	2,800
Wildwood Crest/ Lower Township	2,324
Total	*$8,194*

6.0 BENEFIT ANALYSIS

6.1 WITH PROJECT ALTERNATIVES

6.1.1 Storm Damage Reduction

Expected damages for several different project alternatives were calculated using the same methodologies and databases as previously detailed in the without project conditions. The benefits from the project alternatives were estimated by evaluating damage to structures under with and without project conditions. Potential damage reduction to infrastructure, improved property, and other auxiliary categories is expected to parallel reduced damage to structures and, therefore, was not calculated for the matrix of alternatives. The eroded shoreline in North Wildwood was analyzed first. Plan alternatives A-N are aligned with the current beach profile landward of the amusement pier structures and, therefore, would not protect those structures from storm damage. Table B-31 and Figure B-11 display the results of the storm damage reduction analysis for the oceanfront and nearshore structures in North Wildwood.

The plan alternative selected to alleviate the severe erosion in North Wildwood includes the construction of a dune with a height of 16 feet (NAVD) and a berm with a width of 75 feet. Dredging and backpassing were two options analyzed for acquiring sand for the project. The backpass option was reviewed and selected in an effort to maximize benefits and employ a systems approach to combine protecting property and infrastructure at the northern end of the island with improving beach conditions in Wildwood and Wildwood Crest/Lower Township. The plan would also provide storm damage reduction benefits for the southern Five Mile Island communities. The presence of a wide feeder beach provides adequate sand to form protective dunes in the cells of the study area that lack this additional height buffer. Tables B-32 and B-33 display the results of the storm damage reduction analysis for the oceanfront and nearshore structures in Wildwood, and Wildwood Crest, respectively.

Table B-34 compares the aggregate incremental benefits from constructing a consistent dune of various heights in Wildwood and Wildwood Crest/Lower Township.

Table B-31
NORTH WILDWOOD
STORM DAMAGE REDUCTION BENEFITS
BY PLAN ALTERNATIVE

Plan	Project Type	Without Project Storm Damages	With Project Storm Damages	Storm Damage Reduction Benefits	Percent Reduced
A	12' Dune, 115' Berm	$2,211,000	$1,887,000	$324,000	15%
B	14' Dune, 95' Berm	$2,211,000	$1,137,000	$1,074,000	49%
C	16' Dune, 75' Berm	$2,211,000	$687,000	$1,524,000	69%
D	12' Dune, 140' Berm	$2,211,000	$1,287,000	$924,000	42%
E	14' Dune, 120' Berm	$2,211,000	$975,000	$1,236,000	56%
F	16' Dune, 100' Berm	$2,211,000	$531,000	$1,680,000	76%
G	12' Dune, 165' Berm	$2,211,000	$1,180,000	$1,031,000	47%
H	14' Dune, 145' Berm	$2,211,000	$644,000	$1,567,000	71%
I	16' Dune, 125' Berm	$2,211,000	$459,000	$1,752,000	79%
J	18' Dune, 80' Berm	$2,211,000	$461,000	$1,750,000	79%
K	18' Dune, 105' Berm	$2,211,000	$212,000	$1,999,000	90%
L	20' Dune, 85' Berm	$2,211,000	$203,000	$2,008,000	91%
M	20' Dune, 110' Berm	$2,211,000	$197,000	$2,014,000	91%
N	20' Dune, 160' Berm	$2,211,000	$121,000	$2,090,000	95%

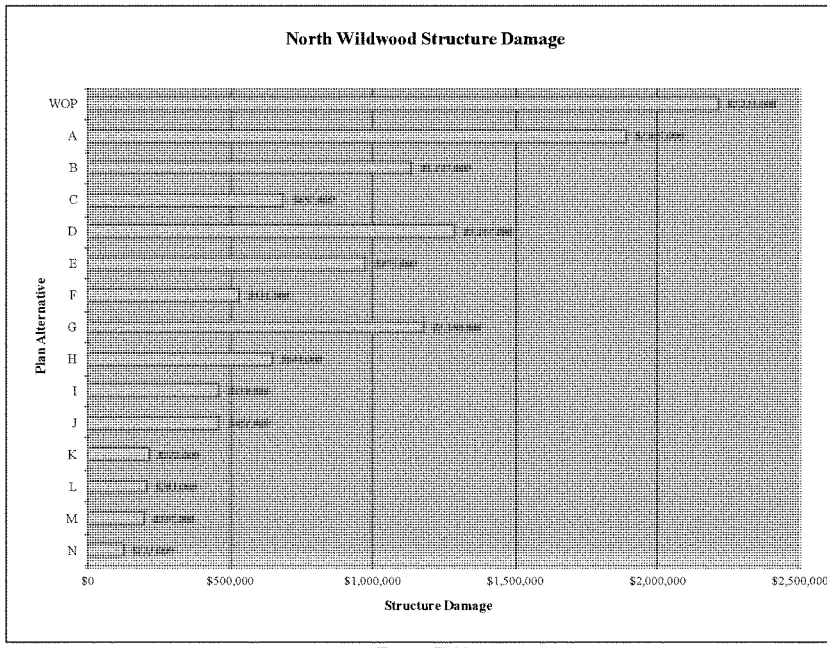


Figure B-12

Table B-32
WILDWOOD
STORM DAMAGE REDUCTION BENEFITS
BY PLAN ALTERNATIVE

Plan	Project Type	Without Project Storm Damages	With Project Storm Damages	Storm Damage Reduction Benefits	Percent Reduced
AA	12' Dune	$1,494,000	$432,000	$1,062,000	71%
BB	14' Dune	$1,494,000	$222,000	$1,272,000	85%
CC	16' Dune	$1,494,000	$121,000	$1,373,000	92%

Table B-33
WILDWOOD CREST/LOWER TOWNSHIP
STORM DAMAGE REDUCTION BENEFITS
BY PLAN ALTERNATIVE

Plan	Project Type	Without Project Storm Damages	With Project Storm Damages	Storm Damage Reduction Benefits	Percent Reduced
AA	12' Dune	$1,165,000	$653,000	$512,000	44%
BB	14' Dune	$1,165,000	$452,000	$713,000	61%
CC	16' Dune	$1,165,000	$306,000	$859,000	74%

Table B-34
WILDWOOD AND WILDWOOD CREST/LOWER TOWNSHIP
AAB, AAC, NET BENEFITS & BCR BY PLAN ALTERNATIVE

Plan	Project Type	AAB	AAC	Net Benefits	BCR
			BYPASS		
AA	12' Dune	$1,574,000	$112,000	$1,462,000	14.05
BB	14' Dune	$1,986,000	$173,000	$1,813,000	11.48
CC	16' Dune	$2,231,000	$245,000	$1,986,000	9.11

**May not add exactly due to rounding*

An interim analysis was conducted to determine the impact of backpassing sand to North Wildwood without construction of the complete project with a protective dune of any height in Wildwood and Wildwood Crest/Lower Township. The reduced berm without inclusion of the dune component of the proposed plan alternative would result in an estimated 6% increase in without project average annual damage to structures from $3,081,000 to $3,263,000.

Plan C with a 16-foot dune and a 75-foot berm was used as a base plan to extend protection to the relatively low-lying amusement piers. The 100-foot berm seaward of the piers is essentially the same as the 75-foot berm landside of the piers at the boardwalk parallel to the shoreline to support the dune. Plans C1, C2, and C3 were developed to determine whether additional beachfill to protect the piers would be incrementally justified. Table B-35 shows the resulting incremental average annual costs to expand protection around the ends of the piers. The benefits include the maximum potential storm damage reduction benefits to pier infrastructure. A steel sheet pile barrier around the piers was also evaluated and is presented. These options were eliminated from the analysis due to the limited benefit potential and prohibitively high cost to extend protection around the piers.

Table B-35
NORTH WILDWOOD AND WILDWOOD PIERS
AAB, AAC, NET BENEFITS & BCR BY PLAN ALTERNATIVE

Plan	Project Type	AAB	AAC	Net Benefits	BCR
			BYPASS (4-YR Nourishment Cycle)		
C1	12' Dune, 100' Berm	$400,000	$857,000	($457,000)	0.47
C2	14' Dune, 100' Berm	$401,000	$1,135,000	($734,000)	0.35
C3	16' Dune, 100' Berm	$497,000	$1,410,000	($913,000)	0.35
			STEEL SHEET PILE		
S1	Steel Sheeting	$497,000	$1,658,000	($1,161,000)	0.30

6.1.2 Local Costs Forgone Benefits

Benefits of coastal storm management projects include reductions in non-physical damages as well as reductions in physical damages to homes, commercial buildings, public property and critical infrastructure. The Coastal Storm Risk Management National Economic Development (NED) Manual (2011) includes reduced costs for public protective measures or local costs forgone, as it is referred to in this document, as a benefit category. This benefit captures future costs that would be expended by the state and local municipalities to protect coastal property in the absence of a plan of protection. The local costs forgone benefits described in the following paragraphs are expected to be realized with implementation of any proposed project.

The beaches of the *Wildwoods* have been historically protected and maintained through state and local government-sponsored beachfill projects in North Wildwood to allay erosion, daily outfall maintenance to remove sand and place barriers around water that ponds at clogged outfalls, and construction projects in Wildwood and Wildwood Crest to extend outfall pipes beyond the accreted shoreline. In 2009, the State of New Jersey constructed a beachfill project of over one million cubic yards of sand at the northern section of the *Wildwoods* to control erosion with subsequent emergency sand placements after other storm events. The future without project condition was based on the expectation that the state would continue to partner and provide protection to the communities. The implementation of a federal project will preclude this action and provide a savings from public protective measures to the State of New Jersey and the local municipalities.

Savings to the State of New Jersey and local communities could potentially be, depending upon the source of material, an estimated average annual $954,000 as a result of the beachfill and nourishment components of a proposed plan. Table B-36 displays this savings for North Wildwood. Acquisition of sand from Hereford Inlet via dredging would ignore the systems approach to the problems of congested outfalls and eliminate realization of local costs forgone benefits to Wildwood or Wildwood Crest (shown in Table B-38). Therefore, the option to dredge material from Hereford Inlet was removed from further consideration.

Local costs forgone were included in the average annual benefits for the backpass alternatives in Table B-37 because the protective dune and berm will be constructed with the accreted beach material from Wildwood and Wildwood Crest. The expected range of the remaining berm widths after implementation of the tentatively selected plan (TSP) will vary with the beach profile from 300 to 1,100 feet.

Table B-36
NORTH WILDWOOD
LOCAL COSTS FORGONE
UNDER WITH PROJECT CONDITIONS

Year	North Wildwood	PW Factor	PW North Wildwood
1	$0	0.966184	$0
2	$0	0.933511	$0
3	$0	0.901943	$0
4	$0	0.871442	$0
5	$0	0.841973	$0
6	$9,750,000	0.813501	$7,931,631
7	$0	0.785991	$0
8	$0	0.759412	$0
9	$0	0.733731	$0
10	$0	0.708919	$0
11	$0	0.684946	$0
12	$0	0.661783	$0
13	$0	0.639404	$0
14	$0	0.617782	$0
15	$0	0.596891	$0
16	$9,750,000	0.576706	$5,622,883
17	$0	0.557204	$0
18	$0	0.538361	$0
19	$0	0.520156	$0
20	$0	0.502566	$0
21	$0	0.485571	$0
22	$0	0.469151	$0
23	$0	0.453286	$0
24	$0	0.437957	$0
25	$0	0.423147	$0
26	$9,750,000	0.408838	$3,986,167
27	$0	0.395012	$0
28	$0	0.381654	$0
29	$0	0.368748	$0
30	$0	0.356278	$0
31	$0	0.344230	$0
32	$0	0.332590	$0
33	$0	0.321343	$0
34	$0	0.310476	$0
35	$0	0.299977	$0
36	$9,750,000	0.289833	$2,825,869
37	$0	0.280032	$0
38	$0	0.270562	$0
39	$0	0.261413	$0
40	$0	0.252572	$0
41	$0	0.244031	$0
42	$0	0.235779	$0
43	$0	0.227806	$0
44	$0	0.220102	$0
45	$0	0.212659	$0
46	$9,750,000	0.205468	$2,003,312
47	$0	0.198520	$0
48	$0	0.191806	$0
49	$0	0.185320	$0
50	$0	0.179053	$0
Total Present Worth:			$22,369,862
CRF (50 years @ 3.500% (FY14)):			0.042634
Average Annual Savings:			**$954,000**

6.2 OPTIMIZATION

Optimization of the alternatives is based on maximizing storm damage reduction to structures, which is the priority benefit category. Project induced benefits were considered during optimization. Storm damage reduction to infrastructure and improved property, and recreation were not used in the optimization process. Benefits which will accrue for those categories will be evaluated for the selected plan alternative. Initial and nourishment costs for the various project alternatives are annualized for comparison to the average annual benefits for each project alternative. Initial construction and periodic nourishment costs are annualized over a 50-year period of analysis at an FY14 discount rate of 3-½%. Monitoring, major rehabilitation, and real estate costs will be included for the selected plan alternative. The average annual costs are subtracted from and compared to average annual benefits to calculate net benefits and the benefit-cost ratio and select the optimal plan, which maximizes net benefits. Theoretically, the plan of improvement identified as the most efficient use of funds is the one in which benefits exceed cost by the maximum amount. The average annual benefits and costs, net benefits and benefit-cost ratio for storm damage reduction are included in Table B-37 for the backpass option.

Plan C, a 16'dune and 75' berm, is the alternative with the greatest net benefits in each periodic nourishment cycle evaluated. Engineering judgment in assessing nourishment cycle performance, recent historical rates of erosion, the lower risk of occurrence of a potentially damaging storm event with a shorter periodic nourishment cycle and the negligible difference between the 4 and 5-year cycle net benefits led to the selection of Plan C within the 4-year nourishment cycle group.

Table B-37
NORTH WILDWOOD
AAB, AAC, NET BENEFITS & BCR BY PLAN ALTERNATIVE (BACKPASS)

Plan	Project Type	AAB	AAB w/LCF	AAC	Net Benefits	BCR
3-YR Nourishment Cycle						
A	12' Dune, 115' Berm	$324,000	$1,278,000	$2,007,000	($729,000)	0.64
B	14' Dune, 95' Berm	$1,074,000	$2,028,000	$2,030,000	($2,000)	1.00
C	16' Dune, 75' Berm	$1,524,000	$2,478,000	$2,056,000	$422,000	1.21
D	12' Dune, 140' Berm	$924,000	$1,878,000	$2,481,000	($603,000)	0.76
E	14' Dune, 120' Berm	$1,236,000	$2,190,000	$2,503,000	($313,000)	0.87
F	16' Dune, 100' Berm	$1,680,000	$2,634,000	$2,543,000	$91,000	1.04
G	12' Dune, 165' Berm	$1,031,000	$1,985,000	$3,012,000	($1,027,000)	0.66
H	14' Dune, 145' Berm	$1,567,000	$2,521,000	$3,035,000	($514,000)	0.83
I	16' Dune, 125' Berm	$1,752,000	$2,706,000	$3,064,000	($358,000)	0.88
J	18' Dune, 80' Berm	$1,750,000	$2,704,000	$2,577,000	$127,000	1.05
K	18' Dune, 105' Berm	$1,999,000	$2,953,000	$3,095,000	($142,000)	0.95
L	20' Dune, 85' Berm	$2,008,000	$2,962,000	$3,140,000	($178,000)	0.94
M	20' Dune, 110' Berm	$2,014,000	$2,968,000	$4,182,000	($1,214,000)	0.71
N	20' Dune, 160' Berm	$2,090,000	$3,044,000	$6,367,000	($3,323,000)	0.48
4-YR Nourishment Cycle						
A	12' Dune, 115' Berm	$324,000	$1,278,000	$1,781,000	($503,000)	0.72
B	14' Dune, 95' Berm	$1,074,000	$2,028,000	$1,803,000	$225,000	1.12
C	16' Dune, 75' Berm	$1,524,000	$2,478,000	$1,831,000	$647,000	1.35
D	12' Dune, 140' Berm	$924,000	$1,878,000	$2,223,000	($345,000)	0.84
E	14' Dune, 120' Berm	$1,236,000	$2,190,000	$2,257,000	($67,000)	0.97
F	16' Dune, 100' Berm	$1,680,000	$2,634,000	$2,285,000	$349,000	1.15
G	12' Dune, 165' Berm	$1,031,000	$1,985,000	$2,703,000	($718,000)	0.73
H	14' Dune, 145' Berm	$1,567,000	$2,521,000	$2,727,000	($206,000)	0.92
I	16' Dune, 125' Berm	$1,752,000	$2,706,000	$2,755,000	($49,000)	0.98
J	18' Dune, 80' Berm	$1,750,000	$2,704,000	$2,319,000	$385,000	1.17
K	18' Dune, 105' Berm	$1,999,000	$2,953,000	$2,794,000	$159,000	1.06
L	20' Dune, 85' Berm	$2,008,000	$2,962,000	$2,834,000	$128,000	1.05
M	20' Dune, 110' Berm	$2,014,000	$2,968,000	$3,776,000	($808,000)	0.79
N	20' Dune, 160' Berm	$2,090,000	$3,044,000	$5,735,000	($2,691,000)	0.53
5-YR Nourishment Cycle						
A	12' Dune, 115' Berm	$324,000	$1,278,000	$1,784,000	($506,000)	0.72
B	14' Dune, 95' Berm	$1,074,000	$2,028,000	$1,796,000	$232,000	1.13
C	16' Dune, 75' Berm	$1,524,000	$2,478,000	$1,823,000	$655,000	1.36
D	12' Dune, 140' Berm	$924,000	$1,878,000	$2,201,000	($323,000)	0.85
E	14' Dune, 120' Berm	$1,236,000	$2,190,000	$2,224,000	($34,000)	0.98
F	16' Dune, 100' Berm	$1,680,000	$2,634,000	$2,255,000	$379,000	1.17
G	12' Dune, 165' Berm	$1,031,000	$1,985,000	$2,696,000	($711,000)	0.74
H	14' Dune, 145' Berm	$1,567,000	$2,521,000	$2,719,000	($198,000)	0.93
I	16' Dune, 125' Berm	$1,752,000	$2,706,000	$2,747,000	($41,000)	0.99
J	18' Dune, 80' Berm	$1,750,000	$2,704,000	$2,284,000	$420,000	1.18
K	18' Dune, 105' Berm	$1,999,000	$2,953,000	$2,781,000	$172,000	1.06
L	20' Dune, 85' Berm	$2,008,000	$2,962,000	$2,819,000	$143,000	1.05
M	20' Dune, 110' Berm	$2,014,000	$2,968,000	$3,747,000	($779,000)	0.79
N	20' Dune, 160' Berm	$2,090,000	$3,044,000	$5,787,000	($2,743,000)	0.53

**Notes: Dune elevation in feet NAVD 88*

June 2007 price level and FY14 - 3.500% discount rate

Figures include local cost forgone (LCF)

Figures excluded infrastructure, improved property, and emergency costs

Table B-38
WILDWOOD AND WILDWOOD CREST/LOWER TOWNSHIP
LOCAL COSTS FORGONE
UNDER WITH PROJECT CONDITIONS

Year	Wildwood	Wildwood Crest	PW Factor	PW Wildwood	PW Wildwood Crest
1	$59,000	$500,000	0.966184	$57,005	$483,092
2	$59,000	$0	0.933511	$55,077	$0
3	$59,000	$0	0.901943	$53,215	$0
4	$95,000	$0	0.871442	$82,787	$0
5	$59,000	$0	0.841973	$49,676	$0
6	$59,000	$500,000	0.813501	$47,997	$406,750
7	$59,000	$0	0.785991	$46,373	$0
8	$59,000	$0	0.759412	$44,805	$0
9	$59,000	$0	0.733731	$43,290	$0
10	$59,000	$0	0.708919	$41,826	$0
11	$59,000	$800,000	0.684946	$40,412	$547,957
12	$59,000	$0	0.661783	$39,045	$0
13	$59,000	$0	0.639404	$37,725	$0
14	$95,000	$0	0.617782	$58,689	$0
15	$59,000	$0	0.596891	$35,217	$0
16	$59,000	$500,000	0.576706	$34,026	$288,353
17	$59,000	$0	0.557204	$32,875	$0
18	$59,000	$0	0.538361	$31,763	$0
19	$59,000	$0	0.520156	$30,689	$0
20	$59,000	$0	0.502566	$29,651	$0
21	$59,000	$500,000	0.485571	$28,649	$242,785
22	$59,000	$0	0.469151	$27,680	$0
23	$59,000	$0	0.453286	$26,744	$0
24	$95,000	$0	0.437957	$41,606	$0
25	$59,000	$0	0.423147	$24,966	$0
26	$59,000	$800,000	0.408838	$24,121	$327,070
27	$59,000	$0	0.395012	$23,306	$0
28	$59,000	$0	0.381654	$22,518	$0
29	$59,000	$0	0.368748	$21,756	$0
30	$59,000	$0	0.356278	$21,020	$0
31	$59,000	$500,000	0.344230	$20,310	$172,115
32	$59,000	$0	0.332590	$19,623	$0
33	$59,000	$0	0.321343	$18,959	$0
34	$95,000	$0	0.310476	$29,495	$0
35	$59,000	$0	0.299977	$17,699	$0
36	$59,000	$500,000	0.289833	$17,100	$144,916
37	$59,000	$0	0.280032	$16,522	$0
38	$59,000	$0	0.270562	$15,963	$0
39	$59,000	$0	0.261413	$15,423	$0
40	$59,000	$0	0.252572	$14,902	$0
41	$59,000	$800,000	0.244031	$14,398	$195,225
42	$59,000	$0	0.235779	$13,911	$0
43	$59,000	$0	0.227806	$13,441	$0
44	$95,000	$0	0.220102	$20,910	$0
45	$59,000	$0	0.212659	$12,547	$0
46	$59,000	$500,000	0.205468	$12,123	$102,734
47	$59,000	$0	0.198520	$11,713	$0
48	$59,000	$0	0.191806	$11,317	$0
49	$59,000	$0	0.185320	$10,934	$0
50	$59,000	$0	0.179053	$10,564	$0
			Total Present Worth:	$1,472,361	$2,910,998
			CRF (50 years @ 3.500% (FY14)):	0.042634	
			Average Annual Maintenance Savings:	**$63,000**	**$124,000**

Table B-39 presents a summary of the combined selected plan by community. The estimated average annual benefits include storm damage reduced and local costs forgone or reduced maintenance costs from a 16' dune and 75' berm in North Wildwood with excess sand conveyed from Wildwood and an engineered 16' dune and enduring berm to supplement oceanfront protection in Wildwood, Wildwood Crest, and Lower Township. The estimated costs include initial construction, periodic nourishment, and interest during construction.

Table B-39
NORTH WILDWOOD, WILDWOOD, AND WILDWOOD CREST/LOWER TOWNSHIP SUMMARY OF AAB, AAC, NET BENEFITS AND BCR FOR THE SELECTED PLAN

Community	Cell	Selected Plan	AAB	AAC	Net Benefits	BCR
North Wildwood	1-2	16' Dune, 75' Berm	$2,478,000	$1,831,000	$647,000	1.4
Wildwood	3	16' Dune	$1,243,000	$117,000	$1,126,000	10.6
Wildwood Crest/ Lower Township	4-6	16' Dune	$674,000	$132,000	$542,000	5.1
The Wildwoods	1-6	16' Dune, 75' Berm; 16' Dune	$4,395,000	$2,080,000	$2,315,000	2.1

6.3 INCIDENTAL BENEFITS

6.3.1 Recreation Benefits

Beaches are consistently the number one travel destination in New Jersey. Tourist dollars contribute directly and indirectly to the regional economy. In 2008, the New Jersey Division of Travel and Tourism reported that travel and tourism generated 359,000 jobs in the state with a total payroll of $11.8 billion.

The Rutgers State University completed in 1994, for previous New Jersey coastal studies, a contingent valuation method survey for the New Jersey Department of Environmental Protection and Energy and the U.S. Army Corps of Engineers (Corps) to determine willingness to pay for the existing beach and an enhanced beach. This was done on a regional basis, encompassing the major beach communities of the New Jersey Atlantic coast such as the communities of Absecon Island, Seven Mile Island, Brigantine, as well as Stone Harbor and Avalon which is just north of the *Wildwoods*. The survey was designed in accordance with the NED Procedures Manual – Recreation II (A Guide for Using the Contingent Value Methodology in Recreation Studies). The original report is included as an attachment to this appendix. The survey consisted of 1,063 interviews of a random sample of recreational beach users. The interviews were conducted in person on the beach. The survey scope was intended for use with all South Jersey shore feasibility studies. The *Wildwoods* is also close, both qualitatively and geographically, to Stone Harbor therefore, it is reasonable that survey results can be representative of the conditions on the island.

Beachgoers were asked to indicate how important different factors were in deciding whether to visit a New Jersey beach. Respondents voiced similar desires. The primary factors of consideration were the quality of the beach scenery, the maintenance of the beach, the width of the beach, the number of lifeguards, and the family-friendliness of the beach.

The survey also used a density measure developed in cooperation with the Corps to determine if crowding was a problem. It was found that over 60% of the time there was at least several yards of space between beach towels or blankets, and only 7% of the time was it very crowded (only 2 feet between towels). Further it was determined that crowding was not considered a very important issue to the majority of beachgoers by asking respondents how important being alone is and how important is it to be with a large number of people. As might be expected, areas with more crowding tended to be frequented by people who like large numbers. People who like to be alone frequented areas that tended to have little crowding.

To estimate the value of the beach, as it exists currently, an iterative bidding process was applied. Beachgoers were first asked if a day at the beach would be worth $4.00 to each member of their household. Based on their answers, they were then asked progressively higher or lower amounts until the amount they value the beach was determined. Using this method it was found that the average value of a day at the beach is $4.22.

Beachgoers were asked how much more they were willing to pay if the beach were widened. While the majority was unwilling to pay any extra, approximately 16% of Stone Harbor beachgoers were willing to pay, on average, $2.47 more per visit. This would be equivalent to an average of $0.39 for all beachgoers. This willingness to pay value for Stone Harbor was adopted because it is the nearest beach to North Wildwood. This value was indexed to a June 2007 price level from an October 1994 price level for the purposes of this study. Since access to the beaches of the *Wildwoods* is free, the number of visitor days was obtained from City of North Wildwood estimates and by comparing beach size within the project area of North Wildwood with that of Stone Harbor. The total number of visitor days for the beach within the project area is estimated at 1,000,000.

Benefits were not found to accrue from increased capacity because crowding was found not to be a significant factor and the selected plan involves conveying accreted sand from Wildwood and Wildwood Crest. Removal of sand from the down drift areas is not expected to negatively affect the recreation experience because the beaches are extremely wide and require beachgoers to walk quite some distance to reach the water's edge. In addition, alleviating the negative impacts of ponding is expected to improve the appearance of the beach. Benefits do, however, arise from an increase in the value of the recreational experience in North Wildwood.

Benefits resulting from this increase in recreational experience were calculated by multiplying the average daily value per beachgoer by the number of visitor days within the project area. This gives total recreational benefits of $580,000, as displayed in Table B-40.

Table B-40
RECREATION VISITOR DAYS & BENEFITS
(June 2007 Price Level)

Community	Visitor Days	Day Value	Total Value
North Wildwood	1,000,000	0.58	$580,000

There is a very low risk and uncertainty to the recommendation for the selected plan of improvement from the derivation of the recreation benefits by utilizing the somewhat dated Rutgers University Contingent Valuation Method (CVM) report as a key input. This report was contracted by the Philadelphia District to Rutgers University, and was spearheaded by a professor with substantial CVM expertise. The Rutgers University effort entailed a large random

sample of interviews with approximately 1000 New Jersey beachgoers. The initial starting point for a visitor day beach experience valuation of $4.22 from the Rutgers report was within the lower range of valuation that could be expected to be applied from an alternate recreation benefit evaluation technique, Unit Day Values. The incremental increase in the willingness to pay, applied as the basis for benefits for an improved recreational experience with a widened with project condition beach berm, was a modest $0.69 per person per day (2014 PL). Also, the recreation benefits are strictly a secondary incidental project purpose for this study and were not used in the formulation/optimization process. The selected plan has positive BCRs for all the communities within the project area (without recreation benefits): North Wildwood (1.4); Wildwood (10.6); Wildwood Crest/Lower Township (5.1); and the Total Project (2.1). The recreation average annual benefits of $693,000 represent only 11% of the total project average annual benefits of $6,253,000. The impact of adding the recreation benefits at the end of the formulation process resulted in the project Benefit-Cost Ratio being adjusted slightly upward from 2.1 to 2.3.

6.3.2 Benefits During Construction

The proposed project will be constructed over nine months with an additional month before and after construction for mobilization and demobilization. Portions of the beach will be fully nourished before the project is completed in its entirety. The portions of the beach nourished early in the construction phase will provide storm damage reduction benefits. Table B-41 shows the monthly benefits during construction (BDC) and the resulting estimated average annual benefit of $86,000.

Table B-41
BENEFITS DURING CONSTRUCTION (BDC)

		Discount Rate:	3.500%	
		Price Level:	Jun-2007	
Construction Month	**Work**	**Monthly Benefit**	**Interest Factor**	**Total Benefit**
1	Mob	$0	1.026137	$0
2	The Wildwoods	113,000	1.023199	$115,622
3	The Wildwoods	113,000	1.020270	$115,291
4	The Wildwoods	206,000	1.017349	$209,574
5	The Wildwoods	206,000	1.014437	$208,974
6	The Wildwoods	310,000	1.011533	$313,575
7	The Wildwoods	326,000	1.008637	$328,816
8	The Wildwoods	363,000	1.005750	$365,087
9	Demob	364,000	1.002871	$365,045
		Total Benefits During Construction:		$2,021,983
		Capital Recovery Factor (50yrs. @3.500% (FY14)):		0.042634
			BDC (Rounded):	**$86,000**

7.0 SELECTED PLAN COMBINATION

Plan C (16' dune, 75' berm) meets the NED criteria of maximization of net benefits within the 4-year periodic nourishment cycle band and, therefore, is the selected plan for North Wildwood. The backpass method of delivering sand to North Wildwood and the implementation of **Plan CC (16' dune)** in Wildwood, Wildwood Crest, and Lower Township will provide additional benefits to those communities. Costs and benefits for the combined selected plan are shown at a March 2014 price level and 3.500% discount rate in the following tables.

7.1 Interest During Construction

Table B-42 displays the calculations for interest during construction. The duration of construction for the project is estimated at nine months. It is assumed the construction costs would be evenly distributed over this period.

Table B-42
INTEREST DURING CONSTRUCTION (IDC)

Annual Discount Rate (FY14):			3.500%	
Monthly Interest Factor (FY14):			0.00287	
Price Level:			Mar-14	
IDC -	9	Months	Interest Factor	Total Cost
Month	1	$5,185,854	0.026137	$135,542
Month	2	$2,052,449	0.023199	$47,615
Month	3	$2,052,449	0.020270	$41,604
Month	4	$2,052,449	0.017349	$35,609
Month	5	$2,052,449	0.014437	$29,632
Month	6	$2,052,449	0.011533	$23,671
Month	7	$2,052,449	0.008637	$17,728
Month	8	$2,052,449	0.005750	$11,802
Month	9	$2,052,449	0.002871	$5,892
Total First Cost:		$21,605,444		
			Total Investment Cost:	$349,094
			Rounded:	$349,000

7.2 Average Annual Costs

Table B-43 displays the calculations for average annual costs. Additional average annual project costs include expenditures for monitoring as shown in Table B-44.

Table B-43
BEACHFILL & NOURISHMENT
PRESENT WORTH ANALYSIS

	Base Year:		2016	
	Discount Rate (FY14):		3.500%	
	Price Level:		Mar-14	
TYPE	**YEAR**	**COST**	**PW FACTOR**	**PW COST**
First Cost	0	20,331,933	1.000000	20,331,933
Real Estate	0	1,273,511	1.000000	1,273,511
IDC	0	349,094	1.000000	349,094
Periodic Nourishment	4	5,952,431	0.871442	5,187,200
Periodic Nourishment	8	5,952,431	0.759412	4,520,345
Periodic Nourishment	12	6,191,877	0.661783	4,097,681
Periodic Nourishment	16	6,191,877	0.576706	3,570,892
Periodic Nourishment	20	6,191,877	0.502566	3,111,826
Major Rehabilitation	24	7,920,450	0.437957	3,468,818
Periodic Nourishment	28	6,191,877	0.381654	2,363,157
Periodic Nourishment	32	6,191,877	0.332590	2,059,355
Periodic Nourishment	36	6,191,877	0.289833	1,794,609
Periodic Nourishment	40	6,191,877	0.252572	1,563,898
Periodic Nourishment	44	6,191,877	0.220102	1,362,846
Periodic Nourishment	48	6,191,877	0.191806	1,187,642
Total Cost				$56,242,805
	Capital Recovery Factor (3.500%, 50 yrs):			0.042634
			Average Annual Costs:	$2,397,839
			Rounded:	$2,398,000

Table B-44

MONITORING COSTS
PRESENT WORTH COST ANALYSIS

Base Year: 2016
Discount Rate (FY14): 3.500%

TYPE	YEAR	COST	PW FACTOR	PW COST
Monitoring	0	0	1.000000000	0
Monitoring	1	214,500	0.966183575	207,246
Monitoring	2	150,000	0.933510700	140,027
Monitoring	3	90,500	0.901942706	81,626
Monitoring	4	215,500	0.871442228	187,796
Monitoring	5	146,000	0.841973167	122,928
Monitoring	6	90,500	0.813500644	73,622
Monitoring	7	90,500	0.785990961	71,132
Monitoring	8	215,500	0.759411556	163,653
Monitoring	9	146,000	0.733730972	107,125
Monitoring	10	90,500	0.708918814	64,157
Monitoring	11	90,500	0.684945714	61,988
Monitoring	12	215,500	0.661783298	142,614
Monitoring	13	146,000	0.639404153	93,353
Monitoring	14	90,500	0.617781790	55,909
Monitoring	15	90,500	0.596890619	54,019
Monitoring	16	215,500	0.576705912	124,280
Monitoring	17	146,000	0.557203779	81,352
Monitoring	18	90,500	0.538361140	48,722
Monitoring	19	90,500	0.520155690	47,074
Monitoring	20	215,500	0.502565884	108,303
Monitoring	21	146,000	0.485570903	70,893
Monitoring	22	90,500	0.469150631	42,458
Monitoring	23	90,500	0.453285634	41,022
Monitoring	24	215,500	0.437957134	94,380
Monitoring	25	146,000	0.423146989	61,779
Monitoring	26	90,500	0.408837671	37,000
Monitoring	27	90,500	0.395012242	35,749
Monitoring	28	215,500	0.381654340	82,247
Monitoring	29	146,000	0.368748155	53,837
Monitoring	30	90,500	0.356278411	32,243
Monitoring	31	90,500	0.344230348	31,153
Monitoring	32	215,500	0.332589709	71,673
Monitoring	33	146,000	0.321342714	46,916
Monitoring	34	90,500	0.310476052	28,098
Monitoring	35	90,500	0.299976862	27,148
Monitoring	36	215,500	0.289832717	62,459
Monitoring	37	146,000	0.280031610	40,885
Monitoring	38	90,500	0.270561942	24,486
Monitoring	39	90,500	0.261412505	23,658
Monitoring	40	215,500	0.252572468	54,429
Monitoring	41	146,000	0.244031370	35,629
Monitoring	42	90,500	0.235779102	21,338
Monitoring	43	90,500	0.227805895	20,616
Monitoring	44	215,500	0.220102314	47,432
Monitoring	45	146,000	0.212659241	31,048
Monitoring	46	90,500	0.205467866	18,595
Monitoring	47	90,500	0.198519677	17,966
Monitoring	48	215,500	0.191806451	41,334
Monitoring	49	146,000	0.185320243	27,057
Monitoring	50	90,500	0.179053375	16,204
		$6,874,500	TOTAL	$3,276,658
Capital Recovery Factor (50 Years @ 3.500%)				0.04263371
		AVERAGE ANNUAL MONITORING COSTS:		$139,696
			Rounded:	$140,000

7.3 Benefit-Cost Summary

Annualized costs are displayed by category in Table **B-45**. The selected plan is expected to provide **$6,253,000** in storm damage reduction and other NED benefits.

Table B-45
BENEFITS AND COSTS FOR THE SELECTED PLAN

DISCOUNT RATE (FY14)	3.50%	
PERIOD OF ANALYSIS	50 YEARS	
PRICE LEVEL	March 2014	
BASE YEAR	2016	
AVERAGE ANNUAL BENEFITS:		
Storm Damage Reduction	4,095,000	
Local Costs Forgone	1,363,000	
Recreation	693,000	
Benefits During Construction	102,000	
TOTAL NED BENEFITS		**$6,253,000**
TOTAL COSTS:		
Initial Construction Costs (including Real Estate)	$21,605,000	
Interest During Construction	349,000	
Periodic Nourishment (cycles 1, 2)	5,952,000	
Periodic Nourishment (other cycles)	6,192,000	
Major Rehabilitation (year 24)	7,920,000	
Average Annual Construction Costs		$ 2,398,000
Average Annual Monitoring Costs		140,000
Average Annual OMRR&R Costs		150,000
TOTAL AVERAGE ANNUAL COSTS		**$ 2,688,000**
NET BENEFITS		**$ 3,565,000**
BENEFIT-COST RATIO		**2.3**
BENEFIT-COST RATIO (computed at 7%)		**1.9**
RESIDUAL DAMAGES	**$ 5,818,000**	

8.0 RISK AND UNCERTAINTY ANALYSIS

Modeling a complex and dynamic coastal environment is subject to various changes and over time there is variation in economic conditions as well as hydraulic and hydrological parameters. Detailed information has been collected to the extent defined by the scope of work for the feasibility analysis. The analysis used statistical modeling techniques that took into account probability of occurrence of storm events, mechanism of storm damages, and resources that take into account regional labor and construction rates.

Approach: Potential sources of risk and uncertainty were reviewed, a damage level risk matrix was developed, and an extensive sensitivity analysis was conducted. The variables included structure elevations and square footage, discount rate, depreciated replacement cost value, content-to-structure percentage as well as other components of the damage analysis. The level of uncertainty of several components was considered to be low because data was collected with a relatively high degree of precision.

Assumptions: The previously provided best estimates of coastal storm parameters and economic parameters serve as the mean condition. The economic risk and uncertainty analysis used the new control files from the Empirical Simulation Technique (EST), which was explained in the H&H Risk and Uncertainty Methodology Section of this report, as model inputs for the COSTDAM modeling while performing a sensitivity analysis by varying key economic parameters that could affect AAD, AAB, Net Benefits and BCRs. Discount rate, depreciated replacement cost value, content-to-structure percentage, and the curves for stage damage were varied for the economic portion of the analysis. The risk and uncertainty evaluation was also performed over a 50-year period of analysis, at the plan formulation discount rate and price level.

Background: Seven frequency storm events (5, 10, 20, 50, 100, 200, and 500 year events) from the SBEACH model were provided for calculation of erosion, wave and inundation damage to structures, infrastructure and improved property. The calculations were performed using COSTDAM (**CO**astal **ST**orm **D**amage **A**ssessment **M**odel). COSTDAM reads an ASCII 'Control' file which contains the storm frequency parameters for each cell and an ASCII 'Structure' file which contains information for each structure. Additional files were created to evaluate the lower and upper 90% confidence interval curve values for the H&H parameters and the economic variables.

Methodology: The economic risk and uncertainty analysis used the new control files from the EST-generated 90% confidence interval bands as model input to determine the "low" and "high" risk damage scenarios while varying key economic parameters. The economic parameters were varied independently and in a multiple-factor sensitivity analysis together with the 90% confidence interval bands determined in the H&H analysis. The following economic components of the analysis were adjusted in the sensitivity analyses:

- It is recognized that the discount rate is likely to change. The federal discount rate is established annually and according to law is not allowed to vary by more than one quarter of one percentage point in any fiscal year. The discount rate was varied by -¼ from the baseline rate in effect at the time of the risk and uncertainty analysis for the "low" risk scenario and by +¼ for the "high" risk scenario;

- The Marshall & Swift Valuation Service was used for estimating depreciated replacement cost values from a combination of structure characteristics such as square footage, construction material, foundation type, and systems. The current depreciated replacement cost values serve as the mean value for each structure. Typically, depreciated replacement cost values have been modified by +/- 10% in a sensitivity analysis to determine the "low" and "high" risk scenarios. This approach was employed to examine the effects on net benefits of the lower and upper 90% confidence interval bands determined in the H&H analysis. Depreciated replacement cost values were also varied for the most likely case scenario independently from the revised H&H parameters;

- The content-to-structure percentage was established using existing percentages from previous studies on the topic. Empirical data established a content value to be approximately 40% of structure value in primary homes and 15 to 20% of structure value in vacation homes. Nearly 70% of the residential structures in North Wildwood are vacation or rental homes. A conservative weighted content-to-structure value of 25% was adopted because it was determined that use of a 40% content-to-structure ratio would overestimate damage potential in a predominately vacation coastal community. The current content-to-structure value ratio of 25% for district coastal studies represents the mean. A sensitivity to show the impact of varying the ratio to 10% for the "low" risk scenario and 40% under the "high" risk scenario was performed. The content-to-structure ratio was also varied for the most likely scenario independently from the EST low and high H&H model results; and

- The stage damage curves for the mean condition were varied by a reasonable level to determine the results' sensitivity to changes in this inundation damage variable. Reasonable levels of variation were obtained by prorating the original stage damage curves by percentage of change for minimum and maximum saltwater curves empirically observed in another coastal area. The significant coastal hydraulics parameters which determine erosion and wave damage vulnerability were addressed within the SBEACH and EST models which are incorporated in the storm damage analysis through revised control files, the engineering component of the program. These critical response parameters include, as explained in the H&H Risk and Uncertainty Methodology Section of this report, sea level rise (SLR), eroded beach volume, shoreline retreat, wave height above dune, and other variables. Sea level rise of approximately 0.66 feet is incorporated during development of the ocean stage frequency analysis which is integrated with the coastal engineering parameters of the model as it calculates damages for each year over the period of analysis.

The combined impact of these changes was applied to the new input files from the EST lower and upper limit 90% confidence interval curves to determine a range of average annual damage for the without project condition and the selected plan.

The COSTDAM model evaluates structure erosion based on the presence of piles for all structures that are identified with a pile foundation. If a structure is on piles, the land below the structure must have eroded through the entire footprint of the structure before total damage is claimed. Prior to this, the percent damage claimed is equal to the linear proportion of erosion under the structure's footprint relative to the total damage point. Pile depths were not evaluated as part of this analysis because actual pile depth or range is not a model parameter. Therefore,

the R&U for this variable could not be addressed within the confines of the COSTDAM model. In addition, pile depth for each inventoried structure was not readily available from the municipalities. Pile depth varies for each structure and is dependent upon soil conditions, structure characteristics, and regulations in place at the time the structure was built. Also, variation in the first floor elevation surveys was not evaluated. The level of uncertainty in the parameters of structure first floor elevation and square footage is considered low. Professional surveyors conducted the elevation survey on a structure by structure basis and the square footage was derived from a geographic information systems (GIS) database.

Due to the effects of long term erosion resulting in a receding shoreline an additional model was set up to evaluate the damage effect of long term erosion which includes the impact of sea level rise. Long term erosion is a dynamic process, however. From a historical perspective this process has been checked at a certain point through local intervention to preclude further erosion as the natural erosion process approaches the footprint of a structure such as a bulkhead. For modeling purposes the natural long term erosion process is assumed not to retreat beyond the toe of the bulkhead. The limit of this condition is realized approximately five years from the base year. This retreat occurs at different rates in different sections of the North Wildwood oceanfront and was taken into account in the sensitivity analysis. The additional modeling allowed assessing expected average annual (EAD) damages for the 50-year period of analysis, weighing in future damages for the range of exceedance probabilities in the computation of EAD. Long term erosion potential is most pronounced in the area adjacent to Hereford Inlet.

The landfall of Hurricane Sandy was one critical parameter in determining which portions of the shore would be most damaged. A plethora of other storm characteristics, shoreline conditions, property location, damage susceptibility, and many other factors combined to establish the level of damage experienced. Areas north of Sandy's landfall received the most destructive impact of the storm, while the areas south of landfall were affected to a lesser extent. The uncertainty and risks associated with coastal storms was clearly displayed in the fall of 2012 when Sandy hit. Commitments to following resilient rebuilding techniques and assigning appropriate risk premiums in flood insurance policies over time have been adopted. A concerted effort has also been continued in some areas and begun in others to protect the shoreline and implement sustainable solutions that can reduce damage. Hurricane Sandy's impact will be felt for many years as stakeholders prepare for the eventuality of future storms.

Figure B-13 indicates the potential damage level to oceanfront and nearshore structures by overlaying a hypothetical future storm comparable to Superstorm Sandy with a landfall south of the study area. It displays potential total damages under future conditions without and with the tentatively selected plan for inventoried structures.

Table B-46 displays a range of hurricane storm damage reduction benefits from a low of $1,043,000 to a high of $34,123,000, compared to the most likely scenario benefit of $4,030,000 (shown in Table B-38). The result of incorporating the cost component of the selected plan, including discount rate variation, in the sensitivity analysis is shown in Table B-47. Net benefits of the different scenarios range from $2,825,000 to $33,035,000 for ten of the twelve sensitivities. The two scenarios with the lowest net benefits are outweighed by the costs which were not varied.

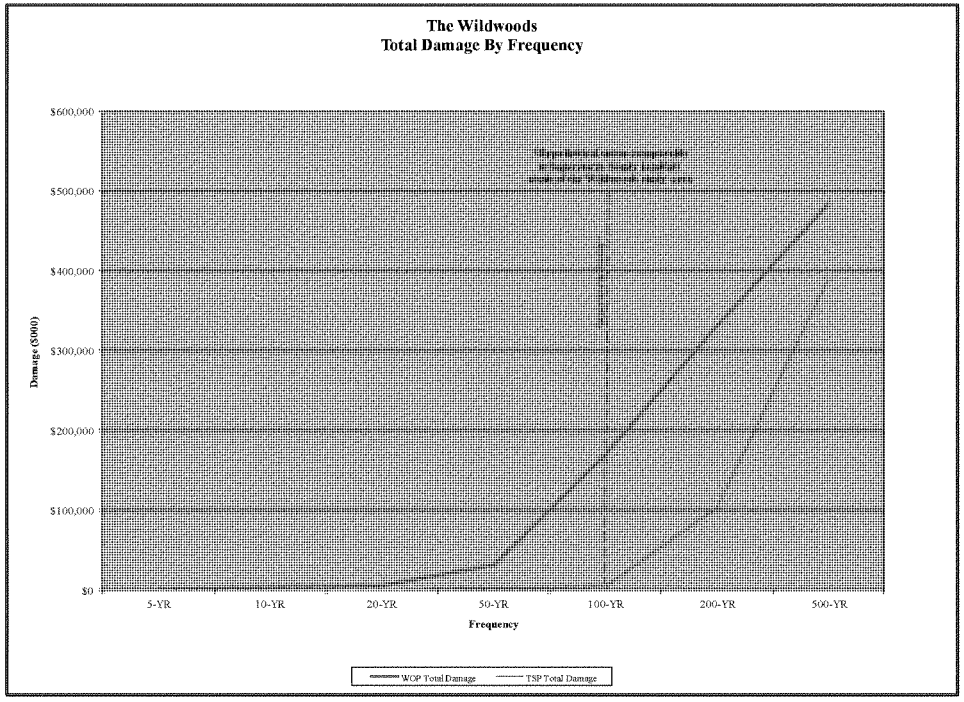

The Wildwoods
Total Damage By Frequency
$600,000
$500,000
$400,000
$300,000
$200,000
$100,000
$0
Damage ($000)
5-YR
10-YR
20-YR
50-YR
100-YR
200-YR
500-YR
Frequency
WOP Total Damage
TSP Total Damage

Figure B-13

Table B-46
SUMMARY OF RISK AND UNCERTAINTY ANALYSIS RESULTS ORDERED
ANNUALIZED HSDR BENEFITS FOR
PLAN C: 16' DUNE; 75' BERM - NORTH WILDWOOD
PLAN CC: 16' DUNE - WILDWOOD & WILDWOOD CREST
(In $000, 4.125% Discount Rate; June 2007 Price Level)

Category	Combined Low	EST Lower	CSR 10%	SDRCV -10%	DDC Min	Most Likely	SDRCV +10%	DDC Max	CSR 40%	EST Upper	Combined High
Storm Damage Reduction											
Erosion	$81	$99	$1,290	$1,319	$1,462	$1,466	$1,612	$1,436	$1,625	$3,512	$4,309
Inundation	$499	$866	$1,580	$1,590	$1,275	$1,766	$1,944	$2,378	$2,084	$16,567	$25,918
Wave	$459	$580	$1,591	$1,629	$1,810	$1,810	$1,991	$1,810	$2,047	$3,161	$3,895
Total Average Annual Benefits	$1,040	$1,545	$4,460	$4,539	$4,547	$5,042	$5,547	$5,624	$5,756	$23,240	$34,123

Risk & Uncertainty Sensitivity Notes:
Combined Low *- EST Lower Limit 90% Confidence Interval, 10% Content-to-Structure Ratio, 10% Decrease in Structure Depreciated Replacement Cost Value, Minimum Stage-Damage Curve*
EST Lower *- H&H Lower Limit 90% Confidence Interval Parameters*
CSR10% *- Content-to-Structure Ratio 10% of Structure Depreciated Replacement Cost Value*
SDRCV-10% *- Structure Depreciated Replacement Cost Value Decreased by 10%*
DDCMin *- Minimum Depth-Damage Curve*
Most Likely *- Mean Condition Scenario*
SDRCV+10% *- Structure Depreciated Replacement Cost Value Increased by 10%*
DDCMax *- Maximum Depth-Damage Curve*
CSR40% *- Content-to-Structure Ratio 40% of Structure Depreciated Replacement Cost Value*
EST Upper *- H&H Upper Limit 90% Confidence Interval Parameters*
Combined High *- EST Upper Limit 90% Confidence Interval, 40% Content-to-Structure Ratio, 10% Increase in Structure Depreciated Replacement Cost Value, Maximum Stage-Damage Curve*

Columns may not add exactly due to rounding; discount rate sensitivity not included in the above table

902

Table B-47
SUMMARY OF RISK AND UNCERTAINTY ANALYSIS RESULTS
ANNUALIZED NED BENEFITS AND COSTS FOR
PLAN C: 16' DUNE; 75' BERM – NORTH WILDWOOD
PLAN CC: 16' DUNE – WILDWOOD AND WILDWOOD CREST

	Most Likely Scenario	Discount Rate		Structure Depreciated Replacement Cost Value		Content-to-Structure Ratio		Stage Damage Curves		EST Confidence Interval		Combined Variations	
Category		3⅞%	4⅞%	-10%	+10%	10%	40%	Min	Max	-90%	+90%	Low	High
Storm Damage Reduction:	$5,042	$5,042	$5,042	$4,539	$5,547	$4,460	$5,756	$4,547	$5,624	$1,545	$23,240	$1,040	$34,123
Benefits During Construction:	93	89	97	84	102	82	106	84	104	28	429	19	629
Recreation:	580	580	580	580	580	580	580	580	580	580	580	580	580
Total AAB:	$5,715	$5,711	$5,719	$5,203	$6,229	$5,122	$6,442	$5,211	$6,308	$2,153	$24,249	$1,639	$35,332
Avg. Ann. Construction Costs:	$2,178	$2,519	$2,602	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178	$2,178
Avg. Ann. Monitoring Costs:	119	119	119	119	119	119	119	119	119	119	119	119	119
Total AAC:	$2,297	$2,638	$2,721	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297	$2,297
Benefit-Cost Ratio:	2.5	2.2	2.1	2.3	2.7	2.2	2.8	2.3	2.7	0.9	10.6	0.7	15.4
Net Benefits:	$3,418	$3,073	$2,998	$2,906	$3,932	$2,825	$4,145	$2,914	$4,011	($ 144)	$21,952	($ 658)	$33,035

Appendix B – Supplement

Contingent Value Method (CVM) Recreation Analysis

REPORT ON FIVE SURVEYS
FOR THE UNITED STATES ARMY CORPS OF ENGINEERS

ABSECON ISLAND AND SEVEN MILE ISLAND, NEW JERSEY:
STONE HARBOR, AVALON, ATLANTIC CITY, LONGPORT, MARGATE, VENTNOR

SURVEYS OF BEACH USERS, BUSINESSES, AND HOMEOWNERS

The Forum for Policy Research and Public Service
Rutgers University, Camden

Data Analysis and Report: Ross Koppel, Ph.D.

November, 1994

In the summer of 1994, The Forum for Policy Research and Public Service of Rutgers University (Camden) administered three surveys to samples of beach users, of businesses and of homeowners in the New Jersey communities of Stone Harbor, Avalon, Atlantic City, Longport, Margate, Ventnor.

The surveys examine respondents' valuations of the beach, the desired characteristics and facilities of a beach, the perceived impact of the beach on properties and businesses, and a variety of demographic measures.

Survey Administration:

The beach user survey was administered to a random sample of over one thousand people. Interviewers were trained to visually segment the beach into strata starting at the ocean. Strata were sampled according to their density (number of people). In addition, interviewers were trained to seek representative weightings of gender, age, and group size. Review of demographic data, of the beach use pattern data (distance from ocean and distribution of people) and of interviewer codes reveals no significant systematic skew or bias.

The homeowner survey was at first administered face-to-face. The process was laborious because so many residents were not at home (i.e., we met renters instead of owners, or homeowners were in their a non-shore house, at work, or on the beach). In consultation with the Corps, it was decided that we would use telephone interviews.

The business survey was generally administered face-to-face. At off-peak hours, business managers and owners are usually "in" and available.

Pretesting

Each of the research instruments was pretested on its target population. Each survey went through several iterations. Fortunately, because the populations were large, we were able to modify the questionnaires and retest them on new respondents. Each iteration of the three main questionnaires (beach users, homeowners, and businesses) were pretested on samples of 25 to 55 people. As with our other surveys, the sample presented here does not incorporate any of the responses from the pretest questionnaire.

Role of the Corps

We would like to thank the members of the Economics and Social Analysis Branch of the U.S. Army Corps of Engineers (Philadelphia District) for their help in developing the research instruments. They provided several examples of questionnaires used by earlier researchers in addition to useful background papers and methodological guides from previous researchers and from Corps documents. They also maintained a willingness to consider our efforts at survey improvement or enhancement. We appreciated their reviews of the many versions of each of the interview schedules that were eventually approved and administered. More important, we also appreciated their suggestionsand refinements to each document.

Training, Supervision and Additional Research

The interviewers were initially trained by Dr. Ross Koppel. Mr. Stephen Kucharski supervised the interviewers, coordinated their work, and provided additional training. Mr. Kucharski was also responsible for the SPSS data formatting, for supervising data entry, and for collection of additional data from State, Federal and local sources.

Structure of This Report

I. In the first section, we analyze the responses to the Beach Users Survey from respondents at the six communities on Absecon and Seven Mile Island (N = 1063).

Frequency distributions and crosstabulations of every item by several key variables have been calculated and are found in the appendix. They are also presented on disk. The following is a list
of the crosstabulations we have calculated. Every variable is crosstabulated by:

Weather (Sunny vs. All Other)
Density of Beach Use (Categories 1 and 2 ["Light Use"] vs. 3, 4, 5 ["Full or More Crowded"])
Community location (Stone Harbor, Avalon, Atlantic City, Longport, Margate, Ventnor)
Yearly Visit Pattern (Visit Every Year; Most or Some Years; First Visit)
Days On Beach (Few -- 1-14; Many -- 15-30; Most -- 31-98)

Own or Rent Property at Shore
Year of Purchase [for owners] ("New" 1985-1994; "Old" 1900 to 1984)
Resident Status (Permanent; Staying for at least a week; Staying less than a week)
Income (Less than $49,999; $50,000 and over)
Education (High School or less vs. Some College or more)
Age (categorized in two formats because the age breakdowns for residents is skewed sharply to the right -- they tend to be over 60 years old)
Age-1 (under 60 vs. 60 and older)
Age-2 (under 40 vs. 40 and older)

As noted, the Appendix presents these crosstabulations for every question in the questionnaire. These data are also provided on disk in SPSS system files.

II. The second section presents the data from the interviews with Business Managers and Owners in the six towns in Absecon and Seven Mile Island. As with the previous findings, the appendix provides a range of crosstabulations in hard copy, and the accompanying disk files (SPSS system files) contain both the crosstabs and a full copy of the data.

The Survey of Businesses is a comparatively small sample (N =156). After review of the data, we have calculated and provide the following two crosstabulations (for every variable):

Business Schedule (Open all year vs. Open summer only)
No. of Employees (0-9 vs. 10-125)

III. The Survey of Homeowners is comprised of two samples:

1. a survey of homeowners from face-to-face interviews and via telephone interviews with residents; and

2. the subset of beach users who owned homes in the shore communities. (This latter group received a separate battery of questions from within the beach users' survey.)

Wherever possible and logical, we combine results from the two instruments. The sample size of the direct survey of homeowners is 251; the sample size of homeowners who were interviewed on the beach is 370. The combined sample size is 621. As with all the data, an SPSS file on disk is also provided.

The following crosstabulations were calculated for the homeowners' data:

Age (under 60 vs. 60 and older)
Education (High School or less vs. Some College or more)
Year of Purchase ("New" 1985-1994; "Old" 1900 to 1984)
Number of Blocks from Beach (1 or less vs more than 1)

Length of Stay (Permanent Resident vs. other)

IV. In the fourth section we use the beach valuation data from the surveys of beach users, businesses and homeowners to calculate a combined valuation figure for the beach and its impact on the communities.

V. The survey of Brigantine Beach users comprises the fifth section. This survey is somewhat shorter than the general beach users survey and addresses issues requested by the Corps. Many of the questions, however, are identical to those used in the other questionnaires.

The sample size is 255, and SPSS files on disk are provided.

VI. A complete copy of all questionnaires is included in section VI.

The Beach Users Survey
The Business Owners/Managers Survey
The Homeowners Survey
The Brigantine Beach Users Survey

Appendix 1 (Book "A") -- Frequency Distributions of:
1.1. The Beach Users Survey
1.2. The Business Owners/Managers Survey
1.3. The Homeowners Survey
1.4. The Brigantine Beach Users Survey

Appendix 2 -- Cross Tabulations (See full listing below)

Appendix 3 -- Digital: SPSS files of all data

APPENDIX TABLE SETS: CROSSTABULATION OF SURVEY DATA

BEACH USERS

APPENDIX
BOOK NO.

1 LOCATION (SIX COMMUNITIES' BEACHES) BY ALL OTHER VARIABLES

1 SHORE VISITING PATTERNS BY ALL OTHER VARIABLES
Recoded: Every year (1); Most or some years (2,3); First visit (4)

2 BEACH USER DENSITY BY ALL OTHER VARIABLES
Recoded: Few (1,2) vs. Crowded

2 WEATHER BY ALL OTHER VARIABLES
Recoded: Sunny (1) vs. All other (2,3,4)

2 DAYS SPENT ON THE BEACH BY ALL OTHER VARIABLES
Recoded: Few (1 to 14); Many (15 to 30); Most (31 to 98)

3 OWN HOME V. RENT BY ALL OTHER VARIABLES

3 YEAR OF HOME PURCHASE BY ALL OTHER VARIABLES
Recoded: "New" -- 1985 to 1994; "Old" -- 1900 to 1984
[for homeowners only]

3 RESIDENT STATUS BY ALL OTHER VARIABLES
Recoded: Permanent (1); All Summer to More than a week (2 to 5); Few days (6,7)

4 EDUCATION BY ALL OTHER VARIABLES
Recoded: High School or less (1,2,3,4) vs. Some College or more (5,6,7)

4 INCOME BY ALL OTHER VARIABLES
Recoded: Income: Less than $49,999 (1); $50,000 and over

5 AGE BY ALL OTHER VARIABLES
Recoded in two formats:

Age-1: under 60 vs. 60 and older

Age-2: under 40 vs. 40 and older

BUSINESS OWNERS AND MANAGERS

6 BUSINESS SCHEDULE BY ALL OTHER VARIABLES
Open all year vs. Open summer only

6 NUMBER OF EMPLOYEES BY ALL OTHER VARIABLES
Recoded: Few (0 to 9) vs. Many (10 to 125)

HOMEOWNERS

7 AGE BY ALL OTHER VARIABLES
Recoded: under 60. vs 60 and older

7 LENGTH OF STAY BY ALL OTHER VARIABLES
Recoded: Permanent Resident vs. All other categories

7 EDUCATION BY ALL OTHER VARIABLES
Recoded: High School or less (1,2,3,4) vs. Some College or more (5,6,7)

7 YEAR OF HOME PURCHASE BY ALL OTHER VARIABLES
Recoded: "New" -- 1985 to 1994;
"Old" -- 1900 to 1984

7 DISTANCE FROM BEACH (No. of Blocks) BY ALL OTHER VARIABLES
Recoded: One or less vs. More than one

I. SURVEY OF BEACH USERS

ON ABSECON ISLAND AND SEVEN MILE ISLAND, NEW JERSEY: STONE HARBOR, AVALON, ATLANTIC CITY, LONGPORT, MARGATE, VENTNOR

Introduction

The analysis in this section generally follows the survey instrument. All of the substantive items in the survey are reviewed except a few concerning homeowners, which are fully discussed inSection III, in the review of homeowner data.

Administration of the Interviews

Month

The Survey was conducted during the summer of 1994. Over two-thirds of the interviews were administered in July. See Table 1.

Table 1
MONTH OF THE INTERVIEW

Value Label	Value	Frequency	Valid Percent	Cum Percent
JUNE	6	133	12.5	12.5
JULY	7	731	68.8	68.8
AUGUST	8	182	17.1	17.1
SEPTEMBER	9	17	1.6	1.6
Total		1063	100.0	100.0

Valid cases 1063 Missing cases 0

Day of Week

Intentionally, each day of the week was not equally represented in the sample. That is, if each day of the week were to account for exactly one-seventh of the sample, then the weekend would reflect 28.57% of the sample. Our sampling of the week, however, seeks to reflect the actual beach usage patterns. Thus, as can be seen in Table 2, the weekend accounts for 36.4% of the sample, rather than 28.57% of the sample.

Table 2
DAY OF THE WEEK

Value Label	Value	Frequency	Valid Percent	Cum Percent
SUNDAY	1	159	15.0	15.0
MONDAY	2	61	5.7	20.7
TUESDAY	3	97	9.1	29.8
WEDNESDAY	4	205	19.3	49.1
THURSDAY	5	141	13.3	62.4
FRIDAY	6	172	16.2	78.6
SATURDAY	7	228	21.4	100.0
	Total	1063	100.0	100.0

Time of Interview

Our earliest interview occurred at 09:45; our last interview was at 18:05. Most of the interviews were conducted in the afternoon. A full listing of the interview times is found in the Appendix.

Air Temperature

The median and modal temperature was 85 degrees Fahrenheit. Ninety-eight percent of the days were between 70 and 90 degrees Fahrenheit. (See Appendix for full listing.)

Water Temperature

The median water temperature was 65 degrees Fahrenheit. The low was 54 degrees F, the high was 75 degrees F. Note that the interviewers were instructed to request both air and water temperature readings from the life guards. They were not always exact.

Wind Speed

The median wind speed was 4.5 mph. The low was 0, the high was 15. Undoubtedly, there were days with higher wind speeds. But the beach tends to be less populated at such times. Note that as with temperature readings, the interviewers were also instructed to ask the life guards about wind speeds.

Weather

Almost three-fifths (59.6%) of the sample was collected during sunny weather; and about a quarter (23.8%) was collected on partly cloudy days. Our sampling focus, of course, was beach users, who tend to be on the beach in better weather. (See Table 3.)

Table 3
TYPE OF DAY

Value Label	Value	Frequency	Valid Percent	Cum Percent
SUNNY	1	634	59.6	59.6
PARTLY CLOUDY	2	253	23.8	83.4
CLOUDY	3	149	14.0	97.5
RAINY	4	27	2.5	100.0
	Total	1063	100.0	

Density of People on the Beach

We used a density measure developed for this study in cooperation with the Corps. As seen in Table 4, the beaches were seldom very crowded (about 7% of the time). Our scale and findings are:

Table 4

	Frq	Pct
1. PEOPLE SCATTERED ABOUT BEACH, BEACH MOSTLY EMPTY:	148	13.9
2. ON AVERAGE, SEVERAL YARDS BETWEEN TOWELS/BLANKET:	518	48.7
3. ON AVERAGE, SEVERAL FEET BETWEEN TOWELS/BLANKETS:	317	29.8
4. ON AVERAGE, DENSE, ONLY A FOOT OR TWO BETWEEN TOWELS/BLANKETS:	54	5.1
5. ON AVERAGE, VERY DENSE, LITTLE ROOM TO WALK:	26	2.4
Totals	1063	100.0%

Distribution of People on the Beach

The distribution of beach users reflects a standard bell shape. Table 5 displays the figures.

Table 5

		Frq	Pct
WATER:	1. MOST AT WATER; REST DISTRIBUTED EQUALLY:	41	3.9
	2. MOST AT WATER; REST TENDING UP BEACH:	12	1.1
	3. MOST AT WATER; REST TENDING MID BEACH:	287	27.0
EQUAL:	4. EQUALLY DISTRIBUTED: UP, MID AND WATERSIDE:	452	42.5
MID:	5. MOST IN MIDDLE; REST EQUALLY DISTRIBUTED:	140	13.2
	6. MOST IN MIDDLE; REST TENDING WATERSIDE:	92	8.7
	7. MOST IN MIDDLE; REST TENDING UP BEACH:	12	1.1
UP:	8. MOST UP BEACH; REST EQUALLY DISTRIBUTED:	9	.8
	9. MOST UP BEACH; REST TENDING TO MIDDLE:	14	1.3
	10. MOST UP BEACH; REST TENDING TO WATERSIDE:	4	.4
	Totals	1063	100.0%

Location: Communities

The communities of Stone Harbor and Avalon (Seven Mile Island) are reflected with samples of 293 and 250, respectively. Thus, the island is "represented" via a combined sample of 543 -- or 51% of our total sample. Absecon Island encompasses the communities of Atlantic City, Longport, Margate, and Ventnor. The samples are: 125, 132, 126, and 137, respectively -- or 49% of our total sample.

Table 6 indicates the information in conventional format.

Table 6
LOCATION OF BEACH

Value Label	Value	Frequency	Valid Percent	Cum Percent	
STONE HARBOR	1	293	27.6	27.6	27.6
AVALON	2	250	23.5	23.5	51.1
ATLANTIC CITY	3	125	11.8	11.8	62.8
LONGPORT	4	132	12.4	12.4	75.3
MARGATE	5	126	11.9	11.9	87.1
VENTNOR	6	137	12.9	12.9	100.0
	Total	1063	100.0	100.0	

SUBSTANTIVE FINDINGS

Visiting Patterns: Yearly Visits

Over three-quarters of the beach users (76.2%) visit the shore every year. Only 2.5% report that it was their first visit.

Table 7
DO YOU VISIT NEW JERSEY BEACHES?

Value Label	Value	Frequency	Valid Percent	Cum Percent
EVERY YEAR	1	810	76.2	76.2
MOST YEARS	2	123	11.6	87.8
SOME YEARS	3	102	9.6	97.4
FIRST VISIT	4	27	2.5	99.9
	40	1	.1	100.0
	Total	1063	100.0	100.0

Days Spent on Beach

The median number of days on the beach during the summer is 18. The minimum is one (presumably, the day of the interview) and the maximum for the "season" is 98. The median, not surprisingly, however, may be deceptive. The data show the expected "lumpiness" of vacation schedules. About one-third spend between 7 and 15 days on the beach. 16% spend less than 7 days on the beach. An additional 10% spend over 70 days on the beach.

The reader must keep in mind that the respondents are trying to calculate both their schedules and probable good "beach days" -- See Appendix Table for full distribution.

Residence at the Shore

We asked respondents if they owned a home or rented a property at the shore. About two-thirds (67.5%) owned or rented. Of those with some type of residence at the shore, 51.7% (370) are owners, and 48.3% (346) are renters.

Number of people in Beach Outing

We asked respondents how many people usually accompanied them to the beach. (The question read: "On the average, including yourself, how many people typically go to the beach with you?") Less than 7% went alone, about one-fifth went with one other person (a party of two), another fifth went with two other people, and another fifth went with three other people. The median number was three. Less than 9% went with more than five people (party of six).

Table 8
NUMBER OF PEOPLE GO TO BEACH WITH

Value Label	Value	Frequency	Valid Percent	Cum Percent
	1	71	6.7	6.7
	2	236	22.2	29.0
	3	227	21.4	50.4
	4	216	20.3	70.8
	5	121	11.4	82.2
	6	70	6.6	88.9
	7	25	2.4	91.2
	8	24	2.3	93.5
	9	7	.7	94.1
	10-15	46	4.3	98.5
	16-50	16	1.5	100.0
	-1	4	.4	Missing
	Total	1063	100.0	100.0

Which Beach?

Almost nine-tenths (87.8%) of the respondents told us the usual beach they visited was the beach on which we conducted the interview. Most of the remaining 12.2% visited nearby New Jersey beaches. Less than 2% listed non-New Jersey beaches.

Table of "other" beaches in Appendix

Beach Tags

Our pretest sensitized us to the number of people who avoid purchasing beach tags. We therefore asked the questions about beach tags in two parts:

To the question: "Do you usually have to buy a beach tag to use this beach? 85.1% responded "Yes" and 14.9% responded "No."

Table 9
DO YOU USUALLY HAVE TO BUY A BEACH TAG?

Value Label	Value	Frequency	Valid Percent	Cum Percent
YES	1	904	85.0	85.1	85.1
NO	2	158	14.9	14.9	100.0
	-1	1	.1	Missing	
	Total	1063	100.0	100.0	

"If yes: We asked, "Do you have a tag, and if so what kind is it?" We received the following:

Table 10
DO YOU HAVE A TAG, WHAT KIND?

Value Label	Value	Frequency	Valid Percent	Cum Percent
SEASON	1	675	63.5	74.6	74.6
WEEK	2	150	14.1	16.6	91.2
WEEKEND	3	3	.3	.3	91.5
DAY	4	21	2.0	2.3	93.8
NO PAY/NO TAG	5	56	5.3	6.2	100.0
	.	158	14.9	Missing	
	Total	1063	100.0	100.0	

Note that 6.2% of the sample indicated they were "cheaters." Note also the high proportion of season and weekly pass holders. This is consistent with our other data on length of stay.

Desired Characteristics of a Beach

The next sixteen questions are within a battery of items on desired characteristics of a beach. Respondents were read the following statement:

"There are several reasons why you might choose to visit New Jersey's beaches. Please indicate how important each of the following reasons is to you?" The following answer codes were also read: 1-not at all important; 2-slightly important; 3-moderately important; 4-very important; 5-extremely important; 6- NA

The questions and results are presented below:

a. To be with a large number of people

This was generally not a prominent reason for coming to the beach. Less than 7% called it very important and only about 10% called it extremely important.

Table 11
TO BE WITH A LARGE NUMBER OF PEOPLE

Value Label	Value	Frequency	Valid Percent	Percent	Cum Percent
NOT AT ALL IMPORTANT	1	515	48.4	48.4	48.4
SLIGHTLY IMPORTANT	2	160	15.1	15.1	63.5
MODERATELY IMPORTANT	3	201	18.9	18.9	82.4
VERY IMPORTANT	4	73	6.9	6.9	89.3
EXTREMELY IMPORTANT	5	108	10.2	10.2	99.4
NA	6	6	.6	.6	100.0
	Total	1063	100.0	100.0	

b. To experience the visual qualities of the beach scenery

Respondents report that this is a compelling reason. Over three-quarters said this was very important or extremely important.

Table 12
EXPERIENCE VISUAL QUALITIES OF BEACH?

Value Label	Value	Frequency	Percent	Valid Percent	Cum
NOT AT ALL IMPORTANT	1	31	2.9	2.9	2.9
SLIGHTLY IMPORTANT	2	35	3.3	3.3	6.2
MODERATELY IMPORTANT	3	191	18.0	18.0	24.2
VERY IMPORTANT	4	308	29.0	29.0	53.2
EXTREMELY IMPORTANT	5	498	46.8	46.8	100.0
	Total	1063	100.0	100.0	

c. To socialize with family, friends and others

This reason was of importance. Almost two-thirds called it very important or extremely important.

Table 13
SOCIALIZE WITH FAMILY, FRIENDS & OTHERS

Value Label	Value	Frequency	Percent	Valid Percent	Cum
NOT AT ALL IMPORTANT	1	82	7.7	7.7	7.7
SLIGHTLY IMPORTANT	2	67	6.3	6.3	14.0
MODERATELY IMPORTANT	3	228	21.4	21.5	35.5
VERY IMPORTANT	4	299	28.1	28.2	63.7
EXTREMELY IMPORTANT	5	383	36.0	36.1	99.8
NA	6	4	.4	.1	100.0
	Total	1063	100.0	100.0	

d. To relax

Relaxation emerges as a prime reason to visit the beach. Almost nine-tenths list this as very important or extremely important.

Table 14
TO RELAX

Value Label	Value	Frequency	Percent	Valid Percent	Cum
NOT AT ALL IMPORTANT	1	12	1.1	1.1	1.1
SLIGHTLY IMPORTANT	2	9	.8	.8	2.0
MODERATELY IMPORTANT	3	87	8.2	8.2	10.2
VERY IMPORTANT	4	180	16.9	16.9	27.1
EXTREMELY IMPORTANT	5	775	72.9	72.9	100.0
	Total	1063	100.0	100.0	

e. To participate in beach activities (swim, surf, etc)

About 30% are not interested in active beach activities. The remaining 70% divide somewhat equally in defining these activities as moderately- very- or extremely important.

Table 15
TO PARTICIPATE IN BEACH ACTIVITIES?

Value Label	Value	Frequency	Percent	Percent	
NOT AT ALL IMPORTANT	1	195	18.3	18.4	18.4
SLIGHTLY IMPORTANT	2	128	12.0	12.1	30.4
MODERATELY IMPORTANT	3	269	25.3	25.3	55.7
VERY IMPORTANT	4	233	21.9	21.9	77.7
EXTREMELY IMPORTANT	5	237	22.3	22.3	100.0
	-1	1	.1	Missing	
	Total	1063	100.0	100.0	

f. To enjoy being alone

Solitude is "extremely" desired by a quarter of the sample, and very important to another fifth. Only 18% called solitude "not at all important."

Table 16
TO ENJOY BEING ALONE

Value Label	Value	Frequency	Percent	Valid Percent	Cum
NOT AT ALL IMPORTANT	1	192	18.1	18.1	18.1
SLIGHTLY IMPORTANT	2	120	11.3	11.3	29.4
MODERATELY IMPORTANT	3	292	27.5	27.5	56.8
VERY IMPORTANT	4	197	18.5	18.5	75.4
EXTREMELY IMPORTANT	5	257	24.2	24.2	99.5
NA	6	5	.5	.5	100.0
		---	---	---	
	Total	1063	100.0	100.0	

g. There is little or no cost to enjoy the beach

This is a major factor, noted by over three-quarters of the respondents.

Table 17
LITTLE OR NO COST TO ENJOY BEACH

Value Label	Value	Frequency	Percent	Valid Percent	Cum
NOT AT ALL IMPORTANT	1	154	14.5	14.5	14.5
SLIGHTLY IMPORTANT	2	110	10.3	10.3	24.8
MODERATELY IMPORTANT	3	264	24.8	24.8	49.7
VERY IMPORTANT	4	198	18.6	18.6	68.3
EXTREMELY IMPORTANT	5	328	30.9	30.9	99.2
NA	6	9	.8	.8	100.0
		---	---	---	
	Total	1063	100.0	100.0	

h. It is a wide enough beach to enjoy many activities

Almost 85% said a wide beach was important. Most claim it is very important or extremely important. (Note, this question is also addressed in the comparison photos of replenished beaches vs. non-replenished beaches. Note also that older persons tended not to want wider beaches because of the difficulty of walking across the sand.)

Table 19
IT BEACH WIDE ENOUGH BEACH TO ENJOY MANY ACTIVITIES

Value Label	Value	Frequency	Percent	Valid Percent	Cum
NOT AT ALL IMPORTANT	1	91	8.6	8.6	8.6
SLIGHTLY IMPORTANT	2	73	6.9	6.9	15.4
MODERATELY IMPORTANT	3	222	20.9	20.9	36.3
VERY IMPORTANT	4	299	28.1	28.1	64.4
EXTREMELY IMPORTANT	5	376	35.4	35.4	99.8
NA	6	2	.2	.2	100.0
		---	---	---	
Total		1063	100.0	100.0	

i. It is a nice family-oriented beach

More than 90% find this important. Over half say it is extremely important.

Table 20
IT IS A NICE FAMILY-ORIENTED BEACH

Value Label	Value	Frequency	Valid Percent	Cum Percent	
NOT AT ALL IMPORTANT	1	51	4.8	4.8	4.8
SLIGHTLY IMPORTANT	2	43	4.0	4.1	8.9
MODERATELY IMPORTANT	3	137	12.9	12.9	21.8
VERY IMPORTANT	4	274	25.8	25.8	47.6
EXTREMELY IMPORTANT	5	553	52.0	52.1	99.7
NA	6	3	.3	.3	100.0
	-1	2	.2	Missing	
		---	---	---	
	Total	1063	100.0	100.0	

j. It is well protected by lifeguards

Not surprisingly, protection by lifeguards is a major factor. Almost four-fifths call it very important or extremely important.

Table 21
IT IS WELL PROTECTED BY LIFE GUARDS

Value Label	Value	Frequency	Percent	Valid Percent	Cum
NOT AT ALL IMPORTANT	1	50	4.7	4.7	4.7
SLIGHTLY IMPORTANT	2	44	4.1	4.1	8.9
MODERATELY IMPORTANT	3	130	12.2	12.3	21.1
VERY IMPORTANT	4	218	20.5	20.5	41.7
EXTREMELY IMPORTANT	5	618	58.1	58.2	99.9
NA	6	1	.1	.1	100.0
	-1	2	.2	Missing	
		---	---	---	
	Total	1063	100.0	100.0	

k. It is well maintained

A well maintained beach is viewed as important as one protected by lifeguards. Over 96% call this factor important to extremely important.

Table 22
IT IS WELL MAINTAINED

Value Label	Value	Frequency	Percent	Valid Percent	Cum
NOT AT ALL IMPORTANT	1	21	2.0	2.0	2.0
SLIGHTLY IMPORTANT	2	19	1.8	1.8	3.8
MODERATELY IMPORTANT	3	111	10.4	10.4	14.2
VERY IMPORTANT	4	267	25.1	25.1	39.3
EXTREMELY IMPORTANT	5	645	60.7	60.7	100.0
		---	---	---	
	Total	1063	100.0	100.0	

l. There is good fishing

Fishing does not emerge as important to most of the sample. Less than 30% seem to care about this activity at the beach.

Table 23
THERE IS GOOD FISHING

Value Label	Value	Frequency	Percent	Valid Percent	Cum
NOT AT ALL IMPORTANT	1	620	58.3	58.3	58.3
SLIGHTLY IMPORTANT	2	129	12.1	12.1	70.5
MODERATELY IMPORTANT	3	137	12.9	12.9	83.3
VERY IMPORTANT	4	67	6.3	6.3	89.7
EXTREMELY IMPORTANT	5	78	7.3	7.3	97.0
NA	6	32	3.0	3.0	100.0
		---	---	---	
	Total	1063	100.0	100.0	

m. It is close to where I am staying at the shore

Proximity is critical. Only 6% fail to call it important.

Table 24
IT IS CLOSE TO WHERE I AM STAYING

Value Label	Value	Frequency	Percent	Valid Percent	Cum
NOT AT ALL IMPORTANT	1	43	4.0	4.0	4.0
SLIGHTLY IMPORTANT	2	21	2.0	2.0	6.0
MODERATELY IMPORTANT	3	131	12.3	12.3	18.3
VERY IMPORTANT	4	270	25.4	25.4	43.7
EXTREMELY IMPORTANT	5	570	53.6	53.6	97.4
NA	6	27	2.5	2.5	99.9
	8	1	.1	.1	100.0
		---	---	---	
	Total	1063	100.0	100.0	

n. It is close to my permanent residence

Proximity of the beach to permanent residence is significantly less important than proximity of the beach to a temporary shore location.

Table 25
IT IS CLOSE TO MY PERMANENT RESIDENCE

Value Label	Value	Frequency	Percent	Valid Percent	Cum
NOT AT ALL IMPORTANT	1	166	15.6	15.6	15.6
SLIGHTLY IMPORTANT	2	97	9.1	9.1	24.7
MODERATELY IMPORTANT	3	210	19.8	19.8	44.5
VERY IMPORTANT	4	222	20.9	20.9	65.4
EXTREMELY IMPORTANT	5	338	31.8	31.8	97.2
NA	6	30	2.8	2.8	100.0
		---	---	---	
	Total	1063	100.0	100.0	

o. There is enough parking

Parking emerges as a central concern for many beach users. Three-fifths call it very important or extremely important. There is, also, understandably, at least a sixth of the sample who do not drive to the beach and for whom parking is irrelevant.

Table 26
THERE IS ENOUGH PARKING

Value Label	Value	Frequency	Percent	Valid Percent	Cum
NOT AT ALL IMPORTANT	1	166	15.6	15.6	15.6
SLIGHTLY IMPORTANT	2	75	7.1	7.1	22.7
MODERATELY IMPORTANT	3	192	18.1	18.1	40.7
VERY IMPORTANT	4	252	23.7	23.7	64.4
EXTREMELY IMPORTANT	5	364	34.2	34.2	98.7
NA	6	14	1.3	1.3	100.0
		---	---	---	
	Total	1063	100.0	100.0	

p. There are adequate snack bars and shops

Because so many respondents have homes, rental units, or hotel rooms near the beach, the importance of snack bars and shops is often less critical than it would be to a more transient population. Nevertheless, less than 30% say it is "not important at all." It is possible that this question should be separated into two: one for snack bars or restaurants, and one for shops that sell non-food items.

Table 27
THERE ARE ADEQUATE SNACK BARS & SHOPS

Value Label	Value	Frequency	Percent	Valid Percent	Cum
NOT AT ALL IMPORTANT	1	312	29.4	29.4	29.4
SLIGHTLY IMPORTANT	2	141	13.3	13.3	42.6
MODERATELY IMPORTANT	3	239	22.5	22.5	65.1
VERY IMPORTANT	4	173	16.3	16.3	81.4
EXTREMELY IMPORTANT	5	196	18.4	18.4	99.8
NA	6	2	.2	.2	100.0
		---	---	---	
	Total	1063	100.0	100.0	

Note: The question about snack bars and shops is the last of the battery. The next group of questions comprise the first of the beach valuation series.

PERCEIVED VALUE OF THE BEACH

We employed the Corps' previously tested series of questions to elicit the respondents' perceived dollar value for a day at the beach. The introductory wording is:

> "The next questions will help us measure the value society places on beaches. We do this by asking about the dollar value of enjoyment for a day on the beach. These estimates reflect only personal values and will not influence beach fees. Beach fees are set by towns; our research is for the U.S. Army Corps of Engineers."

Then, the first question is:

> "Previous studies reveal that, on average, people would be willing to pay about $4.00 per

day per person to use a beach in New Jersey. Do you feel that a day using a New Jersey beach would be worth $4.00 to each member of your household?"

If the respondent says "Yes," he/she is asked about higher figures (e.g., $5.00, $6.00, or more). If the respondent says "No," he/she is asked about $3.00, $2.00 or less. If the respondent indicates zero, he/she is asked:

"Which of the following statements best describes the reasons for your response:

Not enough information
Did not want to place a dollar value
Object to the way the question was presented
That is what it is worth to me
(Other)

Analysis of this series of questions requires combining the responses from all of the items within it. When we do that, we find that the mean perceived value is $5.04 -- for those with non-zero responses; and is $4.22 if those with zero responses are included. The frequency distribution (combining all questions in the series) is:

Table 28

Dollar Value Offered	Frequency
0	167
$.05-.50	30
1.00	83
1.50	1
2.00	220
3.00	129
4.00	114
5.00	129
6.00	84
7.00	7
8.00	6
10.00	49
12.50	1
15.00	3
20.00	3
25.00	2
100.00	1
300.00	1

Mean w/ zeros = $4.22; Mean without zeros = $5.04

Those not willing to pay any amount (the zero responses) indicated the following explanations:

Table 29
REASONS FOR NOT ANSWERING

	Pct of Total	Pct Answering This Question
Not enough information	.3%	1.8%
Did not want to place a dollar value	2.0	12.7
Object to the way the question was presented	.2	1.2
That is what it is worth to me	2.5	16.3
(Other, see below)	10.3	65.7
NA	84.8	2.4

Answers to the "other" category were (in order, from most frequent to least frequent):

	Pct of those answering this "other" category
Taxes should pay for beach	45%
Should be free/public land	21
It's natural; cost inappropriate	18
I'm a resident/land owner	7
I refuse	6
Other	3

Impact of Cost on Number of Visits

The next question was built on the final answer to the bidding process above. Respondents were asked:

If an entry fee of____ [the amount respondent indicated in above question] were charged, how would that affect the number of visits you would make to New Jersey's beaches?

More than now__ If more, how many more visits _____
Same as now __
Fewer than now. If fewer, how many fewer visits_____

Not surprisingly, very few respondents (1%) said "more than now." Most said "same as now" (74.1%); and 25% reported "fewer than now."

Of the 1% (10 people) who said "more than now," two people estimated they would make one more visit, two estimated they would make two more visits, and five estimated they would make five more visits.

Of the 25% who said "fewer than now," the median was 9.5 fewer visits. The "low" was one fewer visits, and the "high" was 78 fewer visits (See Table 30)

Table 30
IF FEWER, HOW MANY FEWER VISITS?

Value Label	Value	Frequency	Valid Percent	Percent	Cum
	1	5	.5	2.1	2.1
	2	21	2.0	8.6	10.7
	3	13	1.2	5.3	16.0
	4	7	.7	2.9	18.9
	5	38	3.6	15.6	34.6
	7	18	1.7	7.4	42.0
	8	2	.2	.8	42.8
	9	3	.3	1.2	44.0
	10	36	3.4	14.8	58.8
	11	3	.3	1.2	60.1
	12	7	.7	2.9	63.0
	13	2	.2	.8	63.8
	14	5	.5	2.1	65.8
	15	14	1.3	5.8	71.6
	16	2	.2	.8	72.4
	19	1	.1	.4	72.8
	20	18	1.7	7.4	80.2
	22	2	.2	.8	81.1
	25	5	.5	2.1	83.1
	28	1	.1	.4	83.5
	30	9	.8	3.7	87.2
	32	3	.3	1.2	88.5
	35	3	.3	1.2	89.7
	36	1	.1	.4	90.1
	37	1	.1	.4	90.5
	40	3	.3	1.2	91.8
	42	5	.5	2.1	93.8
	45	3	.3	1.2	95.1
	48	1	.1	.4	95.5
	49	6	.6	2.5	97.9
	50	1	.1	.4	98.4
	56	2	.2	.8	99.2
	68	1	.1	.4	99.6
	78	1	.1	.4	100.0
	.	820	77.1	Missing	
		---	---	---	
	Total	1063	100.0	100.0	

Perceived Value of Wider Beaches: Response to Photo

The next group of questions seeks to ascertain the perceived value of wider beaches -- an obvious result of beach replenishment. Respondents are shown a photograph of a beach and of a wide beach. They are asked the following:

Interviewer: Show photographs of the two beaches -- "A" with sand replenishment; "B" without sand replenishment. Ask: This survey is part of a study to assess the costs and benefits associated with beach sand replenishment.

Would you be willing to pay: More __ Less __ The Same __ than [amount respondent stated in earlier beach valuation question] if the NJ beach you usually visit were widened like the beach in Photo B [Bottom Photo]?

If more, how much more than [amount stated in earlier question]

If less, how much less than [amount stated in earlier question]

About one-sixth of the sample (16%) were willing to pay more for a wider beach. A small fraction (3.4%) would pay less for a wider beach. And most (80.6%) would pay the same.

Some of these results are associated with the age distribution of the sample. Older people tend to view wide beaches as an obstacle rather than as a benefit. Also, the photograph supplied by the Corps appears to offer a comparison of two rather wide beaches. It is possible that respondents, unaware of the impact of erosion and winter storms, felt the beach without replenishment was sufficient for summeractivities.

Valuation of wider beach: Those willing to pay more suggested a median figure of $1.00 -- with a low of $.50 and a top value of $100.00. (See Table 30 for the distribution.) It must be remembered that the figures here are "added" to the valuations established earlier. In general, one could add the one dollar median to the average $5.04 valuation established above -- to arrive at a "total" average value of $6.04.

Table 30 presents the frequency distribution for the "additional" dollars.

Table 30
IF MORE, HOW MUCH MORE

Value Label	Value	Frequency		Percent	Valid Percent	Cum
	.00	1		.1	.6	.6
	.50	5		.5	3.0	3.6
	1.00	79		7.4	47.9	51.5
	1.50	3		.3	1.8	53.3
	2.00	44		4.1	26.7	80.0
	3.00	11		1.0	6.7	86.7
	4.00	2		.2	1.2	87.9
	5.00	12		1.1	7.3	95.2
	7.00	2		.2	1.2	96.4
	10.00	3		.3	1.8	98.2
	12.00	1		.1	.6	98.8
	50.00	1		.1	.6	99.4
	100.00	1		.1	.6	100.0
	.	898		84.5	Missing	
		---		---	---	
	Total	1063	100.0	100.0		

Of the few people (under 3%) wishing to pay less for a wider beach, the median figure is also $1.00.

Conceptually, these people would like to subtract a dollar from their earlier valuation of a day at the beach. Note that the range varies from fifteen cents to $4.00.

Table 31
IF LESS, HOW MUCH LESS

Value Label	Value	Frequency		Valid Percent	Cum Percent
	.00	1	.1	3.0	3.0
	.15	1	.1	3.0	6.1
	.25	1	.1	3.0	9.1
	.50	4	.4	12.1	21.2
	1.00	9	.8	27.3	48.5
	2.00	10	.9	30.3	78.8
	3.00	4	.4	12.1	90.9
	4.00	3	.3	9.1	100.0
	.	1030	96.9	Missing	
		---		---	---
	Total	1063		100.0	100.0

A Wider Beach, Fees and the Number of Visits

This next question builds on the above question about the value of a wider beach. It was asked of those who indicated that they were willing to pay more (or, for a very few, who wanted to pay less) for wider beaches. The question reads:

If a beach fee of [the amount stated in the question above] were charged, how would that affect the number of visits you would make to New Jersey's beaches?
More than now__ If more, how many more visits _____
Same as now __
Fewer than now. If fewer, how many fewer visits_____

The first tier of responses indicate little change:

Table 32

	N.	Pct.	Adj. Pct.
MORE THAN NOW	4	.4	2.0
SAME AS NOW	153	14.4	77.7
FEWER THAN NOW	40	3.8	20.3
NOT APPLICABLE	866	81.5	--
		100.0	

Because the question only affects less than one-fifth (18.5%) of the sample, results should be approached with some caution.

The very few (three valid responses) who say "more than now" indicate that they would visit the beach one to ten "additional" times.

The 3.8% who say "less than now" indicate that they would visit the beach, on average, 4 fewer times each season. See Appendix for distribution.

Erosion and the Beach

The earlier group of questions concerned wider beaches. This next question addresses the issue of erosion and the role of the beach. The question reads:

> This next question is not about widening beaches, but about maintaining beaches -- stopping them from eroding away. How important is it to you that there be a beach here at all?

The responses indicate that almost all of the sample understand the role of the beach. Less than one percent call the beach not important, and three-quarters call it very- or extremely important (See Table 33).

Table 33
IMPORTANCE OF BEACH AT ALL?

Value Label	Value	Frequency	Valid Percent	Percent	Cum
NOT AT ALL IMPORTANT	1	10	.9	.9	.9
SLIGHTLY IMPORTANT	2	37	3.5	3.5	4.4
MODERATELY IMPORTANT	3	113	10.6	10.7	15.1
VERY IMPORTANT	4	224	21.1	21.1	36.2
EXTREMELY IMPORTANT	5	675	63.5	63.6	99.8
NA	6	1	.1	.1	100.0
	-1	3	.3	Missing	
		---	---	---	
	Total	1063	100.0	100.0	

We then asked if respondents would "stop coming to this area if it did not have a beach"? More than four-fifths (83%) said "yes, they would stop coming.

Establishing an Erosion Protection Fund

Some of the more interesting theoretic debates pertain to the perceived value of a common good, in this case a beach. The question reads:

> Imagine there were a fund established for New Jersey beach protection against erosion. If you were to make a voluntary once-a-year contribution to this fund, even if you did not use the beach, what would be the maximum yearly amount that you would be willing to give?
>
> Keep in mind that this contribution would be in addition to any daily fees that you might pay?

Less than one-fifth (18.6%) indicated that they would contribute nothing. Among those who would contribute some money, the median amount is $50. The range is from less than one dollar to $10,000. Most responses are between $10.00 and $200.00. See appendix for frequency distribution.

Table 34
REASONS FOR NOT CONTRIBUTING

Those who would not contribute (18.6%) suggested that:

	Pct of Total
They did not have enough information	4.2%
They did not want to place a dollar value	2.0
"Zero" was what it is worth to them	2.8

Or a range of reasons, of which the most common were:

Beach fees should pay	3%
Taxes should pay	5%
Other	1%

Cost of Trip to Beach

We asked respondents the perceived relative value of a trip to the beach. The question reads, "All in all, how expensive do you consider a trip to the beach"? Most respondents defined the beach as a very good buy. Table 35 reflects the responses:

Table 35
HOW COSTLY THINK TRIP TO BEACH?

Value Label	Value	Frequency	Valid Percent	Percent	Cum
VERY EXPENSIVE	1	31	2.9	2.9	2.9
SOMEWHAT EXPENSIVE	2	207	19.5	19.5	22.4
SOMEWHAT INEXPENSIVE	3	333	31.3	31.3	53.7
VERY INEXPENSIVE	4	492	46.3	46.3	100.0
		---	---	---	
	Total	1063	100.0	100.0	

DEMOGRAPHICS

The last set of questions are provided to evaluate the sample and allow crosstabulations. The data reflect a robust representation of the beach users.

Employment Status

Table 36
PRESENT EMPLOYMENT STATUS

Value Label	Value	Frequency		Valid Percent	Cum Percent
EMPLOYED FULL TIME	1	624	58.7	58.7	58.7
EMPLOYED PART TIME	2	106	10.0	10.0	68.7
NOT EMPLOYED	3	27	2.5	2.5	71.2
RETIRED	4	119	11.2	11.2	82.4
FULL TIME HOMEMAKER	5	113	10.6	10.6	93.0
STUDENT	6	70	6.6	6.6	99.6
OTHER	7	4	.4	.4	100.0
		---	---	---	
	Total	1063	100.0	100.0	

OTHER (EMPLOYMENT STATUS)

	Frq	Pct
DISABILITY	1	.1%
SELF EMPLOYED	3	.3%

Marital Status

Almost two-thirds (65%) are married. Singles represented 34%.

Keep in mind that the interviewers were instructed to interview people who appeared to be 18 years old or older. (See the "age"question, below.)

Household Income, Before Taxes

Questions about income is one of the more delicate items in any survey. In our surveys, only 10% refused to answer. The data suggest that respondents were reasonably truthful. (The median response is $40,000 through $49,999; higher than the national median but not unexpected for vacationers who can rent or who own shore properties.

Table 37
WHICH BEST DESCRIBES TOTAL INCOME?

Value Label	Value	Frequency	Percent	Valid Percent	Cum
UNDER $10,000	1	54	5.1	5.6	5.6
$10,000 TO $19,999	2	45	4.2	4.7	10.4
$20,000 TO $29,999	3	84	7.9	8.8	19.1
$30,000 TO $39,999	4	128	12.0	13.4	32.5
$40,000 TO $49,999	5	169	15.9	17.7	50.2
$50,000 TO $74,999	6	183	17.2	19.1	69.4
$75,000 TO $99,999	7	127	11.9	13.3	82.6
$100,000 AND OVER	8	166	15.6	17.4	100.0
	-1	107	10.1	Missing	
		---	---	---	
	Total	1063	100.0	100.0	

Number of People in Household this Year

The median number of household members was between two and three.

Table 38
HOW MANY PEOPLE IN YOUR HOUSEHOLD?

Value Label	Value	Frequency	Valid Percent	Percent	Cum
NO. OF PEOPLE IN HOUSEHOLD	1	139	13.1	13.3	13.3
	2	318	29.9	30.4	43.7
	3	213	20.0	20.4	64.1
	4	215	20.2	20.6	84.6
	5	102	9.6	9.8	94.4
	6	32	3.0	3.1	97.4
	7	15	1.4	1.4	98.9
	8	5	.5	.5	99.3
	9	1	.1	.1	99.4
	10	4	.4	.4	99.8
	12	2	.2	.2	100.0
	-1	17	1.6	Missing	
		---	---	---	
	Total	1063	100.0	100.0	

Education

Over half the sample had at least some college.

Table 39
HOW MUCH EDUCATION HAVE YOU COMPLETED?

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
NO SCHOOL	1	6	.6	.6	.6
GRADE SCHOOL (6 YRS)	2	8	.8	.8	1.3
SOME HIGH SCHOOL (7-11)	3	20	1.9	1.9	3.2
HIGH SCHOOL GRADUATE	4	201	18.9	18.9	22.1
SOME COLLEGE (13 TO 15)	5	311	29.3	29.3	51.5
COLLEGE GRADUATE (16)	6	330	31.0	31.1	82.6
POST GRADUATE (OVER 16)	7	185	17.4	17.4	100.0
	-1	2	.2	Missing	
		---	---	---	
	Total	1063	100.0	100.0	

Race/Ethnicity

The sample was overwhelmingly white. Whites represented 95.6% of the sample. African Americans represented only 1.9% of the sample, and Latinos comprised only 1%. While these ratios do not reflect the region, they do appear to approximate beach usage in the communities in which we conducted the research.

Table 40
DESCRIPTION OF RACIAL OR ETHNIC BACKGROUND

Value Label	Value	Frequency	Valid Percent	Percent	Cum
WHITE OR CAUCASIAN	1	1015	95.5	95.6	95.6
BLACK/AFRICAN AMERICAN	2	20	1.9	1.9	97.5
LATINO	3	11	1.0	1.0	98.5
ASIAN	4	13	1.2	1.2	99.6
NATIVE AMERICAN	5	2	.2	.2	100.0
	-1	2	.2	Missing	
		---	---	---	
	Total	1063	100.0	100.0	

Age

The model category is age 30 to 39. Over half of the age distribution is under 39. (Compare this to the population of homeowners -- which is significantly older.)

Table 41
WHICH BEST DESCRIBES YOUR AGE GROUP?

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
10 TO 19	1	32	3.0	3.0	3.0
20 TO 29	2	237	22.3	22.4	25.4
30 TO 39	3	300	28.2	28.3	53.7
40 TO 49	4	236	22.2	22.3	75.9
50 TO 59	5	131	12.3	12.4	88.3
60 TO 69	6	95	8.9	9.0	97.3
70+	7	29	2.7	2.7	100.0
	.	3	.3	Missing	
		---	---	---	
	Total	1063	100.0	100.0	

Clarity Question

The last close-ended question asked about the wording in the our survey. Only 0.4% of the sample claimed that the wording was unclear.

Table 42
CLARITY: HOW DID YOU FIND THE WORDING?

Value Label	Value	Frequency	Percent	Valid Percent	Cum Percent
VERY CLEAR	1	367	34.5	41.1	41.1
CLEAR	2	451	42.4	50.5	91.6
MODERATE	3	71	6.7	8.0	99.6
UNCLEAR	4	3	.3	.3	99.9
VERY UNCLEAR	5	1	.1	.1	100.0
	.	170	16.0	Missing	
		---	---	---	
Total		1063	100.0	100.0	

General Comments

One-sixth of the respondents offered additional comments or suggestions regarding New Jersey's ocean beaches.

The major themes were:

-- Additional efforts should be made to clean up the beaches.
-- The beach fees are needed
-- The beach fees are resented
-- Beach replenishment is needed
-- Taxes should pay for beach replenishment

The appendix and the SPSS data disks contain a complete listing.

Crosstabulations

Crosstabulations of every item by several key variables have been calculated and are found in the appendix. Every variable iscrosstabulated by:

Weather (Sunny vs. All Other)
Density of Beach Use (Categories 1 and 2 ["Light Use"] vs. 3, 4, 5 ["Full or MoreCrowded"])
Community location (Atlantic City, Longport, Margate, Ventnor)
Yearly Visit Pattern (Visit Every Year; Most or Some Years; First Visit)
Days On Beach (Few -- 1-14; Many -- 15-30; Most -- 31-98)
Own or Rent Property at Shore
Year of Purchase [for owners] ("New" 1985-1994; "Old" 1900 to 1984)
Resident Status (Permanent; Staying for at least a week; Staying less than 8 days)
Income (Less than $49,999; $50,000 and over)
Education (High School or less vs. Some College or more)
Age (categorized in two formats because the age breakdowns for residents is skewed sharply to the right -- they tend to be over 60 years old)
Age-1 (under 60 vs. 60 and older)
Age-2 (under 40 vs. 40 and older)

II. SURVEY OF BUSINESSES

STONE HARBOR, AVALON, ATLANTIC CITY, LONGPORT, MARGATE, AND VENTNOR

In appraising the value of a beach, previous research has generally focused on beach users. In our survey of shore businesses, we seek to extend the analysis to include this population (of business
owners and managers) that also benefits from beaches and beach replenishment.

The Survey

The Survey was administered to 157 businesses in the six shore communities identified by the Corps -- Stone Harbor, Avalon, Atlantic City, Longport, Margate and Ventnor. The interviews were conducted in July and August of 1994.

Location

The location of the interviews (the distribution among the six communities) generally reflects the density of businesses in thevarying towns. Thus, for example, there are few business interviews in Longport, but a substantial number in Stone Harbor. Table 1 provides a breakdown of the locations:

Table 1
LOCATION OF INTERVIEW

Value Label	Value	Frequency	Percent	Valid Percent	Cum
Stone Harbor	1	38	24.2	24.4	24.4
Avalon	2	41	26.1	26.3	50.6
Atlantic City	3	24	15.3	15.4	66.0
Longport	4	5	3.2	3.2	69.2
Margate	5	24	15.3	15.4	84.6
Ventnor	6	24	15.3	15.4	100.0
	.	1	.6	Missing	
		---	---	---	
	Total	157	100.0	100.0	

Proximity to the Beach

Because proximity to the beach is usually desirable for a business and because we ask businesspersons about the value of the beach for their businesses, we recorded the number of

blocks to the beach from each business property.
Four businesses (2.6%) were less than one bock from the beach; about a quarter (24.5%) were within one block. Most of the businesses (52.3%) were within two blocks of the beach. (See Table 2 for a full listing.)

Table 2
BLOCKS NUMBER OF BLOCKS TO THE BEACH

Value Label	Value	Frequency	Valid Percent	Percent	Cum
	0	4	2.5	2.6	2.6
	1	33	21.0	21.9	24.5
	2	42	26.8	27.8	52.3
	3	47	29.9	31.1	83.4
	4	16	10.2	10.6	94.0
	5	2	1.3	1.3	95.4
	6	1	.6	.7	96.0
	8	2	1.3	1.3	97.4
	10	1	.6	.7	98.0
	12	1	.6	.7	98.7
	20	1	.6	.7	99.3
	25	1	.6	.7	100.0
	.	6	3.8	Missing	
	---		---	---	
Total		157	100.0	100.0	

Type of Business

The sample consists of the expected range of retail establishments. The sample is:

Clothing, shoes, jewelry, tee shirts	16
Restaurants, bars, fast foods	15
Food Markets	6
Home repair and hardware	5
Hotel and motels	4
Hairdressers, nail shops	4
Realtors	3
Cleaners and tailors	3

ALSO: bait and tackle shop, art gallery, bank, bike store, camera shop, book store, tv repair (2), tv cable dealer, cab service, limo service, car rental agent, baby furniture, furniture (2), liquor store, yarn store, video stores (2), sports supplies (2), pest and bug removal, museum, library,

insurance agents (2), law office, pottery shop, surf shop, and drug stores (2).
Seasonal or Year-Round

Two-thirds of the businesses were open all year -- see Table 3.

Table 3
IS BUSINESS OPEN ALL YEAR OR ONLY DURING SUMMER

Value Label	Value	Frequency	Percent	Valid Percent	Cum
ALL YEAR	1	105	66.9	67.3	67.3
SUMMER SEASON	2	51	32.5	32.7	100.0
	.	1	.6	Missing	
		---	---	---	
	Total	157	100.0	100.0	

Valid cases 156 Missing cases 1

SUBSTANTIVE FINDINGS

Role of Beach

Our first substantive question asked businesspersons to estimate the percentage of customers who were at the shore because of the beach.

The businesspeople recognize the overwhelming role of the beach to their economic existence. The median estimate was that three-quarters of the customers were "due" to the beach. A third of the sample indicated that between 90% to 100% of the customers were attributable to the presence of the beach. Table 4 presents a complete listing. (See next page for Table 4.)

Table 4
WHAT PERCENTAGE OF YOUR CUSTOMERS AT SHORE BECAUSE OF BEACH

Value Label	Value	Frequency	Valid Percent	Percent	Cum
PERCENT OF CUSTOMERS "DUE" TO BEACH	0	1	.6	.7	.7
	1	1	.6	.7	1.3
	4	1	.6	.7	2.0
	5	3	1.9	2.0	3.9
	8	1	.6	.7	4.6
	10	7	4.5	4.6	9.2
	15	1	.6	.7	9.8
	20	9	5.7	5.9	15.7
	25	6	3.8	3.9	19.6
	30	5	3.2	3.3	22.9
	35	2	1.3	1.3	24.2
	40	2	1.3	1.3	25.5
	50	17	10.8	11.1	36.6
	55	1	.6	.7	37.3
	60	2	1.3	1.3	38.6
	65	2	1.3	1.3	39.9
	70	7	4.5	4.6	44.4
	75	11	7.0	7.2	51.6
	80	14	8.9	9.2	60.8
	85	5	3.2	3.3	64.1
	90	23	14.6	15.0	79.1
	95	11	7.0	7.2	86.3
	98	2	1.3	1.3	87.6
	99	2	1.3	1.3	88.9
	100	17	10.8	11.1	100.0
	-1	4	2.5	Missing	
		---	---	---	
	Total	157	100.0	100.0	

Valid cases 153 Missing cases 4

Impact of Erosion

The next question addresses the perceived impact of beach erosion on business income. The question reads:

If the beach were to erode away completely, how would this affect your business? Would it lose:

1. a quarter of its income
2. a half of its income__
3. three-quarters of its income
4. almost all of its income__
5. all of its income
6. other

The results indicate that the question is almost too threatening to consider. Although the above question reveals that businesspersons are aware of the role of the beach in bringing customers, businesspeople are frequently less willing to examine the consequences of total erosion. Table 5 (frequencies) and Table 6 (responses within the "other" category) reveal the inconsistency. Only 4.5% insist that total erosion with have no affect. But at least one-fifth claim the impact of total beach erosion would be less than 25% of their business income. (Note that about half of the sample report that they would lose at least half of their business income if there were total erosion.)

Table 5
HOW WOULD EROSION AFFECT YOUR BUSINESS?

Value Label	Value	Frequency	Valid Percent	Percent	Cum
A QUARTER OF ITS INCOME	1	28	17.8	18.1	18.1
HALF OF ITS INCOME	2	33	21.0	21.3	39.4
THREE-QUARTERS OF ITS INCOME	3	26	16.6	16.8	56.1
ALMOST ALL OF ITS INCOME	4	25	15.9	16.1	72.3
ALL OF ITS INCOME	5	17	10.8	11.0	83.2
OTHER	6	26	16.6	16.8	100.0
	-1	2	1.2	Missing	
Total			100.0	100.0	

Table 6
"OTHER" RESPONSE TO HOW EROSION AFFECTS BUSINESS

Value Label	Value	Frequency	Valid Percent	Percent	Cum
		134	85.4	85.4	85.4
LOSS PERCENTAGE	10%	2	1.3	1.3	86.6
	15%	2	1.3	1.3	87.9
	2/3	1	.6	.6	88.5
	20%	1	.6	.6	89.2

5%	2	1.3	1.3	90.4
60%	1	.6	.6	91.1
80%	1	.6	.6	91.7
90%	1	.6	.6	92.4
DON'T KNOW	1	.6	.6	93.0
NOT SPECIFIED	2	1.3	1.3	94.3
NO AFFECT	7	4.5	4.5	98.7
UNCERTAIN	2	1.3	1.3	100.0
	---	---	---	
Total	157	100.0	100.0	

Business and the Existence of a Beach

The next question is a follow-up item. It reads: "How important is it to your business that there be a beach here at all?" The results are in line with the earlier question. While over three-quarters call it very- to extremely important, a fifth are less sure.

Table 7
HOW IMPORTANT IS IT TO YOUR BUSINESS THAT THERE BE A BEACH AT ALL

Value Label	Value	Frequency	Valid Percent	Percent	Cum
NOT AT ALL IMPORTANT	1	9	5.7	5.8	5.8
SLIGHTLY IMPORTANT	2	8	5.1	5.1	10.9
MODERATELY IMPORTANT	3	16	10.2	10.3	21.2
VERY IMPORTANT	4	36	22.9	23.1	44.2
EXTREMELY IMPORTANT	5	87	55.4	55.8	100.0
	.	1	.6	Missing	
		---	---	---	
	Total	157	100.0	100.0	

Taxes and Replenishment

Beliefs about tax allocations may influence respondents attitudes toward beach replenishment. We wanted to know if businesspersons believed that local taxes are used in any federal/U.S. Army Corps of Engineer projects. The question reads:

> "Do you know if any of the local taxes go toward replacing the sand lost to storms or waves?" Yes Think so No

The results suggest that most believe that their local taxes are not directed toward beach

replenishment. See Table 8

Table 8
DO YOU KNOW IF ANY OF THE LOCAL TAXES GO TO BEACH REPLENISHMENT

Value Label	Value	Frequency	Percent	Valid Percent	Cum
yes	1	24	15.3	15.4	15.4
think so	2	24	15.3	15.4	30.8
no	3	108	68.8	69.2	100.0
	.	1	.6	Missing	
		---	---	---	
	Total	157	100.0	100.0	

The reader is cautioned, however, that the question is potentially flawed. It is not absolutely clear how to interpret the responses. "No," for example, could mean that the respondent does not know if local taxes are used for beach replenishment, or "no" could mean he/she does not believe that local taxes are used for beach replenishment.

The pattern of the data suggest that we may be overly cautious. Given the distribution of "think so" vs. "no," it appears that "no" probably does mean "no." Nevertheless, it is important to maintain some doubt.

Paying More Taxes For a Wider Beach

In a format similar to that used with the beach users' study, we contrasted photographs of a beach with sand replenishment with one without send replenishment.

One-quarter (25.3%) reported that they would be willing to pay more taxes for a wider beach. (And three-quarters said they did not want to pay increased taxes for a wider beach.)

Table 9
WOULD YOU PAY MORE TAXES FOR WIDER BEACH

Value Label	Value	Frequency	Percent	Valid Percent	Cum
more	1	39	24.8	25.3	25.3
no	2	115	73.2	74.7	100.0
	.	3	.9	Missing	
		---	---	---	
	Total	157	100.0	100.0	

Valid cases 154 Missing cases 3

Those who reported they were willing to pay more taxes were asked "how much more."

The "additional" taxes ranged from 1% to 200%. The median increase is 9%. (See Table 10 next page.)

IF MORE, HOW MUCH MORE? Table 10

Value Label	Value	Frequency	Percent	Valid Percent	Cum
PERCENTAGE INCREASE	1.00	1	.6	4.5	4.5
	2.00	4	2.5	18.2	22.7
	5.00	2	1.3	9.1	31.8
	8.00	1	.6	4.5	36.4
	10.00	6	3.8	27.3	63.6
	17.00	1	.6	4.5	68.2
	20.00	3	1.9	13.6	81.8
	25.00	3	1.9	13.6	95.5
	200.00	1	.6	4.5	100.0
	.	135	86.0	Missing	
		---	---	---	
	Total	157	100.0	100.0	

(No respondents indicated how much less they would like to give.)

An Annual Fund for Erosion Protection

As with the beach users survey, we also asked businesspersons if they would contribute to a fund for N.J. beach erosion protection.

Almost a third (29.2%) offered no additional funds -- the .00 in Table 11. The range of non-zero responses was from $5.00/yr to $10,000/yr. The median of all responses (i.e., with zeros included) is approximately $75/yr. The median of all positive responses is approximately $175/yr.

Table 11
YEARLY CONTRIBUTION TO A GENERAL FUND

Value Label	Value	Frequency	Valid Percent	Cum Percent
	.00	35	22.3	29.2	29.2
	5.00	1	.6	.8	30.0
	10.00	1	.6	.8	30.8
	25.00	5	3.2	4.2	35.0
	50.00	8	5.1	6.7	41.7
	100.00	37	23.6	30.8	72.5
	150.00	2	1.3	1.7	74.2
	200.00	11	7.0	9.2	83.3

250.00	1	.6	.8	84.2
300.00	1	.6	.8	85.0
500.00	6	3.8	5.0	90.0
750.00	1	.6	.8	90.8
1000.00	9	5.7	7.5	98.3
1500.00	1	.6	.8	99.2
10000.00	1	.6	.8	100.0
-1.00	37	23.5	Missing	
Total	157	100.0	100.0	

SAMPLE CHARACTERISTICS

Age of Business

The median age of businesses in our sample was 10 years. The minimum was under one year (first season/year), and the longest running business was 100 years. Table 11 displays the distribution.

Table 11
HOW OLD IS BUSINESS?

Value Label	Value	Frequency		Valid Percent	Cum Percent
YEARS IN BUSINESS	0	1	.6	.6	.6
	1	6	3.8	3.9	4.5
	2	4	2.5	2.6	7.1
	3	9	5.7	5.8	12.9
	4	10	6.4	6.5	19.4
	5	10	6.4	6.5	25.8
	6	9	5.7	5.8	31.6
	7	10	6.4	6.5	38.1
	8	6	3.8	3.9	41.9
	9	4	2.5	2.6	44.5
	10	12	7.6	7.7	52.3
	11	4	2.5	2.6	54.8
	12	6	3.8	3.9	58.7
	13	2	1.3	1.3	60.0
	14	2	1.3	1.3	61.3
	15	4	2.5	2.6	63.9
	16	1	.6	.6	64.5
	17	4	2.5	2.6	67.1
	18	3	1.9	1.9	69.0

20	5	3.2	3.2	72.3
22	3	1.9	1.9	74.2
23	2	1.3	1.3	75.5
24	2	1.3	1.3	76.8
25	2	1.3	1.3	78.1
26	2	1.3	1.3	79.4
27	1	.6	.6	80.0
28	2	1.3	1.3	81.3
30	8	5.1	5.2	86.5
36	1	.6	.6	87.1
38	2	1.3	1.3	88.4
40	5	3.2	3.2	91.6
45	2	1.3	1.3	92.9
49	1	.6	.6	93.5
50	6	3.8	3.9	97.4
60	1	.6	.6	98.1
70	1	.6	.6	98.7
73	1	.6	.6	99.4
100	1	.6	.6	100.0
-1	2	1.2	Missing	
	---	---	---	
Total	157	100.0	100.0	

Number of Employees

The businesses ranged in size from no employees (just owner) to 125 employees. The median was 5 employees -- about half had fewer employees and half had more than 5 employees.

Table 12
HOW MANY PEOPLE EMPLOYED AT THIS BUSINESS

Value Label	Value	Frequency		Valid Percent	Cum Percent
NUMBER OF EMPLOYEES					
	0	1	.6	.7	.7
	1	13	8.3	8.6	9.3
	2	15	9.6	9.9	19.2
	3	15	9.6	9.9	29.1
	4	17	10.9	11.3	40.4
	5	17	10.9	11.3	51.7
	6	10	6.4	6.6	58.3
	7	6	3.8	4.0	62.3

8	8	5.1	5.3	67.5
9	3	1.9	2.0	69.5
10	4	2.6	2.6	72.2
11	1	.6	.7	72.8
12	6	3.8	4.0	76.8
13	1	.6	.7	77.5
14	2	1.3	1.3	78.8
15	8	5.1	5.3	84.1
20	1	.6	.7	84.8
23	1	.6	.7	85.4
25	7	4.5	4.6	90.1
26	1	.6	.7	90.7
28	2	1.3	1.3	92.1
30	5	3.2	3.3	95.4
35	1	.6	.7	96.0
40	3	1.9	2.0	98.0
50	1	.6	.7	98.7
60	1	.6	.7	99.3
125	1	.6	.7	100.0
-1	5	3.2	Missing	
	---	---	---	
Total	156	100.0	100.0	

Valid cases 151 Missing cases 5

Education Level of Manager/Owner

Most owners or managers had some college or more schooling. Less than a quarter had a high school education or fewer years of education.

HOW MUCH EDUCATION HAVE YOU COMPLETED?

Value Label	Value	Frequency	Percent	Valid Percent	Cum
GRADE SCHOOL	2	2	1.3	1.3	1.3
SOME HIGH SCHOOL	3	6	3.8	3.9	5.2
HIGH SCHOOL GRADUATE	4	30	19.1	19.6	24.8
SOME COLLEGE	5	46	29.3	30.1	54.9
COLLEGE GRADUATE	6	64	40.8	41.8	96.7
POST GRADUATE	7	5	3.2	3.3	100.0
	-1	4	2.2	Missing	
		---	---	---	
	Total	157	100.0	100.0	

Valid cases 153 Missing cases 4

In the appendix, are crosstabulations of every variable in the businesspersons survey by the following two variables:

Business Schedule (Open all year vs. Open summer only)

No. of Employees (0-9 vs. 10-125)

III. SURVEY OF HOMEOWNERS

We interviewed 251 homeowners in the six shore communities on Absecon and Seven Mile Island. The questionnaire focused on the perceived affects of beach erosion on property values, on perceived tax allocations, on use of the beaches, and on perceptions of sand replenishment efforts.

The primary sample for the homeowners study is comprised of respondents we interviewed in their homes in face-to-face interviews and via phone interviews (N = 251). A second sample is comprised of homeowners we interviewed as part of the beach users survey, i.e., beach users who owned homes in the nearby communities. In the beach user questionnaire we included a series of questions that are identical to questions in the homeowners' survey (N = 370). We present the combined results below.

The Surveys: Comparing the Samples

One task is to compare the two samples -- to contrast the similarities and differences so that the combined results can be better understood.

The 251 homeowners were interviewed in the summer of 1994, the same time as the beach user survey. While there are some systematic differences between the two samples, the similarities predominate. The major difference appears to be age: homeowners interviewed at their homes are, on average, older than homeowners interviewed on the beach.

Because few readers are interested in the methodological concerns of comparing samples, our discussion of the similarities and differences of the two samples is found at the end of this section -- after the review of the substantive findings. The specific data comparing the two samples on demographic and other characteristics are presented in that methodological subsection, in Tables M1 to M11.

FINDINGS

The Cost of Erosion

Our first substantive question seeks to ascertain the homeowners' perceived cost of erosion. The question reads:

> If the beach were to erode away completely, how would this affect the value of your property? Would it lose:
>
> a quarter of its value__ a half of its value__

three-quarters of its value__ almost all of its value__
all of its value__ other

The samples are very consistent. Both homeowners interviewed at their homes (hereafter homeowners) and homeowners interviewed on the beach (hereafter homeowners o-t-b) reported that their properties would lose much of the value in the event of total beach erosion. Review of Table 1 reveals that approximately two-thirds of both samples say their homes would lose at least 75% of the value.

Table 1
HOW WOULD VALUE OF HOUSE CHANGE

	Homeowners percent	Homeowners O-T-B percent
A QUARTER OF ITS VALUE	22.1	25.8
A HALF OF ITS VALUE	5.6	11.1
3/4 OF ITS VALUE	32.1	32.8
ALL OF ITS VALUE	12.9	15.3
ALMOST ALL OF ITS VALUE	4.8	4.2
OTHER	22.5	10.8
	(N=251)	(N=370)

Summary of "Other" Category (Percentages for total samples):

	percent	percent
ABOUT HALF TO THREE-QUARTERS	5.0	3.0
NO AFFECT	7.0	5.0
NO IDEA	9.0	3.0

Allocation of Taxes

We asked respondents if any of their local taxes are allocated toward replacing the sand lost to storms or waves. About three-fifths of the homeowners (both samples) indicated that local taxes were not allocated to beach replenishment. Another quarter said the "think so."

Table 2
TAXES TO REPLENISHMENT?

	Homeowner percent	Homeowner O-T-B percent
YES	17.2	12.8
THINK SO	26.4	26.0
NO	56.4	61.1

Note: As discussed in the first section, the reader is cautioned that the wording of this question is potentially ambiguous. It is possible that respondents are not telling us about the allocation of taxes, but rather about their familiarity with the allocation process.

Taxes/Payments for a Wider Beach

In a question format similar to that discussed in the first section, we asked respondents if they would be willing to pay more taxes for wider beaches.

Less than one-fifth (in either sample) felt that wider beaches were worth the cost of additional taxes or payments. Table 3 presents the results for both the homeowners and the homeowners o-t-b. The similarity in the responses is striking.

Table 3
PAY MORE TAXES/PAYMENTS FOR WIDER BEACH

	Homeowner Homeowner percent	O-T-B percent
WILLING TO PAY MORE	17.5	17.5
NOT WILLING TO PAY MORE	81.2	79.9
WILLING TO PAY LESS	1.3	3.1

Those willing to pay more, were asked "how much more?"

It is difficult to compare the two samples because the follow-up questions were asked somewhat differently for each of the samples. For the homeowners, the question was direct (e.g., "how much more"). But for the homeowners o-t-b, the question was related to an earlier valuation question; respondents were essentially asked "how much more than you were willing to spend in [an earlier question]". Equally significant, the homeowner sample was asked the question in terms of additional taxes, whereas the homeowner o-t-b sample were asked the question in terms of additional payments. (In later economic analysis, we disaggregate the two groups.)

Table 4
"ADDITIONAL" TAXES/PAYMENT FOR WIDER BEACH

	Homeowner percent	Homeowner O-T-B percent
Minimum	0.1%	$0.50
Maximum	200.0%	$100.00
Median	10.0%	$6.72

Keeping Beaches Where They Are

Our next item switches focus to ask not about widening the beach, but rather about the danger of serious erosion. The question reads:

> This next question is not about widening beaches, but about maintaining beaches -- stopping them from eroding away. How important is it to you that there be a beach here at all?
>
> 1-not at all important; 2-slightly important; 3-moderately important; 4-very important; 5-extremely important; 6- NA]

Again, the results for both samples are consistent. Almost four-fifths call it "extremely important." Under 3% call it not important.

Table 5
IMPORTANCE OF BEACH AT ALL?

	Homeowner percent	Homeowner O-T-B percent
NOT AT ALL IMPORTANT	2.4	.3
SLIGHTLY IMPORTANT	.8	.3
MODERATELY IMPORTANT	4.8	2.4
VERY IMPORTANT	23.5	16.7
EXTREMELY IMPORTANT	68.1	79.8
NA	.4	--

Fund Against N.J. Beach Erosion

The last substantive question we examined asks respondents if they would contribute to a general fund for beach protection. The question reads:

> Imagine there were a fund established for New Jersey beach protection against erosion. If you were to make a voluntary once-a-year contribution to this fund, even if you did not use the beach, what would be the maximum yearly amount that you would be willing to give?
>
> Keep in mind that this contribution would be in addition to any taxes and daily fees that you might pay?

The results of this question reflects some divergence between the samples. One possible cause of the differences is the questionnaire structure and length. Given the different contexts, however, we are impressed with the similarities. These are open-ended questions; no guides are offered, and the respondents knew that the questions were hypothetical.

The median offered to the "fund" is $25 to $46.00. The maximum (in each case offered by one person) is $10,000.00 to $20,000.00. The typical high offer is $100 to $300.00. (The full distributions are in the appendix tables.)

Table 6
GIVE MONEY TO A FUND FOR N.J. BEACHES

	Homeowner percent	Homeowner O-T-B percent
Minimum	0.00	0.00
Percent offering $0.00	42.2%	19.4%
Maximum	$20,000.00	$10,100.00
Median with zero offers included	$25.00	$46.00
Median with only non-zero offers included	$380.00	$79.00

Non-Contributors

We asked those who refused to give dollar values why they refused. The responses are:

Table 7
WHAT STATEMENT DESCRIBES YOUR REASON FOR NOT CONTRIBUTING

	Homeowner percent	Homeowner O-T-B percent
NOT ENOUGH INFORMATION	11.6	4.2
NOT WANT TO PLACE $ VALUE	5.2	1.4
OBJECT TO PRESENTATION	.4	0.0
WHAT IT'S WORTH TO ME	6.0	.7
OTHER	22.7	12.7

Reasons in the "other" category include: "can't afford more," "taxes should cover the cost," and "businesses should pay."

Summary

As seen in the previous surveys, homeowners in both samples appear to appreciate the importance of erosion and the need for beach replenishment. While they may not want (nor want to pay for) wider beaches, they certainly do not wish to see the water any closer to their homes than it is currently.

In general, the similarity of the responses between the two samples is striking.

COMPARING THE SAMPLES: HOMEOWNERS AND HOMEOWNERS ON THE BEACH

The data below are provided for those who wish to contrast the two samples.

Age

As noted, homeowners interviewed in their homes were generally older than the homeowners interviewed on the beaches. See Table M1.

Table M1

AGE

	Homeowner Percent	Homeowner O-T-B Percent
10 to 19	3.3	3.0
20 to 29	4.1	14.1
30 to 39	11.0	20.9
40 to 49	16.7	26.4
50 to 59	17.9	16.8
60 to 69	25.6	14.7
70+	21.5	4.7
	(N = 251)	(N = 370)

Homeowners interviewed at home (column on the left) were generally more elderly (and near elderly), i.e., 60 - 69 and those 70 or older.

Visiting Patterns

The homeowners interviewed in their homes and the homeowners interviewed on the beaches (o-t-b) had almost identical visitingpatterns.

Table M2
HOW OFTEN DO YOU COME TO NJ BEACHES?

	Homeowner percent	Homeowner o-t-b percent
EVERY YEAR	95.2	96.7
MOST YEARS	.4	2.7
SOME YEARS	1.6	0.0
FIRST YEAR HERE	0.0	0.5

Days on the Beach

Not all of the homeowners interviewed in their homes visited the beach; 16.8% never went to the beach. In contrast, and by definition, all of the homeowners we interviewed on the beach spent at least one day on the beach. Thus, there is some basic difference in the two samples. On the other hand, if you compare the median days on the beach of the two samples for those who visit the beach at least once, they are very close: 38 days vs. 39 days (see Table M3).

Table M3
MEDIAN NUMBER OF DAYS ON THE BEACH

	Med. no. of days
Homeowners who go to beach	38
Homeowners interviewed on the beach	39

(The median for homeowners interviewed in their homes, when including the 16.8% who never visit the beach, is 22 days.)

Period of Time Spent at the Shore

We asked respondents about the portion of the summer they spent at their N.J. shore residences. Results, overall, are somewhat similar for the two groups. Those interviewed on the beach are less likely (by 5%) to be permanent residents, and are less likely to spend the entire summer at the shore.

Table M4
HOW LONG ARE YOU STAYING AT THE SHORE

	Homeowner percent	Homeowner O-T-B percent
PERMANENT RESIDENT	45.6	40.3
HERE ALL SUMMER, ALL	43.2	34.4
WEEKENDS, ALL SUMMER	4.0	17.4
HERE FOR TWO WEEKS	6.4	4.5
HERE FOR ONE WEEK	.8	1.7
HERE FOR WEEKEND ONLY	--	.3
HERE FOR THE DAY ONLY	--	1.4

Buy House

We asked homeowners when they purchased their houses. The most recent were bought this summer. The least recent was 1900. The median year for home purchases by homeowners was 1978; The median purchase year for homeowners o-t-b was 1983. The difference is consistent with other patterns reflecting the older status of the homeowners interviewed in their homes.

We also asked them if the house was inherited or purchased. No noteworthy difference emerges.

Table M5
INHERITED OR BOUGHT

	Homeowner percent	Homeowner O-T-B percent
INHERITED	9.3%	11.5%
BOUGHT	90.7%	88.5%

Income and Race

The homeowners and homeowners o-t-b appear to be quite similar in income distribution (Table M6) and race/ethnicity (Table M7). The median income is $50,000 to $74,999. The sample is overwhelmingly white.

Table M6

INCOME	Homeowner percent	Homeowner O-T-B percent
UNDER $10,000	4.7	3.2
$10,000 TO $19,999	7.4	2.8
$20,000 TO $29,999	7.4	5.6
$30,000 TO $39,999	9.5	6.9
$40,000 TO $49,999	11.1	10.5
$50,000 TO $74,999	19.5	21.8
$75,000 TO $99,999	12.6	19.0
$100,000 AND OVER	27.2	30.2

Table M7

ETHNIC/RACIAL

	Homeowner percent	Homeowner O-T-B percent
WHITE	94.4	98.9
BLACK	3.9	.3
LATINO	.8	.5
NATIVE AMERICAN	.4	0

Education

Homeowners appear to have a higher percentage of post graduate degrees. Overall, however, the education distributions are similar.

Table M8

EDUCATION

	Homeowners percent	Homeowners O-T-B percent
GRADE SCHOOL (0-6)	.4	.3
SOME HIGH SCHOOL (7-11)	2.4	1.0
HIGH SCHOOL GRADUATE	25.1	1.7
SOME COLLEGE (13-15)	19.0	16.3
COLLEGE GRADUATE (16)	32.0	24.6
POST GRADUATE (16+)	20.6	32.9

Employment Status

Homeowners interviewed at their homes are more than twice as likely to be retired than those interviewed on the beach (44.6% vs. 19%). Correspondingly, those interviewed on the beach are more likely to be employed. These differences are obviously related to the age distribution.

Table M9

EMPLOYMENT STATUS	Homeowner percent	Homeowner O-T-B percent
EMPLOYED FULL TIME	27.6	52.6
EMPLOYED PART TIME	11.6	10.4
NOT EMPLOYED	2.0	4.2
RETIRED	44.6	19.0
FULL-TIME HOMEMAKER	10.4	9.7
STUDENT	3.8	3.8
OTHER	1.2	.3
DISABILITY	--	.3

Location

The samples differ somewhat in the proportions associated with each of the towns.

Table M10

LOCATION ON THE BEACH	Homeowner percent	Homeowner O-T-B percent
STONE HARBOR	31.9	14.5
AVALON	33.9	20.8
ATLANTIC CITY	10.4	12.6
LONGPORT	17.9	9.7
MARGATE	1.6	23.5
VENTNOR	4.4	18.7

The differential is due to several factors:

1. Communities differ in the average age of their residents and the differing age groups had differential use rates for the beach.

2. Some beaches are more popular than others -- they have a net in-flow of residents from other towns.

3. We sampled homeowners on the beach with a different methodology than that used for contacting homeowners in their homes. The beach survey was designed to interview one-half of the sample on each of the two islands -- and it achieved that ratio.

4. Some communities have much higher ratios of homeowners than others during the summer.

Marital Status

About seven-tenths of both samples are married.

Table M11
MARRIED OR SINGLE

	Homeowner percent	Homeowner O-T-B percent
MARRIED	70.3	68.7
SINGLE	29.7	31.3

Number of People in Permanent Residence

Those interviewed in their homes tend to have slightly smaller households than homeowners interviewed on the beach. The median number of people in the household for homeowners (in homes) was 2;

The median number of people in the household for homeowners O-T-B was 2.7.

Comparison of Samples: Summary

While those interviewed at home are, on average, older and less likely to be in the labor force, many issues under analysis in this study -- homeownership and shore visiting patterns -- remain quite similar across a range of comparisons. The similarities include date of purchase, method of acquiring house (inherited or purchased), income, marital status, time spent at the shore, race/ethnicity.

OTHER REFERENCE DATA

Distance from the Beach

We recorded the location of each house in relation to the beach. Typically, wealthier homes are closer to the beach. Most homes were within two blocks of the beach.

A caution is noted, however, that these six communities are on barrier islands; they are typically only a few blocks wide (with some exceptional portions). Thus, the fact that most homes are not far from the beach should not be interpreted as an indication of great wealth.

Table M12
NUMBER OF BLOCKS TO THE BEACH? (Homeowner Survey Only)

Value Label	Value	Frequency	percent	Valid percent	Cum percent
	1	1	.4	.4	.4
	1	81	32.3	32.8	33.2
	2	88	35.1	35.6	68.8
	3	47	18.7	19.0	87.9
	4	13	5.2	5.3	93.1
	5	7	2.8	2.8	96.0
	6	3	1.2	1.2	97.2
	7	1	.4	.4	97.6
	10	4	1.6	1.6	99.2
	15	1	.4	.4	99.6
	20	1	.4	.4	100.0
	-1	4	1.6	Missing	
		---	---	---	
	Total	251	100.0	100.0	
	Total	251	100.0	100.0	

Valid cases 244 Missing cases 7

IV. PERCEIVED VALUE AND DOLLARS

In the previous sections we presented the findings from our surveys on the beaches, in homes, and in businesses. In this section we try to link key survey findings on the individual's value of beaches to dollar estimates for the communities.

In this brief review we can only sketch some of the possible analyses. We hope these examples, however, help suggest some directions for economic use of the survey data.

BEACH USERS AND PERCEIVED VALUE OF A DAY AT THE BEACH

A series of questions in the beach user questionnaire engages the respondent in a process to determine the perceived value of a day at the beach. We derived two figures from that process:

1. The mean value of a day at the beach based on all beach users, including those who provided a "zero" value. The mean was $4.22

2. The mean value of a day at the beach based on all beach users who provided values greater than "zero" -- those who indicated a positive value. This mean was $5.04

Which measure to use? Once a perceived value of a day at the beach is determined, the next step is to multiply that value by the number of beach users. But which measure is more appropriate? Those with zero values, or only those with positive values? We argue that the best measure is the lower figure ($4.22) because it incorporates in it the 16% of beach users who assign a zero value in the bidding process. That is, it already reflects those who might have to be "subtracted" from the higher mean of $5.04. Thus, the more conservative figure will be used in the next step.

Important Note on Beach Tags and Beach Fees: Much of the previous research incorporating this valuation procedure did not involve beaches with beach tags or beach fees. It is most probable that without a beach tag fee we would have derived a higher valuation for a day at the beach (and fewer respondents suggesting a zero contribution). Thus, users of these data are urged to consider the downward impact of these beach fees. Five of the six beaches we surveyed had beach tags/beach fees.

Number of Beach Users: Data on the number of beach users at six communities are derived from the several tourism boards and chambers of commerce. For five of our communities, the best usage figures are obtained from the sale of beach tags. Atlantic City, which is the only community without beach tags, reports what it insists are reliable estimates of beach usage.

To derive a common denominator for the data, we convert each of the beach tag sales figures to

daily estimates. Thus, weekly tags are multiplied by 7 (days), and season tags are multiplied by 98 (days).

Estimate of Beach Days for Beach Tag Communities

Community	Season Tags	Weekly Tags
Margate	28,400	4,699
Ventnor	28,985	29,900
Stone Harbor	22,700	11,100
Avalon	41,961	17,160
Longport	8,883	1,490
Subtotal	130,929	64,349

To derive the total number of days:

130,929 X 98 = 12,831,042

64,349 X 7 = 450,443

Subtotal 13,281,485

To this we correct by the average number of beach tag cheaters (6.2%) ascertained in the beach users survey (see Table 10, Section I).

13,281,485 x 106.2% = 14,104,937 beach user days.

Atlantic City: To the above figure we must add the beach user figures from Atlantic City, the one community without beach tags. Atlantic City informs us that the average daily number of beach users is 100,000. Multiplied by the 98 days in the official season = 9,800,000 beach user days.

(Note that there is no "cheater" correction for the Atlantic City data because there are no beach tags.)

Combining the two figures yields: 23,904,937 beach user days.

The final product: Multiplying the number of beach user days by the mean value of a beach day ($4.22) generates a figure of $100,878,834.00. That is, the beach users' valuation of the beach is almost $101 million each season. Moreover, this figure only reflects the "official"

season. The beach is used much more than the 98 days of our analysis. Also, the $101 million does not reflect the value of the beach for children, who do not buy beach tags. Arguably, many children value the beach more than many adults.

The Value of A Wider Beach

About one-sixth of the beach users (16%) were willing more to pay for a wider beach. (A few [3.4%] are willing to pay for a narrower beach.) Among those willing to pay for a wider beach, the median additional amount (added to perceived value of a day at the beach) was $1.00. Thus if beach widening were undertaken, one could conceivably add $1.00 for 16% of the beach user-days. (And subtract $1.00 for 3.4% of the beach user' valuations.)

The arithmetic of that calculation is straightforward:

To add money for a wider beach:
No. of beach user-days (from above): 23,904,937 X .16 = 3,824,789 X $1.00 = $3,824,789

To subtract money for an (unwanted) wider beach:
No. of beach user-days (from above): 23,904,937 X .034 = 812,768 X $1.00 = $812,786

The net gain:

$3,824,789 (more for a wider beach) less 812,786 (less for a wider beach)
Net value increase= $3,012,003 for a wider beach.

Note that although few want to pay taxes for wider beaches, the beach user survey reveals that almost all respondents say they want wide beaches.

A Special Fund for New Jersey Beach Erosion Protection

Over four-fifths (81.4%) of the respondents indicated they would contribute on an annual basis (beyond taxes) to a special fund for beach erosion protection, even if they did not use the beach. The median contribution offered was $50.00 (with a low of a few cents and a high of $10,000).

Because the question includes the phrase, "even if you did not use the beach," it is unclear which groups could be included (or excluded) in the analysis. All visitors to New Jersey? All Americans? If we take the $50 figure plus the 81.4% contribution rate as a guide to the number who would contribute, we can theoretically extrapolate to any known population. For example, New Jersey is fifth-ranked state in total tourism dollars. If 81.4% of tourists contributed $50.00 each, the resulting figure would be extraordinary. Alternately, one could limit the population to beach users in the state. Here, again, the dollar values would still be remarkable.

BUSINESSES AND THE VALUE OF THE BEACH

We have two questions/measures in the business survey that reflect the value of the beach to businesses.

The first asks the owners/managers to estimate the percentage of their customers who are in the area because of the beach. The median estimate is 75% of customers.

The second measure represents a different approach. It asks business owners/managers to estimate the affect on business income if the beach were to erode away. The result is very similar to the first: the median loss estimate is 75% of income.

Number of Businesses: The next obvious step is to determine the number of businesses in the 6 communities. This information was obtained from the six chambers of commerce and city offices. The data are:

Community	No. of Businesses
Atlantic City	2,940
Ventnor	627
Margate	539
Longport	215
Stone Harbor	672
Avalon	85
Total	5,078

Value of Business Receipts: U.S. Department of Commerce data indicate that the average retail business's receipts are $2,675,270 (Adjusted from Table 861, Statistical Abstract of the United States. U. S. Bureau of the Census. Washington, D.C. 1991). As a heuristic exercise, we assume that the average beach community business is taking in only one-quarter of that amount; thus the average receipts would be $668,817.

Continuing the example, and assuming that the 5,078 businesses take in the average receipts of $668,175., then the total value of receipts is $3,396,255,265.

If we accept the owners/managers' estimates of the value of the beach for their businesses equals 75%, then one way of deriving the value of the beach is to "earmark" 75% of the receipts:

.75 X $3,396,255,265 = $2,447,191,448.

That is, using a modest set of assumptions, and employing either of the survey-derived estimates of the beaches' importance to local businesses (erosion loss or customers draw), indicates that the value of the beach to businesses could be calculated at almost $2.5 billion. Further analysis would require obtaining business receipt data and/or business tax data.

More Taxes for a Wider Beach

As with beach users, business owners and managers were asked if they would be willing to pay more taxes for a wider beach. One quarter (25.3%) stated that they would be willing to pay more taxes for such enhancement. The median increase in taxes offered was 9%. (The minimum percentage increase was 1%, the maximum percentage increase was 200%.) Obviously, if one-quarter of all shore businesses were willing to pay 9% more in taxes for wider beaches, the impact would be considerable.

Again, further analysis would require obtaining business receipt data and/or business tax data.

A Special Fund for New Jersey Beach Erosion Protection:

As with beach users, business owners and managers were asked if they would be willing to contribute on an annual basis (beyond taxes) to a special fund for beach erosion protection, even if they did not use the beach. Seven-tenths of the businesses claimed they would contribute. The minimum offered was $5.00; the maximum offered was $10,000. The median contribution offered (of those 70% offering contributions) was approximately $175.00

Unlike the example of the beach users, we do know the number of businesses in the six communities. Multiplying the 5,078 businesses by the contribution ratio of 70% = 3,555. Multiplying 3,555 (number of businesses contributing) by the median contribution of $175.00

indicates that the total fund contribution is $622,125.

HOMEOWNERS AND THE VALUE OF THE BEACH

Much of the same methodology used in understanding the value of the beach for businesses can be employed with homeowners. That is, while homeowners do not have receipts, they did estimate the cost of erosion to the value of their homes, and they did indicate their willingness to support wider beaches and erosion prevention funds.

Cost of erosion

Each homeowner was asked to estimate the value of his/her property if the beaches were to suffer major erosion -- were to erode away completely. The median response was "three-quarters of its value." Below, we list the median value of homes and the number of homes in the six target communities.

Community	Median House Price	Total No. of Homes
Atlantic City	$73,400	13,453
Ventnor	137,700	6,645
Margate	176,800	7,904
Longport	201,800	3,300
Stone harbor	285,600	7,266
Avalon	285,700	1,474
	Total	40,042

Multiplying each community's median house price by the number of houses, and summing the figures yields a total home value of almost 6.5 billion dollars ($6,462,126,000).

If, based on the survey's median estimate, three-quarters of the value were to be lost due to total beach erosion, than the loss would equal over 4.8 billion dollars -- $4,846,594,500.

Taxes for a Wider Beach

Homeowners were also asked if they would be willing to pay more taxes for a wider beach. About a sixth (17.5%) indicated that they were willing to pay more taxes for such enhancement. The median of additional taxes offered was 10%. The minimum was 0.1% and the maximum was 200% additional taxes.

A Special Fund for New Jersey Beach Erosion Protection:

Last, homeowners were also asked if they would be willing to contribute on an annual basis to a special fund for beach erosion -- even if they did not directly benefit from it. Seven-tenths said they would contribute to such a fund. The median contribution for those offering a contribution was $229.50

If we do the math, the additional contributions to the fund are:

40,042 homes X .70 (contribution ratio) = 28,029 X $229.50 (themedian contribution) = $6,432,655. Thus, homeowners indicate that they would be willing to contribute an additional $6.4 million for a general fund against beach erosion.

Summary and Linking of Estimates

Many factors (e.g., employment and its multipliers, tourism expenditures, beach fees, and rental income) determine the value of the beach to a community or region. This report has focused on several measures obtained from our surveys. It is clearly beyond the scope of this report to ascertain exact dollar figures for the total value of the beach. We have, however, attempted to sketch some of the possible economic analyses and computations that can be based on the survey data and/or on the survey data in concert with other data.

Below, we combine the figures we have derived to provide partial estimates of the value of the beach -- estimates that would not be possible without the survey data:

Beach Users
The beach users' valuation of the beach (official season days only)..... $100,878,834

Net tax increase for a wider beach..... 3,012,003

Contributions to a beach erosion fund ($50 X 81.4% of sample) Specific value... undetermined

Businesses
Value of beach to businesses (percent of customers or loss if total erosion)..... 2,447,191,448

Businesses willing to pay more taxes for wider beach (25.3% of businesses @ median of 9% increase)..... undetermined

Businesses willing to contribute to a beach erosion fund..... 622,125

Homeowners
Cost of erosion to homeowners (their estimate of loss)..... 4,846,594,500
(Note: Unlike the other figures in this list, this number is not repeated annually.)

Homeowners willing to pay more for a wider beach..... undetermined

Homeowners willing to contribute to a beach erosion fund..... 6,432,655

Total annual value = $2.659 billion
Total one-time value = $4.847 billion

The data indicate that the annual added value of the beach, based only on these survey estimates, is $2.659 billion.

This figure does not include any estimate of: beach users contributions to a beach erosion fund; additional taxes that businesses say they would pay for a wider beach; or additional taxes

that homeowners say they are willing to pay for wider beaches. Note also that our calculations do not include the funds paid to the municipalities for beach fees. The undetermined monies could well dwarf the sums listed above.

Last, the $2.659 billion annual figure does not reflect the $4.8 billion that homeowners estimate as their loss to erosion.

Clearly the importance of the beach -- as perceived by its users and as estimated by businesses and homeowners -- is enormous. The data presented in this report should allow analysts to more fully and accurately estimate the true value of this resource.

DRAFT

Appendix C.

Clean Air Act Calculations

General Conformity Review and Emission Inventory
Hereford Inlet to Cape May Inlet Feasibility Study

Table 2. Pollutant Emissions from Employee Vehicles

Assumptions: Average trip distance (1 way) is 30 miles.
Every member of the work crew drives their own vehicle.
Mob/Demob work crew comprised of 12 people.
Mob/Demob work crew works 20 days.
Beach construction work crew comprosed of 12 people.
Beach construction work crew works 248 days with 3 shift changes.
Average NOx vehicle emission factor is 0.96 g/mile.
Average VOC vehicle emission factor is 0.84 g/mile.

NOx

Mob/Demob Work Crew
12 workers * 2 trips/day *20 days * 30 miles/trip * 0.96 g of NOx/mile
NOx emissions from the Mob/Demob work crew = 0.015 tons

Beach Construciton Work Crew
12 workers * 6 trips/day *248 days * 30 miles/trip * 0.96 g of NOx/mile
NOx emissions for beach work crew = 0.57 tons

Total NOx resulting from employee vehicles = 0.582 tons.

VOC

Mob/Demob Work Crew
20 workers * 2 trips/day * 5 days * 30 miles/trip * 0.84 g of VOC/mile
VOC emissions from the Mob/Demob work crew = 0.006 tons

Beach Construction Work Crew
12 workers * 2 trips/day *385 days * 30 miles/trip * 0.84 g of VOC/mile
VOC emissions for beach work crew = 0.257 tons

Total VOC resulting from employee vehicles = 0.263 tons.

Table 3. Total Estimated Pollutant Emissions from Construction Equipment and Employee Vehicles

Nox= 86.8 Tons
VOCs= 3.3 Tons

General Conformity Review and Emission Inventory
Hefeford to Cape May Feasibility Study

Table 1. Project Emission Sources and Estimated Power

Load Factor (LF) represents the average percentage of rated horsepower used during a source's operational profile

Hp-hr = # of engines*Hp*LF*hrs of operation

Emissions (g) = Power Demand (Hp-hr) * Emission Factor (g Nox or VOC/Hp-hr)

Emissions (tons) = Emissions (g) * (1 ton/907180 g)

			Emissions Factors		Total Emissions (Tons)	
Equipment/Engine Category	**# of engines**	**Hp**	**Load Factor**	**Total Hours**	**Hp-Hours**	**Nox**	**VOCs**	**Nox**	**VOCs**
Crane, hydraulic, truck mounted 14 ton	1	130	0.43	589	32,925	9.5	0.2	0.34479205	0.007259
Boat, outboard, 18' river runner, CAP 1,350 lbs	1	115	0.29	800	26,680	9.7	0.37	0.28527525	0.010882
Generator set, portable, 10KW	1	19	0.74	5,501	77,344	9.5	0.2	0.80994794	0.017052
Generator set, skid mtd, 300KW	1	428	0.74	4,800	1,520,256	9.5	0.2	15.9201393	0.335161
Generator set, portable, 5.6KW, 120/240 V 60 Hz	1	11	0.74	286	2,328	9.5	0.2	0.02437926	0.000513
Drill,earth/auger, hydraul auger, 14" dia	1	58	0.74	32	1,373	9.5	0.2	0.01438268	0.000303
Cranes, hydraul.self-propelled, rough terrain, 50 ton, 110' boom, 4X4	1	240	0.43	4,896	505,267	9.5	0.2	5.29116427	0.111393
Loader/backhoe, wheeled, 0.8 CY front end bkt.	1	67	0.59	24	949	9.5	0.2	0.00993501	0.000209
Pump,water,horiz boooster, skid mtd, GIW 12"dia	1	341	0.80	11,424	3,116,467	9.7	0.37	33.3227494	1.271074
Water pump, submersible agitator dredge pump, TOYO, 150 hp	1	150	0.80	4,800	576,000	9.7	0.37	6.15886594	0.234926
Light set, Trailer Mtd, 4-1000W, w/6KW Gen, Man Mast winch	1	12	0.68	5,501	44,888	9.5	0.2	0.47006936	0.009896
Tractor, crawler (dozer), 310 Hp, LGP, w/ 15.3 CY blade	1	310	0.21	9,640	627,564	9.5	0.2	6.57185785	0.138355
Truck, highway, 4x2, 25,000 lbs GVW	1	210	1.00	24	5,040	8.16	0.76	0.04533433	0.004222
Truck, highway, 6x4, 50,000 lbs GVW	1	310	1.00	270	83,700	10.72	0.67	0.98906942	0.061817
Truck,hwy, crew, 1 Ton Pickup, 4X4	1	180	1.00	6,290	1,132,200	10.33	0.54	12.8922882	0.673943
Truck, hwy, conventional, 3/4 ton pickup, 4X4	1	130	1.00	2,024	263,120	10.33	0.54	2.99613043	0.156623
Welder, gas, 300 amp, 3 KW, trailer mtd.	1	45	0.43	210	4,064	9.5	0.2	0.04255302	0.000896
				Total Hp-Hours	8,020,165		**TOTAL:**	**86.2**	**3.0**

Mob/demob Crew: Crew of 12 will travel to work 10 days. Crew of 12 will travel from work 10 days.
Construction Crew: Crew of 12 will travel to work 248 days for 3 8-hr shifts/day. Crew of 12 will travel from work 385 days for 3 shifts/day (total of 6 trips/day).

Load Factors and Emissions Factors were obtained from emissions estimates provided for USACE (2013) and USEPA (2004)

Appendix D.
U.S. Fish and Wildlife Coordination

Planning Aid Report
2b Report

PLANNING AID REPORT

HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY

CAPE MAY COUNTY, NEW JERSEY

Prepared by:

U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey 08232

February 2008

United States Department of the Interior

FISH AND WILDLIFE SERVICE

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In Reply Refer to:

2007-FA-0316

FEB 0 1 2008

Minas M. Arabatzis, Chief
Planning Division, Philadelphia District
U.S. Army Corps of Engineers
Wanamaker Building – 100 Penn Square East
Philadelphia, Pennsylvania 19107 - 3390
Attn: Beth Brandreth

Dear Mr. Arabatzis:

Enclosed is a U.S. Fish and Wildlife Service (Service) planning aid report (PAR) on the U.S. Army Corps of Engineers, Philadelphia District (Corps) Hereford Inlet to Cape May Inlet Feasibility Study, Cape May County, New Jersey. The information presented in this PAR addresses potential beneficial or adverse impacts on fish and wildlife resources from proposed shore protection along the five-mile-long barrier island. This report has been prepared pursuant to the Scope-of-Work and Fiscal Year-2007 and 2008 interagency agreement between the Corps and the Service.

This PAR is provided as technical assistance and does not constitute the report of the Secretary of the Interior pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401; 16 U.S.C. 661 *et seq.*). This PAR is valid only for the described conditions and must be revised if changes to the proposed project take place prior to initiation.

The information presented in this PAR is also provided pursuant to the Endangered Species Act of 1973 (ESA) (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) to ensure the protection of endangered and threatened species and the Migratory Bird Treaty Act of 1918 (MBTA) (40 Stat. 755; 16 U.S.C. 703-712), as amended. These comments do not preclude future review and comments by the Service on any forthcoming environmental documents pursuant to the National Environmental Policy Act of 1969 (NEPA) (83 Stat. 852; 42 U.S.C. 4321 *et seq.*), as amended.

FEDERALLY LISTED THREATENED AND ENDANGERED SPECIES

The federally listed (threatened) piping plover (*Charadrius melodus*) nests on the beaches in the vicinity of North Wildwood, U.S. Coast Guard's LORAN site, and Cape May National Wildlife Refuge; and are known to forage along the beaches of Wildwood Crest and Lower Township.

On a rare note, one pair previously nested in Wildwood Crest in 1998. Piping plovers nest on sandy beaches above 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 sandpits, and on sites with deposits of suitable dredged or pumped sand.

Coastal development for residential and commercial uses, and the subsequent stabilization of the once shifting and dynamic ecosystem, have resulted in the degradation and alteration of natural beaches to such an extent along the Atlantic coast that many beaches no longer provide suitable habitat for piping plovers. Disturbance by humans and the direct loss of nests have become major contributing factors to the population decline of the piping plover (U.S. Fish and Wildlife Service 1996a).

Dredged spoil deposition has the potential to create sub-optimal piping plover nesting habitat, provided the material is deposited prior to nesting (U.S. Fish and Wildlife Service 1996a). As a result, piping plovers could expand their nesting range within the project area after nourishment is completed. This occurred as a result of Corps - New York District beach nourishment projects in Monmouth County, New Jersey in July 2000 (U.S. Fish and Wildlife Service 2002). Prior to initial beach nourishment in 1994, piping plovers were not documented in that project area for at least a decade.

The project may also create habitat for seabeach amaranth (*Amaranthus pumilus*), a federally listed (threatened) plant (U.S. Fish and Wildlife Service 1996b). Seabeach amaranth is an annual plant, endemic to Atlantic coastal plain beach, primarily occurring 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 materials placed as beach replenishment or dredge spoil. Occurrences of seabeach amaranth are known within the proposed project area, the species has recently naturally recolonized coastal sites within New York and Maryland. Therefore, it is possible that seabeach amaranth may become naturally reestablished within the project area during the project life. Colonization of seabeach amaranth occurred in July 2000 after a Corps - New York District beach nourishment project in Monmouth County, New Jersey (U.S. Fish and Wildlife Service 2002).

Other than the piping plover and seabeach amaranth, the federally and State-listed roseate tern (*Sterna dougallii*) (occasional transient) and State-listed peregrine falcon (*Falco peregrinus*) are known to use the project area. In addition, the Federal candidate species red knot (*Calidris canutus rufa*) is known to stopover in Delaware Bay and Hereford Inlet during spring (northward) migration where they feed mainly on the eggs of horseshoe crabs (*Limulus polyphemus*) to build fat reserves for the 3,000 kilometer flight to the arctic breeding grounds and to ensure survival if they arrive when food availability is low (New Jersey Department of Environmental Protection 2007). The crucial importance of Delaware Bay and Hereford Inlet must be considered when evaluating potential project impacts. Red knots also use Hereford Inlet and Delaware Bay during fall migration for feeding and roosting (New Jersey Department of Environmental Protection 2007).

The lead Federal agency for a project has the responsibility, under Section 7(c) of the ESA, to prepare a Biological Assessment (BA) if the proposal is a major construction project that requires an Environmental Impact Statement or if the proposal may affect a federally listed species. Therefore, the Corps must prepare a BA to address potential project-related adverse impacts to the piping plover and seabeach amaranth. The assessment should contain information concerning the piping plover and seabeach amaranth within the action area and an analysis of any potential effect of the proposed action on these species. We strongly recommend including potential effects on the red knot in the BA as the red knot could become federally listed species in the future. The BA may be incorporated into the Corps NEPA documentation.

The National Marine Fisheries Service (NMFS) must be consulted regarding Essential Fish Habitat, as required under Section 305 (b)(2) of the Magnuson – Stevens Fishery Conservation and Management Act (16 U.S.C. 1801-1882). The NMFS must also be consulted regarding the ESA due to the potential presence of the federally listed (endangered) Kemp's ridley sea turtle (*Lepidochelys kempii*), hawksbill sea turtle (*Eretmochelys imbricata*) and leatherback sea turtle (*Dermochelys coriacea*), and the federally listed (threatened) loggerhead sea turtle (*Caretta caretta*) and green sea turtle (*Chelonia mydas*) within the project area and any borrow areas. Appendix A provides a current list of federally listed (endangered and threatened) and candidate species in New Jersey.

Any questions regarding this PAR or federally listed endangered or threatened species should be directed to Ron Popowski. Mr. Popowski is deaf and uses video relay service. He can be reached at (877) 467-4877, extension 42421 or e-mail at Ron_Popowski@fws.gov. The Service looks forward to continued cooperation with the Corps in the planning stages of the proposed project.

Sincerely,

J. Eric Davis Jr.

J. Eric Davis Jr.
Supervisor

Enclosure

LITERATURE CITED

New Jersey Department of Environmental Protection. 2007. Status of the Red knot (*Calidris canutus rufa*) in the Western Hemisphere. Prepared for U.S. Department of the Interior, Fish and Wildlife Service, Region 5, New Jersey Field Office, Pleasantville, NJ. 287 pp.

U.S. Fish and Wildlife Service. 1996a. Piping plover (*Charadrius melodus*), Atlantic Coast population, revised recovery plan. U.S. Department of the Interior, Fish and Wildlife Service, Region 5, Hadley, MA. 245 pp.

_____. 1996b. Recovery plan for seabeach amaranth (*Amaranthus pumilus*) Rafinesque. U.S. Department of the Interior, Fish and Wildlife Service, Region 4, Atlanta, GA. 70 pp.

_____. 2002. Biological opinion on the effects of completion of sections I and II of the Atlantic Coast of New Jersey beach erosion control project Sea Bright to Manasquan, Monmouth County, New Jersey on the piping plover (*Charadrius melodus*) and seabeach amaranth (*Amaranthus pumilus*). U.S. Department of the Interior, Fish and Wildlife Service, Region 5, New Jersey Field Office, Pleasantville, NJ. 124 pp.

EXECUTIVE SUMMARY

The Philadelphia District, U.S. Army Corps of Engineers (Corps) was authorized to conduct a feasibility study to investigate storm damage reduction, beach restoration, and water quality improvement alternatives within Hereford Inlet, North Wildwood and Cape May Inlet, Lower Township project area (project area), Cape May County, New Jersey. The length of the project area is approximately seven miles long and exhibits several different coastal issues. The North Wildwood portion of the project area is prone to moderate to severe erosion, leaving the surrounding community vulnerable to storm damages. Meanwhile, the beaches of Wildwood and Wildwood Crest have been accreting large quantities of sand resulting in a large, low, flat beach offering little habitat value and resulting in human health and water quality concerns due to clogged outfall pipes on the beach. Potential alternatives currently being considered for the project include "bypassing" sand from Wildwood to North Wildwood and changing the beach configuration in Wildwood by increasing berm height or adding a dune. Within the project area no work is planned for either the Cape May National Wildlife Refuge or the U.S. Coast Guard's LORAN site.

In this planning aid report (PAR), the U.S. Fish and Wildlife Service (Service) identifies fish and wildlife resources in the vicinity of the five-mile-long barrier island bordered to the north by Hereford Inlet and to the south by Cape May Inlet (formerly Cold Spring Inlet), discusses potential impacts on those resources from erosion control activities, identifies opportunities for fish and wildlife habitat improvements, and updates the current state of knowledge concerning the proposed activities and their potential beneficial or adverse impacts on fish and wildlife resources, including federally listed species.

The federally listed (threatened) piping plover (*Charadrius melodus*) nests on the beaches within the project area in the vicinity of North Wildwood, U.S. Coast Guard's LORAN site, and Cape May National Wildlife Refuge; and are known to forage along the beaches of Wildwood Crest and Lower Township. Piping plovers nest on sandy beaches above the high-tide line on mainland coastal beaches, sand flats, and barrier island coastal beaches. The Service views this beach nourishment project, specifically at North Wildwood, as an opportunity to enhance nesting habitat for piping plover, shorebirds, and colonial nesting waterbirds, including the Federal candidate red knot (*Calidris canutus rufa*), and the State-listed (endangered) black skimmer (*Rynchops niger*) and least tern (*Sterna antillarum*).

In addition to piping plover, shorebirds, and colonial nesting waterbirds, the project may also create habitat for seabeach amaranth (*Amaranthus pumilus*), a federally listed (threatened) plant (U.S. Fish and Wildlife Service 1996b). Seabeach amaranth is an annual plant, endemic to Atlantic coastal plain beaches, primarily occurring on overwash flats at the accreting ends of barrier beach islands and lower foredunes of non-eroding beaches. Occurrences of seabeach amaranth are known within the proposed project area. The species has recently naturally recolonized coastal sites within New York and Maryland; therefore, it is possible that seabeach amaranth may become naturally reestablished within the project area during the life of the project. Colonization of seabeach amaranth occurred in July 2000 after a New York District Corps beach nourishment project in Monmouth County, New Jersey (U.S. Fish and Wildlife Service 2002). To

minimize potential adverse impacts associated with renourishment activities along the Atlantic Coast in New Jersey, the Service developed a streamlined biological opinion to assess and evaluate project impacts to piping plovers and seabeach amaranth.

In December 2005, the Service developed a Programmatic Biological Opinion (PBO), in accordance with Section 7 of the Endangered Species Act of 1973 (ESA) (87 Stat. 884, as amended,16 U.S.C. 1531 *et seq.*), on the effects of beach nourishment, renourishment, stabilization, and restoration projects funded, permitted, or conducted by the Corps along the Atlantic Coast of New Jersey on the federally listed (threatened) species piping plover and seabeach amaranth. The purpose of the PBO is to expedite review of Corps funded and permitted Program activities.

In closing, this PAR ends with recommendations for beach communities, borrow areas, and beach habitat enhancements. In order to avoid and minimize potential adverse impacts on State-listed and federally listed threatened and endangered species within project area, the Service recommends incorporating nine measures into project planning. The PAR also includes eight recommendations for borrow areas; and six recommendations for habitat enhancement.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY i

LIST OF FIGURES v

LIST OF TABLES v

APPENDICES vi

I. INTRODUCTION 1

II. PROJECT AREA 1

III. METHODS AND PROCEDURES 1

IV. BEACH COMMUNITIES 3

A. AVIAN AND OTHER WILDLIFE RESOURCES 3

1. **Shorebirds and Colonial Nesting Waterbirds** 3
2. **Waterfowl** 4
3. **Raptors** 4
4. **Other Wildlife** 4

B. FEDERALLY LISTED AND CANDIDATE SPECIES UNDER SERVICE JURISDICTION 5

1. **Piping Plover** 5
   a. Species Description 5
   b. Life History 5
   c. Population Status 6
   d. Continuing Threats 8

2. **Red Knot** 9
   a. Species Description 9
   b. Life History 9
   c. Population Status 10

3. **Seabeach Amaranth** 12
   a. Species Description 12
   b. Life History 12
   c. Population Status 14
   d. Continuing Threats 14

C. FEDERALLY LISTED SPECIES UNDER NMFS JURISDICTION 16

D. STATE LISTED SPECIES 16

1. Black Skimmer 17
2. Least Tern 18
3. Coordination with the State 19

V. BORROW AREAS 20

A. MARINE FINFISH 20

B. BENTHIC RESOURCES 21

VI. PROJECT IMPACTS AND RECOMMENDED MITIGATIVE MEASURES 22

A. PIPING PLOVER 22

B. SEABEACH AMARANTH 24

C. RED KNOT, BLACK SKIMMER, AND LEAST TERN 24

D. BIOLOGICAL ASSESSMENT 25

E. MUNICIPAL RESPONSIBILITIES 25

F. BEACH HABITAT ENHANCEMENT 26

G. BORROW AREAS 27

VII. CONCLUSIONS AND SUMMARY OF RECOMMENDATIONS 28

A. BEACH COMMUNITIES 28

B. BEACH HABITAT ENHANCEMENT 29

C. BORROW AREAS 29

VIII. REFERENCES 30

A. LITERATURE CITED 30

B. PERSONAL COMMUNICATIONS 36

LIST OF FIGURES

Figure — Page

Figure 1 Project Area - Hereford Inlet to Cape May Inlet, Cape May County, New Jersey 2

LIST OF TABLES

Table — Page

Table 1 Summary of Piping Plover Productivity Estimates for the U.S. Atlantic Coast, 1994-2003 7

Table 2 Known Vegetative Associates of Seabeach Amaranth 13

Table 3 Re-colonization Dates of Seabeach Amaranth in Five States 14

Table 4 Number of Black Skimmers at New Jersey Nesting Sites: 1999-2006 17

Table 5 Number of Adult Least Terns at New Jersey Nesting Sites: 1999-2006 18

Table 6 Federally Managed Fish Species within the Project Area 20

APPENDICIES

Appendix A	Federally Listed Endangered and Threatened Species and Candidate Species in New Jersey
Appendix B	Colonial Nesting Birds and Shorebirds within Hereford Inlet to Cape May Inlet Project Area (prepared by New Jersey Audubon Society)
Appendix C	State-Listed Endangered and Threatened Species in New Jersey
Appendix D	Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act.
Appendix E	Guidelines for Managing Fireworks in the Vicinity of Piping Plovers and Seabeach Amaranth on the U.S. Atlantic Coast

I. INTRODUCTION

The purpose of this U.S. Army Corps of Engineers (Corps) study is to investigate storm damage reduction, beach restoration, and water quality improvement alternatives within the Hereford Inlet, North Wildwood to Cape May Inlet project area (project area), Lower Township, Cape May County, New Jersey (Figure 1) . The project area exhibits several different coastal issues. The North Wildwood portion of the project area is prone to moderate to severe erosion, leaving the surrounding community vulnerable to storm damages. The beaches of Wildwood and Wildwood Crest have been accreting large quantities of sand, resulting in human health and water quality concerns due to clogged outfall pipes on the beach. Potential alternatives currently being considered for the project include "bypassing" sand from Wildwood to North Wildwood and changing the beach configuration in Wildwood by increasing berm height or adding a dune.

In this planning aid report (PAR), the U.S. Fish and Wildlife Service (Service) identifies fish and wildlife resources in the vicinity of the five-mile-long barrier island bordered to the north by Hereford Inlet and to the south by Cape May Inlet (formerly Cold Spring Inlet), discusses potential impacts on those resources from erosion control activities, identifies opportunities for fish and wildlife habitat improvements, and updates the current state of knowledge concerning the proposed activities and their potential adverse impacts on fish and wildlife resources.

II. PROJECT AREA

The length of the project area is approximately seven miles, including the five-mile-long barrier island from Hereford Inlet to Cape May Inlet located in coastal Cape May County, New Jersey. Municipalities, Boroughs, and Townships on the island include North Wildwood, Wildwood, Wildwood Crest, West Wildwood, Diamond Beach, and Lower Township (Figure 1). The Two-Mile Beach Unit of the Cape May National Wildlife Refuge (CMNWR) managed by the Service and a natural area within the U.S. Coast Guard LORAN site are located at the northern boundary of Cape May Inlet within Lower Township (Figure 1). Hereford Inlet opens to the Atlantic Ocean and is located between Stone Harbor Point and North Wildwood. The inlet contains a scour hole, located along the southern end of the seawall at Angelesea in North Wildwood. The scour hole possibly resulted from dredging of fill materials for the Townsends Inlet to Hereford Inlet or another beach nourishment project. At this time, no detailed information has been provided regarding the physical and biological characteristics of the scour hole.

III. METHODS AND PROCEDURES

This PAR incorporates information compiled from the Service's New Jersey Field Office library and office files, personal communications, the New Jersey Department of Environmental Protection (NJDEP) database, CMNWR, New Jersey Audubon Society (NJAS), and the Corps' Hereford Inlet to Cape May Inlet Feasibility Study Project Management Plan (U.S. Army Corps of Engineers 2005). The database was reviewed for information regarding federally listed species, State-listed species, and other fish and wildlife in the vicinity of Hereford Inlet to Cape

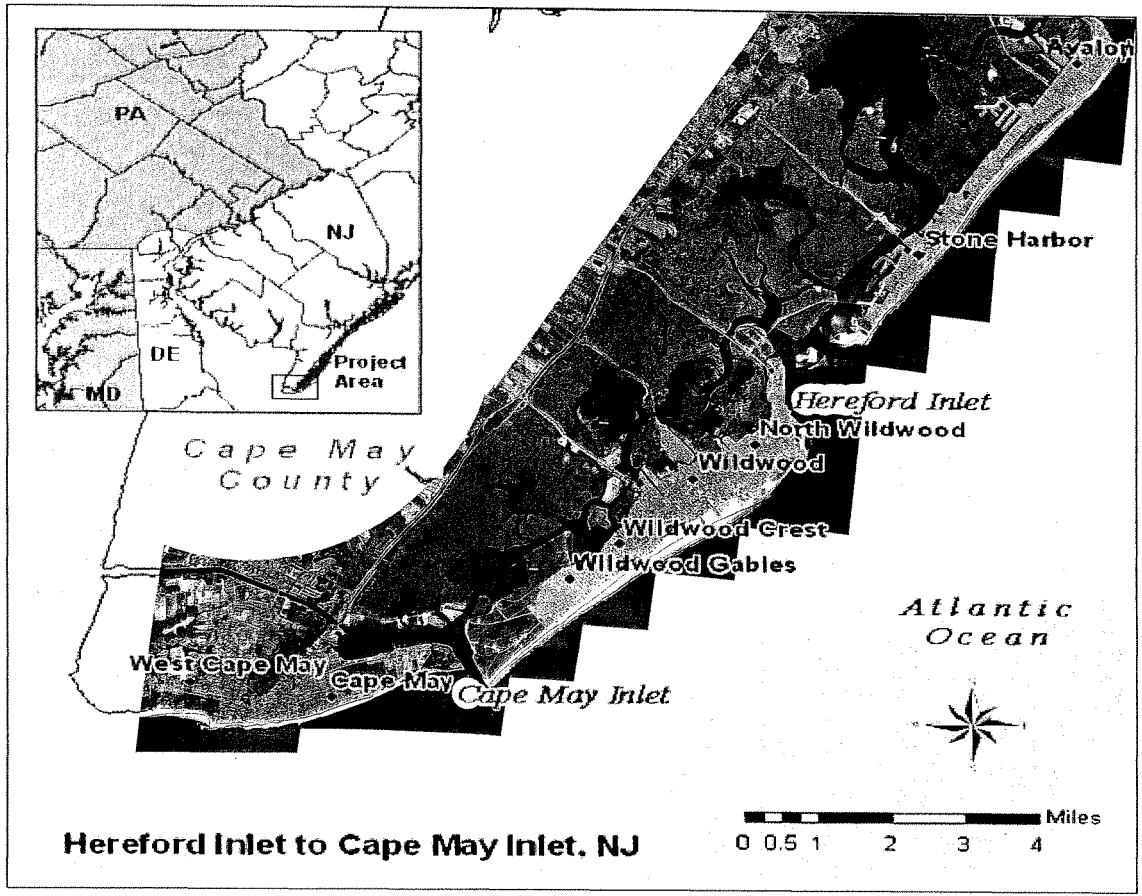

Figure 1. Project area - Hereford Inlet to Cape May Inlet, Cape May County, New Jersey

May Inlet. In addition, personal communications were held with personnel from the CMNWR, New Jersey Division of Fish and Wildlife (NJDFW); New Jersey Bureau of Shellfisheries; New Jersey Bureau of Marine Fisheries; and the National Marine Fisheries Service (NMFS). Representatives of the Corps, the NJDEP, and the Service conducted a site visit of the project area on October 30, 2007. The discussion during the site visit concluded with support to move forward the necessary steps to reconfigure the North Wildwood beach to withstand potential storm damage. The interagency study team determined that beach enhancements such as the creation of gently sloping foredunes within project area would benefit piping plover (*Charadrius melodus*) and other beach nesting birds.

IV. BEACH COMMUNITIES

A. AVIAN AND OTHER WILDLIFE RESOURCES

1. Shorebirds and Colonial Nesting Waterbirds

Migratory shorebirds are a Federal trust resource responsibility of the Service. Wetland areas in the vicinity of the five-mile-long barrier island provide high quality habitats for a variety of migratory shorebirds. Shorebirds that use beach areas and associated estuarine wetlands in the vicinity of the proposed project area include the federally listed (threatened) piping plover and Federal candidate species red knot (*Calidris canutus rufa*), American oystercatcher (*Haematopus palliatus*) (currently proposed as a State species of special concern), short-billed dowitcher (*Limnodromus griseus*), black-bellied plover (*Pluvialis squatarola*), semipalmated plover (*Charadrius semipalmatus*), killdeer (*C. vociferous*), ruddy turnstone (*Arenaria interpres*), dunlin (*Calidris alpina*), sanderling (*C. alba*), least sandpiper (*C. minutilla*), pectoral sandpiper (*C. melanotos*), semipalmated sandpiper (*C. pusilla*), stilt sandpiper (*C. himantopus*), western sandpiper (*C. mauri*), spotted sandpiper (*Actitis macularius*), willet (*Tringa semipalmatus*), and greater yellowlegs (*T. melanoleuca*). During the 2007 nesting season, Service biologists observed piping plovers foraging within the intertidal zone of the project area (Egger,USFWS, pers. comm. 2007).

The colonial nesting waterbirds present within the project area include the State-listed (endangered) least tern (*Sterna antillarum*) and black skimmer (*Rynchops niger*); State-listed (threatened) little blue heron (*Egretta caerulea*) and yellow-crowned night heron (*Nyctanassa violacea*); State species of special concern common tern (*Sterna hirundo*), tricolored heron (*Egretta tricolor*), great blue heron (*Ardea herodias*), and breeding population threatened black-crowned night heron (*Nycticorax nycticorax*). Other colonial species include double-crested cormorant (*Phalacrocorax auritus*), great egret (*Ardea albus*), snowy egret (*Egretta thula*), great black-backed gull (*Larus marinus*), herring gull (*L. argentatus*), laughing gull (*L. atricilla*), ring-billed gull (*L. delawarensis*), glossy ibis (*Plegadis falcinellus*), Forster's tern (*Sterna forsteri*), gull-billed tern (*S. nilotica*), and royal tern (*S. maxima*).

A list of colonial nesting birds and shorebirds prepared by the NJAS for the Hereford Inlet to Cape May Inlet project area is provided in Appendix B.

2. Waterfowl

Migratory waterfowl are also a Federal trust resource responsibility of the Service and are protected under the Migratory Bird Treaty Act of 1918 (MBTA) (40 Stat. 755; 16 U.S.C. 703-712), as amended. The project area is within the Atlantic Coast Joint Venture's New Jersey Waterfowl Focus Area (South Coast Atlantic Focus Area) under the North America Waterfowl Management Plan. Areas adjacent to the project area, including CMNWR are important resting and feeding areas for migratory waterfowl on the Atlantic flyway and provide habitat for Atlantic brant (*Branta bernicla*), Canada goose (*B. canadensis*), American black duck (*Anas rubripes*), northern pintail (*A. acuta*), blue-winged teal (*A. discors*), green-winged teal (*A. crecca*), mallard (*A. platyrhynchos*), gadwall (*A. strepera*), American wigeon (*A. americana*), Northern shoveler (*A. clypeata*), common goldeneye (*Bucephala clangula*), bufflehead (*B. albeola*), oldsquaw (*Clangula hyemalis*), canvasback (*Aythya valisineria*), greater scaup (*A. marila*), wood duck (*Aix sponsa*), hooded merganser (*Lophodytes cucullatus*), red-breasted merganser (*Mergus serrator*), and tundra swan (*Cygnus columbianus*).

3. Raptors

Raptors that occur in the project area include the State-listed (endangered) peregrine falcon (*Falco peregrinus*); State-listed (endangered) short-eared owl (*Asio flammeus*); State-listed (threatened) osprey (*Pandion haliaetus*), barred owl (*Strix varia*), Cooper's hawk (*Accipiter cooperii*), and red-shouldered hawk (*Buteo lineatus*). The osprey feeds primarily on fish in the back bays and inlets of the project area. The red-shouldered hawk and Cooper's hawk migrate over the study area in the spring and fall; however, these transient visitors rarely stay within the area for any significant length of time.

4. Other Wildlife

The five-mile-long barrier island area also supports numerous other wildlife species. Avifauna include the 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 (*Agelaius phoeniceus*).
The northern diamondback terrapin (*Malaclemys terrapin terrapin*) is also known to inhabit marshes, tidal flats, and beaches in New Jersey estuaries. The terrapin has been subject to recent population declines due to entrapment in crab pots and a reduction in nesting habitat. Northern diamondback terrapins occur primarily in emergent wetlands and shallow water habitat and feed on crustaceans, mollusks, and other invertebrates (Palmer and Cordes 1988). During the winter, terrapins burrow into the mud of tidal creeks and ponds to hibernate either individually or in groups. Terrapins mate in the spring and lay their eggs in sandy substrates above the levels of high tides. Predation of eggs and hatchlings represent the major source of natural mortality in most terrapin populations. Eggs and juveniles are preyed upon by raccoons (*Procyon lotor*), crows (*Corvus* sp.), and gulls (*Larus* sp.) (Palmer and Cordes 1988).

Mammals known to occur within the vicinity of project area include raccoon, gray squirrel (*Sciurus carolinensis*), striped skunk (*Mephitis mephitis*), eastern cottontail (*Sylvilagus*

floridanus), Virginia opossum (*Didelphis virginiana*), and white-tailed deer (*Odocoileus virginianus*).

B. FEDERALLY LISTED AND CANDIDATE SPECIES UNDER SERVICE JURISDICTION

1. Piping Plover

The piping plover was listed as a protected species under the ESA in 1986. Along the Atlantic Coast the species is federally designated as threatened. The piping plover has been State-listed as endangered in New Jersey since 1984 (U.S. Fish and Wildlife Service 1996a).

The Atlantic Coast population breeds on coastal beaches from Newfoundland and southeastern Quebec to North Carolina and primarily overwinters from North Carolina to Florida. In New Jersey, piping plovers nest on the coastline of Monmouth, Ocean, Atlantic, and Cape May counties (U.S. Fish and Wildlife Service 2005). Detailed background information regarding piping plover, including species biology, life history, recovery criteria and actions, and management issues are provided in the Service's Programmatic Biological Opinion (PBO) on the effects of beach nourishment, renourishment, stabilization, and restoration projects funded, permitted, or conducted by the Corps along the Atlantic Coast of New Jersey on piping plover and seabeach amaranth (U.S. Fish and Wildlife Service 2005). A summary is provided below.

a. Species Description

Piping plovers are small, sandy-colored territorial shorebirds, approximately 7 inches in length (Palmer 1967; U.S. Fish and Wildlife Service 1985; 1996a). The bird's name was derived from its call, which resembles plaintive bell-like whistles that are often heard before the birds are seen. Breeding adults have orange legs, a black ring around the base of the neck and across the forehead, and an orange bill with a black tip. The female's neck band is often incomplete and is usually thinner than the male's neck band. In winter, the black band completely disappears, and adults and juveniles look similar, with pale yellow legs and a solid black bill. Chicks have speckled gray, buff, and brown down feathers, black beaks, orange legs, and a white collar around the neck.

b. Life History

Piping plovers inhabit New Jersey beaches between March and August, arriving at their breeding grounds in late March through early April (U.S. Fish and Wildlife Service 2005). After choosing mates and establishing territories, piping plovers scrape depressions in the sand to form a nest and lay their eggs (Bent 1929; Burger 1987; Cairns 1982; Patterson 1988; Flemming *et al.* 1990; MacIvor 1990; Strauss 1990). The birds nest above the high tide line, usually on sandy ocean beaches and barrier islands, but also on gently sloping foredunes, blowout areas behind primary dunes, washover areas cut into or between dunes, the ends of sandspits, and deposits of suitable dredged or pumped sand (U.S. Fish and Wildlife Service 1996a; 2005). The nests are frequently lined with shell fragments and often located near small clumps of vegetation such as beachgrass (*Ammophila* spp.) (Patterson 1988; Flemming *et al.* 1990; MacIvor 1990). Plovers will lay their

eggs (up to 4) from mid-April through late June or early July and may renest more than once during the season if earlier clutches are lost (Wilcox 1959; Cairns 1977; MacIvor 1990). The eggs are well camouflaged and blend extremely well with their surroundings. Both the male and female will incubate the nest for about 30 days. After the eggs hatch, the chicks may be present on the beaches with their parents until the end of August when they are ready to fly (Patterson 1988; Goldin 1990; MacIvor 1990; Howard *et al.* 1993).

Piping plover adults and chicks feed on marine macroinvertebrates such as worms, fly larvae, beetles, crustaceans, and mollusks (Bent 1929; Cairns 1977; Nicholls 1989). Feeding areas include the intertidal zone of ocean beaches, ocean washover areas, mudflats, sandflats, wrack lines (organic ocean material left by high tide), and the shorelines of coastal ponds, lagoons, and salt marshes (Gibbs 1986; Coutu *et al.* 1990; Hoopes *et al.* 1992; Loegering 1992; Goldin 1993; Elias-Gerken 1994).

c. Population Status

The Atlantic Coast population increased from 957 pairs in 1989 to 1,676 pairs in 2003, but the increase has been unevenly distributed. Between 1989 and 2003, the New England subpopulation increased by 481 pairs, while the New York-New Jersey subpopulation gained only 211 pairs. The Southern and Atlantic Canada subpopulations gained only 4 pairs and 23 pairs, respectively (U.S. Fish and Wildlife Service 2004). While rapid overall population growth between 1991 and 1995, driven largely by the New England subpopulation, was encouraging, growth in the later half of the decade was more modest, with an essentially flat population trend from 1997 to 2000 (U.S. Fish and Wildlife Service 2005). The New York-New Jersey subpopulation experienced a net decrease of 45 pairs between 1996 and 1998, followed by several years of steady gains accounting for a net increase of 192 nesting pairs (greater than 50% increase) over a 6-year period (1998-2003) (U.S. Fish and Wildlife Service 2004).

Productivity needed to maintain a stationary population for Atlantic Coast piping plovers is estimated at 1.24 fledged chicks per pair (Melvin and Gibbs 1994). Small populations may be highly vulnerable to extinction due to variability in productivity and survival rates; therefore, the average productivity for a stationary population may be insufficient to assure a high probability of species survival. To compensate for small populations, the recovery plan establishes productivity goals needed to assure a secure 2,000-pair population at 1.5 chicks per pair in each of the four recovery units, based on data from at least 90% of each recovery unit's population.

Table 1 provides a summary of piping plover productivity from 1994 to 2003. The 10-year (1994-2003) average productivity for piping plovers in the U.S. Atlantic Coast portion of their range is 1.32 chicks per pair. Peak productivity in the U.S. was observed in 1994 and 1999 when average productivity approached or exceeded the recovery plan productivity goal of 1.5 chicks per pair. However, productivity in 1997, 2000, and 2003 was considerably lower, 1.16, 1.17, and 1.24 chicks per pair, respectively, and well below or just reaching the 1.24 chicks per pair required to maintain a stationary population (U.S. Fish and Wildlife Service 2004). While weather events were major contributors to egg and chick losses in these years (U.S. Fish and Wildlife Service 1998), such periodic natural events are inevitable, and they underscore the need

to reduce the species vulnerability by increasing the breeding population and protecting the species against human caused factors that impinge on productivity.

Mirroring the regional population trends, productivity rates have been unevenly distributed, with other recovery units lagging substantially behind New England. Average productivity from 1994 to 2003 in the New York-New Jersey Recovery Unit was 1.19 chicks per pair. In the New York-New Jersey Recovery Unit, over the past 10 years the 1.24 chicks per pair productivity needed to maintain a stationary population has been attained only four times, in 1994, 1999, 2001, and 2002. Nearly all pairs in the recovery unit for which productivity is unknown nested in New York (U.S. Fish and Wildlife Service 2004).

Table 1. Summary of Piping Plover Productivity Estimates for the U.S. Atlantic Coast, 1994-2003

	AVERAGE YOUNG FLEDGED PER PAIR										
STATE/REGION	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**1994 to 2003 AVG**
Maine	2.00	2.38	1.63	1.98	1.47	1.63	1.60	1.98	1.40	1.28	1.69
New Hampshire	-	-	-	0.60	2.40	2.67	2.33	2.14	0.14	1.00	1.58
Massachusetts	1.80	1.62	1.35	1.33	1.50	1.60	1.09	1.49	1.14	1.26	1.40
Rhode Island	2.00	1.68	1.56	1.34	1.13	1.79	1.20	1.50	1.95	1.03	1.48
Connecticut	1.47	1.35	1.31	1.69	1.05	1.45	1.86	1.22	1.87	1.30	1.45
NEW ENGLAND	1.81	1.67	1.40	1.39	1.46	1.62	1.18	1.55	1.26	1.24	1.44
New York	1.34	0.97	1.14	1.36	1.09	1.35	1.11	1.27	1.62	1.15	1.26
New Jersey	1.16	0.98	1.00	0.39	1.09	1.34	1.40	1.29	1.17	0.92	1.07
NY-NJ REGION	1.25	0.97	1.07	1.02	1.09	1.35	1.19	1.28	1.49	1.07	1.19
Delaware	2.50	2.00	0.50	1.00	0.83	1.50	1.67	1.50	1.17	2.33	1.46
Maryland	2.41	1.73	1.49	1.02	1.30	1.09	0.80	0.92	1.85	1.56	1.36
Virginia	1.65	1.00	1.54	0.71	1.01	1.21	1.42	1.52	1.19	1.90	1.33
North Carolina	0.36	0.45	0.86	0.23	0.61	0.48	0.54	0.50	0.17	0.46	0.46
SOUTHERN REGION	1.37	1.06	1.34	0.68	0.99	1.04	1.09	1.22	1.27	1.63	1.17
U.S. TOTAL	1.56	1.35	1.30	1.16	1.27	1.45	1.17	1.40	1.34	1.24	1.32
EASTERN CANADA	1.25	1.69	1.72	2.10	1.84	1.74	1.47	1.77	1.18	1.62	1.62

d. Continuing Threats

Continuing threats to Atlantic Coast piping plovers in the breeding portion of their range include habitat loss and degradation, disturbance by humans and pets, increased predation, oil spills, and herbivory. These detailed descriptions of threats are provided in the revised recovery plan (U.S. Fish and Wildlife Service 1996a) and PBO (U.S. Fish and Wildlife Service 2005).

Habitat loss results from development as well as from beach stabilization, beach nourishment, and other physical alterations to the beach ecosystem (U.S. Fish and Wildlife Service 1996a). Commercial, residential, and recreational development reduce the amount of suitable habitat available for nesting and feeding. Structures such as seawalls, jetties, groins, and bulkheads promote stabilization of the beach and rapidly promote natural succession, decreasing the sandy, sparsely vegetated habitat required for nesting. Predation on chicks and eggs is intensified by development because predators such as foxes (*Vulpes vulpes*), rats (*Rattus norvegicus*), raccoons (*Procyon lotor*); domestic dogs (*Canis familiaris*), domestic cats (*Felis silvestris*) and gulls (*Larus* spp.), thrive in developed areas and are attracted to beaches by food scraps and trash (Riepe 1989; Jenkins and Nichols 1994; Elias-Gerken 1994; Jenkins and Niles 1999; U.S. Fish and Wildlife Service 1996a; Canale 1997).

Human disturbance of nesting birds includes foot traffic, sunbathing, kite flying, pets, fireworks displays, beach raking, construction, and vehicle use. These disturbances can result in crushing of eggs, failure of eggs to hatch, and death of chicks (Wilcox 1959; Tull 1984; Burger 1987; Patterson *et al.* 1991). Excessive disturbance may cause the parents to desert the nest, exposing eggs or chicks to the summer sun and predators (Welty 1982; Bergstrom 1991). Piping plovers are vulnerable to domestic animals before and after the eggs hatch. Adult plovers will stagger and act as if they have a broken wing to distract predators from their nest or chicks. Flightless chicks are no match for an agile cat or dog that instinctively sees a chick as something to hunt or chase. Camouflaged chicks can also become trapped in tire ruts and be run over by recreational or municipal vehicles.

While removal of human-created trash on the beach is desirable to reduce predation threats, the indiscriminate nature of mechanized beach-cleaning adversely affects piping plovers and their habitat. In addition to danger of directly crushing piping plover nests and chicks and the prolonged disturbance from the machine's noise, this method of beach-cleaning removes the birds' natural wrack line feeding habitat (Eddings and Melvin 1991; Howard *et al.* 1993), and shell fragments, a preferred feature of nesting habitat.

Intensive management, including municipal beach management plans (BMP) to protect piping plovers from disturbance by beach recreationists, pets, and beach-cleaning operations have been implemented at many New York-New Jersey plover nesting sites in recent years. The Service and NJDFW are currently working with several coastal municipalities to develop and implement BMPs. Piping plover protection in this recovery unit is highly dependent on the efforts of State and local government agencies, conservation organizations, and private landowners.

2. Red knot

The Service has designated the red knot as a candidate for ESA protection. The *rufa* subspecies of red knot winters near the tip of South America and begins its long journey north in mid-February. By the time birds arrive, they have depleted their fat reserves and must refuel before continuing their migration to their Arctic breeding grounds. The birds rely heavily on the eggs of horseshoe crabs (*Limulus polyphemus*) to replenish their energy. At the end of May or the beginning of June, the birds depart the mid-Atlantic coast on the last leg of their journey, arriving in the Arctic in early mid-June.

a. Species Description

The red knot is a medium-sized shorebird about 9 to 11 inches (in) (23 to 28 centimeters) in length with a proportionately small head, small eyes, short neck, short tibia, and stout tarsus. The black bill tapers steadily from a relatively thick base to a relatively fine tip; bill length is not much longer than head length. Legs are typically dark gray to black, but sometimes greenish in juveniles or older birds in non-breeding plumage (Harrington 2001). During the breeding season, the plumage of the red knot is distinctive and easily recognizable. The face, breast, and upper belly are a rich rufous-red, while the lower belly and under tail-covert region are light-colored with dark flecks. Upperparts are dark brown with white and rufous feather edges; outer primary feathers are dark brown to black (Davis 1983; Harrington 2001). Females are similar to males, though rufous colors are typically less intense, with more buff or light gray on dorsal parts (Niles *et al.* 2005). Non-breeding plumage is dusky gray above and whitish below. Juveniles resemble non-breeding adults, but the feathers of the scapulars and wing coverts are edged with white and have narrow, dark subterminal bands, giving the upperparts a scalloped appearance (Davis 1983). Body mass varies seasonally, with lowest mean mass during early winter (125 grams (gm)) and highest mean values during spring (205 gm) and fall (172 gm) migration (Harrington 2001; New Jersey Department of Environmental Protection 2007).

b. Life History

Each year red knots travel approximately 30,000 kilometers (km) between wintering grounds in southern South America and breeding areas within the Canadian Arctic. Although a small population is believed to overwinter in northern Brazil, most red knots winter in southern South America along the coast of Patagonia, from approximately San Antonio Oeste, Argentina, southward to the eastern coast of Tierra del Fuego in Chile and Argentina (Harrington 2001; Baker *et al.* 2004; Morrison *et al.* 2004). In austral South American wintering areas, red knots are found principally in intertidal marine habitats, especially near coastal inlets, estuaries, and bays, or along *restinga* formations (an intertidal shelf of densely-packed dirt blown by strong, offshore winds) (Harrington 2001).

During migration, red knots undertake long flights that may span thousands of kilometers without stopping. At some stages of migration, very high proportions of entire populations may use a single migration staging site to prepare for long flights. Migrating red knots are principally found in marine and estuarine habitats (Harrington 2001). During the spring migration, red knots stop over for a period of approximately two to three weeks along the Atlantic coast of the United

States to rebuild energy reserves needed to complete the journey to the Arctic and arrive on the breeding grounds in good condition (Harrington 1996; Baker *et al.* 2004). Historically, the Delaware Bay region of Delaware and New Jersey has supported the largest known spring migration concentration of red knots and is the last major stopover area used by red knots migrating to Arctic breeding areas (Harrington 1996). In the southeastern and mid-Atlantic United States, red knots forage along sandy beaches, tidal mudflats, salt marshes, and peat banks.

In wintering and migration habitats, red knots commonly forage on bivalves, gastropods, and crustaceans (Harrington 2001). An exception occurs each May when the majority of red knots departing South America arrive within the Delaware Bay of Delaware and New Jersey to feed on eggs of horseshoe crabs (Wander and Dunne 1982; Harrington 1996, 2001; Niles *et al.* 2005).

In addition to the large flocks of red knots found in the Delaware Bay, red knots are found in lesser numbers elsewhere along the Atlantic Coast, including the project area during the spring migration, which may be related to these other areas having lesser numbers of breeding horseshoe crabs (Niles *et al.* 2005).

On the breeding grounds, the red knot's diet consists mostly of terrestrial invertebrates, though early in the season, before insects and other macroinvertebrates are active and accessible, red knots will eat grass shoots, seeds, and other vegetable matter (Harrington 2001).

c. Population Status

The range of *C. c. rufa* during migration extends along the Atlantic and Gulf of Mexico coasts of North, Central, and South America, from the Canadian arctic to the southernmost extent of South America. With the exception of a few key wintering areas in South America and the spring migratory stopover site in Delaware Bay, little comparative information is available regarding the historical versus current distribution of the subspecies throughout its range.

Assessing the population size of wide-ranging migratory species such as the red knot is difficult. Counts on the expansive Arctic breeding areas are not feasible. Morrisson *et al.* (2001) compiled published and unpublished counts of shorebirds by season and region to generate a coarse flyway population estimate for North America breeding shorebirds. Populations were determined by summing maximum counts at various sites within a region. Using this method the red knot population was estimated at approximated 170,000 birds for the period of the late 1980s to early 1990s. However, the authors included the central flyway population of approximately 20,000 red knots (Morrison *et al.* 2001). While the origins of the central flyway red knots are uncertain, these birds are generally thought to be *C. c. roselaari* (Harrington 2001; U.S. Fish and Wildlife Service 2003; Niles *et al.* 2005). Morrison *et al.* 2001 estimated the eastern North America flyway population of *C. c. rufa* for the period of the late 1980s to early 1990s at approximately 150,000 birds, and noted that based on information through 1999, the population could be substantially lower.

While the peak count of red knots observed at Delaware Bay is often described as the population estimate for the Bay, raw data from aerial surveys are not useful in estimating total populations of shorebirds in the Bay due to unknown turnover and detection rates (U.S. Fish and Wildlife

Service 2003). The shorebird survey methods used in the Delaware Bay can, however, be used to evaluate trends of migrating red knots. The aerial surveys provide comparative annual counts of numbers of red knots observed once per week during a 5-week survey period in May to early June (Clark *et al.* 1993). Peak aerial survey counts of migrating red knots on the Delaware Bay between 1982 and 1998 varied considerably, with highest recorded peaks of 95,360 and 94,460 birds occurring in 1982 and 1989, respectively, and lowest peak counts of 16,859 and 19,445 birds occurring in 1983 and 1996.

During the period of 1982 to 1998, aerial survey counts were somewhat cyclic where high peak years were generally followed by 1 to 2 years of declining peak counts followed by several years of rebounding peak counts (Dunne *et al.* 1983; Clark *et al.* 1993; Niles *et al.* 2005). However, from 1999-2004 red knot numbers in the Delaware Bay declined, reaching an all-time low peak count of 13,315 birds in 2004 (Niles *et al.* 2005). The 2005 peak count increased to 15,345; however, the peak count for 2006 dropped to 13, 445 (Niles *et al.* 2005). Thus, although 2005 showed an increase, there has been an overall decline in the counts at Delaware Bay in recent years. Insufficient information is available to determine trends of migrating *C. c. rufa* in other areas of the Atlantic coastal United States.

Although many counts of spring migrant red knots have involved the Delaware Bay, as noted above, this provides an index of the status of the species using the Bay but does not necessarily represent the total population of spring migrants along the eastern seaboard. In 2005, for example, the peak aerial count for Delaware Bay was 15,345 red knots (Niles *et al.* 2005). However, in May 2005, an aerial survey for red knots along Virginia's barrier islands recorded an estimated 9,150 knots (Watts and Truitt 2005), and a peak count of approximately 20,000 red knots was reported on the same survey date from ground counts of an Atlantic coastal site in New Jersey, where most Delaware Bay red knots are believed to congregate at a nighttime roost (Sitters 2005). Thus, more red knots were accounted for during the spring 2005 migration than are reflected by the Delaware Bay peak aerial count for that year (Niles *et al.* 2005).

As noted above, the peak counts of red knots at Delaware Bay declined each year from 1999 to 2004. In 2004, following 5 years of reduced horseshoe crab harvest in the bay, the availability of horseshoe crab eggs on principal shorebird foraging beaches increased over previous years. In 2005 the peak count of migrant red knots in the Delaware Bay was 15,345, an increase over the 2004 peak of 13,315 and the first increase in the annual count for Delaware Bay since 1999 (Niles *et al.* 2005). Further, although red knots departed from the Delaware Bay in 2005 about 5 days later on average than in previous years, the majority of red knots reached satisfactory body weights (threshold departure mass) prior to departure (Minton and Taylor 2005). The 2006 surveys by the Canadian Wildlife Service of the principal South American wintering areas indicate that although the counts are at historic lows, there was only a minimal difference in the number observed in 2006 as compared to 2005. Taken together, this information from Delaware Bay and at key wintering areas suggests the possibility that the declining trend may have halted. While these numbers indicate that no further decline has occurred, numbers of red knots remain low and there has been no indication of recovery. The change in horseshoe crab management and the upturn in availability of eggs in 2004, and the finding that the majority of red knots reached satisfactory body weights prior to departure from Delaware Bay, also suggests that the conditions have changed in comparison to the 1997 to 2002 period used for the model of annual survival.

3. Seabeach Amaranth

In 1993, seabeach amaranth was added to the List of Endangered and Threatened Wildlife and Plants as a federally listed (threatened) species. The listing was based upon the elimination of seabeach amaranth from two-thirds of its historic range, and continuing threats to the 55 populations that remained at the time (U.S. Fish and Wildlife Service 1993). Since its rediscovery in New Jersey in 2000, one seabeach amaranth plant was found at the USCG LORAN site in 2003 and six plants in 2004.

a. Species Description

Seabeach amaranth is an annual species and a member of the Amaranth family (Amaranthaceae). Upon germination, the plant initially forms a small, unbranched sprig, but soon begins to branch profusely, forming a low-growing mat. Seabeach amaranth's fleshy stems are prostrate at the base, erect or somewhat reclining at the tips, and pink, red, or reddish in color. The leaves of seabeach amaranth are small, rounded, and fleshy, spinach-green in color, with a characteristic notch at the rounded tip. Leaves are approximately 1.3 to 2.5 cm in diameter and clustered towards the tip of the stem (Weakley and Bucher 1992). The foliage of seabeach amaranth turns deep red in the fall (Snyder 1996). Plants often grow to 30 cm in diameter consisting of 5 to 20 branches, but occasionally reach 90 cm in diameter, with 100 or more branches. Flowers and fruits are inconspicuous, borne in clusters along the stems. Seeds are 2.5 millimeters (mm) in diameter, dark reddish-brown, and glossy, borne in low-density, fleshy, indehiscent utricles (bladder-like seed capsules or fruits), 4 to 6 mm long (Weakley and Bucher 1992). The seed does not fill the utricle, leaving an air-filled space (U.S. Fish and Wildlife Service 1996b).

b. Life History

Individual plants live only one season, with only a single opportunity to produce seed. The species over-winters entirely as seeds. Germination of seedlings begins in April and continues at least through July. Reproductive maturity is determined by size rather than age, and flowering begins as soon as plants have reached sufficient size. Even very small plants can flower under certain conditions. Flowering typically commences in July and continues until the death of the plant. Seed production begins in July or August and usually peaks in September. Seed production likewise continues until the plant dies. Senescence and death occur in late fall or early winter (U.S. Fish and Wildlife Service 1996b).

Seabeach amaranth seems capable of essentially indeterminate growth (Weakley and Bucher 1992). However, predation and weather events, including rainfall, hurricanes, and temperature extremes, have significant effects on the length of the species reproductive season. As a result of one or more of these influences, the flowering and fruiting period can be terminated as early as June or July (U.S. Fish and Wildlife Service 1993).

Seabeach amaranth is native to Atlantic coast barrier island beaches from Massachusetts to South Carolina. The species' primary habitat consists of overwash flats at accreting ends of barrier islands, and lower foredunes and upper strands of non-eroding beaches. This species occasionally establishes small, temporary, and casual populations in secondary habitats including

sound side beaches, blowouts in foredunes, and sand or shell dredge spoil or beach nourishment material (Weakley and Bucher 1992).

Seabeach amaranth occupies a narrow beach zone that lies at elevations from 0.2 to 1.5 m above mean high tide, the lowest elevations at which vascular plants regularly occur. Seaward, the plant grows only above the high tide line, as it is intolerant of even occasional flooding during the growing season. The species is, therefore, dependent on a terrestrial, upper beach habitat that is not flooded during the growing season. This zone is absent on beaches that are experiencing high rates of erosion. Seabeach amaranth is never found on beaches where the foredune is scarped by undermining water at high or storm tides (Weakley and Bucher 1992).

Seabeach amaranth usually occurs on a pure silica sand substrate, occasionally containing shell fragments. The habitat of seabeach amaranth is sparsely vegetated with annual herbs and, less commonly, perennial herbs (mostly grasses) and scattered shrubs. The number and type of seabeach amaranth's vegetative associates have been found to vary with specific habitat type (*i.e.*, overwash flat, accreting barrier island end, or lower foredune) (Chicone Undated). The most constant associates of seabeach amaranth, with which the species almost always co-occurs, are sea rocket (*Cakile edentula*) and seabeach spurge (*Chamaesyce polygonifolia*) (Weakley and Bucher 1992). Known vegetative associates of seabeach amaranth in New Jersey are given in Table 2.

Seabeach amaranth does not occur on well-vegetated sites, particularly where perennials have become strongly established (Weakley and Bucher 1992). Pauley *et al.* (1999) documented a negative correlation between seabeach amaranth and several dominant foredune species. A particularly strong negative association has been reported between seabeach amaranth and beach grasses U.S. Fish and Wildlife Service 1996b). However, a positive correlation has been observed between seabeach amaranth and sea rocket, an annual (Hancock 1995).

Table 2. Known Vegetative Associates of Seabeach Amaranth.

New Jersey (U.S. Fish and Wildlife Service 2002)	sea rocket (*Cakile edentula*) seabeach spurge (*Chamaesyce polygonifolia*) Russian thistle (*Salsola kali*) American beachgrass (*Ammophila breviligulata*) Beach clotbur (*Xanthium echinatum*) seaside goldenrod (*Solidago sempervirens*) goosefoot (*Chenopodium* spp.) crab grass (*Digitaria sanguinalis*) sand grass (*Triplasis purpurea*) seabeach sandwort (*Honkenya peploides*) seabeach orach (*Atriplex cristata*) wild bean (*Strophostyles* spp.) seabeach knotweed (*Polygonum glaucum*)

c. Population Status

Seabeach amaranth is limited by its habitat requirements to a very narrow strip of barrier islands and mainland oceanfront beach strands along the Atlantic coast. The original range of this species extended from Cape Cod in Massachusetts to central South Carolina, a stretch of coast approximately 1,600 km (1,000 miles) long. This stretch correlates with a geographic range of low tidal amplitude. Tidal amplitude and the relative importance of tidal versus wave energy in shaping coastal morphology are thought to limit the geographic range of seabeach amaranth, rather than availability of sandy beach substrates or sea water temperatures. The range of seabeach amaranth is characterized by islands developed by high wave energy, low tidal energy, frequent overwash, and frequent breaching by hurricanes with resulting formation of new inlets (Weakley and Bucher 1992).

Seabeach amaranth is considered globally rare (G2) by the New Jersey Natural Heritage Program (New Jersey Natural Heritage Program 2007). The current known range of naturally occurring seabeach amaranth is Water Mill Beach on Long Island, New York to Debidue Beach in South Carolina (Young 2001; Hamilton 2000). Historic records of seabeach amaranth are known from nine States. Largely due to human activities, the species was eliminated from seven of these States by the 1980s, remaining only in North and South Carolina. Seabeach amaranth is still considered extirpated from two States: Massachusetts and Rhode Island. Since 1990, the species has re-occupied five States from which it had previously been extirpated. Table 3 gives the dates of rediscovery and the last previously known occurrence of the plant in each State.

To date, theories of seabeach amaranth's return to the northern part of its range remain speculative. Sites in these five States may have been re-colonized by long-distance transport of seeds by wind or currents. At some sites, seeds may have been long buried in sediments used in beach nourishment projects. This hypothesis requires that seeds can remain viable after prolonged off-shore burial, an unknown factor.

Table 3. Re-colonization Dates of Seabeach Amaranth in Five States.

State	Date Rediscovered	Date of Last Previously Known Occurrence
New York	July 1990	1950 (Van Schoik and Antenen 1993)
New Jersey	July 2000	1913 (U.S. Fish and Wildlife Service 1996b)
Delaware	August 2000	1875 (McAvoy 2000)
Maryland	August 1998	1967 (Ramsey *et al.* 2000)
Virginia	September 2001	1973 (U.S. Fish and Wildlife Service 1996b)

d. Continuing Threats

The primary threats to seabeach amaranth are the adverse alterations of habitat caused by beach erosion and shoreline stabilization. Although seabeach amaranth does not persist on eroding beaches, erosion is not a threat to the continued existence of the species under natural conditions.

Erosion in some areas is balanced with habitat formation elsewhere, such as accreting inlets and overwash areas, resulting in an equilibrium that allows the plant to survive by moving around in the landscape. In the geologic past, seabeach amaranth has persisted through even relatively rapid episodes of sea level rise and barrier island retreat. A natural barrier island landscape, even a retreating one, contains localized accreting areas, especially in the vicinity of inlets (U.S. Fish and Wildlife Service 1996b).

Even minor structures such as dune stabilization by planting vegetation and vertical sand accretion caused by sand fences appear to be detrimental to seabeach amaranth and contradictory to its life history strategy. Seabeach amaranth only very rarely occurs when sand fences and vegetative stabilization have taken place and, in these situations, is present only as rare, scattered individuals or short-lived populations (Weakley and Bucher 1992).

Beach nourishment can have positive site-specific impacts on seabeach amaranth. Seabeach amaranth has colonized several nourished beaches, and has thrived in some sites through subsequent re-applications of fill material (U.S. Fish and Wildlife Service 1993; 2002). However, on the landscape level, beach nourishment is similar to other beach stabilization efforts in that it stabilizes the shoreline and curtails the natural geophysical processes of barrier islands. These effects are detrimental to the range-wide persistence of the species. In addition, beach nourishment may cause site-specific adverse effects by crushing or burying seeds or plants deeper, or by altering the beach profile or upper beach micro-habitats in ways not conducive to seabeach amaranth colonization or survival.

Intensive recreational use of beaches such as off-road vehicle (ORV) can threaten seabeach amaranth populations, both through direct damage and mortality of plants, and by impacting habitat. Light pedestrian traffic, even during the growing season, usually has little effect on seabeach amaranth (U.S. Fish and Wildlife Service 1993). Substantive impacts generally occur only on narrow beaches, or beaches which receive heavy recreational use. ORV uses on the beach during the growing season can have detrimental effects on the species, as the fleshy stems of this plant are brittle and easily broken. Plants generally do not survive even a single pass by a truck tire (Weakley and Bucher 1992).

Beach grooming may also have contributed to the previous extirpation of seabeach amaranth from that part of its range. Motorized beach rakes, which remove trash and vegetation from bathing beaches, do not allow seabeach amaranth to colonize long stretches of beach (U.S. Fish and Wildlife Service 1996b). In New Jersey, plants were found along a nearly continuous length of beach, noticeably interrupted by stretches that are routinely raked. Intensive management, including BMPs to protect seabeach amaranth from disturbance by beach recreationists and beach-cleaning operations have been implemented at many New York-New Jersey piping plover and seabeach amaranth sites in recent years.

Predation by webworms (caterpillars of small moths) is another source of mortality and lowered fecundity and may decrease seed production by more than 50% (Weakley and Bucher 1992). Five species of webworms so far identified that feed on seabeach amaranth are all native species, their use of barrier islands has probably been altered by changes in the coastal plain landscape (*i.e.*, extensive agricultural use), the development of barrier islands, and the introduction of

weedy plants that can also serve as host plants. All five webworms are "weedy" species, probably much more abundant now than they were in pre-Columbian times. For this reason, the level of predation that seabeach amaranth is experiencing is likely unnaturally high (U.S. Fish and Wildlife Service 1996b). Webworm herbivory is probably a contributing, rather than a leading factor in the decline of seabeach amaranth. However, in combination with extensive habitat alteration, severe herbivory could threaten the existence of the species (Weakley and Bucher 1992).

New threats to seabeach amaranth have been documented since the species was listed in 1993. These factors are lesser threats than habitat modification, but may increase the risk of extinction by compounding the effects of other, more severe threats.

Several additional herbivores of seabeach amaranth have been observed including deer, eastern cottontail, and migratory song birds (Van Schoik and Antenen 1993). There is also strong circumstantial evidence for seabeach amaranth herbivory by grasshopper (U.S. Fish and Wildlife Service 2002). In addition, a cluster of New Jersey plants appeared to have been damaged by a congregation of loafing gulls (*Larus* spp.), based upon feathers and droppings. As with webworms, the abundance of these newly documented predators on barrier islands is increased by human activities.

Asiatic sand sedge (*Carex kobomugi*) has been suggested as another potential threat to seabeach amaranth. This sedge is strongly rhizomatous and dune-forming (National Park Service and Maryland Natural Heritage Program 2000). Asiatic sand sedge was introduced to the east coast (New Jersey to Virginia) from east Asia in the 1930s for erosion control and as a sand stabilizer. Asiatic sand sedge may be detrimental to seabeach amaranth by direct competition and by reducing habitat suitability through sand stabilization and dune building.

C. FEDERALLY LISTED SPECIES UNDER NMFS JURISDICTION

Several species of federally listed (endangered and threatened) sea turtles including the Kemp's ridley sea turtle (*Lepidochelys kempii*), hawksbill sea turtle (*Eretmochelys imbricata*), leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), and green sea turtle (*Chelonia mydas*) may occur in waters throughout the study area. These turtles feed primarily on mollusks, crustaceans, sponges, and a variety of marine grasses and seaweeds. In addition, the leatherback sea turtle may occupy the coastal waters of New Jersey foraging for jellyfish. These sea turtles may be found in New Jersey waters from late spring to mid-fall. The NMFS must be contacted regarding potential impacts, resulting from the proposed project, on federally listed species under its jurisdiction. The NMFS may be contacted at 74 Magruder Road, Highlands, New Jersey 07732; (732) 872-3023.

D. STATE LISTED SPECIES

A variety of State-listed endangered and threatened species inhabit or have been known to occur in the coastal and estuarine ecosystem within the study area. The State-listed (endangered) black skimmer and least tern nest in colonies on sandy islands in the bays and on beaches near inlets within the project area.

1. Black Skimmer

The State-listed (endangered) black skimmer nests within the project area. Piping plovers often nest within or in close proximity to skimmer colonies and least tern colonies. As with least terns, seabeach amaranth would also benefit from the presence of black skimmer colonies since restrictions on public access during the nesting season provides protected areas where plants can become established.

Total black skimmer numbers within colonies in New Jersey for the 8-year period of 1999 to 2006 are shown in Table 4 (New Jersey Endangered and Nongame Species Program 2001, 2002, 2003). All black skimmer nesting sites in New Jersey during this 8-year period were located within the Corps Philadelphia District Program Area. In addition, during summer of 2007 a total of 1,627 black skimmer adults, 719 peak adults, and 709 fledges were recorded at Champagne Island, just north of the project area (Todd Pover, NJDFW, pers. comm. 2007). Black skimmer information for the 2007 nesting seasons is not yet available.

Table 4. Number of Black Skimmers at New Jersey Nesting Sites: 1999-2006.

SITE	1999	2000	2001	2002	2003	2004	2005	2006
Sedge	2							
East Point Island				2	6	2		
Pettit	2	2	2					
North Clam		4	8					
Barrel Island				79				
Island Beach State Park – Dike					89	48		
Mordecai Island					302	316	795	900
East Sedge Island	34				75	15		12
Hester Island					29	55		24
Holgate		250		130	425	275		
Marshelder Island	150	125	180	86			4	
Middle Sedge	2						46	38
Tow Island	250	70	18	60	13		2	
Egg Island		56		12				
Ocean City – North		25	1212	496				
Strathmere Natural Area	1613	1459		562	463		73	
Strathmere Bay Island			465	147	153			
Stone Harbor Point	568	634	870	397	1337	1000	1831	704
Hereford Inlet (Champagne Island)		103		204			247	1619
Coast Guard EECEN				11				
Total Number of Birds	**2621**	**2728**	**2755**	**2186**	**2892**	**1711**	**2998**	**2593**[1]
Number of Active Colonies	**8**	**10**	7	**12**	**10**	**7**	7	**6**

[1]Stone Harbor Point and Champagne Island totals were not summed because they represent the same individuals who nested and failed at Stone Harbor Point and then renested at Champagne Island. Data collected and compiled by NJDEP, Division of Fish and Wildlife – Endangered and Nongame Species Program

2. Least Tern

Piping plovers often nest in association with State-listed (endangered) least tern colonies, presumably benefiting from the aggressive behaviors of terns in driving away predators and have often had higher success than those nesting out of tern colonies (Burger 1987). Total least tern numbers within colonies in New Jersey for the 8-year period of 1999 to 2006 and a summary of sites within and outside the Program Area are shown in Table 5 (Canale 2000; New Jersey Endangered and Nongame Species Program 2001, 2002, 2003; U.S. Fish and Wildlife Service 2005). Least tern information for the 2007 nesting seasons was not available. In addition, Seabeach amaranth also benefits from the presence of least tern colonies, since restrictions on public access in the nesting areas provide protected areas where plants can become established (Weakley and Bucher 1992).

Table 5. Number of Adult Least Terns at New Jersey Nesting Sites: 1999-2006.

SITE	1999	2000	2001	2002	2003	2004	2005	2006
Newark Airport			40				*	22
Sandy Hook:								
Coast Guard	26	20	36	77	95	6		
Critical Zone					75	77	21	
Gunnison	24	22	14	17	53	28	13	20
North Beach	118	46	51	23	74	5		70
Hidden Beach	8	35	109	145	71	24	5	16
Fee Beach	82	195	178	182	110	12	34	6
South Fee Beach					9	4	11	
Sea Bright - North	87	33	38	74	104	82	161	109
Monmouth Beach - North	842	233			281	343	256	80
Monmouth Beach - South	26	82	12	8				
Seven Presidents Park				70	86	176	52	140
Long Branch					128			
Belmar - Shark River Inlet		9	57	151	48		25	57
Sea Girt - Wreck Pond			24	21	191	153	64	
Sea Girt - NGTC		15	197	48	26		2	
Subtotal – Sites Outside Philadelphia Program Area	***1213***	***690***	***756***	***816***	***1351***	***910***	***644***	***520***
Gull Island		67					64	221
Island Beach State Park - Dike					17	32		
Barnegat Light	25			34	6	19	11	9
Holgate		100		70	60	120	60	42
North Brigantine Natural Area	6	4	28	23		16	3	42
Longport- Seaview Harbor Marina				16				155

Ocean City - North	195	379	354	215	12			
Ocean City - Center	191	67	15	12	19		18	31
Corson's Inlet St. Park				7				12
Strathmere – Upper Township						22	9	
Townsends Inlet		28	57	90	36	31	25	
Avalon - North		5	5					
Avalon - Dunes	158	135	142	293	213	110	20	161
Champagne Island				5		64		19
Stone Harbor Point	98	90	37	57	255	65	86	263
N. Wildwood- Hereford In.				105	490	345	342	202
USCG - LSU		4	84	152	41	4		
USCG - TRACEN	50							4
Cape May City – Poverty Beach					66	207	19	47
Cape May Meadows - TNC	30	132	16	38	34	30	150	128
Cape May Point State Park					10	21	118	84
Magnesite Plant			16	5				
Manumuskin River Preserve					*	28		3
Subtotal –Sites within Philadelphia District Program Area	***753***	***1025***	***754***	***1122***	***1259***	***1114***	***925***	***1423***
Total Number of Birds	**1966**	**1715**	**1510**	**1938**	**2610**	**2024**	**1569**	**1943**
Number of Colonies	**16**	**21**	**21**	**26**	**27**	**25**	**24**	**24**

* Birds actively nesting, but not counted
Data collected and compiled by NJDEP, Division of Fish and Wildlife – Endangered and Nongame Species Program.

3. Coordination with the State

The Service recommends that the Corps consider species of special concern and State-listed species (Appendix C) in project planning. The Service's PBO (Service 2005) contains conservation recommendations for least tern and black skimmer. The New Jersey Division of Fish and Wildlife, Endangered and Nongame Species Program (ENSP) and New Jersey Division of Parks and Forestry Natural Heritage Program (NJNHP) may be contacted for further information regarding State-listed endangered and threatened species.

The NJNHP maintains the most up-to-date information on Federal candidate species and State-listed species in New Jersey and may be contacted at the following address:

Natural Heritage Program
Division of Parks and Forestry
CN 404
Trenton, New Jersey 08625
(609) 984-1339

Additionally, information on New Jersey's State-listed wildlife species may be obtained from the following office:

David Jenkins, Chief
Endangered and Nongame Species Program
New Jersey Division of Fish and Wildlife
CN 400
Trenton, New Jersey 08625
(609) 292-9400

V. BORROW AREAS

A. MARINE FINFISH

Shore zones and estuaries provide migratory pathways and spawning, feeding, and nursery areas for many commercial and sport fish, as well as comprising the primary habitat for many forage fish. Such bathymetric contours provide important structure for a variety of commercially and recreationally important finfish species. Shoal areas along the Atlantic coast are highly productive for finfish. Fishing grounds are concentrated near these productive shoal areas.

Coastal waters within the Hereford Inlet to Cape May Inlet project area support significant commercial and recreational fisheries (Corbett, NJDFW, pers. comm. 2007). Commercially important species include: Atlantic croaker (*Micropogonias undulatus*), Atlantic menhaden (*Brevoortia tyrannus*), black sea bass (*Centropristis striata*), bluefish (*Pomatomus saltatrix*), summer flounder (*Paralichthys dentatus*), yellowtail flounder (*Limanda ferruginea*), scup (*Stenotomus chrysops*), tautog (*Tautoga onitis*), weakfish (*Cynoscion regalis*), and white perch (*Morone americana*). Commercial fishermen are not allowed to target American shad (*Alosa sapidissima*) in the ocean but they are allowed to keep a small percent as bycatch. Important recreational fisheries within nearshore of the project area include many of the above-mentioned species plus Atlantic mackerel (*Scomber scombrus*), striped bass (*Morone saxatilis*), red hake (*Urophycis chuss*), silver hake (*Merluccius bilinearis*), and northern kingfish (*Menticirrhus saxatilis*).

Portions of the project area have also been designated as essential fish habitat under the Magnuson - Stevens Fishery Conservation and Management Act (16 U.S.C. 1801-1882) for a number of federally managed species (Table 6):

Table 6. Federally Managed Fish Species within the Project Area (Karen Greene, pers. comm. 2007).

Species	Life Stage
Atlantic herring (*Clupea harengus*)	juveniles and adults
black sea bass (*Centropristis striata*)	juveniles and adults
bluefish (*Pomatomus saltatrix*)	juveniles and adults
butterfish (*Peprilus triacanthus*)	larvae, eggs and juveniles
cobia (*Rachycentron canadum*)	all life stages

king mackerel (*Scomberomorus cavalla*)	all life stages
monkfish (*Lophius americanus*)	eggs and larvae
red hake (*Urophycis chuss*)	eggs, larvae and juveniles
scup (*Stenotomus chrysops*)	juveniles and adults
Spanish mackerel (*Scomberomorus maculatus*)	all life stages
summer flounder (*Paralichthys dentatus*)	larvae, juveniles and adults
windowpane (*Scophthalmus aquosus*)	all life stages
winter flounder (*Pseudopleuronectes americanus*)	all life stages
witch flounder (*Glyptocephalus cynoglossus*)	eggs
clearnose skate (*Raja eglanteria*)	juvenile, adults
little skate (*Raja erinacea*)	juvenile, adult
winter skate (*Raja ocellata*)	juvenile, adult
Atlantic angel shark (*Squatina dumerili*)	all life stages
Atlantic sharpnose shark (*Rhizoprionodon terraenovae*)	adult
dusky shark (*Carcharhinus obscurus*)	neonate/early juvenile
sandbar shark (*Carcharhinus plumbeus*)	all life stages
sand tiger shark (*Odontaspis taurus*)	neonate/early juvenile and adult
scalloped hammerhead shark (*Sphyrna lewini*)	late juvenile/subadult
tiger shark (*Galeocerdo cuvieri*)	neonate/early juvenile

B. BENTHIC RESOURCES

Benthic macroinvertebrates are important food organisms in the marine and estuarine environment, and along with primary producers, perform a crucial role in supporting other forms of fish and wildlife. Approximately 58 species of benthic organisms have been identified from Townsends Inlet to Cape May Inlet (Chaillou and Scott 1996). Benthic organisms of interest in the shallow ocean waters and adjacent inlets and bays of the project area include Atlantic surf clam (*Spisula solidissima*), hard clam (*Mercenaria mercenaria*), and soft clam (*Mya arenaria*). In 2003, the regions south of Great Egg Harbor Inlet to Cape May Inlet accounted for only 10.2% of the total estimated standing stock of surf clams in New Jersey territorial waters. Preliminary data collected in 2007 indicate that the estimated standing stock in this region is now only 4% (Normant, NJDFW, pers. comm. 2007). In 1999, this region had 25% of estimated standing stock in New Jersey territorial waters. In 2003, 60.6% (by weight) of New Jersey molluscan landings were surf clams and 73.9% on total surf clam east coast harvest was landed in New Jersey. Approximately 246,000 bushels were harvested from New Jersey territorial waters in 2003 with 17.5% of harvest coming from this region. There has been a major decline of surf clams State-wide as well as in Federal waters off the Delmarva Peninsula. There has been virtually no harvest in New Jersey territorial waters in the last two years (Normant, NJDFW, pers. comm. 2007).

VI. PROJECT IMPACTS AND RECOMMENDED MITIGATIVE MEASURES

A. PIPING PLOVER

The Corps' activities occurring on or adjacent to sites currently occupied by federally listed species could have direct adverse effects. Beach nourishment generally involves operation of a pipeline to pump sand onto the targeted beach and subsequent contouring of the pumped sand by earth-moving equipment. Even in areas where sand placement will only occur seaward of the present high-tide line, significant disturbance of the upper beach from equipment and crews can be expected. Therefore, beach nourishment during the nesting/growing seasons would likely result in significant adverse effects to piping plovers where they occur.

In addition, other Corps activities, if conducted during the nesting season, could result in disturbance to nesting piping plovers or their young. Operation of equipment and crews on beaches in support of these maintenance and operation activities could destroy or diminish habitat suitability or kill or injure plover adults, nests, or young.

It can be anticipated that, following initial construction of the Federal nourishment projects, similar creation of potentially suitable habitat for piping plovers will occur in areas where they are currently absent. It should be noted that although the Corps nourishment projects will create sandy beach habitat that may attract piping plovers, the habitat created can be expected to be of lesser quality than habitat that is formed through natural coastal process such as overwash. Nevertheless, subsequent renourishment events throughout the coastal areas have the potential to benefit piping plovers by maintaining sandy beach habitat over the life of the project.

While the Federal nourishment projects have potential to create habitat for piping plovers, habitat creation alone will not create a beneficial effect for piping plover if the habitat is suboptimal and does not provide foraging habitat for plover chicks or if disturbance from municipal and recreational users cannot be managed to avoid loss of nests or chicks.

To ensure the continued protection of piping plover over the life of the project, the Service recommends that the Corps reinitiate consultation pursuant to Section 7 of the ESA:

- at least 135 days prior to beginning any beach nourishment associated with the project to allow 90 days for formal consultation and 45 days for issuance of a BO; and

- at least 135 days prior to any beach maintenance activities (*e.g.*, beach renourishment) for the life of the project (*i.e.*, 50 years).

Piping plover nesting activity may occur due to creation of suitable habitat as a result of the project. Therefore, to ensure the protection of piping plovers during the nesting and brood rearing periods from April 1 to August 15, the Service recommends that an endangered species BMP be developed for each municipality within the project area prior to initiation of dredging and beach nourishment. At a minimum, the BMP must adhere to the Service's "Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the ESA" (U.S. Fish and Wildlife Service 1994) (Appendix D)

and the Service's 1997 Fireworks Guidelines (Appendix E). The Service recommends that the BMP specifically include, but not be limited to:

(1) coordination with NJDEP-ENSP to determine whether piping plovers are actively nesting in the project area;

(2) establishment and identification (*e.g.*, fencing and signing) of protective zones around piping plover nests;

(3) ORV (recreational and essential state/municipal) restrictions during the piping plover nesting and brood rearing periods (April 1 to August 15);

(4) monitoring of piping plovers during the nesting and brood rearing period (April 1 to August 15);

(5) prohibition of kite flying from April 1 to August 15;

(6) protection of piping plover nests, chicks, and adults from native and domestic predators;

(7) prohibiting of launching of fireworks within ¾ mile of nesting areas;

(8) restrictions of beach management and maintenance activities (*e.g.*, beach raking) during the nesting season; and

(9) mechanisms for enforcement of item 1-8 above.

Establishment of protective zones and other protective measures developed within the plan would be coordinated with the Service and the ENSP. If off-road vehicles (ORV) access the beach on the project site and if piping plovers nest adjacent to the project site, the Guidelines apply to ORV use. The management plans must be submitted to the Service and ENSP for review and comment prior to project initiation to determine if further consultation pursuant to Section 7 of the Act will be required.

In the event that piping plovers or other beach nesting birds do nest or expand their nesting areas within the project area, the Service recommends that the Corps develop educational materials (*e.g.*, brochures, informational signs) or provide funds for public education and outreach. Development of informational materials would educate beach users about beach nesting birds; thereby reducing disturbance to nesting areas. Public education would also promote public support for protecting beach nesting birds.

Finally, the Service recommends that the Corps develop and implement a shorebird monitoring program, in cooperation with the Service, to monitor the use of the nourished beaches for shorebirds, particularly piping plovers. This shorebird monitoring program should be designed to identify and report use of the project area beaches by shorebirds, particularly the piping plover, for the life of the project. Shorebird monitoring within the project area, except within currently known piping plover locations, is not conducted by ENSP. Monitoring of enhanced

beach areas that are currently not surveyed by ENSP would be the responsibility of the project proponent (*i.e.*, Corps).

B. SEABEACH AMARANTH

Impacts to the beach zone providing potentially suitable habitat for seabeach amaranth from Corps activities are expected to be significant. Any seeds dispersed into previously unoccupied areas from nearby populations would likely be buried if occurring within the project impact area. Additionally, any undetected seabeach amaranth plants or seedlings would likely be buried or crushed.

It can be anticipated that, following initial construction of the Federal nourishment projects, similar creation of potentially suitable habitat for seabeach amaranth will occur in areas where habitat is currently absent. Subsequent renourishment events throughout the coastal areas may benefit seabeach amaranth by maintaining sandy beach habitat over the life of the project.

To ensure that seabeach amaranth will not be adversely affected by project activities, the Service recommends conducting surveys prior to initiation of the project. If plants are found, the Corps should establish a protective zone with a minimum 3-meter buffer around any seabeach amaranth site identified and avoid construction-related pedestrian and vehicular traffic; placement, movement, or maintenance of pipelines; stockpiling of construction materials and equipment; and pumping, placement, or distribution of sand within such zones. The Corps should refer to the Service's PBO (U.S. Fish and Wildlife Service 2005) for additional conservation measures and recommendations to protect seabeach amaranth.

C. RED KNOT, BLACK SKIMMER AND LEAST TERN

The types of impact and the potential benefits of beach nourishment projects to red knot, least tern, and black skimmer are similar to these for piping plovers as described above.

Avoiding or minimizing adverse impacts to red knot, least tern, and black skimmer from project-related activities, especially with respect to timing, should be incorporated in project planning and in post-nourishment monitoring and management. In addition to the direct positive benefits that such protection would afford to these species, piping plovers nesting within or adjacent to protected tern colonies may benefit from the defensive behaviors against avian predators that are typical of this colonial species.

To avoid potential impacts from construction, schedule and implement beach nourishment and associated project activities to avoid construction within 300 meters of least tern and/or black skimmer colonies during the nesting season. The least tern nesting season is generally early June through September.

To protect these species over the project life, include protection of red knot, least terns and black skimmers within endangered species BMPs.

The Service recommends contacting the New Jersey Division of Fish and Wildlife, Endangered and Nongame Species Program (ENSP) and New Jersey Division of Parks and Forestry Natural Heritage Program (NJNHP) for further information and guidance regarding State-listed endangered and threatened species.

D. BIOLOGICAL ASSESSMENT

Federally listed species are afforded protection under the ESA pursuant to Section 7(a)(2), which requires every Federal agency, in consultation with the Service, to ensure that any action it authorize, funds, or carries out, is not likely to jeopardize the continued existence of any listed species or result in the destruction or adverse modification of critical habitat. Project-related activities could adversely affect the piping plover and seabeach amaranth. The lead Federal agency for a project has the responsibility under Section 7(c) of the ESA to prepare a BA if the project is a construction project that requires an Environmental Impact Statement (EIS) and the project may affect a federally listed species. In accordance with the ESA, the Corps must prepare a BA to address potential project-related adverse impacts to the piping plover and seabeach amaranth.

The BA should contain information concerning listed or proposed species that may be present in the action area and an analysis of any potential effects of the proposed action on such species. The following may be considered for inclusion in a BA of the proposed project, although actual contents are at the discretion of the Federal authorizing agency:

(1) results of field surveys to determine if listed species are present or occur seasonally;

(2) views of recognized experts on the species;

(3) literature review;

(4) analysis of direct, indirect, and cumulative effects of the action on the species; and

(5) analysis of alternative actions.

The BA may be consolidated with procedures for interagency coordination required by other statutes such as the FWCA or the NEPA. However, satisfying the requirements of these other statutes does not in itself relieve a Federal agency of its obligation to comply with the BA procedures of the ESA. The results of a BA may be incorporated into an EIS. If the BA indicates that no listed or proposed species are present or will be affected, and the Service concurs, in writing, with the assessment, then no formal consultation pursuant to Section 7 will be required.

E. MUNICIPAL RESPONSIBILITIES

In order to prevent future misunderstanding regarding the protection of piping plovers and seabeach amaranth, the Service recommends that the Corps notify each municipality within the project area individually regarding potential restrictions on recreational activities and beach

management (*e.g.*, beach raking and municipal vehicle traffic) if seabeach amaranth sites are identified and/or piping plovers expand their nesting areas as a result of the proposed project. In addition, each municipality should receive a copy of the aforementioned Guidelines to become familiar with potential recreational activity and beach management restrictions. The purpose of notifying municipalities in advance is to clarify the responsibilities of the municipalities that would be benefiting from the proposed Federal project. If municipalities are unwilling to cooperate with the Corps and the Service regarding piping plover and seabeach amaranth management, the Corps should consider eliminating the municipalities from the proposed project.

The purpose of developing a BMP for each municipality is to provide a framework for cooperation among local beach managers, NJDEP, and the Service in the stewardship of federally and State-listed endangered and threatened beach-nesting birds and flora occurring on New Jersey's beaches. The goal of a BMP is to provide for long-term protection and recovery of listed species populations, while recognizing the need for storm protection, recreation, and public works. Each plan includes descriptions of the roles and responsibilities of local beach managers, the NJDEP, and the Service in the protection and management of listed species. Upon completion, management plans are approved by the appropriate governmental body, such as a town council, and a memorandum of agreement is signed by all parties.

Plans are developed with full input of local officials and staff directly responsible for beach management activities including mechanical beach raking, trash removal, life guards, law enforcement, and recreational uses to reflect a beach's operational needs. Plans address a wide range of issues, including symbolic fencing for protection and management of listed species, trash collection and beach clean-ups, beach raking, sand fencing, vegetation management, predator control, enforcement of pet laws, and State Coastal Zone management rules, operation of vehicles on the beach, designation of portions of beach as protected management zones for listed species, and the role of local site managers in endangered species management.

F. BEACH HABITAT ENHANCEMENT

Beach fill and dune creation provides an opportunity to enhance fish and wildlife habitat. However, any proposed beach creation activities must be closely reviewed in regard to their effects on habitats (*e.g.*, shallow water habitat) within the project area. In addition, other accompanying adverse impacts to fish and wildlife resources, which may occur as a result of project implementation, must be considered in project planning.

Planning activities for beach fill and dune creation should include an evaluation of potential habitat enhancement for beach nesting birds. Wide beaches with gentle slopes generally provide good quality habitat for beach nesting birds (U.S. Fish and Wildlife Service 1996a). Creation of low, wide dunes with washover areas provides adequate foraging and nesting habitat. Dune configurations that are irregular (*e.g.*, staggered and discontinuous) may attract beach nesting birds. In addition, native dune grasses should be planted in sufficient quantity to provide stabilization, but also minimal enough not to prevent nesting opportunities. Fencing systems to trap sand and create dunes should be open to allow passage of juvenile shorebirds between and among the dunes. A broken, zig-zag pattern of fencing parallel to the shore or a Y-type fencing

pattern perpendicular to shore are two examples of open fencing systems. The Service recommends the Corps coordinate with the Service for any dune and beach enhancement or restoration activities in beach-nesting bird or seabeach amaranth habitat.

Additionally, the Service recommends the use of perpetual deed restrictions or conservation easement to protect newly created beach and adjacent beach habitat for beach nesting shorebirds.

G. BORROW AREAS

Similar to other dredging, extraction of material from borrow areas has been documented as causing environmental impacts that may adversely affect fish and other marine species populations and the food chains on which they depend. Kantor (1984) provides a review of dredging impacts specific to New Jersey. These impacts can generally be subdivided into those affecting the water column and those affecting the bottom substrate. Adverse water quality impacts from material extraction include increased turbidity, changes in temperature and oxygen demand, and release or resuspension of toxins and bacteria. These factors may cause direct mortality to fish and shellfish, disrupt fish migrations, hamper fish and shellfish spawning, make shellfish unsuitable for human consumption, and reduce primary productivity. Settling of suspended sediment may result in smothering of shellfish and other benthic organisms downcurrent from the project site.

Bottom impacts include removal of existing benthic communities, change in circulation patterns, and modification of patterns of sediment deposition. Extraction from borrow areas may create bottom depressions with reduced flushing. These depressions can accumulate fine-grained sediments and organic material, including contaminants. Reduced flushing, combined with decomposition of organic materials, can lead to low oxygen conditions in such depressions. Originally occurring or different benthic forms may eventually recolonize the area of extraction depending on the water quality and substrate present.

The type of equipment used and the time of year extraction occur may greatly influence the nature and extent of potential adverse impacts in the water column. For example, the use of hydraulic dredging reduces Service concerns regarding short-term adverse impacts on water quality at and near the site of dredging, but hydraulic dredging may impact eggs and young fish or other slow-moving organisms unable to avoid entrainment. The entrainment of sea turtles has also been documented as an adverse impact of hydraulic dredging (U.S. Fish and Wildlife Service 1991). The NMFS has jurisdiction over endangered and threatened sea turtles and should be contacted if hydraulic dredging is proposed. Conversely, mechanical dredging has greater impacts on turbidity and dissolved oxygen at the dredge site, but, if conducted during periods of low seasonal biological productivity, adverse impacts to organisms can be minimized.

Potential alternatives to offshore borrow sites currently being considered for the project include bypassing sand from Wildwood to North Wildwood and changing the beach configuration in Wildwood by increasing berm height or adding a dune. These alternatives would avoid adverse impacts to finfish and other marine resources.

VI. CONCLUSIONS AND SUMMARY OF RECOMMENDATIONS

A. BEACH COMMUNITIES

In order to avoid and minimize potential adverse impacts on State-listed and federally listed threatened and endangered species within project area, the Service recommends incorporating the following measures into project planning.

1. Reinitiate consultation with the Service to ensure protection of the piping plover:

    a. at least 135 days prior to beginning of any beach nourishment associated with the project to allow for 90 days for formal consultation and 45 days for issuance of a BO; and

    b. at least 135 days prior to any beach maintenance activities (e.g., beach renourishment) for the life of the project (i.e., 50 years).

2. Conduct surveys and establish protective zones around any identified seabeach amaranth sites to ensure that seabeach amaranth will not be adversely affected by project activities

3. Contact NJDFW's ENSP and NJNHP's Natural Heritage Program in considering State species of special concern and State-listed species in project planning (Appendix C).

4. Prepare a BA to address potential project-related adverse impacts to piping plover, seabeach amaranth, and the candidate species red knot. Consult with the Service pursuant to Section 7 of the ESA prior to initial beach nourishment.

5. Require municipalities within the project area to develop and implement an endangered species BMP (should piping plovers expand their current nesting areas as a result of this project) for each municipality within the project area and prior to project initiation, in accordance with the Service "Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the ESA" (U.S. Fish and Wildlife Service 1996a) and the Service's 1997 Fireworks Guidelines (Appendix E).

6. Develop and provide funds for informational materials, public education and outreach, should piping plovers and other beach nesting shorebirds expand their nesting areas within the project area.

7. Implement a shorebird monitoring program, in cooperation with the Service and ENSP, to monitor the use of nourished beaches for shorebirds, particularly piping plovers.

8. Notify each municipality within the project area regarding recreational and beach maintenance restrictions if seabeach amaranth sites are identified and/or piping plovers expand their nesting areas as a result of the project.

9. Refer to the Service's 2005 PBO for additional recommendations, including beach habitat enhancement to protect listed species (U.S. Fish and Wildlife Service 2005).

B. BEACH HABITAT ENHANCEMENT

Incorporate the following recommendations into project planning to create additional shorebird habitat and protect or enhance any existing habitat.

1. Review and evaluate any proposed beach creation activity in regard to potential effects on other habitats within the project area.

2. Include shorebird habitat enhancement plans for beach fill and dune creation activities.

3. Establish native dune grasses in sufficient quantity to provide dune stabilization and nesting opportunities for beach nesting birds.

4. Design dune fencing systems that allow passage of juvenile shorebirds between and among the dunes and allow more natural dunes to form with adequate storm protection.

5. Obtain a perpetual deed restriction or conservation easement for the newly-created beach and adjacent beach areas.

6. Continue to coordinate with the Service and ENSP for any dune and beach enhancement or restoration activities in beach-nesting bird or seabeach amaranth habitat.

C. BORROW AREAS

1. Rely primarily on the components of the benthic diversity indices (*i.e.*, species diversity, species richness, and the distribution of the number of individuals among the species), rather than on the diversity indices alone, in evaluating benthic habitat quality.

2. Evaluate any borrow site alternatives that would minimize adverse impacts to surf clam communities through continued coordination with the New Jersey Bureau of Shellfisheries and the Service.

3. Conduct each renourishment phase in a limited section of the borrow area(s) and alternate locations for each subsequent renourishment cycle.

4. Avoid creating excessively deep, poorly flushed (anoxic) pits at the borrow sites.

5. Avoid dredging during shellfish or finfish spawning activities (the typical spawning period and early life stages of winter flounder are between January 1 and May 31).

6. Use hydraulic-pipeline dredging rather than hopper dredging in order to minimize turbidity at the borrow sites and minimize the potential entrainment of federally listed sea turtles.

7. Contact the NMFS regarding potential adverse impacts on federally listed (threatened or endangered) sea turtle and marine mammal species under its jurisdiction.

8. Coordinate with the New Jersey Bureau of Marine Fisheries regarding the selection of borrow sites.

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APPENDIX A

Federally Listed Endangered and Threatened Species,
and Candidate Species in New Jersey

FEDERALLY LISTED ENDANGERED AND THREATENED SPECIES IN NEW JERSEY

An **ENDANGERED** species is any species that is in danger of extinction throughout all or a significant portion of its range.

A **THREATENED** species is any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.

	COMMON NAME	SCIENTIFIC NAME	STATUS
FISHES	Shortnose sturgeon*	*Acipenser brevirostrum*	E
REPTILES	Bog turtle	*Clemmys muhlenbergii*	T
	Kemp's ridley sea turtle*	*Lepidochelys kempii*	E
	Green sea turtle*	*Chelonia mydas*	T
	Hawksbill sea turtle*	*Eretmochelys imbricata*	E
	Leatherback sea turtle*	*Dermochelys coriacea*	E
	Loggerhead sea turtle*	*Caretta caretta*	T
BIRDS	Piping plover	*Charadrius melodus*	T
	Roseate tern	*Sterna dougallii dougallii*	E
	Red-cockaded woodpecker	*Picoides borealis*	E+
MAMMALS	Eastern cougar	*Felis concolor couguar*	E+
	Indiana bat	*Myotis sodalis*	E
	Gray wolf	*Canis lupus*	E+
	Delmarva fox squirrel	*Sciurus niger cinereus*	E+
	Blue whale*	*Balaenoptera musculus*	E
	Finback whale*	*Balaenoptera physalus*	E
	Humpback whale*	*Megaptera novaeangliae*	E
	Right whale*	*Balaena glacialis*	E
	Sei whale*	*Balaenoptera borealis*	E
	Sperm whale*	*Physeter macrocephalus*	E

	COMMON NAME	SCIENTIFIC NAME	STATUS
INVERTEBRATES	Dwarf wedgemussel	*Alasmidonta heterodon*	E
	Northeastern beach tiger beetle	*Cicindela dorsalis dorsalis*	T
	Karner blue butterfly	*Lycaeides melissa samuelis*	E+
	Mitchell's satyr butterfly	*Neonympha m. mitchellii*	E+
	American burying beetle	*Nicrophorus americanus*	E+
PLANTS	Small whorled pogonia	*Isotria medeoloides*	T
	Swamp pink	*Helonias bullata*	T
	Knieskern's beaked-rush	*Rhynchospora knieskernii*	T
	American chaffseed	*Schwalbea americana*	E
	Sensitive joint-vetch	*Aeschynomene virginica*	T
	Seabeach amaranth	*Amaranthus pumilus*	T

STATUS:			
E	endangered species	PE	proposed endangered
T	threatened species	PT	proposed threatened
+	presumed extirpated**		

* Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service.

** Current records indicate the species does not presently occur in New Jersey, although the species did occur in the State historically.

Note: For a complete listing of Endangered and Threatened Wildlife and Plants, refer to 50 CFR 17.11 and 17.12.

For further information, please contact:

U.S. Fish and Wildlife Service
New Jersey Field Office
927 N. Main Street, Building D
Pleasantville, New Jersey 08232
Phone: (609) 646-9310
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APPENDIX B

Colonial Nesting Birds and Shorebirds within
Hereford Inlet to Cape May Inlet Project Area
(prepared by New Jersey Audubon Society)

Colonial Nesting Birds and Shorebirds - Hereford Inlet to Cape May Inlet
Estuary and nearshore coastal waters, including associated beach, dune, salt marsh, mudflats and coastal forest/scrub
Compiled by Don Freiday
Very rare species (occuring less than annually) are excluded from this list

Nests - Y means known to currently nest

C - common: always seen, more than 20 individuals per day
F - fairly common: usually seen, 5 to 20 individuals per day
U - uncommon: seen in limited numbers, 1-4 per day
S - scarce: usually present, but not seen daily
R - rare: seen only a few times a season

Species	Common Name	Nests	Winter	Spring	Summer	Early fall	Late fall
PHALACROCORACIDAE (Cormorants)							
Phalacrocorax auritus	Double-crested Cormorant		U	C	C	C	C
Phalacrocorax carbo	Great Cormorant		U	U			U
ARDEIDAE (Herons, Egrets and Bitterns)							
Botaurus lentiginosus	American Bittern		S	S		U	U
Ixobrychus exilis	Least Bittern			R		R	R
Ardea herodias	Great Blue Heron		F	F	S	F	F
Ardea alba	Great Egret	Y	R	F	F	F	S
Egretta thula	Snowy Egret	Y		F	F	F	S
Egretta caerulea	Little Blue Heron	Y		U	U	U	S
Egretta tricolor	Tricolored Heron	Y		U	U	U	S
Bubulcus ibis	Cattle Egret			R	R	R	
Nycticorax nycticorax	Black-crowned Night-Heron	Y	U	F	F	F	F
Nyctanassa violacea	Yellow-crowned Night-Heron	Y		U	U	U	U
THRESKIORNITHIDAE (Ibis and Spoonbills)							
Threskiornithinae							
Plegadis falcinellus	Glossy Ibis	Y		F	F	F	U

Species	Common Name	Nests	Winter	Spring	Summer	Early Fall	Late Fall
CHARADRIIDAE (Plovers and Lapwings)							
Charadriinae							
Pluvialis squatarola	Black-bellied Plover		F	C	U	C	C
Pluvialis dominica	American Golden-Plover					S	S
Charadrius semipalmatus	Semipalmated Plover			C	U	C	C
Charadrius melodus	Piping Plover	Y		U	U	U	S
Charadrius vociferus	Killdeer	Y	U	F	F	F	F
HAEMATOPODIDAE (Oystercatchers)							
Haematopus palliatus	American Oystercatcher	Y	F	F	F	F	F
RECURVIROSTRIDAE (Avocets and Stilts)							
Recurvirostra americana	American Avocet				R	R	
SCOLOPACIDAE (Sandpipers and Allies)							
Scolopacinae							
Actitis macularius	Spotted Sandpiper	?		F	U	F	U
Tringa solitaria	Solitary Sandpiper			U	S	U	
Tringa melanoleuca	Greater Yellowlegs		F	C	U	C	C
Tringa semipalmata	Willet	Y	R	C	C	F	R
Tringa flavipes	Lesser Yellowlegs		S	F	U	C	C
Bartramia longicauda	Upland Sandpiper				R		
Numenius phaeopus	Whimbrel			U	S	F	U
Limosa haemastica	Hudsonian Godwit				R	R	
Limosa fedoa	Marbled Godwit		R	R	R	S	S
Arenaria interpres	Ruddy Turnstone		C	C	U	F	C
Calidris canutus	Red Knot		S	C	F	U	U
Calidris alba	Sanderling		C	C	F	C	C
Calidris pusilla	Semipalmated Sandpiper			C	C	C	C
Calidris mauri	Western Sandpiper				F	F	F
Calidris minutilla	Least Sandpiper		R	C	U	C	F
Calidris fuscicollis	White-rumped Sandpiper			U	U	U	U
Calidris bairdii	Baird's Sandpiper				R	R	R
Calidris melanotos	Pectoral Sandpiper			U	S	F	F
Calidris maritima	Purple Sandpiper		U	U			U
Calidris alpina	Dunlin		C	C	R	U	C

Species	Common Name	Nests	Winter	Spring	Summer	Early Fall	Late Fall
Calidris ferruginea	Curlew Sandpiper						
Calidris himantopus	Stilt Sandpiper			R	S	F	U
Tryngites subruficollis	Buff-breasted Sandpiper				R	R	
Limnodromus griseus	Short-billed Dowitcher		R	C	F	C	U
Limnodromus scolopaceus	Long-billed Dowitcher		R		R	U	U
Gallinago delicata	Wilson's Snipe		R	U		U	U
Scolopax minor	American Woodcock		R	U		U	U
Phalaropodinae							
Phalaropus tricolor	Wilson's Phalarope			R	R	R	R
LARIDAE (Gulls)							
Larus atricilla	Laughing Gull	Y	R	C	C	C	C
Larus philadelphia	Bonaparte's Gull		U	U		R	U
Larus delawarensis	Ring-billed Gull		C	C	S	F	C
Larus argentatus	Herring Gull	Y	C	C	C	C	C
Larus glaucoides	Iceland Gull		R				
Larus fuscus	Lesser Black-backed Gull		R	R			R
Larus hyperboreus	Glaucous Gull		R				
Larus marinus	Great Black-backed Gull	Y	C	C	C	C	C
Rissa tridactyla	Black-legged Kittiwake		R				R
STERNIDAE (Terns)							
Sternula antillarum	Least Tern	Y		F	F	F	
Gelochelidon nilotica	Gull-billed Tern	Y		U	U	U	
Hydroprogne caspia	Caspian Tern			R		U	U
Chlidonias niger	Black Tern			R	S	U	
Sterna dougallii	Roseate Tern			R	R	R	
Sterna hirundo	Common Tern	Y		C	C	C	F
Sterna forsteri	Forster's Tern	Y	S	C	C	C	C
Thalasseus maximus	Royal Tern	Y		F	U	C	C
Thalasseus sandvicensis	Sandwich Tern				R	S	
RYNCHOPIDAE (Skimmers)							
Rynchops niger	Black Skimmer	Y		F	F	C	F

APPENDIX C

State-Listed Endangered and Threatened Species

in New Jersey

Conserve Wildlife

New Jersey's Endangered and Threatened Wildlife

Endangered Species are those whose prospects for survival in New Jersey are in immediate danger because of a loss or change in habitat, over-exploitation, predation, competition, disease, disturbance or contamination. Assistance is needed to prevent future extinction in New Jersey.

Threatened Species are those who may become endangered if conditions surrounding them begin to or continue to deteriorate.

There are other classifications for wildlife as well, including Stable, Species of Special Concern Special Concern and Undertermined.

Species names in the below tables link to PDF documents containing identification, habitat and status and conservation information. Additionally, in 2003 twelve species were highlighted as part of the celebration of the 30th anniversary of the NJ Endangered Species Conservation Act. See the "2003 Species of the Month" page for more information.

BIRDS			
Endangered		Threatened	
Bittern, American	*Botaurus lentiginosus* BR	Bobolink	*Dolichonyx oryzivorus* BR
Eagle, bald	*Haliaeetus leucocephalus* BR **	Eagle, bald	*Haliaeetus leucocephalus* NB **
Falcon, peregrine	*Falco peregrinus*	Hawk, Cooper's	*Accipiter cooperii*
Goshawk, northern	*Accipiter gentilis* BR	Hawk, red-shouldered	*Buteo lineatus* NB
Grebe, pied-billed	*Podilymbus podiceps*	Night-heron, black-crowned	*Nycticorax nycticorax* BR
Harrier, northern	*Circus cyaneus* BR	Night-heron, yellow-crowned	*Nyctanassa violaceus*
Hawk, red-shouldered	*Buteo lineatus* BR	Knot, red	*Calidris canutus* BR
Owl, short-eared	*Asio flammeus* BR	Osprey	*Pandion haliaetus* BR
Plover, piping	*Charadrius melodus***	Owl, barred	*Strix varia*
Sandpiper, upland	*Bartramia longicauda*	Owl, long-eared	*Asio otus*
Shrike, loggerhead	*Lanius ludovicianus*	Rail, black	*Laterallus jamaicensis*
Skimmer, black	*Rynchops niger* BR	Skimmer, black	*Rynchops niger* NB
Sparrow, Henslow's	*Ammodramus henslowii*	Sparrow, grasshopper	*Ammodramus savannarum* BR
Sparrow, vesper	*Pooecetes gramineus* BR	Sparrow, Savannah	*Passerculus sandwichensis* BR
Tern, least	*Sterna antillarum*	Sparrow, vesper	*Pooecetes gramineus* NB
Tern, roseate	*Sterna dougallii***	Woodpecker, red-headed	*Melanerpes erythrocephalus*
Wren, sedge	*Cistothorus platensis*		
**Federally endangered or threatened			
BR - Breeding population only; NB - non-breeding population only			

REPTILES			
Endangered		Threatened	
Rattlesnake, timber	*Crotalus h. horridus*	Snake, northern pine	*Pituophis m. melanoleucus*
Snake, corn	*Elaphe g. guttata*	Turtle, Atlantic green	*Chelonia mydas***
Snake, queen	*Regina septemvittata*	Turtle, wood	*Clemmys insculpta*
Turtle, bog	*Clemmys muhlenbergii***		
Atlantic hawksbill	*Eretmochelys imbricata***		
Atlantic leatherback	*Dermochelys coriacea***		
Atlantic loggerhead	*Caretta caretta***		
Atlantic Ridley	*Lepidochelys kempi***		
**Federally endangered or threatened			

AMPHIBIANS			
Endangered		Threatened	
Salamander, blue-spotted	*Ambystoma laterale*	Salamander, eastern mud	*Pseudotriton montanus*
Salamander, eastern tiger	*Ambystoma tigrinum*	Salamander, long-tailed	*Eurycea longicauda*
Treefrog, southern gray	*Hyla chrysoscelis*	Treefrog, pine barrens	*Hyla andersonii*

INVERTEBRATES			
Endangered		Threatened	
Beetle, American burying	*Nicrophorus mericanus***	Elfin, frosted (butterfly)	*Callophrys irus*
Beetle, northeastern beach tiger	*Cincindela d. dorsalis***	Floater, triangle (mussel)	*Alasmidonta undulata*
Copper, bronze	*Lycaena hyllus*	Fritillary, silver-bordered (butterfly)	*Bolaria selene myrina*
Floater, brook (mussel)	*Alasmidonta varicosa*	Lampmussel, eastern (mussel)	*Lampsilis radiata*
Floater, green (mussel)	*Lasmigona subviridis*	Lampmussel, yellow (mussel)	*Lampsilis cariosa*
Satyr, Mitchell's (butterfly)	*Neonympha m. mitchellii***	Mucket, tidewater (mussel)	*Leptodea ochracea*
Skipper, arogos (butterfly)	*Atrytone arogos arogos*	Pondmussel, eastern (mussel)	*Ligumia nasuta*
Skipper, Appalachian grizzled (butterfly)	*Pyrgus wyandot*	White, checkered (butterfly)	*Pontia protodice*
Wedgemussel, dwarf	*Alasmidonta heterodon***		
**Federally endangered or threatened			

MAMMALS	
Endangered	
Bat, Indiana	*Myotis sodalis***
Bobcat	*Lynx rufus*
Whale, black right	*Balaena glacialis***
Whale, blue	*Balaenoptera musculus***
Whale, fin	*Balaenoptera physalus***
Whale, humpback	*Megaptera novaeangliae***
Whale, sei	*Balaenoptera borealis***
Whale,sperm	*Physeter macrocephalus***
Woodrat, Allegheny	*Neotoma floridana magister*
**Federally Endangered	

FISH	
Endangered	
Sturgeon, shortnose	*Acipenser brevirostrum***
**Federally Endangered	

List updated 3/11/04

APPENDIX D

Guidelines for Managing Recreational Activities in
Piping Plover Breeding Habitat on the
U.S. Atlantic Coast to
Avoid Take Under Section 9 of the
Endangered Species Act

GUIDELINES FOR MANAGING RECREATIONAL ACTIVITIES IN PIPING PLOVER BREEDING HABITAT ON THE U.S. ATLANTIC COAST TO AVOID TAKE UNDER SECTION 9 OF THE ENDANGERED SPECIES ACT

Northeast Region, U.S. Fish and Wildlife Service
April 15, 1994

The following information is provided as guidance to beach managers and property owners seeking to avoid potential violations of Section 9 of the Endangered Species Act (16 U.S.C. 1538) and its implementing regulations (50 CFR Part 17) that could occur as the result of recreational activities on beaches used by breeding piping plovers along the Atlantic Coast. These guidelines were developed by the Northeast Region, U.S. Fish and Wildlife Service (Service), with assistance from the U.S. Atlantic Coast Piping Plover Recovery Team. The guidelines are advisory, and failure to implement them does not, of itself, constitute a violation of the law. Rather, they represent the Service's best professional advice to beach managers and landowners regarding the management options that will prevent direct mortality, harm, or harassment of piping plovers and their eggs due to recreational activities.

Some land managers have endangered species protection obligations under Section 7 of the Endangered Species Act (see section I below) or under Executive Orders 11644 and 11989[1] that go beyond adherence to these guidelines. Nothing in this document should be construed as lack of endorsement of additional piping plover protection measures implemented by these land managers or those who are voluntarily undertaking stronger plover protection measures.

This document contains four sections: (I) a brief synopsis of the legal requirements that afford protection to nesting piping plovers; (II) a brief summary of the life history of piping plovers and potential threats due to recreational activities during the breeding cycle; (III) guidelines for protecting piping plovers from recreational activities on Atlantic Coast beaches; and (IV) literature cited.

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[1] Executive Order 11644, Use of Off-Road Vehicles on the Public Lands and Executive Order 11989, Off-Road Vehicles on Public Lands pertain to lands under custody of the Secretaries of Agriculture, Defense, and Interior (except for Indian lands) and certain lands under the custody of the Tennessee Valley Authority.

Section 10 also allows permits to be issued for take that is "incidental to, and not the purpose of, carrying out an otherwise lawful activity" if the Service determines that certain conditions have been met. An applicant for an incidental take permit must prepare a conservation plan that specifies the impacts of the take, steps the applicant will take to minimize and mitigate the impacts, funding that will be available to implement these steps, alternative actions to the take that the applicant considered, and the reasons why such alternatives are not being utilized.

Section 7 of the ESA may be pertinent to beach managers and landowners in situations that have a Federal nexus. Section 7 requires Federal agencies to consult with the Service (or National Marine Fisheries Service for marine species) prior to authorizing, funding, or carrying out activities that may affect listed species. Section 7 also requires that these agencies use their authorities to further the conservation of listed species. Section 7 obligations have caused Federal land management agencies to implement piping plover protection measures that go beyond those required to avoid take, for example by conducting research on threats to piping plovers. Other examples of Federal activities that may affect piping plovers along the Atlantic Coast, thereby triggering Section 7 consultation, include permits for beach nourishment or disposal of dredged material (U.S. Army Corps of Engineers) and funding of beach restoration projects (Federal Emergency Management Authority).

Piping plovers, as well as other migratory birds such as least terns, common terns, American oystercatchers, laughing gulls, herring gulls, and great black-backed gulls, their nests, and eggs are also protected under the Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712). Prohibited acts include pursuing, hunting, shooting, wounding, killing, trapping, capturing, collecting, or attempting such conduct. Violators may be fined up to $5000 and/or imprisoned for up to six months.

Almost all States within the breeding range of the Atlantic Coast piping plover population list the species as State threatened or endangered (Northeast Nongame Technical Committee 1993). Various laws and regulations may protect State-listed species from take, but the Service has not ascertained the adequacy of the guidelines presented in this document to meet the requirements of any State law.

Strauss 1990). Nests are usually found in areas with little or no vegetation although, on occasion, piping plovers will nest under stands of American beachgrass (Ammophila breviligulata) or other vegetation (Patterson 1988, Flemming et al. 1990, MacIvor 1990). Plover nests may be very difficult to detect, especially during the 6-7 day egg-laying phase when the birds generally do not incubate (Goldin 1994).

Plover foods consist of invertebrates such as marine worms, fly larvae, beetles, crustaceans or mollusks (Bent 1929, Cairns 1977, Nicholls 1989). Feeding areas include intertidal portions of ocean beaches, washover areas, mudflats, sandflats, wrack lines[4], and shorelines of coastal ponds, lagoons or salt marshes (Gibbs 1986, Coutu et al. 1990, Hoopes et al. 1992, Loegering 1992, Goldin 1993). Studies have shown that the relative importance of various feeding habitat types may vary by site (Gibbs 1986, Coutu et al. 1990, McConnaughey et al. 1990, Loegering 1992, Goldin 1993, Hoopes 1993) and by stage in the breeding cycle (Cross 1990). Adults and chicks on a given site may use different feeding habitats in varying proportion (Goldin et al. 1990). Feeding activities of chicks may be particularly important to their survival. Cairns (1977) found that piping plover chicks typically tripled their weight during the first two weeks post-hatching; chicks that failed to achieve at least 60% of this weight gain by day 12 were unlikely to survive. During courtship, nesting, and brood rearing, feeding territories are generally contiguous to nesting territories (Cairns 1977), although instances where brood-rearing areas are widely separated from nesting territories are not uncommon (see Table 1). Feeding activities of both adults and chicks may occur during all hours of the day and night (Burger 1993) and at all stages in the tidal cycle (Goldin 1993, Hoopes 1993).

THREATS FROM NONMOTORIZED BEACH ACTIVITIES

Sandy beaches that provide nesting habitat for piping plovers are also attractive recreational habitats for people and their pets. Nonmotorized recreational activities can be a source of both direct mortality and harassment of piping plovers. Pedestrians on beaches may crush

[4] Wrack is organic material including seaweed, seashells, driftwood and other materials deposited on beaches by tidal action.

and intertidal zone. These movements place chicks in the paths of vehicles driving along the berm or through the intertidal zone. Chicks stand in, walk, and run along tire ruts, and sometimes have difficulty crossing deep ruts or climbing out of them (Eddings et al. 1990, Strauss 1990, Howard et al. 1993). Chicks sometimes stand motionless or crouch as vehicles pass by, or do not move quickly enough to get out of the way (Tull 1984, Hoopes et al. 1992, Goldin 1993). Wire fencing placed around nests to deter predators (Rimmer and Deblinger 1990, Melvin et al. 1992) is ineffective in protecting chicks from vehicles because chicks typically leave the nest within a day after hatching and move extensively along the beach to feed (see Table 1).

Vehicles may also significantly degrade piping plover habitat or disrupt normal behavior patterns. They may harm or harass plovers by crushing wrack into the sand and making it unavailable as cover or a foraging substrate, by creating ruts that may trap or impede movements of chicks, and by preventing plovers from using habitat that is otherwise suitable (MacIvor 1990, Strauss 1990, Hoopes et al. 1992, Goldin 1993).

III. GUIDELINES FOR PROTECTING PIPING PLOVERS FROM RECREATIONAL DISTURBANCE

The Service recommends the following protection measures to prevent direct mortality or harassment of piping plovers, their eggs, and chicks.

MANAGEMENT OF NONMOTORIZED RECREATIONAL USES

On beaches where pedestrians, joggers, sun-bathers, picnickers, fishermen, boaters, horseback riders, or other recreational users are present in numbers that could harm or disturb incubating plovers, their eggs, or chicks, areas of at least 50 meter-radius around nests above the high tide line should be delineated with warning signs and symbolic fencing[5]. Only persons engaged in rare species monitoring, management, or research activities should enter posted areas. These areas should remain fenced as long as viable eggs or unfledged chicks are present. Fencing is intended to prevent accidental crushing of nests and repeated flushing of

[5] "Symbolic fencing" refers to one or two strands of light-weight string, tied between posts to delineate areas where pedestrians and vehicles should not enter.

Pets should be leashed and under control of their owners at all times from April 1 to August 31 on beaches where piping plovers are present or have traditionally nested. Pets should be prohibited on these beaches from April 1 through August 31 if, based on observations and experience, pet owners fail to keep pets leashed and under control.

Kite flying should be prohibited within 200 meters of nesting or territorial adult or unfledged juvenile piping plovers between April 1 and August 31.

Fireworks should be prohibited on beaches where plovers nest from April 1 until all chicks are fledged.

MOTOR VEHICLE MANAGEMENT

The Service recommends the following minimum protection measures to prevent direct mortality or harassment of piping plovers, their eggs, and chicks on beaches where vehicles are permitted. Since restrictions to protect unfledged chicks often impede vehicle access along a barrier spit, a number of management options affecting the timing and size of vehicle closures are presented here. Some of these options are contingent on implementation of intensive plover monitoring and management plans by qualified biologists. It is recommended that landowners seek concurrence with such monitoring plans from either the Service or the State wildlife agency.

Protection of Nests

All suitable piping plover nesting habitat should be identified by a qualified biologist and delineated with posts and warning signs or symbolic fencing on or before April 1 each year. All vehicular access into or through posted nesting habitat should be prohibited. However, prior to hatching, vehicles may pass by such areas along designated vehicle corridors established along the outside edge of plover nesting habitat. Vehicles may also park outside delineated nesting habitat, if beach width and configuration and tidal conditions allow. Vehicle corridors or parking areas should be moved, constricted, or temporarily closed if territorial, courting, or nesting plovers are disturbed by passing or parked vehicles, or if disturbance is anticipated because of unusual tides or expected increases in vehicle use during weekends, holidays, or special events.

Protection of Chicks

Sections of beaches where unfledged piping plover chicks are present should be temporarily closed to all vehicles not deemed essential. (See the provisions for essential vehicles below.) Areas where vehicles are prohibited should include all dune, beach, and intertidal habitat within the chicks' foraging range, to be determined by either of the following methods:

1. The vehicle free area should extend 1000 meters on each side of a line drawn through the nest site and perpendicular to the long axis of the beach. The resulting 2000 meter-wide area of protected habitat for plover chicks should extend from the ocean-side low water line to the bay-side low water line or to the farthest extent of dune habitat if no bay-side intertidal habitat exists. However, vehicles may be allowed to pass through portions of the protected area that are considered inaccessible to plover chicks because of steep topography, dense vegetation, or other naturally-occurring obstacles.

OR

2. The Service OR a State wildlife agency that is party to an agreement under Section 6 of the ESA provides written concurrence with a plan that:

A. Provides for monitoring of all broods during the chick-rearing phase of the breeding season and specifies the frequency of monitoring.

AND

B. Specifies the minimum size of vehicle-free areas to be established in the vicinity of unfledged broods based on the mobility of broods observed on the site in past years and on the frequency of monitoring. Unless substantial data from past years show that broods on a site stay very close to their nest locations, vehicle-free areas should extend at least 200 meters on each side of the nest site during the first week following hatching. The size and location of the protected area should be adjusted in response to the observed mobility of the brood, but in no case should it be reduced to less than 100 meters on each

OR

2) Without intensive monitoring: Restrictions should begin on May 15 (the earliest probable hatch date). If the nest is discovered after May 15, then restrictions should start immediately.

If hatching occurs earlier than expected, or chicks are discovered from an unreported nest, restrictions on vehicles should begin immediately.

If ruts are present that are deep enough to restrict movements of plover chicks, then restrictions on vehicles should begin at least 5 days prior to the anticipated hatching date of plover nests. If a plover nest is found with a complete clutch, precluding estimation of hatching date, and deep ruts have been created that could reasonably be expected to impede chick movements, then restrictions on vehicles should begin immediately.

Essential Vehicles

Because it is impossible to completely eliminate the possibility that a vehicle will accidently crush an unfledged plover chicks, use of vehicles in the vicinity of broods should be avoided whenever possible. However, the Service recognizes that life-threatening situations on the beach may require emergency vehicle response. Furthermore, some "essential vehicles" may be required to provide for safety of pedestrian recreationists, law enforcement, maintenance of public property; or access to private dwellings not otherwise accessible. On large beaches, maintaining the frequency of plover monitoring required to minimize the size and duration of vehicle closures may necessitate the use of vehicles by plover monitors.

Essential vehicles should only travel on sections of beaches where unfledged plover chicks are present if such travel is absolutely necessary and no other reasonable travel routes are available. All steps should be taken to minimize number of trips by essential vehicles through chick habitat areas. Homeowners should consider other means of access, eg. by foot, water, or shuttle services, during periods when chicks are present.

The following procedures should be followed to minimize the probability that chicks will be crushed by essential (non-emergency) vehicles:

In some unusual circumstances, Service or State biologists may recognize situations where this guidance provides insufficient protection for piping plovers or their nests. In such a case, the Service or the State wildlife agency may provide written notice to the landowner describing additional measures recommended to prevent take of piping plovers on that site.

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APPENDIX E

Guidelines for Managing Fireworks in the Vicinity of
Piping Plovers and Seabeach Amaranth
on the U.S. Atlantic Coast

GUIDELINES FOR MANAGING FIREWORKS IN THE VICINITY OF PIPING PLOVERS AND SEABEACH AMARANTH ON THE U.S. ATLANTIC COAST

February 4, 1997

The following is provided as guidance to Federal agencies, landowners, commercial fireworks companies, and fireworks event sponsors seeking to avoid adverse effects on piping plovers and seabeach amaranth. They are intended to advise Federal agencies that conduct, fund, or authorize fireworks activities regarding the measures needed to avoid adverse effects on listed species, thereby averting the need for formal consultation under Section 7 of the Endangered Species Act (ESA). These practices also constitute the U.S. Fish and Wildlife Service's (Services's) best professional advice to non-Federal entities on avoiding take of piping plovers under Section 9 of the ESA.

These guidelines supplement information about protection of piping plovers from a variety of recreational activities, provided in the Service's April 15, 1994 *Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act* (appended)[1].

Seabeach amaranth, a threatened plant species protected under the Endangered Species Act (ESA), occurred historically along coastal beaches from southern Massachusetts to South Carolina. At the present time it is found only on Long Island, New York; North Carolina; and South Carolina. Section 7 of the ESA requires Federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that directly or indirectly affect listed plants; this requirement is applicable to permits related to fireworks events that are issued by the U.S. Coast Guard.

Potential Impacts Related to Fireworks Displays

Direct Impacts

Fireworks are highly disturbing to piping plovers. Fireworks early in the breeding season may cause plovers conducting courtship activities to abandon their territories. Direct injury can be caused by the explosions or debris, and piping plovers and terns (which often nest adjacent to or near plovers) will often abandon their nests and broods during fireworks displays, exposing eggs and chicks to weather and predators. If a flightless chick were to become permanently separated from its parents during the confusion, mortality would be almost certain.

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[1] Copies of the 1994 Guidelines for general recreational activities are also available, on request, from the U.S. Fish and Wildlife Service, Wier Hill Road, Sudbury, MA 01776, Attn: Anne Hecht; telephone 508-443-4325; fax 508-443-2898.

Several situations where fireworks caused severe adverse effects on least terns, colonial nesting birds often found in the vicinity of piping plovers, serve as indicators of the effects that pyrotechnics can exert on beach-nesting birds. An August 1993 fireworks display in New Jersey caused permanent abandonment of a least tern colony located more than 250 m away, and a 1994 New Jersey fireworks display caused temporary abandonment and displays of distress by terns within a colony located more than 3/4 mile away. Incidents in New York where piping plovers were disturbed by fireworks also caused prolonged disturbance to least terns and black skimmers nesting nearby.

Seabeach amaranth can be directly affected by launch activities if they occur in areas where the plants may be crushed or damaged by launch personnel or equipment.

Indirect Impacts

In addition to adverse effects from the noise and lights of the pyrotechnics, commercial fireworks displays often draw large crowds that may pose threats to nearby plovers. These crowds may be situated at some distance from the actual launch site, for example, across an inlet. Potential indirect impacts that may adversely affect piping plovers include: spectators walking through and/or throwing objects (including illegal pyrotechnics) into plover nesting and brood-rearing areas; additional off-road vehicle patrols by public safety personnel; increased boat landings by spectators on relatively remote stretches of beach; low-flying aircraft, including helicopter patrols and personal spectator aircraft; additional trash (which attracts predators). Signs and symbolic fences that are adequate for the purpose of alerting daytime beach users to locations of plover breeding areas are often insufficient to prevent accidental entry by fireworks spectators wandering in the dark.

Potential indirect adverse effects on seabeach amaranth include trampling or crushing of unprotected plants by pedestrian or vehicular traffic on the beach.

Measures for Avoiding and Monitoring Direct and Indirect Impacts of Fireworks Events

Direct Impacts

Fireworks displays including launch areas and debris fallout areas should be located to avoid disturbance of breeding piping plovers. In general, the Service recommends that the launch site be located a minimum of 3/4 mile from the nearest plover nesting and/or foraging area. Access routes for personnel deploying the fireworks and other public safety personnel (including fire prevention/suppression and law enforcement officers) should conform with the vehicle management recommendations contained in the *Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act.* Launch sites should also be located to prevent trampling any seabeach amaranth plants.

Indirect Impacts

Event sponsors should plan and implement measures to assure that spectators will not walk through and/or throw objects into plover nesting and brood-rearing areas. Sufficient law enforcement and other personnel must also be on-site during these events to enforce plover protection measures and prevent use of illegal fireworks in the vicinity of the birds.

1. Plover habitats in the vicinity of where spectators may congregate should be intensively surveyed by qualified biologists[2] for at least four days prior to the event to locate nests, adult plovers, chicks, and/or post-fledged juveniles. For events prior to July 1, surveyors should also search for territorial and/or courting adults that have not yet established nests or may be preparing to re-nest. In New York, potential habitat for seabeach amaranth should be surveyed to locate any seabeach amaranth plants.

2. Plover habitats should be symbolically fenced in accordance with the Service's *Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act* (see pages 7-8). Seabeach amaranth plants should be symbolically fenced to provide a minimum 3 meter buffer zone around individual plants or groups of plants.

3. Additional protection measures recommended to avoid impacts that may occur when the large crowds are drawn to the beach at night include[3]:

   a. Close parking lots and beach access points in the vicinity of breeding plovers.

   b. Increase the size of symbolically fenced areas around plover nesting areas to provide extra buffers between birds and pedestrians that may be on the beach. The size of buffers should be appropriate for the size of the anticipated crowd; for large crowds, buffers should be expanded from the standard 50 meters to a total of 100 meters from established nests.

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[2] State wildlife agencies and private environmental groups often conduct plover monitoring activities and can be consulted for available information about plover breeding locations. However, intensity of surveys needed to avoid adverse effects from fireworks events will often exceed those routinely conducted by these wildlife agencies/organizations. Arrangements and commitments for added surveys for these events are the responsibility of the permitting agencies and/or event sponsors. It is recommended that these arrangements be made well in advance of the potential event, due to limited availability of qualified personnel.

[3] For extremely large fireworks events, additional protection measures may be needed, including: issuing air traffic advisory for all aircraft to remain >1000' above sensitive areas; issuing mariners advisory telling boaters not to land in sensitive areas; boat patrols; extensive advanced publicity advising spectators where they *should* go to watch the fireworks and about closed areas; training about protection needs of rare plants and/or animals for law enforcement personnel.

c. Increase the visibility of fencing using reflectorized tape or by substituting snowfences, plastic orange highway construction fences, or wire mesh fences for string fencing, as string fences are very difficult to see at night. Snowfences and highway construction fences should be removed the next day if there is any chance that they will impede chick movements.

d. Fence and post foraging territories of unfledged chicks, as delineated by a qualified biologist, especially in areas where large crowds are anticipated and/or if the day of the event is especially hot (since heat often deters chick foraging during the daytime, increasing the birds' reliance on evening feeding).

e. Provide adequate numbers (consistent with anticipated numbers of spectators) of monitors and law enforcement personnel in the vicinity of plover breeding areas or seabeach amaranth locations to patrol fenced areas from the time when spectators begin congregating on the beach until the crowd disperses after the event. Assure that monitors and enforcement personnel receive accurate current information about the locations of threatened birds and plants so that they can minimize any disruptions from their own activities.

f. Prohibit all pets on the beach during the event and ensure compliance with this prohibition.

4. Remove any trash or litter from the beach immediately following the event. However, any trash located within fenced areas should be left until daylight and then removed by or under the supervision of plover monitors. Further, vehicles should not be used at night to remove trash within 100 meters of unfledged plover chicks.

5. In order to gauge the effectiveness of the measures 3 and 4, the following data should be collected:

a. Locations and status of all adult plovers, nests, and chicks within 1/4 mile of spectator viewing areas should be determined by a qualified biologist on the day of the event and again on the following day.

b. Counts of human and dog tracks that intersect the perimeter of symbolically fenced areas before and after the event.

c. Counts of any persons actually observed inside symbolically fenced areas during the event.

d. Counts of any instances of illegal pyrotechnics used on the beach during the event.

e. Counts of trash/litter items inside symbolically fenced areas before and after the event. For very large areas or areas that have substantial amounts of trash before the event, trash counts may be conducted in sample plots.

f. Count of breaks in symbolic fences.

6. Except when responding to an actual emergency situation, all law enforcement, fire department, public works, fireworks deployment, and other vehicles in the vicinity of breeding plovers should only be operated in conformance with the Service's *Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act* (see discussion of Essential Vehicles, pages 13-14).

DRAFT

FISH AND WILDLIFE COORDINATION ACT SECTION 2(b) REPORT

HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY CAPE MAY COUNTY, NEW JERSEY

Prepared by:

U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey 08232

Preparer: Frederick C. Deppe
Supervisory Fish and Wildlife Biologist: Ron Popowski
Acting Project Leader: Eric Schrading

August 2013

United States Department of the Interior

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LTC Chris Becking
District Engineer, Philadelphia District
U.S. Army Corps of Engineers
Wanamaker Building – 100 Penn Square East
Philadelphia, Pennsylvania 19107 - 3390
Attn: Beth Brandreth

AUG 15 2013

Dear LTC Becking:

Enclosed is a U.S. Fish and Wildlife Service (Service) draft report prepared pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) on the U.S. Army Corps of Engineers, Philadelphia District (Corps) Hereford Inlet to Cape May Inlet Feasibility Study, Cape May County, New Jersey. The information presented in this draft FWCA Section 2 (b) report addresses potential beneficial or adverse impacts on fish and wildlife resources from proposed shore protection along the five-mile-long barrier island. This report has been prepared pursuant to the Scope-of-Work and Fiscal Year-2007 and 2008 interagency agreement between the Corps and the Service.

The following comments are provided pursuant to Section 2(b) of the FWCA. Comments are also provided under authority of the Endangered Species Act of 1973 (ESA) (87 Stat. 884, as amended; 16 U.S.C 1531 *et seq.*), and the Migratory Bird Act Treaty of 1918 (40 Stat. 775, as amended; 16 U.S.C. 703-712), and are consistent with the intent of the Service's Mitigation Policy (Federal Register, Vol. 46, No. 15, Jan. 23, 1981).

FEDERALLY LISTED THREATENED AND ENDANGERED SPECIES

The federally listed (threatened) piping plover (*Charadrius melodus*) nests on the beaches of Hereford Inlet including (Stone Harbor Point and North Wildwood from Central Avenue to the intersection of John F. Kennedy Beach Drive and 2nd Avenue), on the U.S. Coast Guard's LORAN site, and on Cape May National Wildlife Refuge; and are known to forage along the beaches of Wildwood Crest and Lower Township. Piping plovers are not listed as "historical" within the project area as erroneously stated on page 2.3 of the Corps' draft feasibility report. On the Atlantic coastal beaches within the project area, piping plovers last nested in North Wildwood and Wildwood Crest in the 1990's, and the Service has no current or historical records of nesting in

Wildwood. Piping plovers nest on sandy beaches above 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 sandpits, and on sites with deposits of suitable dredged or pumped sand.

Coastal development for residential and commercial uses, and the subsequent stabilization of the once shifting and dynamic ecosystem, have resulted in the degradation and alteration of natural beaches to such an extent along the Atlantic coast that many beaches no longer provide suitable habitat for piping plovers. Disturbance by humans and the direct loss of nests have become major contributing factors to the population decline of the piping plover (U.S. Fish and Wildlife Service 1996a).

Dredged spoil deposition has the potential to create piping plover nesting habitat, although this is sub-optimal, provided the material is deposited prior to nesting (U.S. Fish and Wildlife Service 1996a). As a result, piping plovers could expand their nesting range within the project area after nourishment is completed. This occurred in 1997 as a result of Corps - New York District beach nourishment projects in Monmouth County, New Jersey (U.S. Fish and Wildlife Service 2002). Prior to initial beach nourishment in 1994, piping plovers were not documented in that project area for at least a decade.

The project may also create habitat for seabeach amaranth (*Amaranthus pumilus*), a federally listed (threatened) plant (U.S. Fish and Wildlife Service 1996b). Seabeach amaranth is an annual plant, endemic to Atlantic coastal plain beach, primarily occurring 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 materials placed as beach replenishment or dredge spoil. Previous occurrences of seabeach amaranth are known within the proposed project area (*i.e.*, the U.S. Coast Guard's LORAN Unit in 2003-2004) and may become naturally reestablished within the project area during the project life. Colonization of seabeach amaranth in New Jersey occurred in July 2000 after a Corps - New York District beach nourishment project in Monmouth County, (U.S. Fish and Wildlife Service 2002). Prior to the 2000 rediscovery, this species had last been documented in New Jersey in 1913 (U.S. Fish and Wildlife Service 1996b).

Other than the piping plover and seabeach amaranth, the federally and State-listed roseate tern (*Sterna dougallii*) (occasional transient) and State-listed peregrine falcon (*Falco peregrinus*) are known to use the project area. In addition, red knots (*Calidris canutus rufa*), a Federal candidate species, are known to stopover in the project area during spring (northward) and fall (southward) migration where they feed mainly on the spat of mussels and other invertebrates to build fat reserves to complete their migration.

The National Marine Fisheries Service (NMFS) must be consulted regarding Essential Fish Habitat, as required under Section 305 (b)(2) of the Magnuson – Stevens Fishery Conservation and Management Act (16 U.S.C. 1801-1882). The NMFS must also be consulted regarding the ESA due to the potential presence of the federally listed (endangered) kemps ridley sea turtle (*Lepidochelys kempii*), hawksbill sea turtle (*Eretmochelys imbricata*) and leatherback sea turtle (*Dermochelys coriacea*), and the federally listed (threatened) loggerhead sea turtle (*Caretta*

caretta) and green sea turtle (*Chelonia mydas*) within the project area and any borrow areas. Appendix A provides a current list of federally listed (endangered and threatened) and candidate species in New Jersey.

The Service appreciates the opportunity to comment on the proposed plan and is pleased to submit this draft FWCA Section 2(b) report as technical input to the *Hereford Inlet to Cape May Inlet Feasibility Study*. Should you have any questions, please contact Ron Popowski at Ron_Popowski@fws.gov.

Sincerely,

Eric Schrading
Acting Field Supervisor

Enclosure
CC: Ralph Tiner, RO
Karen Green, NMFS
Todd Pover, NJCWF
Dave Jenkins, ENSP
Bill Dixon, NJDEP Bureau of Coastal Engineering

LITERATURE CITED

U.S. Fish and Wildlife Service. 1996a. Piping plover (*Charadrius melodus*), Atlantic Coast population, revised recovery plan. U.S. Department of the Interior, Fish and Wildlife Service, Region 5, Hadley, MA. 245 pp.

_____. 1996b. Recovery plan for seabeach amaranth (*Amaranthus pumilus*) Rafinesque. U.S. Department of the Interior, Fish and Wildlife Service, Region 4, Atlanta, GA. 70 pp.

_____. 2002. Biological opinion on the effects of completion of sections I and II of the Atlantic Coast of New Jersey beach erosion control project Sea Bright to Manasquan, Monmouth County, New Jersey on the piping plover (*Charadrius melodus*) and seabeach amaranth (*Amaranthus pumilus*). U.S. Department of the Interior, Fish and Wildlife Service, Region 5, New Jersey Field Office, Pleasantville, NJ. 124 pp.

DRAFT

FISH AND WILDLIFE COORDINATION ACT

SECTION 2(b) REPORT

HEREFORD INLET TO CAPE MAY INLET
FEASIBILITY STUDY
CAPE MAY COUNTY, NEW JERSEY

Prepared for:

U.S. Army Corps of Engineers
Philadelphia District
Philadelphia, Pennsylvania 19107

Prepared by:

U.S. Fish and Wildlife Service
Ecological Services, Region 5
New Jersey Field Office
Pleasantville, New Jersey 08232

Preparer: Frederick C. Deppe
Supervisory Fish and Wildlife Biologist: Ron Popowski
Acting Project Leader: Eric Schrading

EXECUTIVE SUMMARY

The Philadelphia District, U.S. Army Corps of Engineers (Corps) was authorized by Congress under the Water Resources Development Act of 1986 (P.L. 99-662), to conduct a feasibility study to investigate storm damage reduction, beach restoration, and water quality improvement alternatives from Hereford Inlet to Cape May Inlet within the municipalities of North Wildwood, Wildwood, Wildwood Crest, and Lower Township, Cape May County, New Jersey (project area). The length of the project area is approximately seven miles long and exhibits several different coastal issues. The North Wildwood portion of the project area is prone to moderate to severe erosion, leaving the surrounding community vulnerable to storm damages. Meanwhile, the beaches of Wildwood and Wildwood Crest have been accreting large quantities of sand resulting in a large, low, flat beach offering little habitat value and resulting in human health and water quality concerns due to clogged outfall pipes on the beach. The preferred alternative currently being considered for the project is "bypassing" sand through hydraulic back passing from Wildwood to North Wildwood and changing the beach configuration in Wildwood by increasing berm height and adding a dune. Within the project area, no work is planned for either the Cape May National Wildlife Refuge or the U.S. Coast Guard's LORAN site, or along Hereford Inlet beyond the jetty at the intersection of Beach Avenue and 2nd Avenue in North Wildwood.

In this draft Section 2(b) report of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. *et. seq*) (FWCA), the U.S. Fish and Wildlife Service (Service) identifies fish and wildlife resources in the vicinity of the 5-mile-long barrier island bordered to the north by Hereford Inlet and to the south by Cape May Inlet (formerly Cold Spring Inlet); discusses potential impacts on those resources from proposed project activities (including federally listed species); identifies opportunities for fish and wildlife habitat improvements; and updates the current state of knowledge concerning the proposed activities.

The federally listed (threatened) piping plover (*Charadrius melodus*) nests on the beaches of Hereford Inlet including (Stone Harbor Point and North Wildwood from Central Avenue to the intersection of John F. Kennedy Beach Drive and 2nd Avenue), on the U.S. Coast Guard's LORAN site, and on Cape May National Wildlife Refuge; and are known to forage along the beaches of Wildwood Crest and Lower Township. On the Atlantic coastal beaches within the project area, piping plovers last nested in North Wildwood and Wildwood Crest in the 1990's, and the Service has no current or historical records of nesting in Wildwood. Piping plovers nest on sandy beaches above 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 sandpits, and on sites with deposits of suitable dredged or pumped sand. The Service views this beach nourishment project, specifically at North Wildwood, as an opportunity to enhance nesting habitat for piping plover, shorebirds, and colonial nesting waterbirds; target species for habitat enhancement include the Federal candidate red knot (*Calidris canutus rufa*), and the State-listed (endangered) black skimmer (*Rynchops niger*) and least tern (*Sterna antillarum*).

In addition to piping plover, shorebirds, and colonial nesting waterbirds, the project may also create habitat for seabeach amaranth (*Amaranthus pumilus*), a federally listed (threatened) plant

(U.S. Fish and Wildlife Service 1996b). Seabeach amaranth is an annual plant, endemic to Atlantic coastal plain beaches, primarily occurring on overwash flats at the accreting ends of barrier beach islands and lower foredunes of non-eroding beaches. Occurrences of seabeach amaranth are known from 2003-2004 within the U.S. Coast Guard's LORAN unit. The species has also recently naturally recolonized coastal sites within New York and Maryland; therefore, it is possible that seabeach amaranth may become naturally reestablished within the project area during the life of the project. Colonization of seabeach amaranth occurred in July 2000 after a New York District Corps beach nourishment project in Monmouth County, New Jersey (U.S. Fish and Wildlife Service 2002). Prior to the 2000 rediscovery, this species had last been documented in New Jersey in 1913 (U.S. Fish and Wildlife Service 1996b).

In December 2005, the Service issued a Programmatic Biological Opinion (PBO), in accordance with Section 7 of the Endangered Species Act of 1973 (ESA) (87 Stat. 884, as amended, 16 U.S.C. 1531 *et seq.*), on the effects of beach nourishment, renourishment, stabilization, and restoration projects funded, permitted, or conducted by the Corps along the Atlantic Coast of New Jersey on the federally listed (threatened) species piping plover and seabeach amaranth. The purpose of the PBO is to expedite review of Corps funded and permitted Program activities, and to account for landscape-level causes of incidental take (*e.g.*, from preclusion of natural habitat formation).

In closing, this draft FWCA Section 2(b) report provides recommendations for beach communities, borrow areas, and beach habitat enhancements. In order to avoid and minimize potential adverse impacts on State-listed and federally listed threatened and endangered species within the project area, the Service recommends incorporating five measures into the project. This draft FWCA Section 2(b) report also includes seven recommendations for habitat enhancement and nine recommendations for borrow areas.

TABLE OF CONTENTS

Page

EXECUTIVE SUMMARY i

LIST OF FIGURES v

APPENDICES v

I. INTRODUCTION 1

II. DESCRIPTION OF PROPOSED ACTION

A. SELECTED BEACH NOURISHMENT PLAN 2

B. SELECTION OF ONSHORE BORROW AREAS 4

C. BACK-PASSING 4

III. STUDY AREA 5

IV. METHODS AND PROCEDURES 5

V. FEDERALLY LISTED AND CANDIDATE SPECIES UNDER SERVICE JURISDICTION 7

A. PIPING PLOVER 7
1. Species Description 7
2. Life History 7
3. Population Status 8
4. Continuing Threats 8

B. RED KNOT 10
1. Species Description 10
2. Life History 10
3. Population Status 11
4. Continuing Threats 12

C. SEABEACH AMARANTH 12
1. Species Description 12
2. Life History 13
3. Population Status 14
4. Continuing Threats 15

VI. OTHER FISH AND WILDLIFE RESOURCES....16

A. FEDERALLY LISTED SPECIES UNDER NMFS JURISDICTION

1. Turtles....16
2. Fish....17

B. STATE LISTED SPECIES

1. Black Skimmer....18
2. Least Tern....19
3. Evening Primrose....19
4. Coordination with the State....19

C. AVIAN AND OTHER WILDLIFE RESOURCES

1. Shorebirds and Colonial Nesting Waterbirds....20
2. Waterfowl....21
3. Raptors....21
4. Other Wildlife....21

VII. BORROW AREAS

A. BENTHIC RESOURCES....22

B. COASTAL BARRIER RESOURCES ACT....22

VIII. PROJECT IMPACTS AND RECOMMENDED MITIGATIVE MEASURES

A. PIPING PLOVER, SEA BEACH AMARANTH, RED KNOT....23

B. BEACH HABITAT ENHANCEMENT....24

C. BORROW AREAS....25

IX. CONCLUSIONS AND SUMMARY OF RECOMMENDATIONS

A. BEACH COMMUNITIES....26

B. BEACH HABITAT ENHANCEMENT....26

C. BORROW AREAS....27

X. REFERENCES

A. LITERATURE CITED....29

B. PERSONAL COMMUNICATIONS.....36

LIST OF FIGURES

Figure **Page**

Figure 1 **Project Areas - Hereford Inlet to Cape May Inlet, Cape May County, NJ** 1

Figure 2 **Location of Cape May NWR in relation to project area**.....6

APPENDICES

Appendix A **Federally Listed Endangered, Threatened Species and Candidate Species in New Jersey**

Appendix B **Project Plan showing Project Area**

Appendix C **State-Listed Endangered and Threatened Species in New Jersey**

Appendix D **Colonial Nesting Birds and Shorebirds within Hereford Inlet to Cape May Inlet Project Area (prepared by New Jersey Audubon Society)**

Appendix E **Status of the Red Knot (*Calidris canutus rufa*) in the Western Hemisphere**

Appendix F **Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act**

Appendix G **Guidelines for Managing Fireworks in the Vicinity of Piping Plovers and Seabeach Amaranth on the U.S. Atlantic Coast**

Appendix H **Piping Plover Nesting Results in New Jersey: 2012 (prepared by New Jersey Endangered and Nongame Species Program)**

I. INTRODUCTION

The purpose of this U.S. Army Corps of Engineers (Corps) project, authorized under the Water Resources Development Act 1986 (PL 99-662), is to provide storm damage reduction, beach restoration, and water quality improvements within the Hereford Inlet, North Wildwood, Wildwood, Wildwood Crest Borough, Lower Township to Cape May Inlet, Cape May County, New Jersey (project area) (Figure 1). Although the project area extends from Hereford Inlet to Cape May Inlet, no activities will be conducted within Hereford Inlet north of the jetty, at the Cape May Inlet, on the Cape May National Wildlife Refuge (CMNWR), or on U.S. Coast Guard's LORAN facility. The project area exhibits several different coastal issues. The North Wildwood portion of the project area is prone to moderate to severe erosion, leaving the surrounding community vulnerable to storm damages. The beaches of Wildwood and Wildwood Crest have been accreting large quantities of sand, resulting in human health and water quality concerns due to clogged outfall pipes on the beach. The selected plan being proposed for the project involves "back-passing" sand using mobile hydraulic dredges located in the surf zones from Wildwood to North Wildwood and changing the beach configuration in Wildwood by increasing berm height and adding a dune.

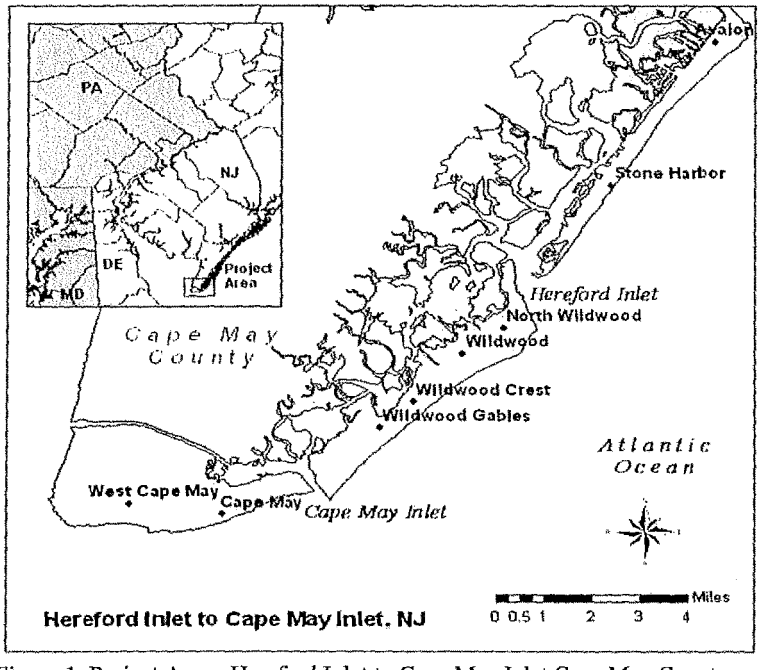

Figure 1: Project Area - Hereford Inlet to Cape May Inlet Cape May County, New Jersey

This draft FWCA Section 2(b) report, submitted to the Corps by the U.S. Fish and Wildlife Service (Service) identifies fish and wildlife resources in the vicinity of the five-mile-long barrier island bordered to the north by Hereford Inlet and to the south by Cape May Inlet (formerly Cold Spring Inlet); discusses potential impacts on those resources from proposed project activities; identifies opportunities for fish and wildlife habitat improvements; and updates the current state of knowledge concerning the proposed activities.

II. DESCRIPTION OF PROPOSED PLAN

A. SELECTED BEACH NOURISHMENT PLAN

The selected plan consists of a dune and berm constructed using sand obtained from an onshore borrow source located near the southern end of Five Mile Island (the Wildwoods). The project area extends approximately 4.5 miles from Hereford Inlet to Cape May Inlet and encompasses the municipalities of North Wildwood, Wildwood, Wildwood Crest and Lower Township (Appendix B). The southernmost beach section, which is managed by the Service as the CMNWR, is not included in the initial construction. Dimensions of the proposed project are a +16 foot NAVD 88 dune, with a 25 foot crest on a 75 foot-wide berm that is 6.5 feet in elevation from North Wildwood to the northern border of Wildwood. In Wildwood and Wildwood Crest the project will consist of a dune only, constructed to the elevation of +16 feet NAVD 88 on top of the existing berm. Side slopes for the dune will be in a 1 foot vertical: 5 foot horizontal ratio. The plan includes installing approximately 64 acres of dune grass, 28,000 linear feet of sand fence, 44 extended crossovers, 7 new pedestrian crossovers, 7 extended handicap crossovers, 6 new handicap crossovers, 8 existing vehicle crossover extensions and 5 new vehicular crossovers. The Corps proposes to hydraulically pump sand from the Wildwood and Wildwood Crest onshore borrow areas via an 8-inch pipe to the North Wildwood placement area using mobile back-passing technology. The sand quantity is estimated at 1,362,000 cubic yards, which includes a design quantity of 1,057,000 cubic yards and advanced nourishment of 305,000 cubic yards.

Periodic sand nourishment is included in project design to maintain the integrity of the design beach template over the project life and will be conducted in 5 year intervals. Without periodic nourishment, ongoing erosion would compromise the design template and reduce storm protection. Nourishment requirements were determined by considering losses resulting from diffusion of the design beach fill platform and natural background erosion. The diffusion component refers to "spreading out" losses that occur because the design beach is wider than adjacent beach areas. Background erosion refers to the average long-term rate of shoreline erosion that occurs along the project reach. Background erosion rates were determined through an analysis to determine potential longshore sediment; this analysis was done to ascertain possible post-dredging infilling rates of the borrow area along the beaches of Wildwood and Wildwood Crest. Longshore or littoral transport can both supply and remove sand from coastal areas. To determine the balance of sediment losses and gains for an area such as the borrow area, net, rather than gross, transport rates are required. Net longshore transport refers to the difference

between volume of material moving in one direction along the coast and that moving in the opposite direction. The time period analyzed using available data was from 1986 to 1998. As part of the investigation, potential longshore transport rates due to waves were computed. Data indicate that generally, there is a net southward transport within the study area that may vary from 370,000 to 440,000 cubic yards per year. The trends in the estimates for the net longshore transport show that southward transport is almost double northward transport. The rates computed can be used as a potential infilling rate for the borrow area along the beaches of Wildwood and Wildwood Crest.

All data gathered should be viewed as representative of average conditions over a span of 12 years from 1986 to 1998. It can be expected that changes in longshore sediment transport could happen in a seasonal manner and could contribute significantly to both the short- and long-term infilling rates of the borrow areas. It would be anticipated that shortly after removing any sand from a borrow area that there would be a short-term accelerated infilling rate of sand coming from the north followed by a period more representative of the long-term average infilling rate. The selected plan recommends that any removal of sand from the borrow area be done over as wide of an area as possible within the borrow area as opposed to removing sand in a small concentrated area; this practice will help maintain the natural coastal processes in the area.

The constructed beach fill template typically varies from the design template because of working limitations of equipment used to place and shape the fill. After placement, sorting of the fill by waves and currents will naturally shape the constructed fill profile to an equilibrium form consistent with the design template. To account for these factors, the construction template is developed based on the "overbuilding method."

The overbuilding method involves placing the required design sand quantity at the proposed berm elevation, but with a berm width greater than the design width. The seaward slope of the construction berm is generally equal to or steeper than the natural existing equilibrium slope. The constructed berm is "overbuilt" in the sense that it is wider than the intended design berm. Coastal processes readjust the profile to a natural equilibrium state. Much of the overbuilt berm sand moves offshore to form the intended design profile. The advanced nourishment quantity (1.3 million cubic yards) is also included in the overbuilt construction berm template.

Beach fill construction using the overbuilding method often leaves the impression that much of the project sand has been lost soon after construction due to rapid readjustment of the construction profile. However, rather than being "lost," this offshore movement of sand is an indication that the construction profile is functioning as intended to naturally form the design template.

The selected project plan incorporates the use of only onshore borrow areas. The Corps also evaluated, but rejected, the use of offshore borrow areas to nourish North Wildwood. Primarily Hereford Inlet was examined as it has been used in past authorized Federal projects. Rejection of Hereford Inlet and other offshore locations was based on several

factors, particularly overabundance of sand along beaches in Wildwood and Wildwood Crest. Use of any offshore borrow location that would cause accretion of sand is an issue in the Wildwoods, leading to even wider beaches, and is unacceptable to those municipalities.

As the Service has noted during planning for other Corps projects, the use of Hereford Inlet would impact the Coastal Barrier Resources System (CBRS), and could indirectly affect nearby piping plover nesting beaches by changing the inlet's sediment dynamics. If plans should change and additional borrow sites, specifically offshore locations, are needed, additional coordination with the Service will need to be conducted.

B. SELECTION OF ONSHORE BORROW AREAS

The Corps chose back-passing from a beach borrow source as the preferred method of re-nourishment. There is a surplus of sand in Wildwood and Wildwood Crest that has been accumulating through natural processes and as a result of existing hard stabilization structures. By adding more sand to the island from an offshore source the project would have contributed to a problem that the local communities have been concerned with over the past 10-15 years (*e.g.*, clogging of the storm water outfall system, and excessively large beaches). Back-passing ameliorates both problems.

C. BACK-PASSING

Sediment back-passing involves the removal of sand from a source area to a sink with mechanical means, usually in the opposite direction of long-shore transport. This can be accomplished with scraping and truck hauling the material to the deposition site or with mobile hydraulic back-passing techniques. The latter is being proposed for the Hereford Inlet to Cape May Inlet project. Mobile hydraulic sediment back-passing will involve the use of 1 to 2 crawler cranes deploying a submersible/ centrifugal pump in the surf zone to remove sand from a source area, pump it through an 8-inch wide pipeline to a sink area, and shape the material into a dune and berm for storm damage reduction.

A conceptual layout of a sediment back-pass system for the Hereford Inlet to Cape May Inlet project is shown on pages 5-10 and 5-11 of the Corps Hereford Inlet to Cape May Inlet Feasibility Study (U.S. Army Corps of Engineers 2013). The system would involve a crawler crane mounted with an eductor pump on a 100-foot-long boom excavating material from the beach in Wildwood and Wildwood Crest and be attached to an 8-inch-wide High Density Polyethylene Pipe (HDPE) with a series of boosters that would be transporting the material to the design locations.

Craters are a byproduct of the creation of slurry material that is excavated and pumped to a deposition area on the beach. Craters will be approximately 15 feet in diameter and 5 feet deep. Each crater created from the mobile dredge contains roughly 11 cubic yards of fill material. The distance the sand will have to travels also impacts design considerations, and booster pumps stationed on the beach will likely be required. These pumps are stationed every few thousand feet along the beach depending on the grain size

of the material and the distance that material has to be pumped. Based on preliminary estimates, it is likely that 2-3 booster pumps connected by 8-inch-wide HDPE pipelines will be required to move the material from the borrow area.

III. STUDY AREA

The project area includes North Wildwood, Wildwood, Wildwood Crest, and Lower Township (Figure 1). Locations within the study area that no work or dredging will be conducted are the two-mile beach unit of the CMNWR; the U.S. Coast Guard's LORAN site located adjacent to Cape May Inlet within Lower Township at the southern end of the project area; Cape May Inlet; Hereford Inlet; Stone Harbor; and areas north of the groin on 2nd Avenue (Figure 2). Hereford Inlet opens to the Atlantic Ocean and is located between Stone Harbor Point and North Wildwood. The inlet contains a scour hole, located along the southern end of the seawall at Anglesea in North Wildwood. The scour hole possibly resulted from dredging of fill materials for the Townsends Inlet to Hereford Inlet or another beach nourishment projects. At this time, the Service would like to remind the Corps that dredging of Inlets may impact Coastal Barrier Resource Act (CBRA) (96 Stat. 1653, 16 U.S.C. 3504) areas and even though the Corps is not proposing to dredge any inlets for this project, future projects that involve borrowing from Inlets associated with CBRA should be avoided.

IV. METHODS AND PROCEDURES

This draft FWCA report incorporates information compiled from files, reports and personal communications from the Service's New Jersey Field Office, the New Jersey Department of Environmental Protection (NJDEP) database, CMNWR, New Jersey Audubon Society (NJAS), as well as, the Corps' Hereford Inlet to Cape May Inlet Feasibility Study Project Management Plan (U.S. Army Corps of Engineers 2005) and the Corps' Feasibility Study (U.S. Army Corps of Engineers 2013). The database was reviewed for information regarding federally listed species, State-listed species, and other fish and wildlife in the vicinity of Hereford Inlet to Cape May Inlet. In addition, personal communications were conducted with personnel from the CMNWR, New Jersey Division of Fish and Wildlife (NJDFW), New Jersey Bureau of Shellfisheries, New Jersey Bureau of Marine Fisheries, and the National Marine Fisheries Service (NMFS). Representatives of the Corps, the NJDEP, and the Service conducted a site visit of the project area on October 30, 2007. The discussion during the site visit concluded with support to reconfigure the North Wildwood beach to provide storm protection for the proposed project area. The interagency study team determined that beach enhancements such as the creation of gently sloping foredunes within the project area would benefit piping plover and other beach nesting birds.

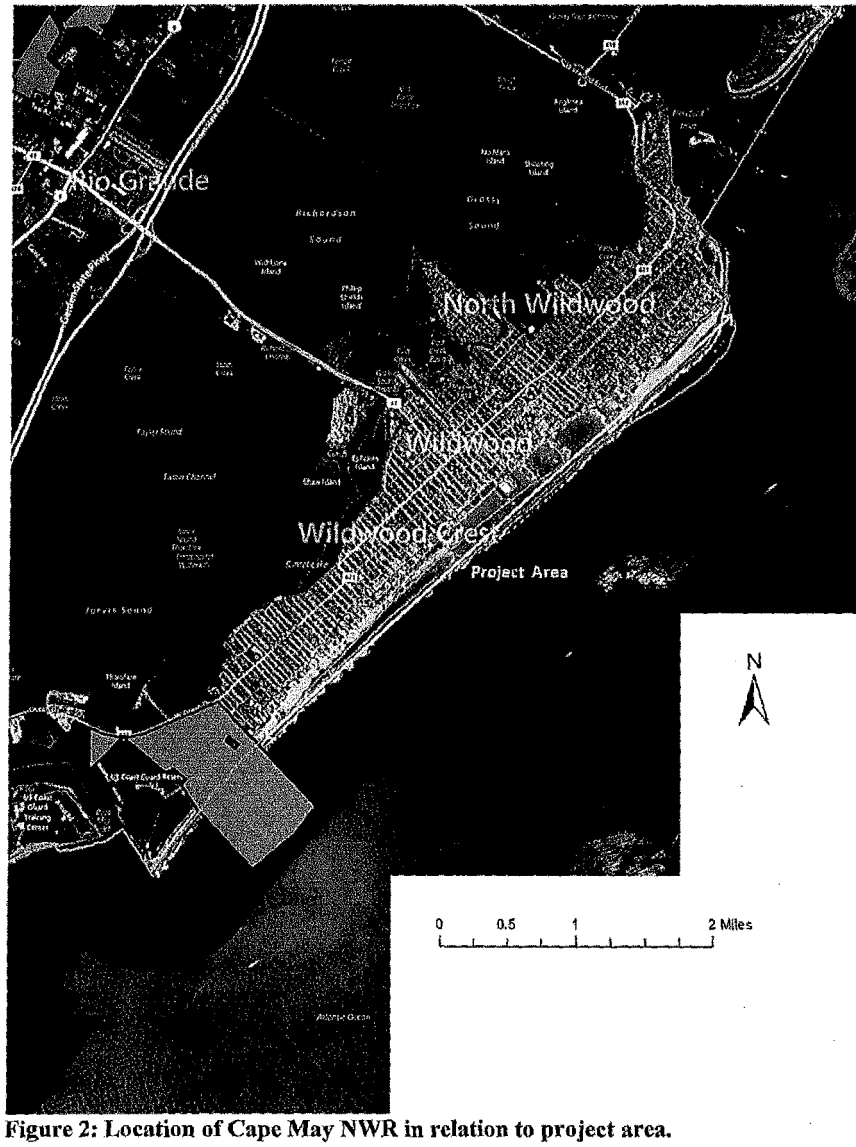

Figure 2: Location of Cape May NWR in relation to project area.

V. FEDERALLY LISTED AND CANDIDATE SPECIES UNDER SERVICE JURISDICTION

A. PIPING PLOVER

1. Species Description

Piping plovers are small, sandy-colored territorial shorebirds, approximately 7 inches in length (Palmer 1967; U.S. Fish and Wildlife Service 1985; 1996a). The bird's name was derived from its call, which resembles plaintive bell-like whistles that are often heard before the birds are seen. Breeding adults have orange legs, a black ring around the base of the neck and across the forehead, and an orange bill with a black tip. The female's neck band is often incomplete and is usually thinner than the male's neck band. In winter, the black band completely disappears, and adults and juveniles look similar, with pale yellow legs and a solid black bill. Chicks have speckled gray, buff, and brown down feathers, black beaks, orange legs, and a white collar around the neck.

2. Life History

New information confirms inter- and intra-annual fidelity of piping plovers to migration and wintering sites (U.S. Fish and Wildlife 2009). Observations reported that six of 259 banded piping plovers observed more than once per winter moved across boundaries of seven continental U.S. regions. Of 216 birds observed in different years, only eight changed regions between years, and several of these shifts were associated with late summer or early spring migration periods (Gratto-Trevor *et al.* 2009). Local movements are more common. In South Carolina surveys documented many cross-inlet movements by wintering banded piping plovers as well as occasional movements of up to 18 kilometers by approximately 10% of the banded population; larger movements within South Carolina were seen during fall and spring migration (Maddock *et al.* 2009). Similarly, eight banded piping plovers that were observed in two locations during 2006-2007 surveys in Louisiana and Texas were all in close proximity to their original location, such as on the bay and ocean side of the same island or on adjoining islands (Maddock 2008).

Piping plovers inhabit New Jersey beaches between March and August, arriving at their breeding grounds in late March through early April (U.S. Fish and Wildlife Service 2005a). After choosing mates and establishing territories, piping plovers scrape depressions in the sand to form a nest and lay their eggs (Bent 1929; Burger 1987; Cairns 1982; Patterson 1988; Flemming *et al.* 1990; MacIvor 1990; Strauss 1990). The birds nest above the high tide line, usually on sandy ocean beaches and barrier islands, but also on gently sloping foredunes, blowout areas behind primary dunes, washover areas cut into or between dunes, the ends of sandspits, and deposits of suitable dredged or pumped sand (U.S. Fish and Wildlife Service 1996a; 2005a). The nests are frequently lined with

shell fragments and often located near small clumps of vegetation such as beachgrass (*Ammophila breviligulata*) (Patterson 1988; Flemming *et al.* 1990; MacIvor 1990). Plovers will lay their eggs (up to 4) from mid-April through late June or early July and may re-nest during the season if earlier clutches are lost (Wilcox 1959; Cairns 1977; MacIvor 1990). The eggs are well camouflaged and blend extremely well with their surroundings. Both the male and female will incubate the nest for about 30 days. After the eggs hatch, the chicks may be present on the beaches with their parents until the end of August when they are ready to fly (Patterson 1988; Goldin 1990; MacIvor 1990; Howard *et al.* 1993).

Piping plover adults and chicks feed on marine macroinvertebrates such as worms, fly larvae, beetles, crustaceans, and mollusks (Bent 1929; Cairns 1977; Nicholls 1989). Feeding areas include the intertidal zone of ocean beaches, ocean washover areas, mudflats, sand flats, wrack lines (organic ocean material left by high tide), and the shorelines of coastal ponds, lagoons, and salt marshes (Gibbs 1986; Coutu *et al.* 1990; Hoopes *et al.* 1992; Loegering 1992; Goldin 1993; Elias-Gerken 1994).

3. Population Status

One hundred twenty-one (121) pairs of piping plovers nested in New Jersey in 2012, a 9% increase compared to 2011 (111 pairs) (NJENSP 2012). The statewide population trend had been flat over the previous four years (111, 105, 108, and 111 pairs from 2008-2011, respectively). Despite the increase in nesting pairs in 2012, the population remained about average for the years since federal listing (119 pairs) and substantially below the peak of 144 pairs in 2003 (Appendix H). The total number of adults recorded for the entire nesting season (243) was nearly the same as the count during the date-restricted survey conducted June 1-9 (236). However, the number of pairs tallied during the entire nesting season (121) was higher than those counted during the date-restricted census (106), which is a typical survey result in New Jersey. The low percentage of pairs monitored by NJDFW was the result of less suitable habitat conditions. The southern region of the state, which encompasses the project area (Stone Harbor Point to Cape May Point) recorded even lower productivity, just 0.22 fledglings per pair (18 pairs). Flooding was the leading cause of nest failure statewide, accounting for just over a third (35%) of the failed nests. Abandonment and predation each accounted for about a quarter of the nest failures (24% and 23%, respectively). The exact cause of failure could not be determined for 18% of the failed nests. Nest abandonment was relatively high and there was no apparent pattern as to the causes on a statewide basis.

4. Continuing Threats

Continuing threats to Atlantic Coast piping plovers in the breeding portion of their range include habitat loss and degradation, disturbance by humans and pets, increased predation, oil spills, and herbivory. These detailed descriptions of threats are provided in the revised recovery plan (U.S. Fish and Wildlife Service 1996a) and PBO (U.S. Fish and Wildlife Service 2005a). In the project area piping plover are primarily subject to human interference in multiple forms and predation. According to the North Wildwoods BMP,

human disturbance amounts to vehicular use, beach management, maintenance, and nourishment, and recreational activities including the use of fireworks and flying of kites. Predation in the area consists of preexisting species and species drawn to the area because of human use or proximity of local residents (New Jersey Department of Environmental Protection and U.S. Fish and Wildlife Service 2009).

One emerging threat to piping plover within the project area is climate change (especially sea-level rise) and is likely to affect Atlantic Coast piping plovers throughout their life cycle. This threat requires further study to ascertain effects on piping plovers and/or their habitat, as well as the need for specific protections to prevent or mitigate impacts that could otherwise increase overall risks to the species.

Habitat loss results from development as well as from beach stabilization, beach nourishment, and other physical alterations to the beach ecosystem (U.S. Fish and Wildlife Service 1996a). Commercial, residential, and recreational development reduce the amount of suitable habitat available for nesting and feeding. Structures such as seawalls, jetties, groins, and bulkheads promote stabilization of the beach and rapidly promote natural succession, decreasing the sandy, sparsely vegetated habitat required for nesting. Predation on chicks and eggs is intensified by development because predators such as foxes (*Vulpes vulpes*), rats (*Rattus norvegicus*), raccoons (*Procyon lotor*); domestic dogs (*Canis familiaris*), domestic cats (*Felis silvestris*) and gulls (*Larus* spp.) thrive in developed areas and are attracted to beaches by food scraps and trash (Riepe 1989; Jenkins and Nichols 1994; Elias-Gerken 1994; Jenkins and Niles 1999; U.S. Fish and Wildlife Service 1996a; Canale 1997). Piping plovers are vulnerable to domestic animals before and after the eggs hatch. Adult plovers will stagger and act as if they have a broken wing to distract predators from their nest or chicks. Flightless chicks are no match for an agile cat or dog that instinctively sees a chick as something to hunt or chase. Camouflaged chicks can also become trapped in tire ruts and be run over by recreational or municipal vehicles.

Human disturbance of nesting birds includes but is not limited to, foot traffic, sunbathing, kite flying, pets, fireworks displays, beach raking, construction, and vehicle use. These disturbances can result in crushing of eggs, failure of eggs to hatch, and death of chicks (Wilcox 1959; Tull 1984; Burger 1987; Patterson *et al.* 1991). Excessive disturbance may cause the parents to desert the nest, exposing eggs or chicks to the summer sun and predators (Welty 1982; Bergstrom 1991). While removal of human-created trash on the beach is desirable to reduce predation threats, the indiscriminate nature of mechanized beach-cleaning adversely affects piping plovers and their habitat. In addition to danger of directly crushing piping plover nests and chicks and the prolonged disturbance from the machine's noise, this method of beach-cleaning removes the birds' natural wrack line feeding habitat (Eddings and Melvin 1991; Howard *et al.* 1993), and shell fragments, a preferred feature of nesting habitat.

Intensive management, including municipal beach management plans (BMP) to protect piping plovers from disturbance by beach recreationists, pets, and beach-cleaning operations have been implemented at many New Jersey plover nesting sites in recent

years. The Service and NJDFW are currently working with several coastal municipalities to develop and implement BMPs. Piping plover protection in the New Jersey recovery unit is highly dependent on the efforts of State and local government agencies, conservation organizations, and private landowners.

North Wildwood is actively implementing an approved BMP dated August 2009 that covers red knot, seabeach amaranth, and State-listed species in addition to piping plovers. The Service appreciates the cooperation of North Wildwood in preparing and implementing this plan for the protection of these federally and State-listed species.

B. RED KNOT

1. Species Description

The red knot is a medium-sized shorebird about 9 to 11 inches (23 to 28 centimeters) in length with a proportionately small head, small eyes, short neck, short tibia, and stout tarsus. The black bill tapers steadily from a relatively thick base to a relatively fine tip; bill length is not much longer than head length. Legs are typically dark gray to black, but sometimes greenish in juveniles or older birds in non-breeding plumage (Harrington 2001). During the breeding season, the plumage of the red knot is distinctive and easily recognizable. The face, breast, and upper belly are a rich rufous-red, while the lower belly and under tail-covert region are light-colored with dark flecks. Upperparts are dark brown with white and rufous feather edges; outer primary feathers are dark brown to black (Davis 1983; Harrington 2001). Females are similar to males, though rufous colors are typically less intense, with more buff or light gray on dorsal parts (Niles *et al.* 2005). Non-breeding plumage is dusky gray above and whitish below. Juveniles resemble non-breeding adults, but the feathers of the scapulars and wing coverts are edged with white and have narrow, dark subterminal bands, giving the upperparts a scalloped appearance (Davis 1983). Body mass varies seasonally, with lowest mean mass during early winter (125 grams (gm)) and highest mean values during spring (205 gm) and fall (172 gm) migration (Harrington 2001; New Jersey Department of Environmental Protection 2007).

2. Life History

Each year red knots travel up to 19,000 miles between wintering grounds (in South America and the southern United States) and breeding areas within the central Canadian Arctic. In non-breeding locations (wintering and migration stopover areas), red knots are found principally in intertidal marine habitats, especially near coastal inlets, estuaries, and bays, foraging and roosting along sandy beaches, tidal mudflats, salt marshes, and peat banks. (Harrington 2001)

During migration, red knots undertake long flights that may span thousands of miles without stopping. At some stages of migration, very high proportions of entire populations may use a single migration staging site to prepare for the next long flight (Harrington 2001). During the spring and fall migrations, red knots stop over along the Gulf and Atlantic coasts of the United States to rebuild energy reserves needed to

complete the journey. The Delaware Bay supports the largest known spring migration concentration of red knots (50 to 80 percent of the total population) and is the last major stopover area used by red knots during spring migration before departing for Arctic breeding areas (Brown *et al.* 2001). In the southeastern and mid-Atlantic United States, red knots forage along sandy beaches, tidal mudflats, salt marshes, and peat banks.

In wintering and migration habitats, red knots commonly forage on bivalves, gastropods, and crustaceans (Harrington 2001). An exception occurs each May when the majority of red knots arrive in Delaware Bay to feed on the eggs of horseshoe crabs (*Limulus polyphemus*) (Wander and Dunne 1982; Harrington 1996, 2001; Niles *et al.* 2008).

In addition to the large flocks of red knots found in the Delaware Bay, red knots are found in lower densities during the spring and fall migration elsewhere along the Atlantic Coast, including the project area. The NJDEP Landscape Project maps show red knot habitat from Cape May Inlet north to East Washington Avenue in Lower Township, and in North Wildwood from New York Avenue on Hereford Inlet extending to around 23rd Street on the ocean side beach. In this northern area, red knot usage is concentrated along Hereford Inlet and the Atlantic side beach to 13th Avenue; however red knots have been observed using beaches all the way through to 23rd Street. This area is used primarily by fall migrants (August - December). In 2008 several hundred red knots were reported from North Wildwood and Avalon throughout the fall, and small numbers (up to 60 red knots) remained until February (Pitts pers. comm. 2013). Upwards of 1,500 knots used Avalon through at least late November 2011 (U.S. Fish and Wildlife Service 2011).

3. Population Status

In breeding habitats, red knots are thinly distributed across a huge and remote area of the Arctic. Despite some localized survey efforts, (*e.g.*, Niles *et al.* 2008), there are no regional or comprehensive estimates of breeding abundance, density, or productivity (Niles *et al.* 2008). Few regular surveys are conducted in fall because southbound red knots tend to be less concentrated than during winter or spring.

Some survey data are available for most of the red knot's wintering and spring stopover areas. For a few key areas, long-term data sets have been compiled using consistent survey methodology. Because there can be considerable annual fluctuations in red knot counts, these longer-term trends are more meaningful. At several key sites, the best available data show that numbers of red knots declined and remain low relative to counts from the 1980s, although the rate of decline appears to have leveled off since the late 2000s. Among these sites with documented declines are the Tierra del Fuego wintering area in southern Argentina and Chile and the Delaware Bay spring stopover site. At both of these important sites, red knot counts since the mid-2000s have been roughly 75 percent lower than they were during the 1980s (G. Morrison pers. comm. 2012; A. Dey pers. comm. 2012; Clark *et al.* 2009, Kochenberger 1983, Dunne *et al.* 1983, Wander and Dunne, 1982). See also (Appendix E)

4. Continuing Threats

Overharvest of the horseshoe crab, leading to decreasing food supplies (horseshoe crab eggs) in the Delaware Bay, is the best supported explanation for the red knot population declines that occurred in the 2000s (Niles *et al.* 2008). Because the horseshoe crab fishery is now managed, with harvest limits explicitly tied to red not population targets, the current crab harvest is no longer a threat to the red knot. However, horseshoe crab populations have not fully rebounded, and the crab egg food resource is not yet fully secure. The red knot also faces other threats to its food resources from bivalve diseases and parasites, marine invasive species, sediment placement (*e.g.*, beach nourishment, dredge material disposal), ORV use, and climate change (*e.g.*, ocean acidification and warming coastal waters). Climate change also threatens the red knot by potentially disrupting the timing of its annual cycle (causing "asynchronies") relative to favorable food and weather conditions along the migration route and on the Arctic breeding grounds.

In addition, the red knot faces ongoing and emerging threats from habitat loss caused by shoreline stabilization and coastal development, and accelerating sea level rise. Mechanical beach raking and invasive or overly dense beach vegetation can also degrade nonbreeding habitats. In addition, many key nonbreeding habitats are in close proximity to oil extraction or transport operations, and would be impacted by a spill in these areas. Red knots have been killed by red tides along the Gulf coast, and are especially vulnerable to harmful algal blooms due to their shellfish diet. In the Arctic, red knots face habitat loss and potentially increasing predation of eggs and chicks brought about by climate change.

Red knots are exposed to disturbance from recreational and other human activities throughout their nonbreeding range, for example from pedestrians, dogs, vehicles, boats, aircraft, and heavy equipment. Excessive disturbance has been shown to preclude shorebird use of otherwise preferred habitats and can impact energy budgets. Both of these effects are likely to exacerbate other threats to the red knot, such as habitat loss, reduced food availability, and asynchronies in the annual cycle. Finally, red knots are hunted for sport and food in some Caribbean and South American countries. Threats to habitat and from disturbance are the most significant within the project area.

C. SEABEACH AMARANTH

1. Species Description

Seabeach amaranth is an annual species and a member of the Amaranth family (Amaranthaceae). Upon germination, the plant initially forms a small, unbranched sprig, but soon begins to branch profusely, forming a low-growing mat. Seabeach amaranth's fleshy stems are prostrate at the base, erect or somewhat reclining at the tips, and pink, red, or reddish in color. The leaves of seabeach amaranth are small, rounded, and fleshy, spinach-green in color, with a characteristic notch at the rounded tip. Leaves are approximately 1.3 to 2.5 centimeters (cm) in diameter and clustered towards the tip of the

stem (Weakley and Bucher 1992). The foliage of seabeach amaranth turns deep red in the fall (Snyder 1996). Plants often grow to 30 cm in diameter consisting of 5 to 20 branches, but occasionally reach 90 cm in diameter, with 100 or more branches. Flowers and fruits are inconspicuous, borne in clusters along the stems. Seeds are 2.5 millimeters (mm) in diameter, dark reddish-brown, and glossy, borne in low-density, fleshy, indehiscent utricles (bladder-like seed capsules or fruits), 4 to 6 mm long (Weakley and Bucher 1992). The seed does not fill the utricle, leaving an air-filled space (U.S. Fish and Wildlife Service 1996b).

2. Life History

Individual plants live only one season, with only a single opportunity to produce seed. The species over-winters entirely as seeds. Germination of seedlings begins in April and continues at least through July. Reproductive maturity is determined by size rather than age, and flowering begins as soon as plants have reached sufficient size. Even very small plants can flower under certain conditions. Flowering typically commences in July and continues until the death of the plant. Seed production begins in July or August and usually peaks in September. Seed production likewise continues until the plant dies. Senescence and death occur in late fall or early winter (U.S. Fish and Wildlife Service 1996b).

Seabeach amaranth seems capable of essentially indeterminate growth (Weakley and Bucher 1992). However, predation and weather events, including rainfall, hurricanes, and temperature extremes, have significant effects on the length of the species reproductive season. As a result of one or more of these influences, the flowering and fruiting period can be terminated as early as June or July (U.S. Fish and Wildlife Service 1993).

Seabeach amaranth is native to Atlantic coast barrier island beaches from Massachusetts to South Carolina. The species' primary habitat consists of overwash flats at accreting ends of barrier islands, and lower foredunes and upper strands of non-eroding beaches. This species occasionally establishes small, temporary, and casual populations in secondary habitats including sound side beaches, blowouts in foredunes, and sand or shell dredge spoil or beach nourishment material (Weakley and Bucher 1992).

Seabeach amaranth occupies a narrow beach zone that lies at elevations from 0.2 to 1.5 m above mean high tide, the lowest elevations at which vascular plants regularly occur. Seaward, the plant grows only above the high tide line, as it is intolerant of even occasional flooding during the growing season. The species is, therefore, dependent on a terrestrial, upper beach habitat that is not flooded during the growing season. This zone is absent on beaches that are experiencing high rates of erosion. Seabeach amaranth is never found on beaches where the foredune is scarped by undermining water at high or storm tides (Weakley and Bucher 1992).

Seabeach amaranth usually occurs on a pure silica sand substrate, occasionally containing shell fragments. The habitat of seabeach amaranth is sparsely vegetated with annual herbs and, less commonly, perennial herbs (mostly grasses) and scattered shrubs. The number

and type of seabeach amaranth's vegetative associates have been found to vary with specific habitat type (*i.e.*, overwash flat, accreting barrier island end, or lower foredune) (Chicone undated). The most constant associates of seabeach amaranth, with which the species almost always co-occurs, are sea rocket (*Cakile edentula*) and seabeach spurge (*Chamaesyce polygonifolia*) (Weakley and Bucher 1992).

Seabeach amaranth does not occur on well-vegetated sites, particularly where perennials have become strongly established (Weakley and Bucher 1992). Pauley *et al.* (1999) documented a negative correlation between seabeach amaranth and several dominant foredune species. A particularly strong negative association has been reported between seabeach amaranth and beach grasses (U.S. Fish and Wildlife Service 1996b). However, a positive correlation has been observed between seabeach amaranth and sea rocket, an annual (Hancock 1995).

3. Population Status

Seabeach amaranth is limited by its habitat requirements to a very narrow strip of barrier islands and mainland oceanfront beach strands along the Atlantic coast. The original range of this species extended from Cape Cod in Massachusetts to central South Carolina, a stretch of coast approximately 1,600 km (1,000 miles) long. This stretch correlates with a geographic range of low tidal amplitude. Tidal amplitude and the relative importance of tidal versus wave energy in shaping coastal morphology are thought to limit the geographic range of seabeach amaranth, rather than availability of sandy beach substrates or sea water temperatures. The range of seabeach amaranth is characterized by islands developed by high wave energy, low tidal energy, frequent overwash, and frequent breaching by hurricanes with resulting formation of new inlets (Weakley and Bucher 1992).

Seabeach amaranth is ranked as globally rare (G2) by NatureServe and listed as endangered by the New Jersey Natural Heritage Program (NJNHP) (2010). The current known range of naturally occurring seabeach amaranth is Water Mill Beach on Long Island, New York to Debidue Beach in South Carolina (Young 2001; Hamilton 2000). Historic records of seabeach amaranth are known from nine States. Largely due to human activities, the species was eliminated from seven of these States by the 1980s, remaining only in North and South Carolina. Seabeach amaranth is still considered extirpated from two States: Massachusetts and Rhode Island. Since 1990, the species has re-occupied five States from which it had previously been extirpated. Currently while the seabeach amaranth occurs on many New Jersey beaches there is no evidence of the plant within the project area since 2004 (U.S. Fish and Wildlife 2012).

To date, theories of seabeach amaranth's return to the northern part of its range remain speculative. Sites in New Jersey may have been re-colonized by long-distance transport of seeds by wind or currents. At some sites, seeds may have been long buried in sediments used in beach nourishment projects. This hypothesis requires that seeds can remain viable after prolonged off-shore burial, an unknown factor.

4. Continuing Threats

The primary threats to seabeach amaranth are the adverse alterations of habitat caused by beach erosion and shoreline stabilization. Although seabeach amaranth does not persist on eroding beaches, erosion is not a threat to the continued existence of the species under natural conditions. Erosion in some areas is balanced with habitat formation elsewhere, such as accreting inlets and overwash areas, resulting in an equilibrium that allows the plant to survive by moving around in the landscape. In the geologic past, seabeach amaranth persisted through even relatively rapid episodes of sea level rise and barrier island retreat. A natural barrier island landscape, even a retreating one, contains localized accreting areas, especially in the vicinity of inlets (U.S. Fish and Wildlife Service 1996b).

Even minor structures such as dune stabilization by planting vegetation and vertical sand accretion caused by sand fences appear to be detrimental to seabeach amaranth and contradictory to its life history strategy. Seabeach amaranth only very rarely occurs when sand fences and vegetative stabilization have taken place and, in these situations, is present only as rare, scattered individuals or short-lived populations (Weakley and Bucher 1992).

Beach nourishment can have positive site-specific impacts on seabeach amaranth. Seabeach amaranth has colonized several nourished beaches, and has thrived in some sites through subsequent re-applications of fill material (U.S. Fish and Wildlife Service 1993; 2002). However, on the landscape level, beach nourishment is similar to other beach stabilization efforts in that it stabilizes the shoreline and curtails the natural geophysical processes of barrier islands. These effects are detrimental to the range-wide persistence of the species. In addition, beach nourishment may cause site-specific adverse effects by crushing or burying seeds or plants deeper, or by altering the beach profile or upper beach micro-habitats in ways not conducive to seabeach amaranth colonization or survival.

Intensive recreational use of beaches can threaten seabeach amaranth populations, both through direct damage and mortality of plants, and by impacting habitat. ORV uses on the beach during the growing season can have detrimental effects on the species, as the fleshy stems of this plant are brittle and easily broken. Plants generally do not survive even a single pass by a truck tire (Weakley and Bucher 1992). Light pedestrian traffic, even during the growing season, usually has little effect on seabeach amaranth (U.S. Fish and Wildlife Service 1993). Substantive impacts generally occur only on narrow beaches, or beaches which receive heavy recreational use.

Beach grooming may also have contributed to the previous extirpation of seabeach amaranth from that part of its range. Motorized beach rakes, which remove trash and vegetation from bathing beaches, do not allow seabeach amaranth to colonize long stretches of beach (U.S. Fish and Wildlife Service 1996b). In New Jersey, plants were found along a nearly continuous length of beach, noticeably interrupted by stretches that are routinely raked. Intensive management, including BMPs to protect seabeach amaranth from disturbance by beach recreationists and beach-cleaning operations have been

implemented at many New York-New Jersey piping plover and seabeach amaranth sites in recent years.

Predation by webworms (caterpillars of small moths) is another source of mortality and lowered fecundity and may decrease seed production by more than 50% (Weakley and Bucher 1992). Five native species of webworms have been identified to feed on seabeach amaranth. These webworms use of barrier islands has probably been altered by changes in the coastal plain landscape (*i.e.*, extensive agricultural use), the development of barrier islands, and the introduction of weedy plants that can also serve as host plants. All five webworms are "weedy" species, probably much more abundant now than they were in pre-Columbian times. For this reason, the level of predation that seabeach amaranth is experiencing is likely unnaturally high (U.S. Fish and Wildlife Service 1996b). Webworm herbivory is probably a contributing, rather than a leading factor in the decline of seabeach amaranth. However, in combination with extensive habitat alteration, severe herbivory could threaten the existence of the species (Weakley and Bucher 1992).

Several additional herbivores of seabeach amaranth have been observed including deer, eastern cottontail, and migratory song birds (Van Schoik and Antenen 1993). There is also strong circumstantial evidence for seabeach amaranth herbivory by grasshopper (U.S. Fish and Wildlife Service 2002). In addition, a cluster of New Jersey plants appeared to have been damaged by a congregation of loafing gulls (*Larus* spp.), based upon feathers and droppings. As with webworms, the abundance of these newly documented predators on barrier islands is increased by human activities.

Asiatic sand sedge (*Carex kobomugi*) has been suggested as another potential threat to seabeach amaranth. This sedge is strongly rhizomatous and dune-forming (National Park Service and Maryland Natural Heritage Program 2000). Asiatic sand sedge was introduced to the east coast (New Jersey to Virginia) from East Asia in the 1930s for erosion control and as a sand stabilizer. Asiatic sand sedge may be detrimental to seabeach amaranth by direct competition and by reducing habitat suitability through sand stabilization and dune building.

In the project are there are no known occurrences of seabeach amaranth, but should the species again recolonize the area the threats that would most impact it would come from human use both for maintenance and recreational use of the beach, and from climate change which could change the position of the current high tide lines and bring more storms washing away suitable habitat (U.S. Fish and Wildlife 2005b, 2012).

VI. OTHER FISH AND WILDLIFE RESOURCES

A. FEDERALLY LISTED SPECIES UNDER NMFS JURISDICTION

1. Turtles

Several species of federally listed (endangered and threatened) sea turtles including the Kemp's ridley sea turtle (*Lepidochelys kempii*), hawksbill sea turtle (*Eretmochelys*

imbricata), leatherback sea turtle (*Dermochelys coriacea*), loggerhead sea turtle (*Caretta caretta*), and green sea turtle (*Chelonia mydas*) may occur in waters throughout the study area. These turtles feed primarily on mollusks, crustaceans, sponges, and a variety of marine grasses and seaweeds. In addition, the leatherback sea turtle may occupy the coastal waters of New Jersey foraging for jellyfish. These sea turtles may be found in New Jersey waters from late spring to mid-fall.

2. Fish

There are five distinct population segments (DPSs) of Atlantic sturgeon (*Acipenser oxyrinchus*) listed as threatened or endangered. Atlantic sturgeon originating from the New York Bight, Chesapeake Bay, South Atlantic and Carolina DPSs are listed as endangered, while the Gulf of Maine DPS is listed as threatened (77 FR 5880; 77 FR 5914; February 6, 2012). The marine range of all five DPSs extends along the Atlantic coast from Canada to Cape Canaveral, Florida.

Atlantic sturgeon spawn in their natal river, with spawning migrations generally occurring during February-March in southern regions, April-May in Mid-Atlantic regions, and May-July in Canadian regions (Murawski and Pacheco 1977; Smith, 1985; Bain 1997; Smith and Clugston 1997; Caron *et al.* 2002). Young remain in the river/estuary until approximately age 2 and at lengths of 30-36 inches before emigrating to open ocean as subadults (Holland and Yelverton 1973; Dovel and Berggen 1983; Dadswell 2006; ASSRT 2007). After emigration from the natal river/estuary, subadults and adult Atlantic sturgeon travel within the marine environment, typically in waters between 16 to 164 feet in depth, using coastal bays, sounds, and ocean waters (Vladykov and Greeley 1963; Murawski and Pacheco 1977; Dovel and Berggren 1983; Smith 1985; Collins and Smith 1997; Welsh *et al.* 2002; Savoy and Pacileo 2003; Stein *et al.* 2004; Laney *et al.* 2007; Dunton *et al.* 2010; Erickson *et al.* 2011).

The Atlantic sturgeon occurs in the project area and falls under NMFS protection. The Atlantic sturgeon moves into estuary environments during the spring and summer and exits into the open ocean during the fall. There are no known aggregations of the sturgeon in the project area south of Hereford Inlet, and it is unlikely any fish will be impacted by the onshore back-passing of sand (Lynn Lankshen, pers. comm. 2013).

The NMFS must be contacted regarding potential impacts, resulting from the proposed project, on federally listed species under its jurisdiction. The NMFS may be contacted at: 74 Magruder Road, Highlands, New Jersey 07732; (732) 872-3023.

B. STATE LISTED SPECIES

A variety of State-listed endangered and threatened species inhabit or have been known to occur in the coastal and estuarine ecosystem within the study area. The State-listed (endangered) black skimmer and least tern nest in colonies on sandy islands in the bays and on inlet beaches within the project area, and a State-listed (endangered) plant evening

primrose (*Oenothera humifusa*) inhabits sandy dune environments along New Jersey beaches.

1. Black Skimmer

The State-listed (endangered) black skimmer nests within the project area. Piping plovers often nest within or in close proximity to skimmer colonies and least tern colonies. As with least terns, seabeach amaranth would also benefit from the presence of black skimmer colonies since restrictions on public access during the nesting season provides protected areas where plants can become established.

The black skimmer nests on open sandy beaches, inlets, sandbars, offshore islands, and dredge disposal islands that are sparsely vegetated and contain shell fragments. The growth of dense vegetation may cause colony relocation. Skimmers also frequently nest on wrack mats (deposits of dead sea grasses and other vegetation) on marsh islands in the back bays; however, these colonies are typically much smaller than the beach colonies. Black skimmers forage in shallow-water tidal creeks, inlets, and ponds. Similar coastal and estuarine habitats are used throughout the year.

In the early 1800s, the black skimmer was a common breeder along the New Jersey coast. Egg collecting and hunting decimated skimmer populations in the state by the early 1900s. Protection afforded by the Migratory Bird Treaty Act of 1918 (MBTA) (40 Stat. 775, as amended; 16 U.S.C. 703-712) enabled skimmer numbers to rebound. By the late 1970s, the black skimmer had declined and concern arose over its status in the state. Consequently, the black skimmer was listed as an endangered species in New Jersey in 1979. The majority of the state's population remains in two to three large colonies that are threatened by habitat loss or human activity. The New Jersey Natural Heritage Program considers the black skimmer to be "demonstrably secure globally," yet "imperiled in New Jersey because of rarity" (New Jersey Department of Environmental Protection 1992). Each year, the New Jersey Endangered and Nongame Species Program (ENSP) monitors the state's black skimmer population. Nesting colonies are enclosed and patrolled by personnel. Counts of adults and young are conducted to monitor population size and productivity. Despite annual fluctuations, the state's breeding population has remained relatively stable since the time of its original listing, although the number of active colonies has declined significantly. Human disturbance, beach raking, tidal flooding, and predation continue to threaten nesting skimmers and their habitat.

All black skimmer nesting sites in New Jersey during an 8-year period were located within the Corps Philadelphia District Program Area. In addition, during the summer of 2007, a total of 1,627 black skimmer adults, 719 peak adults, and 709 fledges were recorded at Champagne Island, just north of the project area (Todd Pover, pers. comm. 2007).

2. Least Tern

New Jersey least tern nest colonies of a few to several hundred pairs are found primarily along barrier island beaches or mainland beach strands. Bare sandy areas or areas sparsely vegetated with such typical beach vegetation as sea rocket, American beach grass (*Ammophila breviligulata*), beach clotbur (*Xanthium echinatum*), and seaside spurge (*Euphorbia polygonifolia*) that are just beyond the reach of normal spring tides are preferred. Nesting colonies are also found on sandy dredge disposal sites, especially after recent deposition before the establishment of dense vegetation. Least terns may also nest near sand and gravel pits where sand piles from mining operations provide suitable nesting habitat. Nesting on gravel rooftops has occurred in Florida, Mississippi and other locations (Fisk 1975, Jackson and Jackson 1985) but has not been documented in New Jersey. The birds typically forage in bays, lagoons, estuaries, rivers and lakes along the coast.

Through most of the 19th Century, the least tern was a common breeder along the New Jersey coast. However, as was true for so many of coastal birds, by the early 20th century, egg collecting and hunting for the millenary trade had decimated least tern populations. Protection afforded by the MBTA of 1918 and changing fashion trends enabled least tern numbers to rebound, but new coastal development and the elevated recreational use of beaches in the 1940's led to another population decline. Populations stabilized in recent decades as management measures were implemented, but recently, populations have begun declining again, due primarily to predation losses and increases in losses to coastal flooding.

Piping plovers often nest in association with State-listed least tern colonies, presumably benefiting from the aggressive behaviors of terns in driving away predators, and have often had higher success than those nesting out of tern colonies (Burger 1987). In addition, seabeach amaranth also benefits from the presence of least tern colonies, since restrictions on public access in the nesting areas provide protected areas where plants can become established (Weakley and Bucher 1992).

3. Evening Primrose

The seabeach evening primrose is a state listed (endangered) plant that inhabits New Jersey beaches and dune areas. The project area is a significant site for seabeach evening primrose, which has been consistently documented in beach surveys of North Wildwood, Wildwood, Wildwood Crest, and Two Mile Beach (Kelly pers. comm. 2013).

4. Coordination with the State

The Service recommends that the Corps consider species of special concern and State-listed species (Appendix C) in project planning. The Service's PBO (U.S. Fish and Wildlife Service 2005a) contains conservation recommendations for least tern and black

skimmer. The NJENSP and NJNHP may be contacted for further information regarding State-listed endangered and threatened species.

The NJNHP maintains the most up-to-date information on Federal candidate species and State-listed species in New Jersey and may be contacted at the following address:

Natural Heritage Program
Division of Parks and Forestry
CN 404
Trenton, New Jersey 08625
(609) 984-1339

Additionally, information on New Jersey's State-listed wildlife species may be obtained from the following office:

David Jenkins, Chief
Endangered and Nongame Species Program
New Jersey Division of Fish and Wildlife
CN 400
Trenton, New Jersey 08625
(609) 292-9400

C. AVIAN AND OTHER WILDLIFE RESOURCES

1. Shorebirds and other Colonial Nesting Waterbirds

Migratory shorebirds are protected under the MBTA and are a Federal trust resource responsibility of the Service. Wetland areas in the vicinity of the project area provide high quality habitats for a variety of migratory shorebirds. Shorebirds that use beach areas and associated estuarine wetlands in the vicinity of the proposed project area include the piping plover and red knot, American oystercatcher (*Haematopus palliatus*) (State species of special concern), short-billed dowitcher (*Limnodromus griseus*), black-bellied plover (*Pluvialis squatarola*), semipalmated plover (*Charadrius semipalmatus*), killdeer (*C. vociferous*), ruddy turnstone (*Arenaria interpres*), dunlin (*Calidris alpina*), sanderling (*C. alba*), least sandpiper (*C. minutilla*), pectoral sandpiper (*C. melanotos*), semipalmated sandpiper (*C. pusilla*), stilt sandpiper (*C. himantopus*), western sandpiper (*C. mauri*), spotted sandpiper (*Actitis macularius*), willet (*Tringa semipalmatus*), and greater yellowlegs (*T. melanoleuca*). During the 2007 nesting season, Service biologists observed piping plovers foraging within the intertidal zone of the project area (Egger pers. comm. 2007).

Colonial nesting waterbirds present within the project area include the State-listed (endangered) least tern and black skimmer; State-listed (threatened) little blue heron (*Egretta caerulea*) and yellow-crowned night heron (*Nyctanassa violacea*); State species of special concern common tern (*Sterna hirundo*), tricolored heron (*Egretta tricolor*), great blue heron (*Ardea herodias*), and breeding population threatened black-crowned

night heron (*Nycticorax nycticorax*). Other colonial species include double-crested cormorant (*Phalacrocorax auritus*), great egret (*Ardea albus*), snowy egret (*Egretta thula*), great black-backed gull (*Larus marinus*), herring gull (*L. argentatus*), laughing gull (*L. atricilla*), ring-billed gull (*L. delawarensis*), glossy ibis (*Plegadis falcinellus*), Forster's tern (*Sterna forsteri*), gull-billed tern (*S. nilotica*), and royal tern (*S. maxima*).

A list of colonial nesting birds and shorebirds prepared by the NJAS for the Hereford Inlet to Cape May Inlet project area is provided in Appendix D.

2. Waterfowl

Migratory waterfowl are also a Federal trust resource responsibility of the Service and are protected under the MBTA. The project area is within the Atlantic Coast Joint Venture's New Jersey Waterfowl Focus Area (South Coast Atlantic Focus Area) under the North America Waterfowl Management Plan. Areas adjacent to the project area, including CMNWR are important resting and feeding areas for migratory waterfowl on the Atlantic flyway and provide habitat for Atlantic brant (*Branta bernicla*), Canada goose (*B. canadensis*), American black duck (*Anas rubripes*), northern pintail (*A. acuta*), blue-winged teal (*A. discors*), green-winged teal (*A. crecca*), mallard (*A. platyrhynchos*), gadwall (*A. strepera*), American wigeon (*A. americana*), northern shoveler (*A. clypeata*), common goldeneye (*Bucephala clangula*), bufflehead (*B. albeola*), oldsquaw (*Clangula hyemalis*), canvasback (*Aythya valisineria*), greater scaup (*A. marila*), wood duck (*Aix sponsa*), hooded merganser (*Lophodytes cucullatus*), red-breasted merganser (*Mergus serrator*), and tundra swan (*Cygnus columbianus*).

3. Raptors

Raptors that occur in the project area include the State-listed (endangered) peregrine falcon (*Falco peregrinus*); State-listed (endangered) short-eared owl (*Asio flammeus*); State-listed (endangered) red-shouldered hawk (*Buteo lineatus*); State-listed (threatened) osprey (*Pandion haliaetus*), barred owl (*Strix varia*), and Cooper's hawk (*Accipiter cooperii*). The osprey feeds primarily on fish in the back bays and inlets of the project area. The red-shouldered hawk and Cooper's hawk migrate over the study area in the spring and fall; however, these transient visitors rarely stay within the area for any significant length of time.

4. Other Wildlife

The five-mile-long barrier island area also supports numerous other wildlife species. Avifauna include, but are not limited to, the 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 (*Agelaius phoeniceus*). The northern diamondback terrapin (*Malaclemys terrapin terrapin*) is also known to inhabit marshes, tidal flats, and beaches in New Jersey estuaries. The terrapin has been subject to recent population declines due to entrapment in crab pots and a reduction in nesting habitat.

Northern diamondback terrapins occur primarily in emergent wetlands and shallow water habitat and feed on crustaceans, mollusks, and other invertebrates (Palmer and Cordes 1988). During the winter, terrapins burrow into the mud of tidal creeks and ponds to hibernate either individually or in groups. Terrapins mate in the spring and lay their eggs in sandy substrates above the levels of high tides. Predation of eggs and hatchlings represent the major source of natural mortality in most terrapin populations. Eggs and juveniles are preyed upon by raccoons, crows (*Corvus* sp.), and gulls (Palmer and Cordes 1988).

Mammals known to occur within the vicinity of project area include raccoon, gray squirrel (*Sciurus carolinensis*), striped skunk (*Mephitis mephitis*), eastern cottontail (*Sylvilagus floridanus*), Virginia opossum (*Didelphis virginiana*), and white-tailed deer (*Odocoileus virginianus*).

VII. BORROW AREAS

A. BENTHIC RESOURCES

Benthic macroinvertebrates are important food organisms in the marine and estuarine environment, and along with primary producers, perform a crucial role in supporting other forms of fish and wildlife. Approximately 58 species of benthic organisms have been identified from Townsends Inlet to Cape May Inlet (Chaillou and Scott 1996). Benthic organisms of interest in the shallow ocean waters of the project area include Atlantic surf clam (*Spisula solidissima*), hard clam (*Mercenaria mercenaria*), and soft clam (*Mya arenaria*). In 2003, the regions south of Great Egg Harbor Inlet to Cape May Inlet accounted for only 10.2% of the total estimated standing stock of surf clams in New Jersey territorial waters. Preliminary data collected in 2007 indicate that the estimated standing stock in this region is now only 4% (Normant pers. comm. 2007). In 1999, this region had 25% of estimated standing stock in New Jersey territorial waters. In 2003, 60.6% (by weight) of New Jersey molluscan landings were surf clams and 73.9% of the total surf clam east coast harvest was landed in New Jersey. Approximately 246,000 bushels were harvested from New Jersey territorial waters in 2003, with 17.5% of harvest coming from this region. There has been a major decline of surf clams state wide as well as in Federal waters off the Delmarva Peninsula. There has been virtually no harvest of surf clams in New Jersey territorial waters in many years (Normant pers. comm. 2007).

B. COASTAL BARRIER RESOURCE ACT

The purpose of the CBRA is to minimize the loss of human life; wasteful expenditures of Federal revenues; and damage to fish, wildlife, and other natural resources associated with coastal barriers along the Atlantic, Gulf of Mexico, Great Lakes, U.S. Virgin Islands, and Puerto Rico coasts of the United States. To accomplish this purpose, CBRA established the John H. Chafee Coastal Barrier Resources System (CBRS), a system of relatively undeveloped coastal barriers and associated aquatic habitat that is delineated on a set of official maps that are maintained by the Service. Most new Federal expenditures

and financial assistance, including Federal funding for dredging and beach nourishment projects, are prohibited within System units of the CBRS.

Please note that Federal agencies are required to consult with the Service prior to committing funds for projects or actions within or affecting the CBRS. The Service developed an online mapper that depicts the approximate boundaries of the CBRS to assist Federal agencies in complying with the provisions of CBRA. The CBRS mapper and additional information on the CBRA consistency consultations process for proposed projects can be found on the Service's CBRA website at: http://www.fws.gov/cbra.

VIII. PROJECT IMPACTS AND RECOMMENDED MITIGATIVE MEASURES

The following is a summary of the potential project impacts and recommended mitigative measures to avoid and/or minimize adverse impacts on fish and wildlife resources.

A. PIPING PLOVER, SEABEACH AMARANTH, AND RED KNOT

In 2005, the Service finalized a PBO for the Corps' funding or authorizing of beach nourishment in Ocean, Atlantic, and Cape May counties. The PBO reflects extensive coordination and cooperation between the Corps and the Service to minimize adverse effects to the piping plover and seabeach amaranth. The Service appreciates the Corps' ongoing cooperation in implementing the PBO to date.

As described in a Streamlined Biological Opinion (SBO) for Cape May City (November 6, 2011), an informal consultation for the Wildwoods (March 30, 2012), and a Biological Opinion for Avalon (December 15, 2011), back-passing (neither hydraulic nor via trucks) was not contemplated in the PBO. Some effects of back-passing (*e.g.*, at the sand placement site) are similar for back-passing and other types of beach nourishment. However, other effects are unique to back-passing, such as long-shore vehicle traffic or pipe placement, and borrow area impacts including creation of temporary pits, vehicle use, and persistent narrowing of the beach. To date, these unique effects have been considered project-by-project concurrent with each SBO (or other type of consultation) involving back-passing. Given the likely trend toward increasing use of back-passing in the Corps' public works and regulatory programs, the Service recommends that our agencies work cooperatively to update and amend the PBO to include this practice. We further recommend that the PBO revision include enhanced coordination with the Federal Emergency Management Authority (FEMA) due to FEMA's increasing role in beach nourishment in New Jersey. Finally, the Service will publish a listing determination for the red knot by September 30, 2013. If the red knot is proposed for listing, we recommend that the revised PBO also address conservation measures, effects, and any anticipated incidental take for this species under the Corps' beach nourishment program.

Specific to the proposed Cape May Inlet to Hereford Inlet project, we do not anticipate adverse effects to piping plovers or seabeach amaranth based on the proposed limits of disturbance, specifically that no work will occur in any of the following locations: in or adjacent to the CMNWR, in the USCG Loran Support Unit, in the Cape May Inlet, along

Hereford Inlet in North Wildwood (past the groin at the intersection of 2nd Avenue and John F. Kennedy Beach Boulevard), in Stone Harbor Borough, or in Hereford Inlet (*i.e.*, no dredging) including Champagne Island (if/when present). If project plans change or if piping plovers or seabeach amaranth colonize the proposed work areas, further assessment of effects and conservation measures will be necessary under the PBO. Even if these species remain absent from the proposed work areas, streamlined consultation will be necessary under the PBO. In addition, we recommend early coordination between the Corps and the Service to develop conservation measures and evaluate effects to the red knot specific to the proposed Hereford Inlet to Cape May Inlet project, even prior to the revision of the PBO. Significant numbers of red knots currently utilize a portion of the proposed work area during the fall migration season, and may be affected by the project including disturbance and changes in habitat.

Finally, we recommend the continued implementation of the North Wildwood BMP, with continued and enhanced coordination among the City of North Wildwood, the NJDFW, and the Service on issues such as enforcement of the City's dog ordinance and vehicle management. We also recommend timely revision of the plan following the schedule agreed upon by all parties.

B. BEACH HABITAT ENHANCEMENT

Regular cycles of beach nourishment along North Wildwood's oceanfront beach have the potential to create and enhance habitat for the red knot, seabeach amaranth, and State-listed plant species. Perpetuation of wider beach in this area may also attract beach nesting birds such as piping plover, least tern, black skimmer, and American oystercatcher.

Planning activities for beach fill and dune creation should include an evaluation of potential habitat enhancement for beach nesting birds. Wide beaches with gentle slopes generally provide good quality habitat for beach-dependent birds (U.S. Fish and Wildlife Service 1996a). Creation of low, wide dunes with washover areas provides suitable foraging and nesting habitat, and dune configurations that are irregular (*e.g.*, staggered and discontinuous) can enhance bird habitat. In addition, native dune grasses should be planted in sufficient quantity to provide stabilization, but also minimal enough not to impair habitat. In addition, only native, non-woody vegetation should be used. Fencing systems to trap sand and create dunes should be open to allow passage of shorebirds between and among the dunes, and to allow for the perpetuation of the dynamic beach conditions favored by listed species. A broken, zig-zag pattern of fencing parallel to the shore or a Y-type fencing pattern perpendicular to shore are two examples of open fencing systems. The Service recommends the Corps coordinate with the Service and the ENSP regarding the potential for habitat enhancements as the project plans continue to be refined. Refer to the Service's 2005 PBO for additional recommendations, including beach habitat enhancement to protect listed species (U.S. Fish and Wildlife Service 2005a) (Appendix F) and (Appendix G).

Additionally, the Service recommends the use of perpetual deed restrictions or conservation easement to protect newly created beach and adjacent beach habitat for listed species (see PBO conservation measure #7).

C. BORROW AREAS

Similar to other dredging, extraction of material from borrow areas has been documented as causing environmental impacts that may adversely affect fish and other marine species populations and the food chains on which they depend. Kantor (1984) provides a review of dredging impacts specific to New Jersey. These impacts can generally be subdivided into those affecting the water column and those affecting the bottom substrate. Adverse water quality impacts from material extraction include increased turbidity, changes in temperature and oxygen demand, and release or resuspension of toxins and bacteria. These factors may cause direct mortality to fish and shellfish, disrupt fish migrations, hamper fish and shellfish spawning, make shellfish unsuitable for human consumption, and reduce primary productivity. Settling of suspended sediment may result in smothering of shellfish and other benthic organisms down current from the project site.

Bottom impacts include removal of existing benthic communities, change in circulation patterns, and modification of patterns of sediment deposition. Extraction from borrow areas may create bottom depressions with reduced flushing. These depressions can accumulate fine-grained sediments and organic material, including contaminants. Reduced flushing, combined with decomposition of organic materials, can lead to low oxygen conditions in such depressions. Originally occurring or different benthic forms may eventually recolonize the area of extraction depending on the water quality and substrate present.

The type of equipment used and the time of year extraction occur may greatly influence the nature and extent of potential adverse impacts in the water column. For example, the use of hydraulic dredging reduces Service concerns regarding short-term adverse impacts on water quality at and near the site of dredging, but hydraulic dredging may impact eggs and young fish or other slow-moving organisms unable to avoid entrainment. The entrainment of sea turtles has also been documented as an adverse impact of hydraulic dredging (U.S. Fish and Wildlife Service 1991). The NMFS has jurisdiction over endangered and threatened sea turtles and should be contacted if hydraulic dredging is proposed. Conversely, mechanical dredging has greater impacts on turbidity and dissolved oxygen at the dredge site, but, if conducted during periods of low seasonal biological productivity, adverse impacts to organisms can be minimized.
According to the official CBRS map for Hereford Inlet (Stone Harbor Unit NJ-09/NJ-09P dated July 12, 1996), proposed sand borrow areas described in the Corps draft feasibility study under the National Economic Development alternative which is the alternative that reasonably maximizes net economic benefits are located within System Unit NJ-09 of the CBRS. Any proposed Federal action designed to nourish beaches located outside the System using beach material taken from within the System does not meet the criteria for a section 6(a)(6)(G) exception of the CBRA.

The preferred alternatives to offshore borrow sites being considered for the project is bypassing sand from Wildwood to North Wildwood by back-passing and changing the beach configuration in Wildwood by increasing berm height or adding a dune described as plan C in the Corps draft feasibility study. This alternative would avoid adverse impacts to finfish and other marine resources and negate the need to borrow from Hereford Inlet.

IX. CONCLUSIONS AND SUMMARY OF RECOMMENDATIONS

A. BEACH COMMUNITIES

In order to avoid and minimize potential adverse impacts on State-listed and federally listed threatened and endangered species within project area, the Service recommends incorporating the following measures into project planning.

1. Work collaboratively with the Service to update and amend the PBO to include back-passing (both hydraulic and vehicle based), enhanced coordination with FEMA, and the red knot.

2. Specific to the proposed Hereford to Cape May Inlet project, we do not anticipate adverse effects to piping plovers or seabeach amaranth based on the proposed limits of disturbance; if project plans change or if piping plovers or seabeach amaranth colonize the proposed work areas, further assessment of effects and conservation measures will be necessary under the PBO. Even if not present in the work areas, streamlined consultation for these species will be necessary under the PBO. (Specifically the PBO calls for initiation of streamlined consultation 6 months prior to the start of work). In addition, we recommend early coordination regarding the red knot.

3. Contact NJDFW's ENSP and NJNHP's in considering State species of special concern and State-listed species in project planning (Appendix C).

4. Implement the North Wildwood BMP, with continued and enhanced coordination among the City of North Wildwood, the NJDFW, and the Service. Revise the plan following the schedule agreed upon by all parties.

5. Refer to the Service's 2005 PBO for additional recommendations, including beach habitat enhancement to protect listed species (U.S. Fish and Wildlife Service 2005a) (Appendix F) and (Appendix G).

B. BEACH HABITAT ENHANCEMENT

Incorporate the following recommendations into project planning to create additional shorebird habitat and protect or enhance any existing habitat.

1. Review and evaluate any proposed beach creation activity in regard to potential effects on other habitats within the project area.

2. Include habitat enhancement for listed species in plans for beach fill and dune creation activities.
3. Coordinate with the Service and NJDEP on planting of any vegetation on dunes for dune stabilization.

4. Avoid the introduction of invasive and non-native plant species and consult with the Service and NJDEP on management of the dune system.

5. Design dune fencing systems that allow passage of juvenile shorebirds between and among the dunes and allow more natural dunes to form with adequate storm protection, and to allow for the perpetuation of natural beach processes.

6. Obtain a perpetual deed restriction or conservation easement for the newly-created beach and adjacent beach areas, as per the PBO.

7. Continue to coordinate with the Service and ENSP for any dune and beach enhancement or restoration activities in listed species habitat.

C. BORROW AREAS

1. Rely primarily on the components of the benthic diversity indices (*i.e.*, species diversity, species richness, and the distribution of the number of individuals among the species), rather than on the diversity indices alone, in evaluating benthic habitat quality.

2. Evaluate any borrow site alternatives that would minimize adverse impacts to surf clam communities through continued coordination with the New Jersey Bureau of Shellfisheries and the Service.

3. Conduct each renourishment phase in a limited section of the borrow area(s) and alternate locations for each subsequent renourishment cycle.

4. Avoid creating excessively deep, poorly flushed (anoxic) pits at the borrow sites.

5. Avoid dredging during shellfish or finfish spawning activities (the typical spawning period and early life stages of winter flounder are between January 1 and May 31).

6. Use hydraulic-pipeline dredging rather than hopper dredging in order to minimize turbidity at the borrow sites and minimize the potential entrainment of federally listed sea turtles.

7. Contact the NMFS regarding potential adverse impacts on federally listed (threatened or endangered) sea turtle and marine mammal species under its jurisdiction.

8. Coordinate with the New Jersey Bureau of Marine Fisheries regarding the selection of borrow sites.

9. Consult with the Service concerning borrow areas pursuant to the CBRA.

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APPENDIX A

Federally Listed Endangered and Threatened Species,
and Candidate Species in New Jersey

FEDERALLY LISTED AND CANDIDATE SPECIES IN NEW JERSEY

	COMMON NAME	SCIENTIFIC NAME	STATUS
FISHES	Shortnose sturgeon*	*Acipenser brevirostrum*	E
	Atlantic sturgeon*	*Acipenser oxyrinchus*	PE
REPTILES	Bog turtle	*Clemmys muhlenbergii*	T
	Loggerhead sea turtle*	*Caretta caretta*	PE
BIRDS	Piping plover	*Charadrius melodus*	T
	Red knot	*Calidris canutus rufa*	C
	Roseate tern	*Sterna dougallii dougallii*	E
	Red-cockaded woodpecker	*Picoides borealis*	E+
MAMMALS	Eastern cougar	*Puma concolor couguar*	E+
	Indiana bat	*Myotis sodalis*	E
	Gray wolf	*Canis lupus*	E+
	Delmarva fox squirrel	*Sciurus niger cinereus*	E+
INVERTEBRATES	Dwarf wedgemussel	*Alasmidonta heterodon*	E
	Northeastern beach tiger beetle	*Cicindela dorsalis dorsalis*	T
	Karner blue butterfly	*Lycaeides melissa samuelis*	E+
	Mitchell's satyr butterfly	*Neonympha m. mitchellii*	E+
	American burying beetle	*Nicrophorus americanus*	E+
PLANTS	Small whorled pogonia	*Isotria medeoloides*	T
	Swamp pink	*Helonias bullata*	T
	Knieskern's beaked-rush	*Rhynchospora knieskernii*	T

	Hirsts' panic grass	*Dichanthelium hirstii*	C
	American chaffseed	*Schwalbea americana*	E
	Sensitive joint-vetch	*Aeschynomene virginica*	T
	Seabeach amaranth	*Amaranthus pumilus*	T

STATUS:		
E	Endangered Species	Any species that is in danger of extinction throughout all or a significant portion of its range.
T	Threatened Species	Any species that is likely to become an endangered species within the foreseeable future throughout all or a significant portion of its range.
C	Candidate Species	Species that appear to warrant listing. Although these species receive no substantive or procedural protection under the Endangered Species Act, Federal agencies and other planners are encouraged to consider these species in environmental planning.
P	Proposed Species	A species for which a proposed rule to list as endangered or threatened has been published in the Federal Register.
*	Except for sea turtle nesting habitat, principal responsibility for these species is vested with the National Marine Fisheries Service.	
+	Presumed extirpated from New Jersey.	

Note: For a complete listing of Endangered and Threatened Wildlife and Plants, refer to 50 CFR 17.11 and 17.12. For a complete listing of taxa under review as candidate species, refer to http://www.fws.gov/endangered/

For further information, please visit our website at:
http://www.fws.gov/northeast/njfieldoffice/endangered/

U.S. Fish and Wildlife Service
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Revised 1/2/2013

FEDERAL CANDIDATE SPECIES IN NEW JERSEY

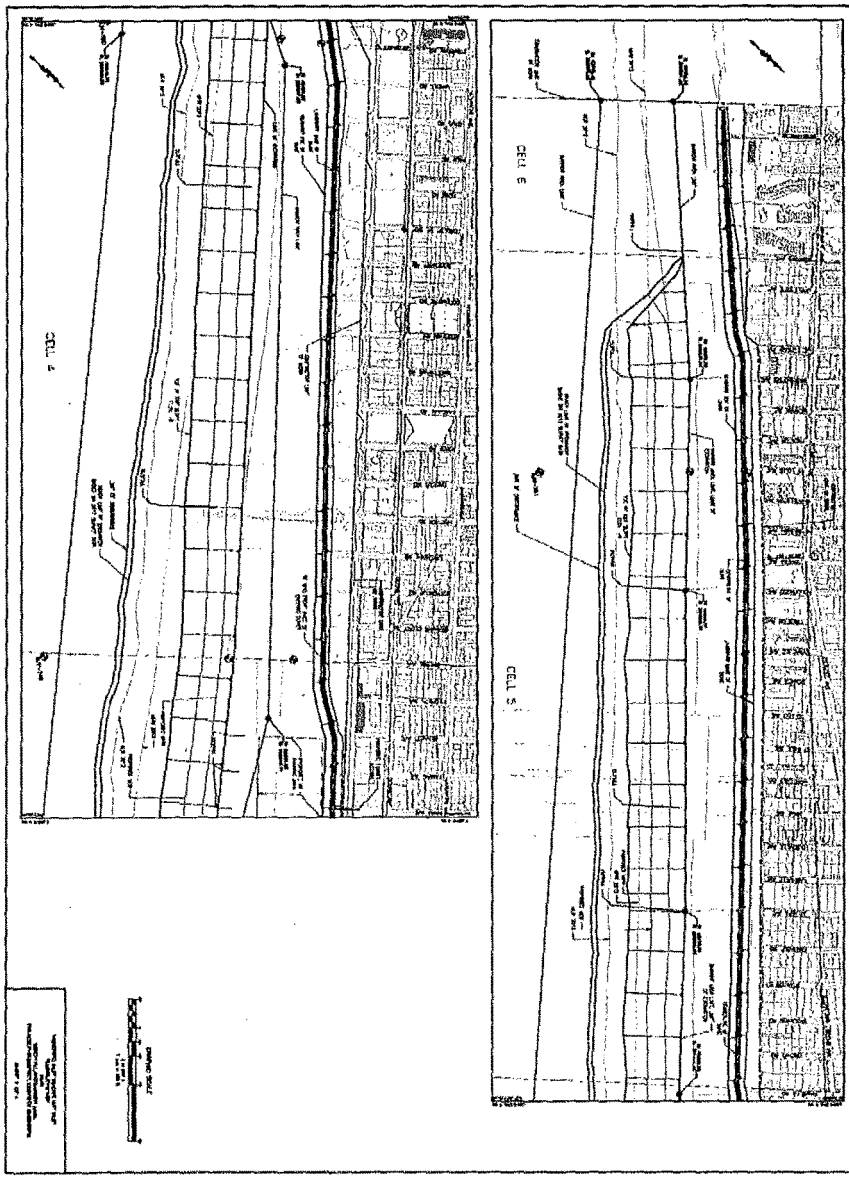
CANDIDATE SPECIES are species that appear to warrant consideration for addition to the federal List of Endangered and Threatened Wildlife and Plants. Although these species receive no substantive or procedural protection under the Endangered Species Act, the U.S. Fish and Wildlife Service encourages federal agencies and other planners to give consideration to these species in the environmental planning process.

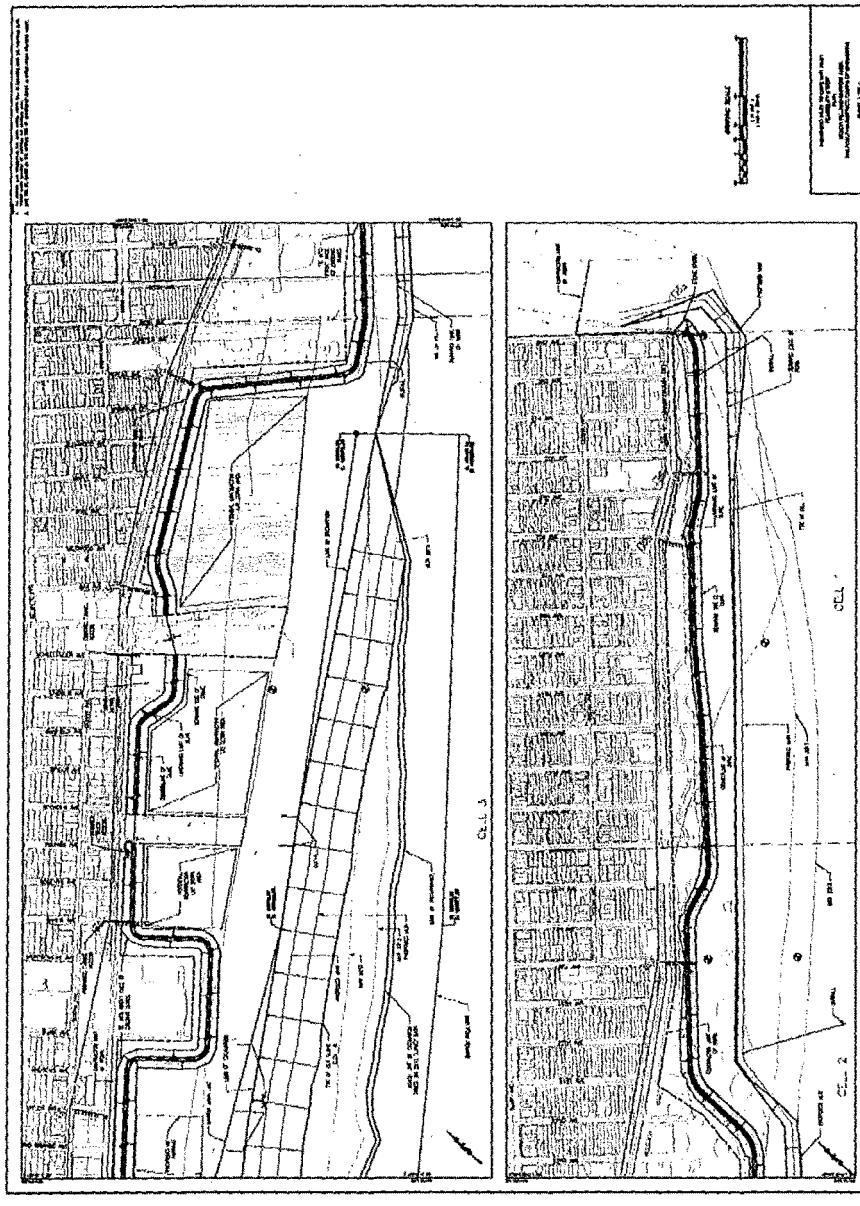
SPECIES	SCIENTIFIC NAME
Red Knot	*Calidris canutus rufa*
Hirsts' panic grass	*Dichanthelium hirstii*

Revised January 18, 2013

APPENDIX B

Project Plans showing Project Area





APPENDIX C

State-Listed Endangered and Threatened Species
in New Jersey

Conserve Wildlife

New Jersey Department of Environmental Protection
Division of Fish & Wildlife
Endangered & Nongame Species Program

New Jersey's Endangered and Threatened Wildlife

DEP Adopts Updated Threatened and Endangered Species List, Revises Species Listings Based on Latest Science - DEP News Release, 2/23/12

Endangered Species are those whose prospects for survival in New Jersey are in immediate danger because of a loss or change in habitat, over-exploitation, predation, competition, disease, disturbance or contamination. Assistance is needed to prevent future extinction in New Jersey.

Threatened Species are those who may become endangered if conditions surrounding them begin to or continue to deteriorate.

There are other classifications for wildlife as well, including Stable, Species of Special Concern and Undetermined.

Species names in the below tables link to PDF documents containing identification, habitat and status and conservation information. For more detailed descriptions, photographs, and range maps of New Jersey's endangered, threatened, and special concern species, please refer to the Conserve Wildlife Foundation of NJ's on-line field guide.

BIRDS			
Endangered		**Threatened**	
Bittern, American BR	*Botaurus lentiginosos* BR	Bobolink BR	*Dolichonyx oryzivorus* BR
Eagle, bald BR	*Haliaeetus leucocephalus* BR	Eagle, bald NB	*Haliaeetus leucocephalus* NB
Falcon, peregrine BR	*Falco peregrinus* BR	Egret, cattle BR	*Bubulcus ibis* BR
Goshawk, northern BR	*Accipiter gentilis* BR	Kestrel, American	*Falco sparverius*
Grebe, pied-billed BR	*Podilymbus podiceps* BR	Lark, horned BR	*Eremophila alpestris* BR
Harrier, northern BR	*Circus cyaneus* BR	Night-heron, black-crowned BR	*Nycticorax nycticorax* BR
Hawk, red-shouldered BR	*Buteo lineatus* BR	Night-heron, yellow-crowned	*Nyctanassa violacea*

Knot, red NB	*Calidris canutus* NB	Osprey BR	*Pandion haliaetus* BR
Owl, short-eared BR	*Asio flammeus* BR	Owl, barred	*Strix varia*
Plover, piping**	*Charadrius melodus***	Owl, long-eared	*Asio otus*
Rail, black BR	*Laterallus jamaicensis* BR	Rail, black NB	*Laterallus jamaicensis* NB
Sandpiper, upland	*Batramia longicauda*	Sparrow, grasshopper BR	*Ammodramus savannarum* BR
Shrike, loggerhead NB	*Lanius ludovicianus* NB	Sparrow, Savannah BR	*Passerculus sandwichensis* BR
Skimmer, black	*Rynchops niger*	Woodpecker, red-headed	*Melanerpes erythrocephalus*
Sparrow, Henslow's	*Ammodramus henslowii*		
Sparrow, vesper BR	*Pooecetes gramineus* BR		
Tern, least	*Sternula antillarum*		
Tern, roseate**	*Sterna dougallii***		
Warbler, golden-winged BR	*Vermivora chrysoptera* BR		
Wren, sedge	*Cistothorus platensis*		
**Federally endangered or threatened			
BR - Breeding population only; NB - non-breeding population only			

REPTILES			
Endangered		**Threatened**	
Rattlesnake, timber	*Crotalus h. horridus*	Snake, northern pine	*Pituophis m. melanoleucus*
Snake, corn	*Elaphe g. guttata*	Turtle, Atlantic green**	*Chelonia mydas***
Snake, queen	*Regina septemvittata*	Turtle, wood	*Glyptemys insculpta*
Turtle, bog**	*Glyptemys muhlenbergii***		
Hawksbill, Atlantic**	*Eretmochelys imbricata***		
Leatherback, Atlantic	*Dermochelys*		

**	*coriacea***	
Loggerhead, Atlantic **	*Caretta caretta***	
Ridley, Atlantic **	*Lepidochelys kempii***	
**Federally endangered or threatened		

AMPHIBIANS			
Endangered		**Threatened**	
Salamander, blue-spotted	*Ambystoma laterale*	Salamander, eastern mud	*Pseudotriton montanus*
Salamander, eastern tiger	*Ambystoma tigrinum*	Salamander, long-tailed	*Eurycea longicauda*
Treefrog, southern gray	*Hyla chrysocelis*	Treefrog, pine barrens	*Hyla andersonii*

INVERTEBRATES			
Endangered		**Threatened**	
Beetle, American burying**	*Nicrophorus americanus***	Baskettail, robust(dragonfly)	*Epitheca spinosa*
Beetle, northeastern beach tiger**	*Cincindela d. dorsalis***	Clubtail, banner (dragonfly)	*Gomphus apomyius*
Copper, bronze	*Lycaena hyllus*	Clubtail, harpoon (dragonfly)	*Gomphus descriptus*
Floater, brook (mussel)	*Alasmidonta varicosa*	Elfin, frosted (butterfly)	*Callophrys irus*
Floater, green (mussel)	*Lasmigona subviridis*	Emerald, Kennedy's (dragonfly)	*Somatochlora kennedyi*
Petaltail, gray (dragonfly)	*Tachopteryx thoreyi*	Floater, triangle (mussel)	*Alasmidonta undulata*
Satyr, Mitchell's (butterfly)**	*Neonympha m. mitchellii***	Fritillary, silver-bordered (butterfly)	*Bolaria selene myrina*
Skipper, arogos (butterfly)	*Atrytone arogos arogos*	Jewelwing, superb (dragonfly)	*Calopteryx amata*
Skipper, Appalachian grizzled (butterfly)	*Pyrgus wyandot*	Lampmussel, eastern (mussel)	*Lampsilis radiata*

Wedgemussel, dwarf**	*Alasmidonta heterodon***	Lampmussel, yellow (mussel)	*Lampsilis cariosa*
		Mucket, tidewater (mussel)	*Leptodea ochracea*
		Pondmussel, eastern (mussel)	*Ligumia nasuta*
		Snaketail, brook, (dragonfly)	*Ophiogomphus asperses*
		White, checkered (butterfly)	*Pontia protodice*
**Federally endangered or threatened			

MAMMALS	
Endangered	
Bat, Indiana**	*Myotis sodalis***
Bobcat	*Lynx rufus*
Whale, North Atlantic right**	*Eubalaena glacialis***
Whale, blue**	*Balaenoptera musculus***
Whale, fin**	*Balaenoptera physalus***
Whale, humpback**	*Megaptera novaeangliae***
Whale, sei**	*Balaenoptera borealis***
Whale,sperm**	*Physeter macrocephalus***
Woodrat, Allegheny	*Neotoma magister*
**Federally Endangered	

FISH	
Endangered	
Sturgeon, Atlantic**	*Acipenser oxyrinchus oxyrinchus***
Sturgeon, shortnose**	*Acipenser brevirostrum***
**Federally Endangered	

List updated 4/2/12

APPENDIX D

Colonial Nesting Birds and Shorebirds within
Hereford Inlet to Cape May Inlet Project Area
(prepared by New Jersey Audubon Society)

Colonial Nesting Birds and Shorebirds - Hereford Inlet to Cape May Inlet
Estuary and nearshore coastal waters, including associated beach, dune, salt marsh, mudflats and coastal forest/scrub
Compiled by Don Freiday
Very rare species (occuring less than annually) are excluded from this list

Nests - Y means known to currently nest

C - common: always seen, more than 20 individuals per day
F - fairly common: usually seen, 5 to 20 individuals per day
U - uncommon: seen in limited numbers, 1-4 per day
S - scarce: usually present, but not seen daily
R - rare: seen only a few times a season

Species	Common Name	Nests	Winter	Spring	Summer	Early fall	Late fall
PHALACROCORACIDAE (Cormorants)							
Phalacrocorax auritus	Double-crested Cormorant		U	C	C	C	C
Phalacrocorax carbo	Great Cormorant		U	U			U
ARDEIDAE (Herons, Egrets and Bitterns)							
Botaurus lentiginosus	American Bittern		S	S		U	U
Ixobrychus exilis	Least Bittern			R		R	R
Ardea herodias	Great Blue Heron		F	F	S	F	F
Ardea alba	Great Egret	Y	R	F	F	F	S
Egretta thula	Snowy Egret	Y		F	F	F	S
Egretta caerulea	Little Blue Heron	Y		U	U	U	S
Egretta tricolor	Tricolored Heron	Y		U	U	U	S
Bubulcus ibis	Cattle Egret			R	R	R	

1118

Nycticorax nycticorax	Black-crowned Night-Heron	Y	U	F	F	F	F
Nyctanassa violacea	Yellow-crowned Night-Heron	Y		U	U	U	U
THRESKIORNITHIDAE (Ibis and Spoonbills)							
Threskiornithinae							
Plegadis falcinellus	Glossy Ibis	Y		F	F	F	U
Species	**Common Name**	**Nests**	**Winter**	**Spring**	**Summer**	**Early Fall**	**Late Fall**
CHARADRIIDAE (Plovers and Lapwings)							
Charadriinae							
Pluvialis squatarola	Black-bellied Plover		F	C	U	C	C
Pluvialis dominica	American Golden-Plover					S	S
Charadrius semipalmatus	Semipalmated Plover			C	U	C	C
Charadrius melodus	Piping Plover	Y		U	U	U	S
Charadrius vociferous	Killdeer	Y	U	F	F	F	F
HAEMATOPODIDAE (Oystercatchers)							
Haematopus palliatus	American Oystercatcher	Y	F	F	F	F	F
RECURVIROSTRIDAE (Avocets and Stilts)							
Recurvirostra americana	American Avocet				R	R	
SCOLOPACIDAE (Sandpipers and Allies)							
Scolopacinae							
Actitis macularius	Spotted Sandpiper	?		F	U	F	U
Tringa solitaria	Solitary Sandpiper			U	S	U	
Tringa melanoleuca	Greater Yellowlegs		F	C	U	C	C
Tringa semipalmata	Willet	Y	R	C	C	F	R
Tringa flavipes	Lesser Yellowlegs		S	F	U	C	C
Bartramia longicauda	Upland Sandpiper				R		

Numenius phaeopus	Whimbrel			U	S	F	U
Limosa haemastica	Hudsonian Godwit				R	R	
Limosa fedoa	Marbled Godwit		R	R	R	S	S
Arenaria interpres	Ruddy Turnstone		C	C	U	F	C
Calidris canutus	Red Knot		S	C	F	U	U
Calidris alba	Sanderling		C	C	F	C	C
Calidris pusilla	Semipalmated Sandpiper			C	C	C	C
Calidris mauri	Western Sandpiper				F	F	F
Calidris minutilla	Least Sandpiper		R	C	U	C	F
Calidris fuscicollis	White-rumped Sandpiper			U	U	U	U
Calidris bairdii	Baird's Sandpiper				R	R	R
Calidris melanotos	Pectoral Sandpiper			U	S	F	F
Calidris maritime	Purple Sandpiper		U	U			U
Calidris alpina	Dunlin		C	C	R	U	C
Species	**Common Name**	**Nests**	**Winter**	**Spring**	**Summer**	**Early Fall**	**Late Fall**
Calidris ferruginea	Curlew Sandpiper						
Calidris himantopus	Stilt Sandpiper			R	S	F	U
Tryngites subruficollis	Buff-breasted Sandpiper				R	R	
Limnodromus griseus	Short-billed Dowitcher		R	C	F	C	U
Limnodromus scolopaceus	Long-billed Dowitcher		R		R	U	U
Gallinago delicate	Wilson's Snipe		R	U		U	U
Scolopax minor	American Woodcock		R	U		U	U
Phalaropodinae							
Phalaropus tricolor	Wilson's Phalarope			R	R	R	R
LARIDAE (Gulls)							
Larus atricilla	Laughing Gull	Y	R	C	C	C	C
Larus Philadelphia	Bonaparte's Gull		U	U		R	U
Larus delawarensis	Ring-billed Gull		C	C	S	F	C
Larus argentatus	Herring Gull	Y	C	C	C	C	C

1120

Larus glaucoides	Iceland Gull		R				
Larus fuscus	Lesser Black-backed Gull		R	R			R
Larus hyperboreus	Glaucous Gull		R				
Larus marinus	Great Black-backed Gull	Y	C	C	C	C	C
Rissa tridactyla	Black-legged Kittiwake		R				R
STERNIDAE (Terns)							
Sternula antillarum	Least Tern	Y		F	F	F	
Gelochelidon nilotica	Gull-billed Tern	Y		U	U	U	
Hydroprogne caspia	Caspian Tern			R		U	U
Chlidonias niger	Black Tern			R	S	U	
Sterna dougallii	Roseate Tern			R	R	R	
Sterna hirundo	Common Tern	Y		C	C	C	F
Sterna forsteri	Forster's Tern	Y	S	C	C	C	C
Thalasseus maximus	Royal Tern	Y		F	U	C	C
Thalasseus sandvicensis	Sandwich Tern				R	S	
RYNCHOPIDAE (Skimmers)							
Rynchops niger	Black Skimmer	Y		F	F	C	F

1121

APPENDIX E

Status of the Red Knot (*Calidris canutus rufa*) in the Western Heimsphere.

STATUS OF THE RED KNOT (*CALIDRIS CANUTUS RUFA*) IN THE WESTERN HEMISPHERE

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Abstract. The population of the *rufa* subspecies of the Red Knot (*Calidris canutus*), which breeds in the central Canadian Arctic and mainly winters in Tierra del Fuego, has declined dramatically over the past 20 yr. Previously estimated at 100,000–150,000, the population now numbers 18,000–33,000 (18,000 if just the Tierra del Fuego birds are *C. c. rufa*, more if the Red Knots of uncertain subspecific status that winter in northern Brazil (7,500) or Florida (7,500) are also *C. c. rufa*). Counts show that the main Tierra del Fuego wintering population dropped from 67,546 in 1985 to 51,255 in 2000, 29,271 in 2002, 31,568 in 2004, but only 17,653 in 2005 and 17,211 in 2006.

Demographic studies covering 1994–2002 showed that the population decline over that period was related to a drop in annual adult survival from 85% during 1994–1998 to 56% during 1999–2001. Population models showed that if adult survival remained low, *C. c. rufa* would go extinct within about 10 yr. After 2002, the population held up in 2003–2004, but plunged again by nearly 50% in 2005 increasing the likelihood of extinction within the next decade. Despite intensive studies, the reasons for the population decline and reduced adult survival are imperfectly known.

During northward migration, most *C. c. rufa* stopover in Delaware Bay where they feed mainly on the eggs of horseshoe crabs (*Limulus polyphemus*) and lay down fat and protein reserves both to fuel the 3,000 km fl ight to the arctic breeding grounds and ensure their survival after they arrive at a time when food availability is often low. The crucial importance of Delaware Bay is demonstrated by studies that show that Red Knots with lower mass in Delaware Bay have lower survival than heavier birds and that from 1998–2002 the proportion of birds there at the end of May weighing more than the estimated departure mass of 180 g declined by >60%. This might be the result of the progressive failure of the food supply in Delaware Bay and/or a trend for birds to arrive there later and/or in poorer condition. In years when Red Knots experience reduced food availability and arrive late, the result may be an exacerbation of the effects of each of these deleterious factors. The main identified threat to the *C. c. rufa* population is the reduced availability of horseshoe crabs eggs in Delaware Bay arising from elevated harvest of adult crabs for bait in the conch and eel fishing industries. Since 1990 the crab population has declined substantially. Although significant uncertainty regarding the extent of the decline of the horseshoe crab population remains, there is general agreement that horseshoe crab stocks have declined to a level where increased management of the fishery is necessary and appropriate. The decline in crabs has led to a decrease in the density of eggs available to shorebirds. Because of the crab's delayed maturity, demographic models indicate that even if further exploitation of

crabs ceases immediately, it will be some years before the horseshoe crab population recovers to its former level. Although clear evidence, as in 2003 and 2005, shows that the reduced availability of eggs is already having an impact in some years on the Red Knots ability to gain mass in Delaware Bay, it is likely that other threats to *C. c. rufa* exist and that these are the cause of some birds arriving in the bay late and/or in poor condition. It is not known what these are, but they could be related to Bahia Lomas, the main wintering site in Tierra del Fuego (because the largest reduction in recent years has occurred there and because northward migration from Bahia Lomas along the Atlantic coast of Argentina has taken place 1–2 wk later since year 2000). If it is proved that something leads Red Knots to arrive late in Delaware Bay and/or in poor condition, this does not diminish the importance of the Delaware Bay food resource. If anything, it is increased because it is of critical importance in enabling the birds to recover quickly and reach the breeding grounds on time and in good reproductive condition. Actions being taken to improve feeding conditions for Red Knots and other shorebirds in Delaware Bay include beach closures to prevent disturbance and exclosures to reduce competition from gulls. However, although these measures help, they are no substitute for a recovered horseshoe crab population. Actions to conserve horseshoe crabs have included reduced harvest quotas, more efficient use of crabs as bait, closure of the harvest in certain seasons and places and the designation of a sanctuary off the mouth of Delaware Bay. The latest information indicates that the crab population may have stabilized, but there is no evidence of recovery.

Studies in Avian Biology No. 36:1–185
2 STUDIES IN AVIAN BIOLOGY NO. 36

Another Red Knot subspecies, *C. c. roselaari*, breeds in Alaska and is presumed to include those Red Knots that winter on the Pacifi c coast of the United States and Mexico. Two other Red Knot wintering populations are of uncertain subspecifi c status—one in the southeastern U.S. (mainly Florida) of about 7,500 and one on the north coast of Brazil also of about 7,500. These populations have not been the subject of regular systematic surveys, but it is not thought that either has suffered the same catastrophic decline as the *C. c. rufa* that winter in Tierra del Fuego. Substantial proportions of both pass through Delaware Bay during northward migration, but banding shows that these are distinct populations without interchange with the Tierra del Fuego birds. Moreover, genetic studies show that no exchange of genes has occurred between the southeastern U.S. and the Tierra del Fuego birds for at least 1,200 yr. Some progress has been made toward understanding why the Tierra del Fuego population has suffered a major decline, but the northern wintering birds have apparently remained more stable. It appears that physiological constraints mean that the southern birds, which mostly make a long, non-stop fl ight to Delaware Bay from at least northern Brazil, are more reliant on soft, easily-digested horseshoe crab eggs in Delaware Bay than the northern winterers, many of which feed on blue mussel (*Mytilus edulis*) spat or surf clams (*Donax variablis*) on the Atlantic coast of New Jersey. Evidence from Patagonia suggests that, for a reason that remains obscure, northward migration of Tierra del Fuego birds has become 1–2 wk later since the year 2000 and this has probably led to more Red Knots arriving late in Delaware Bay. Late arriving birds have been shown to have the ability to make up lost time by increasing their mass at a higher rate than usual provided they have suffi cient food resources. However, late-arriving Red Knots failed to do this in 2003 and 2005 when egg availability was low. Although *C. c. rufa* Red Knots are spread thinly across a

large area of the Canadian Arctic during the breeding season, for the rest of the year they occur mainly in large fl ocks at a limited number of key coastal wintering and staging sites. This review describes each of these sites and the threats the birds face ranging from oil pollution to disturbance and reclamation for development.

Overall the goal of conservation activities throughout the flyway should be to increase the *C. c. rufa* population to at least the number of 25 yr ago—100,000–150,000 by 2015. Given the uncertain genetic relationships between the three main wintering populations we suggest the following population increases: (1) Tierra del Fuego wintering population to 70,000–80,000 birds, (2) Brazilian wintering population to 20,000–25,000, (3) Florida wintering population to 20,000–25,000, and (4) other sites to 15,000–20,000. The means whereby such population increases might be achieved include: (1) recovery and maintenance of Delaware Bay horseshoe crab egg densities to levels suffi cient to sustain stopover populations of all shorebirds including 100,000 Red Knots, (2) control impact of disturbance at all stopovers and wintering areas, particularly in high-importance, high-disturbance areas like Delaware Bay and the west coast of Florida, (3) by 2008, develop a system for the yearly determination of population demographic status based on counts, capture data, and resightings of banded individuals, (4) by 2008, determine the genetic and breeding status of the three main wintering populations (Tierra del Fuego, Maranhão, and Florida), (5) by 2008, identify all important breeding locations in Canada and recommend protection needs and designations for the most important sites, (6) by 2009, complete site assessments and management plans for all important wintering areas and stopovers in the flyway, (7) by 2009, delineate and propose protection measures for key habitats within the main wintering areas of Maranhão, Tierra del Fuego, and Florida, and develop management plans to guide protection, (8) by 2009, determine key southbound and northbound stopovers that account for at least 80% of stopover areas supporting at least 100 Red Knots, and develop coast-wide surveillance of birds as they migrate, and (9) by 2011, create a hemisphere-wide system of protected areas for each signifi cant wintering, stopover, and breeding area. Also crucial to *C. c. rufa*'s recovery is adequate funding to support the conservation actions and research needed. Despite the fact that much of the research, survey, monitoring, and conservation work has been carried out by volunteers and has been supported fi nancially by state, federal government and non-government agencies, present funding levels are inadequate to sustain the work required.

APPENDIX F

Guidelines for Managing Recreational Activities in
Piping Plover Breeding Habitat on the
U.S. Atlantic Coast to
Avoid Take Under Section 9 of the
Endangered Species Act

GUIDELINES FOR MANAGING RECREATIONAL ACTIVITIES IN PIPING PLOVER BREEDING HABITAT ON THE U.S. ATLANTIC COAST TO AVOID TAKE UNDER SECTION 9 OF THE ENDANGERED SPECIES ACT

Northeast Region, U.S. Fish and Wildlife Service

April 15, 1994

The following information is provided as guidance to beach managers and property owners seeking to avoid potential violations of Section 9 of the Endangered Species Act (16 U.S.C. 1538) and its implementing regulations (50 CFR Part 17) that could occur as the result of recreational activities on beaches used by breeding piping plovers along the Atlantic Coast. These guidelines were developed by the Northeast Region, U.S. Fish and Wildlife Service (Service), with assistance from the U.S. Atlantic Coast Piping Plover Recovery Team. The guidelines are advisory, and failure to implement them does not, of itself, constitute a violation of the law. Rather, they represent the Service's best professional advice to beach managers and landowners regarding the management options that will prevent direct mortality, harm, or harassment of piping plovers and their eggs due to recreational activities.

Some land managers have endangered species protection obligations under Section 7 of the Endangered Species Act (see section I below) or under Executive Orders 11644 and 119891 that go beyond adherence to these guidelines. Nothing in this document should be construed as lack of endorsement of additional piping plover protection measures implemented by these land managers or those who are voluntarily undertaking stronger plover protection measures.

This document contains four sections: (I) a brief synopsis of the legal requirements that afford protection to nesting piping plovers; (II) a brief summary of the life history of piping plovers and potential threats due to recreational activities during the breeding cycle; (III) guidelines for protecting piping plovers from recreational activities on Atlantic Coast beaches; and (IV) literature cited.

I. LEGAL CONSIDERATIONS

Section 9 of the Endangered Species Act (ESA) prohibits any person subject to the jurisdiction of the United States from harassing, harming, pursuing, hunting, shooting, wounding, killing, trapping, capturing, or collecting listed wildlife species. It is also unlawful to attempt such acts, solicit another to commit such acts, or cause such acts to be committed. A "person" is defined in Section 3 to mean "an individual, corporation, partnership, trust, association, or any other private entity; or any officer, employee, agent, department, or instrumentality of the Federal Government, of any State, municipality, or political subdivision of a State, or of any foreign government; any State, municipality, or political subdivision of a State; or any other entity subject to the jurisdiction of the United States." Regulations implementing the ESA (50 CFR 17.3) further define "harm" to include significant habitat modification or degradation that results in the killing or injury of wildlife by significantly impairing essential behavioral patterns including breeding, feeding, or sheltering. "Harass" means an intentional or negligent act or omission which creates the likelihood of injury to wildlife by annoying it to such an extent as to significantly disrupt normal behavioral patterns which include, but are not limited to, breeding, feeding, or sheltering. Penalties for violations of Section 9 are provided in Section 11 of the ESA; for threatened species, these penalties include fines of up to $25,000, imprisonment for not more than six months, or both.

Section 10 of the ESA and related regulations provide for permits that may be granted to

authorize acts prohibited under Section 9, for scientific purposes or to enhance the propagation or survival of a listed species. States that have Cooperative Agreements under Section 6 of the ESA, may provide written authorization for take that occurs in the course of implementing conservation programs. For example, State agencies have authorized certain biologists to construct predator exclosures for piping plovers. It is also legal for employees or designated agents of certain Federal or State agencies to take listed species without a permit, if the action is necessary to aid sick, injured, or orphaned animals or to salvage or dispose of a dead specimen.

Section 10 also allows permits to be issued for take that is "incidental to, and not the purpose of, carrying out an otherwise lawful activity" if the Service determines that certain conditions have been met. An applicant for an incidental take permit must prepare a conservation plan that specifies the impacts of the take, steps the applicant will take to minimize and mitigate the impacts, funding that will be available to implement these steps, alternative actions to the take that the applicant considered, and the reasons why such alternatives are not being utilized. Section 7 of the ESA may be pertinent to beach managers and landowners in situations that have a Federal nexus. Section 7 requires Federal agencies to consult with the Service (or National Marine Fisheries Service for marine species) prior to authorizing, funding, or carrying out activities that may affect listed species. Section 7 also requires that these agencies use their authorities to further the conservation of listed species. Section 7 obligations have caused Federal land management agencies to implement piping plover protection measures that go beyond those required to avoid take, for example by conducting research on threats to piping plovers. Other examples of Federal activities that may affect piping plovers along the Atlantic Coast, thereby triggering Section 7 consultation, include permits for beach nourishment or disposal of dredged material (U.S. Army Corps of Engineers) and funding of beach restoration projects (Federal Emergency Management Authority).

Piping plovers, as well as other migratory birds such as least terns, common terns, American oystercatchers, laughing gulls, herring gulls, and great black-blacked gulls, their nests, and eggs are also protected under the Migratory Bird Treaty Act of 1918 (16 U.S.C. 703-712). Prohibited acts include pursuing, hunting, shooting, wounding, killing, trapping, capturing, collecting, or attempting such conduct. Violators may be fined up to $5000 and/or imprisoned for up to six months.

Almost all States within the breeding range of the Atlantic Coast piping plover population list the species as State threatened or endangered (Northeast Nongame Technical Committee 1993). Various laws and regulations may protect State-listed species from take, but the Service has not ascertained the adequacy of the guidelines presented in this document to meet the requirements of any State law.

II. LIFE HISTORY AND THREATS FROM HUMAN DISTURBANCE

Piping plovers are small, sand-colored shorebirds that nest on sandy, coastal beaches from South Carolina to Newfoundland. Since 1986, the Atlantic Coast population has been protected as a threatened species under provisions of the U.S. Endangered Species Act of 1973 (U.S. Fish and Wildlife Service 1985). The U.S. portion of the population was estimated at 875 pairs in 1993 (U.S. Fish and Wildlife Service 1993). Many characteristics of piping plovers contribute to their

susceptibility to take due to human beach activities.

LIFE HISTORY

Piping plovers begin returning to their Atlantic Coast nesting beaches in mid-March (Coutu *et al.* 1990, Cross 1990, Goldin 1990, MacIvor 1990, Hake 1993). Males establish and defend territories and court females (Cairns 1982). Eggs may be present on the beach from mid-April through late July. Clutch size is generally four eggs, and the incubation period2 usually lasts for 27-28 days. Piping plovers fledge only a single brood per season, but may renest several times if previous nests are lost. Chicks are precocial3 (Wilcox 1959, Cairns 1982). They may move hundreds of yards from the nest site during their first week of life (see Table 1, Summary of Chick Mobility Data). Chicks remain together with one or both parents until they fledge (are able to fly) at 25 to 35 days of age. Depending on date of hatching, flightless chicks may be present from mid-May until late August, although most fledge by the end of July (Patterson 1988, Goldin 1990, MacIvor 1990, Howard *et al.* 1993).

Piping plover nests are situated above the high tide line on coastal beaches, sand flats at the ends of sandspits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, and washover areas cut into or between dunes. They may also nest on areas where suitable dredge material has been deposited. Nest sites are shallow scraped depressions in substrates ranging from fine grained sand to mixtures of sand and pebbles, shells or cobble (Bent 1929, Burger 1987a, Cairns 1982, Patterson 1988, Flemming *et al.* 1990, MacIvor 1990, Strauss 1990).

Nests are usually found in areas with little or no vegetation although, on occasion, piping plovers will nest under stands of American beachgrass (Ammophila breviligulata) or other vegetation (Patterson 1988, Flemming *et al.* 1990, MacIvor 1990). Plover nests may be very difficult to detect, especially during the 6-7 day egg-laying phase when the birds generally do not incubate (Goldin 1994).

Plover foods consist of invertebrates such as marine worms, fly larvae, beetles, crustaceans or mollusks (Bent 1929, Cairns 1977, Nicholls 1989). Feeding areas include intertidal portions of ocean beaches, washover areas, mudflats, sandflats, wrack lines4, and shorelines of coastal ponds, lagoons or salt marshes (Gibbs 1986, Coutu *et al.* 1990, Hoopes *et al.* 1992, Loegering 1992, Goldin 1993). Studies have shown that the relative importance of various feeding habitat types may vary by site (Gibbs 1986, Coutu *et al.* 1990, McConnaughey *et al.* 1990, Loegering 1992, Goldin 1993, Hoopes 1993) and by stage in the breeding cycle (Cross 1990). Adults and chicks on a given site may use different feeding habitats in varying proportion (Goldin *et al.* 1990). Feeding activities of chicks may be particularly important to their survival. Cairns (1977) found that piping plover chicks typically tripled their weight during the first two weeks post-hatching; chicks that failed to achieve at least 60% of this weight gain by day 12 were unlikely to survive. During courtship, nesting, and brood rearing, feeding territories are generally contiguous to nesting territories (Cairns 1977), although instances where brood-rearing areas are widely separated from nesting territories are not uncommon . Feeding activities of both adults and chicks may occur during all hours of the day and night (Burger 1993) and at all stages in the tidal cycle (Goldin 1993, Hoopes 1993).

THREATS FROM NONMOTORIZED BEACH ACTIVITIES

Sandy beaches that provide nesting habitat for piping plovers are also attractive recreational habitats for people and their pets. Nonmotorized recreational activities can be a source of both direct mortality and harassment of piping plovers. Pedestrians on beaches may crush eggs (Burger 1987b, Hill 1988, Shaffer and Laporte 1992, Cape Cod National Seashore 1993, Collazo *et al.* 1994). Unleashed dogs may chase plovers (McConnaughey *et al.* 1990), destroy nests (Hoopes *et al.* 1992), and kill chicks (Cairns and McLaren 1980).

Pedestrians may flush incubating plovers from nests exposing eggs to avian predators or causing excessive cooling or heating of eggs. Repeated exposure of shorebird eggs on hot days may cause overheating, killing the embryos (Bergstrom 1991). Excessive cooling may kill embryos or retard their development, delaying hatching dates (Welty 1982). Pedestrians can also displace unfledged chicks (Strauss 1990, Burger 1991, Hoopes *et al.* 1992, Loegering 1992, Goldin 1993). Fireworks are highly disturbing to piping plovers (Howard *et al.* 1993). Plovers are particularly intolerant of kites, compared with pedestrians, dogs, and vehicles; biologists believe this may be because plovers perceive kites as potential avian predators (Hoopes *et al.* 1992).

THREATS FROM MOTOR VEHICLES

Unrestricted use of motorized vehicles on beaches is a serious threat to piping plovers and their habitats. Vehicles can crush eggs (Wilcox 1959; Tull 1984; Burger 1987b; Patterson *et al.* 1991; United States of America v. Breezy Point Cooperative, Inc., U.S. District Court, Eastern District of New York, Civil Action No. CV-90-2542, 1991; Shaffer and Laporte 1992), adults, and chicks. In Massachusetts and New York, biologists documented 14 incidents in which 18 chicks and 2 adults were killed by vehicles between 1989 and 1993 (Melvin *et al.* 1994). Goldin (1993) compiled records of 34 chick mortalities (30 on the Atlantic Coast and 4 on the Northern Great Plains) due to vehicles. Many biologists that monitor and manage piping plovers believe that many more chicks are killed by vehicles than are found and reported (Melvin *et al.* 1994). Beaches used by vehicles during nesting and brood-rearing periods generally have fewer breeding plovers than available nesting and feeding habitat can support. In contrast, plover abundance and productivity has increased on beaches where vehicle restrictions during chickrearing periods have been combined with protection of nests from predators (Goldin 1993; S.Melvin, pers. comm., 1993).

Typical behaviors of piping plover chicks increase their vulnerability to vehicles. Chicks frequently move between the upper berm or foredune and feeding habitats in the wrack line and intertidal zone. These movements place chicks in the paths of vehicles driving along the berm or through the intertidal zone. Chicks stand in, walk, and run along tire ruts, and sometimes have difficulty crossing deep ruts or climbing out of them (Eddings *et al.* 1990, Strauss 1990, Howard *et al.* 1993). Chicks sometimes stand motionless or crouch as vehicles pass by, or do not move quickly enough to get out of the way (Tull 1984, Hoopes *et al.* 1992, Goldin 1993). Wire fencing placed around nests to deter predators (Rimmer and Deblinger 1990, Melvin *et al.* 1992) is ineffective in protecting chicks from vehicles because chicks typically leave the nest within a day after hatching and move extensively along the beach to feed.

Vehicles may also significantly degrade piping plover habitat or disrupt normal behavior patterns. They may harm or harass plovers by crushing wrack into the sand and making it unavailable as cover or a foraging substrate, by creating ruts that may trap or impede movements of chicks, and by preventing plovers from using habitat that is otherwise suitable (MacIvor 1990, Strauss 1990, Hoopes *et al.* 1992, Goldin 1993).

III. GUIDELINES FOR PROTECTING PIPING PLOVERS FROM RECREATIONAL DISTURBANCE

The Service recommends the following protection measures to prevent direct mortality or harassment of piping plovers, their eggs, and chicks.

MANAGEMENT OF NONMOTORIZED RECREATIONAL USES

On beaches where pedestrians, joggers, sun-bathers, picnickers, fishermen, boaters, horseback riders, or other recreational users are present in numbers that could harm or disturb incubating plovers, their eggs, or chicks, areas of at least 50 meter-radius around nests above the high tide line should be delineated with warning signs and symbolic fencing. Only persons engaged in rare species monitoring, management, or research activities should enter posted areas. These areas should remain fenced as long as viable eggs or unfledged chicks are present. Fencing is intended to prevent accidental crushing of nests and repeated flushing of incubating adults, and to provide an area where chicks can rest and seek shelter when large numbers of people are on the beach.

Available data indicate that a 50 meter buffer distance around nests will be adequate to prevent harassment of the majority of incubating piping plovers. However, fencing around nests should be expanded in cases where the standard 50 meter-radius is inadequate to protect incubating adults or unfledged chicks from harm or disturbance. Data from various sites distributed across the plover's Atlantic Coast range indicates that larger buffers may be needed in some locations. This may include situations where plovers are especially intolerant of human presence, or where a 50 meter-radius area provides insufficient escape cover or alternative foraging opportunities for plover chicks.

In cases where the nest is located less than 50 meters above the high tide line, fencing should be situated at the high tide line, and a qualified biologist should monitor responses of the birds to passersby, documenting his/her observations in clearly recorded field notes. Providing that birds are not exhibiting signs of disturbance, this smaller buffer may be maintained in such cases. On portions of beaches that receive heavy human use, areas where territorial plovers are observed should be symbolically fenced to prevent disruption of territorial displays and courtship. Since nests can be difficult to locate, especially during egg-laying, this will also prevent accidental crushing of undetected nests. If nests are discovered outside fenced areas, fencing should be extended to create a sufficient buffer to prevent disturbance to incubating adults, eggs, or unfledged chicks.

Pets should be leashed and under control of their owners at all times from April 1 to August 31 on beaches where piping plovers are present or have traditionally nested. Pets should be

prohibited on these beaches from April 1 through August 31 if, based on observations and experience, pet owners fail to keep pets leashed and under control.

Kite flying should be prohibited within 200 meters of nesting or territorial adult or unfledged juvenile piping plovers between April 1 and August 31. Fireworks should be prohibited on beaches where plovers nest from April 1 until all chicks are fledged. (See the Service's February 4, 1997 Guidelines for Managing Fireworks in the Vicinity of Piping Plovers and Seabeach Amaranth on the U.S. Atlantic Coast.)

MOTOR VEHICLE MANAGEMENT

The Service recommends the following minimum protection measures to prevent direct mortality or harassment of piping plovers, their eggs, and chicks on beaches where vehicles are permitted. Since restrictions to protect unfledged chicks often impede vehicle access along a barrier spit, a number of management options affecting the timing and size of vehicle closures are presented here. Some of these options are contingent on implementation of intensive plover monitoring and management plans by qualified biologists. It is recommended that landowners seek concurrence with such monitoring plans from either the Service or the State wildlife agency.

Protection of Nests

All suitable piping plover nesting habitat should be identified by a qualified biologist and delineated with posts and warning signs or symbolic fencing on or before April 1 each year. All vehicular access into or through posted nesting habitat should be prohibited. However, prior to hatching, vehicles may pass by such areas along designated vehicle corridors established along the outside edge of plover nesting habitat. Vehicles may also park outside delineated nesting habitat, if beach width and configuration and tidal conditions allow. Vehicle corridors or parking areas should be moved, constricted, or temporarily closed if territorial, courting, or nesting plovers are disturbed by passing or parked vehicles, or if disturbance is anticipated because of unusual tides or expected increases in vehicle use during weekends, holidays, or special events.

If data from several years of plover monitoring suggests that significantly more habitat is available than the local plover population can occupy, some suitable habitat may be left unposted if the following conditions are met:

1. The Service OR a State wildlife agency that is party to an agreement under Section 6 of the ESA provides written concurrence with a plan that:
A. Estimates the number of pairs likely to nest on the site based on the past monitoring and regional population trends.

AND

B. Delineates the habitat that will be posted or fenced prior to April 1 to assure a high probability that territorial plovers will select protected areas in which to court and nest. Sites where nesting or courting plovers were observed during the

last three seasons as well as other habitat deemed most likely to be pioneered by plovers should be included in the posted and/or fenced area.

AND

C. Provides for monitoring of piping plovers on the beach by a qualified biologist(s). Generally, the frequency of monitoring should be not less than twice per week prior to May 1 and not less than three times per week thereafter. Monitoring should occur daily whenever moderate to large numbers of vehicles are on the beach. Monitors should document locations of territorial or courting plovers, nest locations, and observations of any reactions of incubating birds to pedestrian or vehicular disturbance.

AND

2. All unposted sites are posted immediately upon detection of territorial plovers.

Protection of Chicks

Sections of beaches where unfledged piping plover chicks are present should be temporarily closed to all vehicles not deemed essential. (See the provisions for essential vehicles below.) Areas where vehicles are prohibited should include all dune, beach, and intertidal habitat within the chicks' foraging range, to be determined by either of the following methods:

1. The vehicle free area should extend 1000 meters on each side of a line drawn through the nest site and perpendicular to the long axis of the beach. The resulting 2000 meterwide area of protected habitat for plover chicks should extend from the ocean-side low water line to the bay-side low water line or to the farthest extent of dune habitat if no bay-side intertidal habitat exists. However, vehicles may be allowed to pass through portions of the protected area that are considered inaccessible to plover chicks because of steep topography, dense vegetation, or other naturally-occurring obstacles.

OR

2. The Service OR a State wildlife agency that is party to an agreement under Section 6 of the ESA provides written concurrence with a plan that:

A. Provides for monitoring of all broods during the chick-rearing phase of the breeding season and specifies the frequency of monitoring.

AND

B. Specifies the minimum size of vehicle-free areas to be established in the vicinity of unfledged broods based on the mobility of broods observed on the site in past years and on the frequency of monitoring. Unless substantial data from past years show that broods on a site stay very close to their nest locations, vehicle-free areas should extend at least 200 meters on each side of the nest site

during the first week following hatching. The size and location of the protected area should be adjusted in response to the observed mobility of the brood, but in no case should it be reduced to less than 100 meters on each side of the brood. In some cases, highly mobile broods may require protected areas up to 1000 meters, even where they are intensively monitored. Protected areas should extend from the ocean-side low water line to the bay-side low water line or to the farthest extent of dune habitat if no bay-side intertidal habitat exists. However, vehicles may be allowed to pass through portions of the protected area that are considered inaccessible to plover chicks because of steep topography, dense vegetation, or other naturally-occurring obstacles. In a few cases, where several years of data documents that piping plovers on a particular site feed in only certain habitat types, the Service or the State wildlife management agency may provide written concurrence that vehicles pose no danger to plovers in other specified habitats on that site.

Timing of Vehicle Restrictions in Chick Habitat

Restrictions on use of vehicles in areas where unfledged plover chicks are present should begin on or before the date that hatching begins and continue until chicks have fledged. For purposes of vehicle management, plover chicks are considered fledged at 35 days of age or when observed in sustained flight for at least 15 meters, whichever occurs first.

When piping plover nests are found before the last egg is laid, restrictions on vehicles should begin on the 26th day after the last egg is laid. This assumes an average incubation period of 27 days, and provides a 1 day margin of error.

When plover nests are found after the last egg has been laid, making it impossible to predict hatch date, restrictions on vehicles should begin on a date determined by one of the following scenarios:

1) With intensive monitoring: If the nest is monitored at least twice per day, at dawn and dusk (before 0600 hrs and after 1900 hrs) by a qualified biologist, vehicle use may continue until hatching begins. Nests should be monitored at dawn and dusk to minimize the time that hatching may go undetected if it occurs after dark. Whenever possible, nests should be monitored from a distance with spotting scope or binoculars to minimize disturbance to incubating plovers.
OR

2) Without intensive monitoring: Restrictions should begin on May 15 (the earliest probable hatch date). If the nest is discovered after May 15, then restrictions should start immediately.

If hatching occurs earlier than expected, or chicks are discovered from an unreported nest, restrictions on vehicles should begin immediately.

If ruts are present that are deep enough to restrict movements of plover chicks, then restrictions

on vehicles should begin at least 5 days prior to the anticipated hatching date of plover nests. If a plover nest is found with a complete clutch, precluding estimation of hatching date, and deep ruts have been created that could reasonably be expected to impede chick movements, then restrictions on vehicles should begin immediately.

Essential Vehicles

Because it is impossible to completely eliminate the possibility that a vehicle will accidently crush an unfledged plover chicks, use of vehicles in the vicinity of broods should be avoided whenever possible. However, the Service recognizes that life-threatening situations on the beach may require emergency vehicle response. Furthermore, some "essential vehicles" may be required to provide for safety of pedestrian recreationists, law enforcement, maintenance of public property, or access to private dwellings not otherwise accessible. On large beaches, maintaining the frequency of plover monitoring required to minimize the size and duration of vehicle closures may necessitate the use of vehicles by plover monitors.

Essential vehicles should only travel on sections of beaches where unfledged plover chicks are present if such travel is absolutely necessary and no other reasonable travel routes are available. All steps should be taken to minimize number of trips by essential vehicles through chick habitat areas. Homeowners should consider other means of access, eg. by foot, water, or shuttle services, during periods when chicks are present.

The following procedures should be followed to minimize the probability that chicks will be crushed by essential (non-emergency) vehicles:

1. Essential vehicles should travel through chick habitat areas only during daylight hours, and should be guided by a qualified monitor who has first determined the location of all unfledged plover chicks.

2. Speed of vehicles should not exceed five miles per hour.

3. Use of open 4-wheel motorized all-terrain vehicles (ATVs) or non-motorized allterrain bicycles is recommended whenever possible for monitoring and law enforcement because of the improved visibility afforded operators.

4. A log should be maintained by the beach manager of the date, time, vehicle number and operator, and purpose of each trip through areas where unfledged chicks are present. Personnel monitoring plovers should maintain and regularly update a log of the numbers and locations of unfledged plover chicks on each beach. Drivers of essential vehicles should review the log each day to determine the most recent number and location of unfledged chicks.

Essential vehicles should avoid driving on the wrack line, and travel should be infrequent enough to avoid creating deep ruts that could impede chick movements. If essential vehicles are creating ruts that could impede chick movements, use of essential vehicles should be further reduced and, if necessary, restricted to emergency vehicles only.

SITE-SPECIFIC MANAGEMENT GUIDANCE

The guidelines provided in this document are based on an extensive review of the scientific literature and are intended to cover the vast majority of situations likely to be encountered on piping plover nesting sites along the U.S. Atlantic Coast. However, the Service recognizes that site-specific conditions may lead to anomalous situations in which departures from this guidance may be safely implemented. The Service recommends that landowners who believe such situations exist on their lands contact either the Service or the State wildlife agency and, if appropriate, arrange for an on-site review. Written documentation of agreements regarding departures from this guidance is recommended.

In some unusual circumstances, Service or State biologists may recognize situations where this guidance provides insufficient protection for piping plovers or their nests. In such a case, the Service or the State wildlife agency may provide written notice to the landowner describing additional measures recommended to prevent take of piping plovers on that site.

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APPENDIX G

Guidelines for Managing Fireworks in the Vicinity of
Piping Plovers and Seabeach Amaranth
on the U.S. Atlantic Coast

GUIDELINES FOR MANAGING FIREWORKS IN THE VICINITY OF PIPING PLOVERS AND SEABEACH AMARANTH ON THE U.S. ATLANTIC COAST

February 4, 1997

The following is provided as guidance to Federal agencies, landowners, commercial fireworks companies, and fireworks event sponsors seeking to avoid adverse effects on piping plovers and seabeach amaranth. They are intended to advise Federal agencies that conduct, fund, or authorize fireworks activities regarding the measures needed to avoid adverse effects on listed species, thereby averting the need for formal consultation under Section 7 of the Endangered Species Act (ESA). These practices also constitute the U.S. Fish and Wildlife Service's (Services's) best professional advice to non-Federal entities on avoiding take of piping plovers under Section 9 of the ESA.

These guidelines supplement information about protection of piping plovers from a variety of recreational activities, provided in the Service's April 15, 1994 *Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act* (appended)[1].

Seabeach amaranth, a threatened plant species protected under the Endangered Species Act (ESA), occurred historically along coastal beaches from southern Massachusetts to South Carolina. At the present time it is found only on Long Island, New York; North Carolina; and South Carolina. Section 7 of the ESA requires Federal agencies to consult with the Service prior to authorizing, funding, or carrying out activities that directly or indirectly affect listed plants; this requirement is applicable to permits related to fireworks events that are issued by the U.S. Coast Guard.

Potential Impacts Related to Fireworks Displays

Direct Impacts

Fireworks are highly disturbing to piping plovers. Fireworks early in the breeding season may cause plovers conducting courtship activities to abandon their territories. Direct injury can be caused by the explosions or debris, and piping plovers and terns (which often nest adjacent to or near plovers) will often abandon their nests and broods during fireworks displays, exposing eggs and chicks to weather and predators. If a flightless chick were to become permanently separated from its parents during the confusion, mortality would be almost certain.
Several situations where fireworks caused severe adverse effects on least terns, colonial nesting birds often found in the vicinity of piping plovers, serve as indicators of the effects that pyrotechnics can exert on beach-nesting birds. An August 1993 fireworks display in New Jersey

[1] Copies of the 1994 Guidelines for general recreational activities are also available, on request, from the U.S. Fish and Wildlife Service, Wier Hill Road, Sudbury, MA 01776, Attn: Anne Hecht; telephone 508-443-4325; fax 508-443-2898.

caused permanent abandonment of a least tern colony located more than 250 m away, and a 1994 New Jersey fireworks display caused temporary abandonment and displays of distress by terns within a colony located more than 3/4 mile away. Incidents in New York where piping plovers were disturbed by fireworks also caused prolonged disturbance to least terns and black skimmers nesting nearby.

Seabeach amaranth can be directly affected by launch activities if they occur in areas where the plants may be crushed or damaged by launch personnel or equipment.

Indirect Impacts

In addition to adverse effects from the noise and lights of the pyrotechnics, commercial fireworks displays often draw large crowds that may pose threats to nearby plovers. These crowds may be situated at some distance from the actual launch site, for example, across an inlet. Potential indirect impacts that may adversely affect piping plovers include: spectators walking through and/or throwing objects (including illegal pyrotechnics) into plover nesting and brood-rearing areas; additional off-road vehicle patrols by public safety personnel; increased boat landings by spectators on relatively remote stretches of beach; low-flying aircraft, including helicopter patrols and personal spectator aircraft; additional trash (which attracts predators). Signs and symbolic fences that are adequate for the purpose of alerting daytime beach users to locations of plover breeding areas are often insufficient to prevent accidental entry by fireworks spectators wandering in the dark.

Potential indirect adverse effects on seabeach amaranth include trampling or crushing of unprotected plants by pedestrian or vehicular traffic on the beach.

Measures for Avoiding and Monitoring Direct and Indirect Impacts of Fireworks Events

Direct Impacts

Fireworks displays including launch areas and debris fallout areas should be located to avoid disturbance of breeding piping plovers. In general, the Service recommends that the launch site be located a minimum of 3/4 mile from the nearest plover nesting and/or foraging area. Access routes for personnel deploying the fireworks and other public safety personnel (including fire prevention/suppression and law enforcement officers) should conform with the vehicle management recommendations contained in the *Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act.* Launch sites should also be located to prevent trampling any seabeach amaranth plants.

Indirect Impacts

Event sponsors should plan and implement measures to assure that spectators will not walk through and/or throw objects into plover nesting and brood-rearing areas. Sufficient law enforcement and other personnel must also be on-site during these events to enforce plover protection measures and prevent use of illegal fireworks in the vicinity of the birds.

1. Plover habitats in the vicinity of where spectators may congregate should be intensively surveyed by qualified biologists[2] for at least four days prior to the event to locate nests, adult plovers, chicks, and/or post-fledged juveniles. For events prior to July 1, surveyors should also search for territorial and/or courting adults that have not yet established nests or may be preparing to re-nest. In New York, potential habitat for seabeach amaranth should be surveyed to locate any seabeach amaranth plants.

2. Plover habitats should be symbolically fenced in accordance with the Service's *Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act* (see pages 7-8). Seabeach amaranth plants should be symbolically fenced to provide a minimum 3 meter buffer zone around individual plants or groups of plants.

3. Additional protection measures recommended to avoid impacts that may occur when the large crowds are drawn to the beach at night include[3]:

   a. Close parking lots and beach access points in the vicinity of breeding plovers.

   b. Increase the size of symbolically fenced areas around plover nesting areas to provide extra buffers between birds and pedestrians that may be on the beach. The size of buffers should be appropriate for the size of the anticipated crowd; for large crowds, buffers should be expanded from the standard 50 meters to a total of 100 meters from established nests.

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[2] State wildlife agencies and private environmental groups often conduct plover monitoring activities and can be consulted for available information about plover breeding locations. However, intensity of surveys needed to avoid adverse effects from fireworks events will often exceed those routinely conducted by these wildlife agencies/organizations. Arrangements and commitments for added surveys for these events are the responsibility of the permitting agencies and/or event sponsors. It is recommended that these arrangements be made well in advance of the potential event, due to limited availability of qualified personnel.

[3] For extremely large fireworks events, additional protection measures may be needed, including: issuing air traffic advisory for all aircraft to remain >1000' above sensitive areas; issuing mariners advisory telling boaters not to land in sensitive areas; boat patrols; extensive advanced publicity advising spectators where they *should* go to watch the fireworks and about closed areas; training about protection needs of rare plants and/or animals for law enforcement personnel.

c. Increase the visibility of fencing using reflectorized tape or by substituting snowfences, plastic orange highway construction fences, or wire mesh fences for string fencing, as string fences are very difficult to see at night. Snowfences and highway construction fences should be removed the next day if there is any chance that they will impede chick movements.

d. Fence and post foraging territories of unfledged chicks, as delineated by a qualified biologist, especially in areas where large crowds are anticipated and/or if the day of the event is especially hot (since heat often deters chick foraging during the daytime, increasing the birds' reliance on evening feeding).

e. Provide adequate numbers (consistent with anticipated numbers of spectators) of monitors and law enforcement personnel in the vicinity of plover breeding areas or seabeach amaranth locations to patrol fenced areas from the time when spectators begin congregating on the beach until the crowd disperses after the event. Assure that monitors and enforcement personnel receive accurate current information about the locations of threatened birds and plants so that they can minimize any disruptions from their own activities.

f. Prohibit all pets on the beach during the event and ensure compliance with this prohibition.

4. Remove any trash or litter from the beach immediately following the event. However, any trash located within fenced areas should be left until daylight and then removed by or under the supervision of plover monitors. Further, vehicles should not be used at night to remove trash within 100 meters of unfledged plover chicks.

5. In order to gauge the effectiveness of the measures 3 and 4, the following data should be collected:

a. Locations and status of all adult plovers, nests, and chicks within 1/4 mile of spectator viewing areas should be determined by a qualified biologist on the day of the event and again on the following day.

b. Counts of human and dog tracks that intersect the perimeter of symbolically fenced areas before and after the event.

c. Counts of any persons actually observed inside symbolically fenced areas during the event.

d. Counts of any instances of illegal pyrotechnics used on the beach during the event.

e. Counts of trash/litter items inside symbolically fenced areas before and after the event. For very large areas or areas that have substantial amounts of trash before the event, trash counts may be conducted in sample plots.

f. Count of breaks in symbolic fences.

6. Except when responding to an actual emergency situation, all law enforcement, fire department, public works, fireworks deployment, and other vehicles in the vicinity of breeding plovers should only be operated in conformance with the Service's *Guidelines for Managing Recreational Activities in Piping Plover Breeding Habitat on the U.S. Atlantic Coast to Avoid Take Under Section 9 of the Endangered Species Act* (see discussion of Essential Vehicles, pages 13-14).

APPENDIX H

Piping Plover Nesting Results in New Jersey: 2012
(Prepared by the New Jersey Endangered and Nongame Species Program)

Table 1. Number of pairs of piping plovers at New Jersey nesting sites: 2003-2012.

	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Sandy Hook NRA	*38*	*32*	*22*	*22*	*30*	*32*[1]	*35*	*45*	*49*	*50*
Coast Guard	*8*	*7*	*3*	*4*	*4*	*4*	*4*	*5*	*4*	*4*
North Beach	*9*	*10*	*6*	*4*	*8*	*8*	*9*	*13*	*14*	*14*
North Gunnison	*5*	*3*	*2*	*3*	*4*	*7*	*9*	*9*	*9*	*13*
South Gunnison	*1*	*1*	*0*	*0*	*1*	*2*	*5*	*5*	*4*	*5*
D-Lot	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*
Skeleton Hill Island	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*0*	*1*	*0*
Critical Zone	*4*	*3*	*3*	*3*	*4*	*4*	*2*	*6*	*5*	*6*
Hidden Beach	*4*	*3*	*3*	*3*	*4*	*2*	*3*	*3*	*5*	*4*
Fee Beach	*6*	*4*	*4*	*4*	*4*	*5*[1]	*3*	*3*	*5*	*3*
South Fee Beach	*1*	*1*	*1*	*1*	*1*	*2*[1]	*0*	*1*	*1*	*1*
Sea Bright North	7	5	7	7	8	8	6	3	2	2
Monmouth Beach North	2	4	3	3	1	1	1	2	0	0
Seven Presidents Park	1	1	1	2	3	3	2	2	2	0
Long Branch	1	0	0	0	0	0	0	0	0	0
Region 2 subtotal	**49**	**42**	**33**	**34**	**42**	**44**	**44**	**52**	**53**	**52**
Sea Girt - Wreck Pond	1	1	1	0	1	0	1	0	0	1
Sea Girt - NGTC	0	0	0	0	1	0	0	0	0	0
Island Beach SP - Dike	2	3	2	0	0	0	0	0	0	0
Barnegat Light	3	3	4	3	4	3	1	3	3	1
Region 3 subtotal	**6**	**7**	**7**	**3**	**6**	**3**	**2**	**3**	**3**	**2**
Holgate	*13*	*16*	*13*	*16*	*14*	*11*	*7*	*10*	*6*	*14*
Little Beach	*19*	*19*	*11*	*12*	*17*	*12*	*10*	*13*	*17*	*18*
North Brigantine NA	17	8	8	8	8	8	6	3	5	8
Region 4 subtotal	**49**	**43**	**32**	**36**	**39**	**31**	**23**	**26**	**28**	**40**
Seaview Harbor Marina	0	0	1[1]	0	0	0	0	0	1	1
Ocean City - North	2	1	1[1]	0	0	0	0	0	0	0
Ocean City - Center	8	8	5	7	4	3	1	0	1	0
Region 5 subtotal	**10**	**9**	**6**	**7**	**4**	**3**	**1**	**0**	**2**	**1**
Corson's Inlet SP	2	3	2	2	2	1	2	0	0	0
Strathmere NA	0	0	1	1	0	0	0	1	1	1
Strathmere (Upper Twp.)	1	1	1	0	0	0	0	1	2	2
Townsend's Inlet	1	1	1	0	0	0	0	0	0	0
Avalon - Dunes	8	8	5	4	5	4	4	5	5	5
Region 6 subtotal	**12**	**13**	**10**	**7**	**7**	**5**	**6**	**7**	**8**	**8**
Stone Harbor Point	6	9	10	17	17	11	15	9	10	9
Champagne Island	0	1	1	2	1	0	0	0	0	0
N. Wildwood - Hereford	3	4	3	3	2	1	2	2	1	1
Two-Mile Beach	*2*	*1*	*1*	*1*	*2*	*0*	*0*	*1*	*0*	*0*
Cape May NWR	*0*	*0*	*0*	*0*	*1*	*0*	*0*	*0*	*0*	*0*
Coast Guard - LSU	*2*	*1*	*1*	*1*	*1*	*0*	*0*	*1*	*0*	*0*
Coast Guard - TRACEN	4	1	3	0	2	1	0	0	0	2
Cape May City	0	1	0	0	0	1	1	0	0	0
Cape May Meadows	3	4	5	6	7	11	11	8	6	6
The Nature Conservancy	*2*	*1*	*4*[1]	*3*	*4*	*7*	*7*	*5*	*4*	*3*
Cape May Point SP[1]	1	3	2[1]	3	3	4	4	3	2	3
Region 7 subtotal	**18**	**21**	**23**	**29**	**31**	**25**	**29**	**20**	**17**	**18**
Total Pairs	**144**	**135**	**111**	**116**	**129**	**111**	**105**	**108**	**111**	**121**
Pairs at NJDFW sites	**70**	**66**	**61**	**62**	**62**	**49**	**46**	**34**	**35**	**36**

[1] The same pair nested at two nearby sites. Therefore "subtotals" and "totals" will be less than sum of individual sites.
Note: Sites in italics were monitored by agencies other than NJDFW: Sandy Hook NRA by the National Park Service, Holgate and Little Beach by USFWS - Edwin B. Forsythe NWR, Two-Mile Beach by USFWS - Cape May NWR, Cape May Meadows-TNC by The Nature Conservancy - Delaware Bayshores Office.

Appendix E.

Cultural Resources

Cultural Resources

The USACE has determined that the Area of Potential Effect (APE) for the selected plan includes the beaches and intertidal areas from Hereford Inlet to Cape May inlet, marking the northern and southern limits, and from the existing dunes to the intertidal area marking the eastern and western limits. The limits of construction disturbance for the selected plan are located within the APE.

Although there are several recorded historic properties eligible for or listed on the National Register of Historic Places (NRHP) within the vicinity of the APE for the selected plan, the USACE has determined that dune and berm construction along approximately 4.5 miles from Hereford Inlet to Cape May Inlet using recently accreted sand from the intertidal zone from the southern end of Five Mile Island will have *No Effect*.

A cultural resource assessment of the proposed intertidal sand source was conducted by FEMA as part of the Section 106 review for post-Hurricane Irene beach restoration of North Wildwood. An assessment of the beach in the adjacent communities of Wildwood Crest in the south to North Wildwood was conducted to determine the sensitivity of below ground archaeological resources. Several aspects were analyzed including the project's proximity to know archaeological resources, waterways and historic properties as well as the site's environmental characteristics such as spoil analysis and previous ground disturbing activities within the project APE, which is roughly the APE of the selected plan.

Remnants of the *Nancy*, a revolutionary war brig set afire by troops at Turtle Gut Inlet (Site 28CM0013) are located southwest of the APE and site 28CM0008 is currently underneath the existing Wildwood Boardwalk. There are no structures within the project APE; however the Chateau Blue Motes, the Hereford Inlet Lighthouse and the J. Thompson Baker House are all listed on the NRHP, but will not be affected. Also, the Wildwood Shore Resort Historic District runs parallel to the beach and is within the project viewshed but will also not be affected.

The APE is a previously disturbed, engineered beaches. The proposed project will collect, transport and place sand entirely within the previously disturbed areas. No part of the proposed undertaking is located within an archaeologically sensitive area, and no historic properties are within the APE. Therefore, per 36 CFR 800.3(a)(1), no historic properties eligible for or listed on the NRHP will be affected by the selected plan activities.

Appendix F.

Real Estate Plan

US Army Corps of Engineers
Philadelphia District

Hereford Inlet to Cape May Inlet

Cape May County,
New Jersey

New Jersey Shore Protection
Study

Real Estate Plan

Prepared by:

Heather Sachs, Baltimore

District

APRIL 2014

U.S. ARMY CORPS OF ENGINEERS,
North Atlantic Division

REAL ESTATE PLAN
FOR THE
New Jersey Shore Protection Study
Hereford to Cape May Inlet Feasibility Study
Cape May County, New Jersey

1. GENERAL

2. REAL ESTATE REQUIREMENTS
   a. Description of Land, Easements, Rights of Way and Access Road Requirements for Project
   b. Standard Estates
   c. Non-Standard Estates
   d. Current Ownership
   e. Real Estate Mapping

3. EXISTING FEDERAL PROJECTS

4. EXISTING FEDERALLY OWNED LANDS

5. LANDS OWNED BY THE NON-FEDERAL SPONSOR

6. NAVIGATIONAL SERVITUDE

7. INDUCED FLOODING

8. BASELINE COST ESTIMATE FOR REAL ESTATE

9. PUBLIC LAW 91-646 RELOCATIONS

10. MINERAL ACTIVITY

11. TIMBER RIGHTS

12. ASSESSMENT OF NON-FEDERAL SPONSOR ACQUISITION CAPABILITY

13. ZONING

14. ACQUISITION SCHEDULE

15. UTILITY AND FACILITY RELOCATIONS

16. ENVIRONMENTAL CONCERNS

17. ATTITUDES OF THE LANDOWNERS

18. NOTIFICATION TO NON-FEDERAL SPONSOR

19. RISK ANALYSIS

Abstract of Project Data:

Project Name: Hereford Inlet to Cape May Inlet Shore Protection Study

Location: Cape May County, New Jersey

Project Purpose: Storm Damage Reduction

Acreage: Perpetual Storm Damage Reduction Easement 606.42

Borrow Easement 245.00

Gross Appraisal Estimate $1,018,972

Estimate with (25%) Contingency: $1,273,511

Project Non-Federal Sponsor (NFS): New Jersey Department of Environmental Protection

1. GENERAL:

This Real Estate Plan is in support of the Hereford Inlet to Cape May Inlet Feasibility Study Report Decision. The New Jersey Shore Protection Study was completed under authority of resolutions adopted by the Committee on Public Works and Transportation, U.S. House of Representatives, and the Committee on Environment and Public Works, U.S. Senate, dated December 1987. The resulting Report of Limited Reconnaissance, completed in September 1990, asserted that the situation between the Hereford Inlet and Cape May Inlet was not critical and recommended that other areas along the New Jersey Coast required immediate attention.

A subsequent increase in shoreline problems developing in the Hereford-Cape May Inlet area in the 1990's generated a letter of urgency in 2002 from the current Non-Federal Sponsor for this project, the New Jersey Department of Environmental Protection (NJDEP). The resulting 2002 Hereford Inlet to Cape May Inlet Reconnaissance Study/Preliminary Financial Analysis was completed in January 2002 and approved by North Atlantic Division by letter dated January 28, 2002. The Feasibility Cost-Sharing Agreement was signed between the Philadelphia District and the NJDEP on September 30, 2002. The damage and destruction caused to the barrier island communities of the New Jersey shore by Hurricane Sandy in October 2012 prompted Congressional passage of the Disaster Relief Appropriations Act of 2013, as signed into law on January 29, 2013, to address outstanding shoreline issues. The passage of additional available funding for shoreline protection projects accelerated the timeline for the completion of in-process feasibility reports.

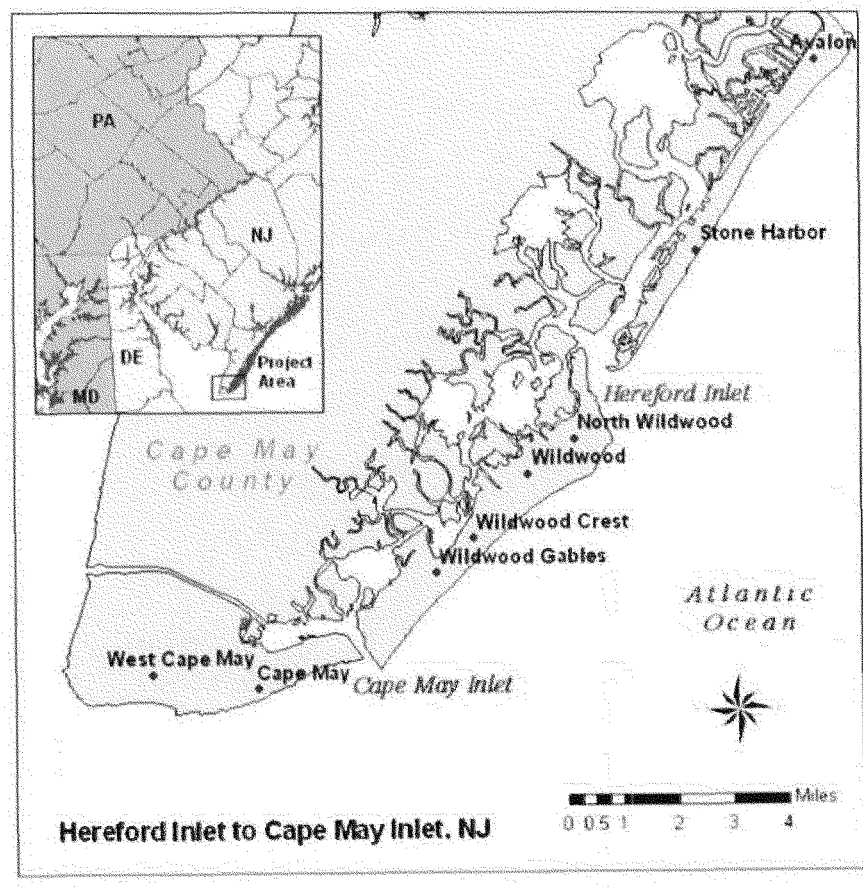
The study area is a barrier island located in Cape May County, New Jersey, bordered to the north by Hereford Inlet and to the south by Cape May Inlet (Figure 1). Known locally as "Five Mile Island," municipalities on the island include North Wildwood, Wildwood, Wildwood Crest and a portion of Lower Township. The study area is a popular resort community with the majority of vacationers to the island visiting Wildwood. The southern end of the island is comprised of the Cape May National Wildlife Refuge (managed by the U.S. Fish and Wildlife Service) and the former U.S. Coast Guard Electronics Center (managed jointly by the U.S. Coast Guard and the U.S. Fish and Wildlife Service). No federal lands are included in the project.

Description of Recommended Plan: The primary purpose of this project is to provide hurricane and storm damage protection. The selected plan for this project extends approximately 4.5 miles from Hereford Inlet to Cape May Inlet and will include the towns of North Wildwood, Wildwood, Wildwood Crest and Lower. The project will include the creation of a 16' North American Vertical Datum (NAVD) 88 dune with a 25' wide crest and 75' wide berm base, including a 30' offset for maintenance access and dune taper, at an elevation of 6.5' NAVD using sand back-passed from a beach borrow source on a four-year nourishment cycle. The sand for the dune and berm will be pumped from the southern borrow area using mobile backpassing technology to hydraulically pump the sand from the Wildwood and Wildwood Crest borrow source to the placement area on a four-year nourishment cycle. The dune and berm restoration

and maintenance are designed to provide a high level of storm protection, conform to and enhance the existing environs and provide an adaptive and productive use for the excess sand currently clogging beach outfalls by shaping it into a dune and berm for storm reduction benefits.

Therefore, this Real Estate Plan supports the currently-available design drawings. Due to the accelerated timeline, certain items in this plan will require additional investigation. These items are noted in the report below as applicable. The information contained herein is tentative in nature for planning purposes only.

Figure 1. Hereford Inlet to Cape May Inlet



2. REAL ESTATE REQUIREMENTS

Application of sound real estate principles including blocking out along regular and definable boundaries; minimizing severance; and maintaining usable and economic remainders outside the project footprint have designated the project footprint. The project footprint is deemed sufficient to accommodate the construction, operation, maintenance, repair and replacement of the proposed project.

a. Description of Land, Easements, Rights-of-Way and Access Road Requirements for Project

The selected plan will require two (2) types of standard easements for the project. All project activities, including mobilization and construction, lay down and storage of contractor materials and equipment, planting of dune grass and placement of sand fences, as well as crossover areas, are located within the project area Limit of Construction within the acreages listed below. Therefore, no Temporary Work Area or Road/Access Easements are required for these areas.

A standard Perpetual Beach Storm Damage Reduction Easement (Standard Estate No. 26) is required for the construction of the beach berm and dune system on the beachfront properties that are above the MHWL or that include riparian grants below MHWL, including those owned by the local municipalities. The total numbers of properties requiring easement acquisition are 43 township-owned properties and 48 privately-owned properties above MHWL. The total acreage amounts for acquisition are 540.42 acres for municipally-owned properties, 66.00 acres for privately-owned properties. For the State-owned borrow area below MHWL, a standard Perpetual Borrow Easement would be the minimum estate required if not owned by the State. This 245 acres will be valued as a borrow easement for LERRD crediting purposes, but since the property is owned by the Non-Federal Sponsor, the State will provide access to the property through a Right-of-Entry to the Government. The number of parcels requiring easement acquisition of the entire parcel and those requiring acquisition over part of the entire parcel for each municipality:

	Publicly-Owned		Privately-Owned	
Municipality	Partial Coverage	Full Coverage	Partial Coverage	Full Coverage
North Wildwood	4	4	2	N/A
Wildwood	2	6	7	34
Wildwood Crest	2	25	N/A	N/A
Lower	N/A	N/A	1	4

State of NJ (Borrow Area)	1	N/A	N/A	N/A

Some of the properties listed above include parcels located below the MHWL currently subject to riparian grants. Easements will either have to be subordinated to the State of New Jersey through a legal determination of the State under the State public trust doctrine, or must be acquired over the areas below the MHWL covered by riparian grants for construction, operation and maintenance required by the Non-Federal Sponsor and the Government over the life of the project. The State is currently making a determination as which approach it will take in addressing riparian grants. The same easement acquisition criteria applies to areas below the MHWL required for beach-shaping and activities related to the dredging of material to be placed on this site. A Perpetual Borrow Easement is also required for properties below the mean high water line not covered by riparian grants, since said properties are not subject to navigation servitude. See Section 6 entitled "Navigational Servitude" for further explanation of this easement acquisition requirement.

b. Standard Estates

A standard Perpetual Beach Storm Damage Reduction Easement (Standard Estate No. 26, EC 405-1-11, Exhibit 5-29) and Perpetual Borrow Area Easement (Standard Estate No. 14, EC 405-1-11, Exhibit 5-29) are required for the construction of the beach berm and dune for upland beachfront properties above the MHWL and those covered by riparian grants, plus the borrow areas below MHWL. As noted on the project drawing included as Exhibit A, the City of Wildwood has proposed the inclusion of a Camper/RV Parking Lot within the project construction limit. Although generally not allowed under the standard beach storm damage reduction easement below, an exception to the easement has been determined to be acceptable since the planned parking area will be a location of public access and accommodation and will be owned and operated by the City of Wildwood. The inclusion of this parking area was reviewed by the project design team and has been determined to not interfere with the selected plan design. The City of Wildwood is the underlying owner of the fee estate of this property. Therefore, no modified standard easement is required for the inclusion of the proposed Camper/RV Parking Lot, or any other part of the project.

PERPETUAL BEACH STORM DAMAGE REDUCTION EASEMENT
(Standard Estate No. 26)

A perpetual and assignable easement and right-of-way in, on, over and across (the land described in Schedule A) (Tract No. __) for use by the (Project Sponsor), its representatives, agents, contractors, and assigns, to construct; preserve; patrol; operate; maintain; repair; rehabilitate; and replace; a public beach [a dune system] and other erosion control and storm damage reduction measures together with appurtenances thereto, including the right to deposit sand; to accomplish any alterations of contours on said land; to construct berms [and dunes]; to nourish and renourish periodically; to move, store and remove equipment and supplies; to erect and remove temporary

structures; and to perform any other work necessary and incident to the construction, periodic renourishment and maintenance of the (Project Name), together with the right of public use and access; [to plant vegetation on said dunes and berms; to erect, maintain and remove silt screens and sand fences; to facilitate preservation of dunes and vegetation through the limitation of access to dune areas;] to trim, cut, fell, and remove from said land all trees, underbrush, debris, obstructions, and any other vegetation, structures and obstacles within the limits of the easement (except_____); [reserving, however, to the grantor(s), (his) (her) (its) (their) (heirs), successors and assigns, the right to construct dune overwalk structures in accordance with any applicable Federal, State or local laws or regulations, provided that such structures shall not violate the integrity of the dune in shape, dimension or function, and that prior approval of the plans and specifications for such structures is obtained from the (designated representative of the Project Sponsor) and provided further that such structures are subordinate to the construction, operation, maintenance, repair, rehabilitation and replacement of the project; and further] reserving to the grantor(s), (his) (her) (its) (their) (heirs), successors and assigns all such rights and privileges as may be used and enjoyed without interfering with or abridging the rights and easements hereby acquired; subject however to existing easements for public roads and highways, public utilities, railroads and pipelines.

PERPETUAL BORROW EASEMENT

(Standard Estate No. 14)

A perpetual and assignable right and easement to clear, borrow, excavate and remove soil, dirt, and other materials from (the land described in Schedule A) (Tracts Nos. _____, _____ and _____); [1] subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges in said land as may be used without interfering with or abridging the rights and easement hereby acquired.

c. Non-Standard Estates

There are no non-standard estates required for this project. However, there are five (5) entertainment pier structures, one (1) fishing pier structure and two (2) private beaches included in the project area. The Non-Federal Sponsor provided draft deeds for both situations, which were submitted to HQUSACE for review as non-standard estates. Upon further review, HQUSACE determined that these deeds do not have any changes to the standard estate language that would be considered non-standard, but language is added to the deeds to address site specific issues pertaining to this project and existing or new piers or private beaches as follows:

i. Entertainment and Fishing Piers: Currently, the existing standard Perpetual Storm Damage Reduction Easement language is used for parcels currently situated under such structures. However, changes to the other areas of the required easement have been required for the continued operation of these structures within the project area. It is in the best interest of the

local communities, the Non-Federal Sponsor and the United States for these structures to remain, and protection of these structures is included in project formulation.

ii. Private Beach Clubs: Although current regulations preclude the continued existence of private beach clubs in a federal project area, HQUSACE is currently reviewing State of New Jersey guidelines and requirements for public use of and charges at privately-owned beach clubs. Current "open beach" regulations and recent court rulings have allowed the State of New Jersey broader authorities to regulate and require public availability of beach badges at reasonable expense at private beach clubs, as monitored by the New Jersey Department of Community Affairs. As currently explained by the Non-Federal Sponsor, the beach badge system in certain areas is open to the entire public on equal terms and proceeds from the sale of badges are utilized to cover custodial maintenance of the beach area. Any changes required to the easements used for private beach clubs are anticipated to be outside of the Standard Grant of Easement language in the current standard Perpetual Storm Damage Reduction Easement.

Crediting will follow standard procedures as set out in a model Project Partnership Agreement (PPA). No Credit will be afforded to any lands or interests previously acquired and credited for any applicable Corps of Engineers Project.

Credit will only be applied to the acreage within the "project footprint", namely the lands or corridor required for the Recommended Plan of improvements. Lands outside of the project requirements and lands that may be acquired for the sponsor's own purposes would not be creditable LERRD's. Only lands deemed necessary to be included in the project have been included.

Corps policy prescribes that credit will not afforded for lands purchased with Federal funds or grants where the granting of such credit is not permissible, either as prescribed by statute, or as determined by the head of the Federal agency administering such grants or programs. The Federal Emergency Management Agency's (FEMA's) floodplain hazard mitigation and elimination grants are examples of such Federal grant programs were credit would not be allocated.

d. Current Ownership

A tax data list of all project required parcels for the construction and operation and maintenance of the proposed project is attached to the report as Exhibit A. This list provides the owner names for all parcels as provided in 2.a. above, identified by block and lot number, as currently recorded in County and Municipal tax property records. A table of the real estate or Lands, Easements, Rights-of-way, Relocations, and Disposal (LERRD) requirements in summary fashion is presented as follows:

Land Category	Number of Parcels	Acreage	Gross Appraisal Est.
Municipalities	43	Included below	$ 0
Private Parcels	48	540.42	$
State of New Jersey	1	245	$ 0
TOTALS	92	606.42	$

e. Real Estate Mapping

Real Estate Maps, Plates R-1 to R-5, dated 22 April 2014 are attached as Exhibit B. The maps include delineation of the lands to be acquired, bulk acreage data for each estate, off-beach borrow areas identified and indicated parcels impacted by the project as listed in Exhibit A above.

3. EXISTING FEDERAL PROJECTS

There are currently no active federal shoreline protection projects in the project area. Existing active Federal navigation projects within the study area currently include the following: In 1964, the Federal Government constructed four 639-foot long timber groins east of the east jetty at Cape May Point under an earlier shoreline erosion control project. The 400-foot wide Cape May Inlet is currently maintained as a Federal navigation project. Initially constructed in 1908-1911, the navigation portion is maintained by two parallel stone jetties and is dredged to maintain its authorized depth of 25 feet at low tide.

4. EXISTING FEDERALLY OWNED LANDS

The project area contains no lands owned or managed by the federal government. Although there is property adjacent to the project at the southern end of the island managed by the United States Fish and Wildlife Service and the United States Coast Guard, along the Cape May Inlet. None of the lands are federally owned that lie within this proposed project alignment. Specifically, neither the Cape May Wildlife Refuge or U.S, Coast Guard's LORAN sites are included in this project. Coordination with FWS has occurred and will continue as appropriate.

5. LANDS OWNED BY THE NON-FEDERAL SPONSOR

There are currently no upland areas owned by the State of New Jersey in the project area, which are either privately owned or owned by local municipalities. Submerged lands below the MHWL of the Atlantic Ocean are owned by the State of New Jersey and managed by the NJDEP Bureau of Tidelands Management. These areas will be addressed by the Non-Federal Sponsor as discussed in 2.a. above.

6. NAVIGATIONAL SERVITUDE

Navigational servitude is the right of the federal Government (under the Commerce Clause of the U.S. Constitution) to use, control, and regulate the navigable waters of the United States and the submerged lands thereunder for various commerce-related purposes including navigation and flood control. In tidal areas, the servitude extends to all lands below the mean high water mark. In non-tidal areas, the servitude extends to all within the bed and banks of a navigable stream that lie below the ordinary high water. As this project is for storm damage reduction purposes, not navigational purposes, the Government will not exercise its rights under

the doctrine of Navigational Servitude for this project on areas below MHWL because a nexus to maintaining or improving navigation has not been established.

The State of New Jersey also has the right of navigational servitude over submerged lands within its borders, it is not as encompassing as that of the United States. Therefore, the Non-Federal Sponsor must acquire some form easement or rights over lands covered by riparian grants below MHWL as discussed in 2.a. above.

7. INDUCED FLOODING

Although the entire project area is prone to storm-induced flooding from both the ocean front and back bay, there is nothing in the main feasibility report to indicate that the constructed project features will induce flooding in new areas or increase flooding in existing flood prone areas. Overall, the project is designed to decrease storm-induced flooding and damage. Appropriate measures will be taken for the care and diversion of water, if any, during construction. There should be no construction induced flooding.

8. BASELINE COST ESTIMATE FOR REAL ESTATE

The detailed Real Estate Cost Estimate in MCACES format is included in Exhibit C. The Perpetual Beach Storm Damage Reduction Easement (approximately 606.42 acres) and Perpetual Borrow Area Easement (approximately 245 acres) value is considered to be of minimal value ($1.00 per parcel) due to the application of offsetting project benefits, also known as special benefits. The appraisal approach assumes that there proposed project will create a special benefit to the properties that otherwise would not exist due to erosion. The total estimated cost for real estate is $1,273,511, which is less than 6 % of total project costs. Because real estate costs did not exceed 10% of total project costs, a gross appraisal was not prepared for this project (refer to Real Estate Policy Guidance Letter No. 31-Real Estate Support to Civil Works Planning Paradigm (3x3x3) dated January 10, 2013). LER costs are based on a cost estimate prepared by the Appraisal Branch. It is noted that while most of the private and public properties are of nominal value, commercial properties are of substantial value and make up the most of the LER estimated value. These are major commercial pier properties of the area, so command substantial value.

Private land holdings subject to shore erosion and required for project purposes must be appraised considering special benefits in accordance with the relevant statutes. The Uniform Appraisal Standards for Federal Land Acquisition guidelines regarding the use of special benefits when appraising partial acquisitions taking special benefits into account were used to develop the appraisal estimate required for this Real Estate Plan. Although the consideration of special benefits is required by Federal policy and process, the courts of the State of New Jersey recently ruled that no special benefits exists as a result of a similar shore protection project. Therefore, the court held that the special benefits could not be used to offset damages to the remainder when determining just compensation for an easement similar to the easements required for this project (*Borough of Harvey Cedars v. Karan, Docket No. OCN-L-3797-08, Appellate No. A-4555-10T3, Supreme Court Docket 070512*). However, the case was accepted by the New Jersey State Supreme Court for review and was argued May 13, 2013. In their July 8, 2013 decision, the

New Jersey Supreme Court held that a property's fair market value should be used as the benchmark in computing "just compensation" in a partial-takings case, but non-speculative, reasonably calculable benefits that increase the property's value at the time of the taking should be considered in determining just compensation regardless of whether those benefits are enjoyed to a lesser or greater degree by others in the community (Borough of Harvey Cedars v. Karan, A-120, September term 2011, 070512).

The Karan's have since settled with Borough of Harvey Cedars for $1, plus litigation costs of $24,260. In order to complete the cost estimate for this HSLRR at this time, the number of and the amount of funding required for possible condemnation actions for this project have been increased in the Baseline Cost Estimate based on prior court awards.

Recent legislation introduced by the New Jersey legislature would require that any settlement for an easement for shore protection projects must include the application of special benefits to the remainder. Either passage of this legislation or a favorable ruling by the State Supreme Court would reduce the funding amount estimated for condemnations on the attached MCACES report. The Baseline Cost Estimate for Real Estate will be reviewed as the project progresses to reflect and changes in the law as a result of the above litigation or legislation.

In the limited time available for real estate investigation, additional complex relationships between non-beachfront landowners and private beachfront clubs have come to light, which raises issues as to the definition of what has traditionally been considered free "public" access to the beaches that have been replenished with federal funds. Some owners have been granted perpetual easements for access, egress and recreational use of beachfront property within the limits of construction, provided they pay an annual maintenance fee to the underlying fee owner. If the project progresses, the procurement of title information and additional research may produce additional parties with private rights to the beachfront. These privately-owned rights must either be subordinated to the State of New Jersey through a legal determination of the State under the State public trust doctrine or acquired for the subject project. Since it is impossible to determine the extent of these interests without a title search, a higher than usual contingency of 20% has been included. This estimate of potential project costs was primarily for project feasibility and the total project cost estimates. It is not a representation of actual credit that may be approved should the project be approved and proceed toward implementation. Actual crediting shall follow the crediting and appraisal procedures set forth in a signed Project Partnership Agreement.

Based on all of the factors discussed in this section, the total Baseline Cost for Real Estate for the project is $1,273,511, summarized as follows:

Acquisition/Administrative Costs:	$ 345,200.00
Condemnation Costs: 3 Estimated Properties	$ 71,000.00
Appraisals	$ 196,000.00
P.L. 91-646 Assistance:	0.00

Real Estate Payments:

Privately-Owned	36 Properties	$ 18,864.00
Commercial	12 Properties	$ 364,852.00
Publically-Owned	44 Properties	$ 23,056.00
Contingency:		$ 254,539.00
	TOTAL:	$1,273,511.00

9. PUBLIC LAW 91-646 RELOCATIONS

No P.L. 91-646 relocations are anticipated for this project. Any structures within the project footprint are in the form of piers, which will remain in place as amenities to the beach. There are no other structures or improvements within the project bounds requiring relocation.

10. MINERAL ACTIVITY

There is no present or anticipated mining and drilling activity in the vicinity of the project that may affect the operation thereof.

11. TIMBER RIGHTS

There are no trees in this coastal beach area. No positive or negative impacts to project purposes.

12. ASSESSMENT OF NON-FEDERAL SPONSOR ACQUISITION CAPABILITY

The Non-Federal Sponsor, the NJDEP, is vested with sufficient power to acquire and hold title, and to condemn lands as needed for public purposes. The sponsor has previously participated in other Corps of Engineers' Local Cooperation Projects such as the Flood Control and Bank Stabilization Project and has demonstrated their capabilities in acquiring real estate and performing the related obligations of a Non-Federal Sponsor. The Assessment of the Non-Federal Sponsor's Real Estate Acquisition Capability is attached at the end of this report as Exhibit D.

13. ZONING

The enactment of zoning ordinances is not proposed to facilitate acquisition. So far, beach municipalities in the State of New Jersey have not zoned beach properties in such a way as to impact the proposed project. The Non-Federal Sponsor is not using any zoning ordinances in lieu of acquisitions of lands or easements within the project take areas and the proposed project is consistent with current planning and zoning.

14. ACQUISITION SCHEDULE

The Non-Federal Sponsor will officially initiate real estate acquisition activities after final execution of the Project Partnership Agreement (PPA). Due to there not yet being a date

specific schedule for this project, the following estimated LERRD acquisition schedule indicates the length of time required for each step in the standard acquisition process. As there is currently no estimated PPA signing date, the following is a generic, worst-case scenario real estate timeline. Once an anticipated signing date for the PPA is identified, a more specific schedule will be prepared.

a. PPA Execution	Start Date
b. Forward Maps to Sponsor	Within 1 week of Start Date
c. Survey and Title Work	Within 14 weeks of sponsor map receipt
d. Appraisals receipt	Within 10 weeks of survey and title
e. Review Appraisals	Within 4 weeks of appraisal receipt
f. Negotiations	Within 9 weeks after appraisal review
g. Closings	Within 6 weeks of completion of negotiations
h. Possession	Within 1 day of closings
i. Certification of Real Estate	Within 1 week of possession; requires The transmittal of the Non-Federal Sponsor's Authorization for Entry for Construction and Certificate of Authority.
Approximate Total	1 year

Condemnations are anticipated for two properties required for this project. Condemnations may take up to six total months from initiation of negotiation to possession, adding approximately three months to the entire acquisition process. However, the State may exercise it's Disaster Control Act, allowing immediate possession, while condemnation subsequently proceeds.

15. UTILITY AND FACILITY RELOCATIONS

No detailed information has been provided to date by April 22, 2014 or identified by the Project Delivery Team (PDT), regarding the necessity for any facility/utility relocations in the project area. Further engineering and design work will refine requirements for facility relocations during subsequent phases and Pre-Construction Engineering and Design (PED). Given the objectives of this project the current strategy is to leave utilities, piers, boardwalks, and limited infrastructure in place, and that the engineering and design team will "work around" and consider the constraints of all existing infrastructure and work to avoid or minimize unneeded expenditures to replace or relocate existing utility infrastructure. The Non-Federal Sponsor is currently investigation what, if any, surbordination rights may be required on such property under State law.

Note: The following policy statement and disclaimer concerning any potential facility relocations prevails over any other statement, description or presentation in this report:

Any conclusion or categorization contained in this report that an item is a utility or facility relocation to be performed by the Non Federal Sponsor as part of its LERRD responsibilities is preliminary only. The Government will make a final determination of the relocations necessary for the construction, operation and maintenance of the project after further analysis. An Attorney's Opinion of Compensability will be generated for each facility/utility relocation that is required for the project and which will be performed by, and credited to, the Non-Federal Sponsor under the definitions and terms of the PPA.

There are no relocations of utilities or facilities anticipated for this project at this time. The most common type of utility relocation for shoreline protection projects is stormwater pipeline drainage structures, which often have to be extended farther out with the newly created beach. However, this project does not require such outfall extension or relocation of any other type of utility lines. Any crossovers or boardwalks removed to construct the project are the responsibility of the owner or municipality to replace, if needed. Therefore, no Attorney's Reports of Compensability are required.

16. ENVIRONMENTAL CONCERNS

The sponsor fully understands its responsibilities for assessing the properties for any potential or presence of hazardous waste materials as defined and regulated under CERCLA. There is no known "Superfund" sites or sites presently under CERCLA remediation or response orders identified in the project area. There are no known presences of any substances in the project area that are regulated under CERCLA or other environmental statutes or regulations. The LERRD estimate is predicated on the assumption that all lands and properties are clean and require no remediation. The model PCA conditions contain specific terms and conditions governing the sponsor's responsibility for environmental cleanup for CERCLA regulated substances. Hazardous Waste Assessments are covered as a project cost under the model PPA.

There are no known or suspected project areas contaminated by HTRW, either CERCLA or non-CERCLA) There is no known or suspected on-site contamination and the real estate cost estimates contained in this Real Estate Plan do not reflect the presence of contamination. The discharge material from the borrow area 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.

17. ATTITUDES OF THE LANDOWNERS

Per discussion with the Non-Federal Sponsor, the municipalities of North Wildwood, Wildwood Crest and Wildwood consider the project essential to the continued growth of the communities and the safety of both residents and resort-goers alike.

There is no focused or organized landowner opposition to the project. The sponsor will be conducting landowner and public information meetings to promote understanding of the project and how the landowners will be affected. A large percentage, 30%, of the land needed for the project is already owned by the municipal governments. Given the benefits of the project to landowners and recent New Jersey Supreme Court case, we anticipate public support, but have planned for a couple of condemnation actions as a contingency. While there is currently no strong opposition to the proposed project, the general response has ranged from support to ambivalence. Due to the recent turnover in township administration, the Non-Federal Sponsor is unaware of the Township of Lower's views on the proposed project. However, the Township of Lower only has two properties located in the study area.

18. NOTIFICATION TO NON-FEDERAL SPONSOR

The Non-Federal Sponsor, the New Jersey Department of Environmental Protection, will be notified in writing regarding the risks associated with the acquisition of land prior to execution of the PPA once the Feasibility Study is approved and the project is funded.

19. RISK ANALYSIS

Currently, there are no known significant risks associated with this project involving real estate. The Non-Federal Sponsor has been meeting LER acquisition schedules on similar and much larger projects. More recently, since Hurricane Sandy, the State of New Jersey has enacted the Disaster Control Act, which allows the State to take quick possession of property for project construction in anticipation of following up and acquiring these properties by normal means.

EXHIBIT A

Project: Hereford to Cape May
Cape May County, New Jersey

Property Summary

Township	# of Properties
North Wildwood	10
Wildwood	49
Wildwood Crest	27
Lower	5
TOTAL:	**91**

EXHIBIT A

Feasibility Report Property List
Hereford to Cape May
NORTH WILDWOOD

Address	Township	Owner	Municipality	APN	Block	Lot	Perpetual Storm	TWAE	Private	Public	Commercial	Vacant	Mailing Address	
2501 Boardwalk	Wildwood	The Morey Org	North Wildwood	07-00288-0002-00001	288.02	1	X		X		X		3501 Boardwalk, Wildwood, NJ 08260-5427	*
Beach	North Wildwood	City of North Wildwood (per tax map)	North Wildwood	07-00289-0003-00001	289.03	1	X			X		X	901 Atlantic Avenue, North Wildwood, NJ 08260-5778	
2301 Boardwalk	Wildwood	Sportland Investments	North Wildwood	07-00290-0001-00001	290.01	1	X		X		X		1922 Harold Ave, Lancaster, PA 17601	
2201 Boardwalk	North Wildwood	City of North Wildwood	North Wildwood	07-00291-0001-00001	291.01	1	X			X		X	901 Atlantic Avenue, North Wildwood, NJ 08260-5778	*
Beach	North Wildwood	City of North Wildwood	North Wildwood	07-00317-0003-00001	317.03	1	X			X			901 Atlantic Avenue, North Wildwood, NJ 08260-5778	
Riparian Grant	North Wildwood	City of North Wildwood	North Wildwood	07-00317-0003-00001-001	317.03	1.01	X			X			901 Atlantic Avenue, North Wildwood, NJ 08260-5778	
1801 Boardwalk	Wildwood	City of North Wildwood	North Wildwood	07-00315-0002-00001	315.02	1	X			X		X	901 Atlantic Avenue, North Wildwood, NJ 08260-5778	
1701 Beach	Wildwood	City of North Wildwood	North Wildwood	07-00316-0002-00001	316.02	1	X			X		X	901 Atlantic Avenue, North Wildwood, NJ 08260-5778	
1600 Beach	Wildwood	City of North Wildwood	North Wildwood	07-00317-0002-00001	317.02	1	X			X		X	901 Atlantic Avenue, North Wildwood, NJ 08260-5778	
1601 Boardwalk	Wildwood	City of North Wildwood	North Wildwood	07-00317-0002-00002	317.02	2	X			X		X	901 Atlantic Avenue, North Wildwood, NJ 08260-5778	
Total # of Properties:	10													

Property Acquisition List - NFS
Hereford to Cape May
WILDWOOD

Address	Township	Owner	Municipality	APN	Block	Lot	Perpetual Storm	TWAE	Private	Public	Commercial	Vacant	Mailing Address	
Beach Cresse & Baker Ave	Wildwood	City of Wildwood	Wildwood	14-00267-0000-00001	267	1	X			X		X	4400 New Jersey Avenue, Wildwood, NJ 08260-1729	
Beach Cresse & Baker Ave	Wildwood	City of Wildwood	Wildwood	14-00267-0000-00001-0002	267	1.02	X			X		X	4400 New Jersey Avenue, Wildwood, NJ 08260-1729	
Beach Cresse & Baker Ave	Wildwood	City of Wildwood	Wildwood	14-00267-0000-00001-0003	267	1.03	X			X		X	4400 New Jersey Avenue, Wildwood, NJ 08260-1729	
4001 Boardwalk	Wildwood	Morey Org, The	Wildwood	14-00140-0000-00001-0001 & 0002	140	1.01 & 1.02	X		X		X	X	3501 Boardwalk, Wildwood, NJ 08260-5427	
Spencer & Schellenger Beach	Wildwood	City of Wildwood	Wildwood	14-00268-0000-00001	268	1	X			X		X	4400 New Jersey Avenue, Wildwood, NJ 08260-1729	
Spencer & Schellenger Beach	Wildwood	City of Wildwood	Wildwood	14-00268-0000-00001-0002	268	1.02	X			X		X	4400 New Jersey Avenue, Wildwood, NJ 08260-1729	
						1.01/1.02								
3501 Boardwalk	Wildwood	Morey Org, The	Wildwood	14-00180-0000-00001	180	2.01/2.02	X		X		X	X	3501 Boardwalk, Wildwood, NJ 08260-5427	
3401 Boardwalk	Wildwood	Scwartz, Martin L. & Phyllis J.	Wildwood	14-00188-0000-00001-0001	188	1.01	X		X		X		1901 N Ocean Blvd #12C, Fort Lauderdale, FL 33305-3703	
3420 Beach	Wildwood	Mariners Landing, Inc	Wildwood	14-00269-0000-00001-0001	269	1.01	X		X				P.O. Box 269, Wildwood, NJ 08260-0269	*
3320 Beach	Wildwood	Morey Org, The	Wildwood	14-00270-0000-00001-0001	270	1.01	X		X		X	X	3501 Boardwalk, Wildwood, NJ 08260-5427	
3318 Beach	Wildwood	Mole, Robert & B. Prentiss & Holly B Go	Wildwood	14-00270-0000-00002-0001	270	2.01	X		X		X	X	105 E. Rambler Road, Wildwood Crest, NJ 08260-3819	
3316 Beach	Wildwood	Karvounis, Jr., Daniel H.	Wildwood	14-00270-0000-00003-0001	270	3.01	X		X			X	311 McDaniel Ave, Wilmington, DE 19803-2533	
3314 Beach	Wildwood	Carol Daniel Elaine LLC	Wildwood	14-00270-0000-00004-0001	270	4.01	X		X			X	2 Murphy Lane, Cape May, NJ 08204-4706	
3312 Beach	Wildwood	Golamis, Peter J	Wildwood	14-00270-0000-00005-0001	270	5.01	X		X			X	P.O. Box 635, Wildwood, NJ 08260-0635	
3310 Beach	Wildwood	Arrow, Berle & Arlene	Wildwood	14-00270-0000-00006-0001	270	6.01	X		X			X	1922 Haroldson Ave, Lancaster, PA 17601-3624	
3308 Beach	Wildwood	Tsokas, Vasilios & Constantinos	Wildwood	14-00270-0000-00007-0001	270	7.01	X		X			X	38 Highland Ave, Belmont Hills, PA 19004-1839	
3306 Beach	Wildwood	Schwartz, Martin & Lewis	Wildwood	14-00270-0000-00008-0001	270	8.01	X		X			X	1901 N. Ocean Blvd #12C, Fort Lauderdale, FL 33305-3703	
3301 Boardwalk	Wildwood	Douglass Candy Corporation	Wildwood	14-00270-0000-00009-0001	270	9.01	X		X		X		P.O. Box 264, Wildwood, NJ 08260-0264	
3222 Beach	Wildwood	Morey Org, The	Wildwood	14-00271-0000-00001-0001	271	1.01	X		X			X	3501 Boardwalk, Wildwood, NJ 08260-5427	
3220 Beach	Wildwood	City of Wildwood	Wildwood	14-00271-0000-00002-0001	271	2.01	X			X		X	4400 New Jersey Avenue, Wildwood, NJ 08260-1729	
3218 Beach	Wildwood	Joe & Duke Realty, Inc.	Wildwood	14-00271-0000-00003-0001	271	3.01	X		X			X	1416 Morris Ave, Union, NJ 07083-3335	
3214-3216 Beach	Wildwood	Nickels Midway Pier LLC	Wildwood	14-00271-0000-00004-0001	271	4.01	X		X			X	3500 Boardwalk, Wildwood, NJ 08260-5464	
3212 Beach	Wildwood	Pawlus, Claudio & Fabio	Wildwood	14-00271-0000-00005-0001	271	5.01	X		X			X	P.O. Box 185, Wildwood, NJ 08260-0185	
3210 Beach	Wildwood	Artrss Associates LLC	Wildwood	14-00271-0000-00006-0001	271	6.01	X		X			X	43 Kings Highway W, Haddonfield, NH 08033-2128	
3208 Beach	Wildwood	Snyder, Lillian	Wildwood	14-00271-0000-00007-0001	271	7.01	X		X			X	3206 Boardwalk, Wildwood, NJ 08260-5422	
3200 Beach	Wildwood	Sabbagh Brothers LLC	Wildwood	14-00271-0000-00008-0001	271	8.01	X		X			X	384 Avenue T, Brooklyn, NY 11223-3936	
3120 Beach	Wildwood	Morey Org, The	Wildwood	14-00272-0000-00001-0001	272	1.01	X		X			X	3501 Boardwalk, Wildwood, NJ 08260-5427	
3105 Boardwalk	Wildwood	Levin, Miriam	Wildwood	14-00272-0000-00002-0001	272	2.01	X		X		X		6 Simtat Aviviim #22, Kafir Saba, Israel	
3020 Beach	Wildwood	Morey Org, The	Wildwood	14-00273-0000-00001-0001	273	1.01	X		X			X	3501 Boardwalk, Wildwood, NJ 08260-5427	
2920 Beach	Wildwood	Morey Org, The	Wildwood	14-00274-0000-00001-0001	274	1.01	X		X			X	3501 Boardwalk, Wildwood, NJ 08260-5427	
2918 Beach	Wildwood	Weiner, Bernard & Marvin	Wildwood	14-00274-0000-00002-0001	274	2.01	X		X			X	P.O. Box 1649, Wildwood, NJ 08260-7649	
2914 Beach	Wildwood	Je-Rob Inc, a NJ Corporation	Wildwood	14-00274-0000-00003-0001	274	3.01	X		X			X	4 Hatteras Dr, Cape May, NJ 08204-4202	
2910 Beach	Wildwood	Meridians 3 LLC	Wildwood	14-00274-0000-00004-0001	274	4.01	X		X			X	2 Murphy Lane, Cape May, NJ 08204-4706	
2908 Beach	Wildwood	Rosenthal, G	Wildwood	14-00274-0000-00005-0001	274	5.01	X		X			X	1 Yukon Terrace, Morganville, NJ 07751-1317	
2906 Beach	Wildwood	City of Wildwood	Wildwood	14-00274-0000-00006-0001	274	6.01	X			X		X	4400 New Jersey Avenue, Wildwood, NJ 08260-1729	
2900 Beach	Wildwood	Arrow, Berle & Arlene and Snyder, Theo	Wildwood	14-00274-0000-00007-0001	274	7.01	X		X			X	1922 Haroldson Ave, Lancaster, PA 17601-3624	
2820 Beach	Wildwood	Morey Org, The	Wildwood	14-00275-0000-00001-0001	275	1.01	X		X			X	3501 Boardwalk, Wildwood, NJ 08260-5427	
2812-20 Beach	Wildwood	Arrow, Berle & Arlene	Wildwood	14-00275-0000-00002-0001	275	2.01	X		X			X	1922 Haroldson Ave, Lancaster, PA 17601-3624	
2806 Boardwalk	Wildwood	Snyder, Herman & Lillian	Wildwood	14-00275-0000-00003-0001	275	3.01	X		X			X	2806 Boardwalk, Wildwood, NJ 08260-5418	
2804 Beach	Wildwood	Pardos Family, Kitty Matchica	Wildwood	14-00275-0000-00004-0001	275	4.01	X		X			X	118 Ferguson Avenuem Broomall, PA 19008-3013	
2802 Beach	Wildwood	Kenis, Helen	Wildwood	14-00275-0000-00005-0001	275	5.01	X		X			X	1 Bel Aire Dr, Yardley, PA 19067-2805	
2600 Boardwalk	Wildwood	Snyder, Theodore	Wildwood	14-00275-0000-00006-0001	275	6.01	X		X			X	2800 Boardwalk, Wildwood, NJ 08260	
2720 Beach	Wildwood	2701 Associates LLC	Wildwood	14-00276-0000-00001-0001	276	1.01	X		X			X	3501 Boardwalk, Wildwood, NJ 08260-5427	
2701 Boardwalk	Wildwood	2701 Associates LLC	Wildwood	14-00248-0000-00001-0001	248	1/1.01/1.02	X		X		X		3501 Boardwalk, Wildwood, NJ 08260-5427	*
2620 Beach	Wildwood	The Morey Org	Wildwood	14-00277-0000-00001-0001	277	1.01	X		X			X	3501 Boardwalk, Wildwood, NJ 08260-5427	*
2600 Beach	Wildwood	The Morey Org	Wildwood	14-00277-0000-00002-0001	277	2.01	X		X			X	3501 Boardwalk, Wildwood, NJ 08260-5427	*
2600 Boardwalk	Wildwood	Samax, Inc	Wildwood	14-00277-0000-00002-0002	277	2.02	X		X			X	2600 Boardwalk, Wildwood, NJ 08260	
3901 Boardwalk	Wildwood	Morey Org, The	Wildwood	14-00278-0000-00001-0001 & -0002	278	1.01 & 1.02	X		X		X	X	3501 Boardwalk, Wildwood, NJ 08260-5427	
1st Ward Beach	Wildwood	City of Wildwood	Wildwood	14-00280-0000-00001	280	1	X			X		X	4400 New Jersey Avenue, Wildwood, NJ 08260-1729	
		Total # of Properties:	49											

EXHIBIT A

EXHIBIT A

Property Acquisition List - NFS
Hereford to Cape May
WILDWOOD CREST

Address	Township	Owner	Municipality	APN	Block	Lot	Perpetual Storm	TWAE	Private	Public	Commercial	Vacant	Mailing Address
Beach	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00001-0005-00001	1.05	1	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach (riparian grant)	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00001-0005-00001-0001	1.05	1.01	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00006-0005-00001	6.05	1	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach at Lavendar Rd	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00016-0005-00001-0001	16.05	1.01	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach at Heather Rd	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00016-0005-00001-0002	16.05	1.02	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00021-0005-00001	21.05	1	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach Ave	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00038-0005-00001-0001	38.05	1.01	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach Ave	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00038-0005-00001-0002	38.05	1.02	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00042-0005-00001	42.05	1	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach & Rosemary Rd	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00050-0005-00001	50.05	1	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00068-0006-00001	68.06	1	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00100-0003-00001	100.03	1	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00117-0003-00001	117.03	1	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach (riparian grant)	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00117-0003-00001-0001	117.03	1.01	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00117-0004-00001	117.04	1	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach (riparian grant)	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00117-0004-00001-0001	117.04	1.01	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00118-0003-00001	118.03	1	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach (riparian grant)	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00118-0003-00001-0001	118.03	1.01	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00118-0004-00001	118.04	1	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach (riparian grant)	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00118-0004-00001-0001	118.04	1.01	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00125-0003-00001	125.03	1	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach (riparian grant)	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00125-0003-00001-0001	125.03	1.01	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00126-0003-00001	126.03	1	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach (riparian grant)	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00126-0003-00001-0001	126.03	1.01	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	15-00133-0003-00001	133.03	1	X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach Ave (2 segments)*	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	None			X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260
Beach Ave (1 segments)*	Wildwood Crest	Borough of Wildwood Crest	Wildwood Crest	None			X			X		X	6101 Pacific Avenue, Wildwood Crest, NJ 08260

Total # of Properties: 27

Beach Avenue Segments: Between Hollywood and Monterey/Street End of Miami Avenue and Between Louisville and Farragut

EXHIBIT A

Feasibility Report Property List
Hereford to Cape May
LOWER

Address	Township	Owner	Municipality	APN	Block	Lot	Perpetual Storm	TWAE	Private	Public	Commercial	Vacant	Mailing Address
9601 Atlantic Avenue	Lower	Diamond Beach LP	Lower Township	05-00700-0002-00001-0004	700.02	1.04	X		X			X	2501 Seaport Drive, Suite 400, Chester, PA 19013-2249
9601 Atlantic Avenue	Lower	Diamond Beach LP	Lower Township	05-00700-0002-00001-0005	700.02	1.05	X		X			X	2501 Seaport Drive, Suite 400, Chester, PA 19013-2249
Atlantic & Rochester	Lower	Achristavest Pier 6600 LLC	Lower Township	05-00710-0002-00001-01/02/03	710.02	1.03	X		X			X	2501 Seaport Drive, Suite 400, Chester, PA 19013-2249
9902 Seapointe Blvd	Lower	Seapointe Village Master Association	Lower Township	05-00719-0000-00003-01	719	3.01	X		X			X	9901 Seapointe Blvd, Wildwood Crest, NJ 08260-6203
Beach South Station Tomadison	Lower	Club at Diamond Beach LLC, The	Lower Township	05-00730-0002-00001-02	730.02	1.02 & 1.03	X		X		X	X	1136 Springfield Ave, Mountainside, NJ 07092-2906

Total # of Properties: 5

Feasibility Study Cost Estimate-MCACES Format
Real Estate Acquisition Requirements
Hereford Inlet to Cape May Inlet
Cape May County, New Jersey

	Private			Commercial			Public			Requirement		
	#	$ each	req	#	$ each	req	#	$ each	req	Base	Contingency	Total
0102------- ACQUISITIONS												
010201--- By Government												
010202--- By Non-Federal Sponsor (NFS)												
01020201 Survey and Legal Descriptions	36	750	27,000	12	750	9,000	44	750	33,000	69,000	10,350	79,350
01020102 Title Evidence	36	900	32,400	12	900	10,800	44	900	39,600	82,800	12,420	95,220
01020203 Negotiations	36	1,200	43,200	12	2,000	24,000	44	1,200	52,800	120,000	18,000	138,000
010203--- By Government on Behalf of NFS												
010204--- Review of NFS												
01020401 Survey and Legal Descriptions	36	150	5,400	12	150	1,800	44	150	6,600	13,800	2,070	15,870
01020402 Title Evidence	36	150	5,400	12	150	1,800	44	150	6,600	13,800	2,070	15,870
01020403 Negotiations	36	150	5,400	12	150	1,800	44	150	6,600	13,800	2,070	15,870
SUBTOTAL										319,200	46,980	366,180
0103------- CONDEMNATIONS												
010301--- By Government												
010302--- By Non-Federal Sponsor (NFS)	2	20,000	40,000	1	25,000	25,000	0		0	65,000	9,750	74,750
010303--- By Government on Behalf of NFS												
010304--- Review of NFS	2	2,000	4,000	1	2,000	2,000	0		0	6,000	900	6,900
SUBTOTAL										71,000	10,650	81,650
0105------- APPRAISALS												
010501--- By Government												
010502--- By Non-Federal Sponsor (NFS)	36	1,500	54,000	12	2,500	30,000	44	1,500	66,000	150,000	22,500	172,500
010503--- By Government on Behalf of NFS												
010504--- Review of NFS	36	500	18,000	12	500	6,000	44	500	22,000	46,000	6,900	52,900
SUBTOTAL										196,000	29,400	225,400
0106------- PL 91-646 ASSISTANCE												
010601--- By Government												
010602--- By Non-Federal Sponsor (NFS)	0		0	0	5,000	0	0		0	0	0	0
010603--- By Government on Behalf of NFS												
010604--- Review of NFS	0		0	0	1,500	0	0		0	0	0	0
SUBTOTAL										0	0	0
0107------- TEMPORARY PERMITS/LICENSES/RIGHTS-OF-WAY												
010701--- By Government			0			0			0	0	0	0
010702--- By Non-Federal Sponsor (NFS)			0			0			0	0	0	0
010703--- By Government on Behalf of NFS			0			0			0	0	0	0
010704--- Review of NFS	0		0	0		0	0		0	0	0	0
010705--- Other			0			0			0	0	0	0
010706--- Damage Claims			0			0			0	0	0	0
SUBTOTAL										0	0	0
0115------- REAL ESTATE PAYMENTS												
011501--- Land Payments												
01150101 By Government										0	0	0
01150102 By Non-Federal Sponsor (NFS)	36	524	18,864	12	30,404	364,852	44	524	23,055	406,772	162,709	569,481
01150103 By Government on Behalf of NFS										0	0	0
01150104 Review of NFS	36	250	9,000	12	1,000	12,000	44	250	11,000	32,000	4,800	36,800
011502--- PL 91-646 Assistance Payments										0	0	0
01150201 By Government										0	0	0
01150202 By Non-Federal Sponsor (NFS)				0	0	0				0	0	0
01150203 By Government on Behalf of NFS										0	0	0
01150204 Review of NFS				0	0	0				0	0	0
011503--- Damage Payments										0	0	0
01150301 By Government										0	0	0
01150302 By Non-Federal Sponsor (NFS)										0	0	0
01150303 By Government on Behalf of NFS										0	0	0
01150304 Review of NFS										0	0	0
SUBTOTAL										438,772	167,509	606,281
Account 02 Facility/Utility Relocations (Construction cost only)											0	0
REAL ESTATE ACQUISITION TOTAL										**$1,018,972**	**$254,539**	**$1,273,511**

EXHIBIT C

ASSESSMENT OF NON-FEDERAL SPONSOR'S REAL ESTATE ACQUISITION CAPABILITY

Project: Hereford Inlet to Cape May Inlet Feasibility Report, Cape May County, New Jersey

Non-Federal Sponsor: New Jersey Department of Environmental Protection (NJDEP)

I. Legal Authority:

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes?

Yes. The non-Federal sponsor (NFS), the NJDEP, has acquisition authority in the project area.

b. Does the sponsor have the power of eminent domain for this project?

No. Although the State of New Jersey does have the power of eminent domain, the delegated authority to the NFS' department was rescinded more than 10 years ago. Nevertheless, the NFS has indicated that assistance would be contracted from the local municipalities involved, through a State Aid Agreement, to acquire the necessary real estate interests. The local municipalities do have the power of eminent domain.

c. Does the sponsor have "quick-take" authority for this project?

No. The NFS does not have "quick-take" authority for this project. If a local municipality were to acquire the real estate, they would file a Declaration of Taking and deposit the estimated just compensation with the court. Possession would be granted within a period of 72 hours to 45 days, depending on whether preliminary objection resolution is required.

d. Are any of the lands/interests in land required for the project located outside the sponsor's political boundary?

No.

e. Are any of the lands/interests in land required for the project owned by an entity whose property the sponsor cannot condemn?

The NFS does not have condemnation authority for this project, but there are no lands/interests that may not be condemned by the local municipalities.

II. Human Resource Requirements:

a. Will the sponsor's in-house staff require training to become familiar with the real estate requirements of Federal projects including P.L. 91-646, as amended?

No. The NFS is familiar with the requirements of P.L. 91-646.

b. If the answer to II.a. is "yes", has a reasonable plan been developed to provide such training?

N/A

c. Does the sponsor's in-house staff have sufficient real estate acquisition experience to meet its responsibilities for the project?

Yes.

d. Is the sponsor's projected in-house staffing level sufficient considering its other work load, if any, and the project schedule?

Yes. The NFS has indicated that assistance would be requested from the local municipalities to acquire the necessary real estate interests. The NFS will utilize State Aid agreements as necessary to enlist the assistance of local townships.

e. Can the sponsor obtain contractor support, if required, in a timely fashion?

Yes.

f. Will the sponsor likely request USACE assistance in acquiring real estate?

No.

III. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site?

Yes.

b. Has the sponsor approved the project/real estate schedule/milestones?

Yes.

IV. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects?

Yes.

b. With regard to this project, the sponsor is anticipated to be fully capable.

V. Coordination:

a. Has this assessment been coordinated with the sponsor? Yes

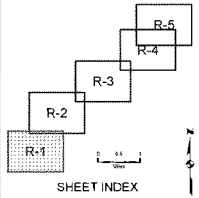
b. Does the sponsor concur with this assessment? Yes

Prepared by:

HEATHER M. SACHS
Realty Specialist

Approved by:

CRAIG R. HOMESLEY
Chief, Civil/IIS Projects Support Branch
Real Estate Division



REAL ESTATE PROJECT PLANNING MAP

HEREFORD TO CAPE MAY SHORELINE RESTORATION PROJECT

N

ESTATES REQUIRED

PERPETUAL STORM DAMAGE REDUCTION

PUBLIC	540.42 AC
PRIVATE	66.00 AC
TOTAL	606.42 AC

PERPETUAL BORROW EASEMENT 245 AC

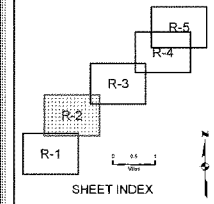
BORROW AREA LINE

0 250 500 1,000
Feet

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT
REAL ESTATE DIVISION
BALTIMORE, MARYLAND

PROJECT FILE: REP_Map_APR2014
CREATED BY: rts
DATE: 22 APRIL 2014
SCALE: AS SHOWN

PLATE: **R-1**



REAL ESTATE PROJECT PLANNING MAP

HEREFORD TO CAPE MAY SHORELINE RESTORATION PROJECT

ESTATES REQUIRED

PERPETUAL STORM DAMAGE REDUCTION

PUBLIC	540.42 AC
PRIVATE	66.00 AC
TOTAL	606.42 AC

PERPETUAL BORROW EASEMENT 245 AC

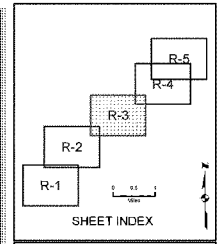
BORROW AREA LINE

0 250 500 1,000
Feet

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT
REAL ESTATE DIVISION
BALTIMORE, MARYLAND

PROJECT FILE: REP_Map_APR2014
CREATED BY: rts
DATE: 22 APRIL 2014
SCALE: AS SHOWN

PLATE: **R-2**



REAL ESTATE PROJECT PLANNING MAP

HEREFORD TO CAPE MAY SHORELINE RESTORATION PROJECT

N

ESTATES REQUIRED

PERPETUAL STORM DAMAGE REDUCTION

PUBLIC	540.42 AC
PRIVATE	66.00 AC
TOTAL	606.42 AC

PERPETUAL BORROW EASEMENT 245 AC

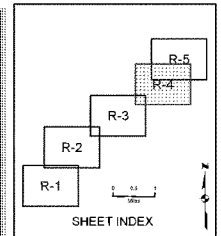
BORROW AREA LINE

0 250 500 1,000
Feet

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT
REAL ESTATE DIVISION
BALTIMORE, MARYLAND

PROJECT FILE: REP_Map_APR2014
CREATED BY: rts
DATE: 22 APRIL 2014
SCALE: AS SHOWN

PLATE: **R-3**



SHEET INDEX

REAL ESTATE PROJECT PLANNING MAP

HEREFORD TO CAPE MAY SHORELINE RESTORATION PROJECT

N

ESTATES REQUIRED

PERPETUAL STORM DAMAGE REDUCTION

PUBLIC	540.42 AC
PRIVATE	66.00 AC
TOTAL	606.42 AC

PERPETUAL BORROW EASEMENT 245 AC

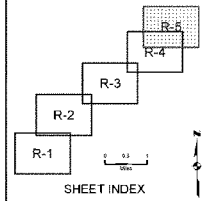
BORROW AREA LINE

0 250 500 1,000
Feet

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT
REAL ESTATE DIVISION
BALTIMORE, MARYLAND

PROJECT FILE: REP_Map_APR2014
CREATED BY: rts
DATE: 22 APRIL 2014
SCALE: AS SHOWN

PLATE: **R-4**



REAL ESTATE PROJECT PLANNING MAP

HEREFORD TO CAPE MAY SHORELINE RESTORATION PROJECT

N

ESTATES REQUIRED

PERPETUAL STORM DAMAGE REDUCTION

PUBLIC	540.42 AC
PRIVATE	66.00 AC
TOTAL	606.42 AC

PERPETUAL BORROW EASEMENT 245 AC

BORROW AREA LINE

0 250 500 1,000
Feet

U.S. ARMY CORPS OF ENGINEERS
BALTIMORE DISTRICT
REAL ESTATE DIVISION
BALTIMORE, MARYLAND

PROJECT FILE: REP_Map_APR2014
CREATED BY: rts
DATE: 22 APRIL 2014
SCALE: AS SHOWN

PLATE: **R-5**

Appendix G
Pertinent Correspondence

Section –1 General Correspondence

State of New Jersey

James E. McGreevey
Governor

Department of Environmental Protection
Natural and Historic Resources
Division of Engineering and Construction

Bradley M. Campbell
Acting Commissioner

January 17, 2002

Mr. Robert Callegari, Chief
Planning Division
Phila. Dist. Corps of Engineers
100 Penn Square East, Wanamaker Bldg.
Philadelphia, PA 19107

Dear Mr. Callegari:

Per our recent discussions, now that we have addressed portions of the coast with critical existing or imminent needs, we look forward in continuing toward completion of the New Jersey Shore Protection Study.

Since the completion of the Reconnaissance Phase, the situation at Wildwood in the Hereford Inlet area has worsened and now requires being addressed immediately. In addition we are in a position to analyze the entire coast as a system in order to maximize the efficiency of the New Jersey Shore Protection Program. The goal is to analyze and maximize the projects into a complete coastal system and to make changes to reduce renourishment requirements, environmental impacts and life-cycle cost.

The State of New Jersey, therefore, wishes to express its support for the following Feasibility studies:

1) Alternative Long Term Nourishment, New Jersey (NJ Regional Sediment and Coastal Processes Study)

2) Hereford Inlet to Cape May Inlet, NJ

Recognizing the importance of efficiently managing our sand resource in the Hereford Inlet area, as well as along the entire coast, we fully intend to sign the Feasibility Cost Sharing Agreements (FCSA) for these two studies.

Sincerely,

Bernard Moore
Administrator

mm

1510 Hooper Avenue, Toms River, NJ 08753

Phone
(732) 255-0770

Fax
(732) 255-0774

New Jersey is an Equal Opportunity Employer

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO
ATTENTION OF

17 JAN 2002

CENAP-PL

MEMORANDUM FOR Commander, CECW ATTN: CECW-PM (Montvai)

THRU Commander, CENAD ATTN: CENAD-ET-P (Arabatzis)

SUBJECT: Request for Approval of Preliminary Analyses for Hereford Inlet to Cape May Inlet and the Regional Sediment Management – Long-term Nourishment Projects

1. Request. Attached for your review and subsequent approval are the Preliminary Analyses of the Hereford Inlet to Cape May Inlet and the Regional Sediment Management – Long-term Nourishment Projects. These Preliminary Analyses are the basis for developing the PMP, executing the Feasibility Cost Sharing Agreement (FCSA) with the non-Federal sponsor, and proceeding to the feasibility phase of the study.

2. Letter of Support. Attached is a copy of the non-Federal Letter of Support for the referenced projects.

3. Point of Contact. Our point of contact is Ms. Susan S. Lucas, CENAP-PL-PC, (215) 656-6573.

FOR THE COMMANDER:

ROBERT L. CALLEGARI
Chief, Planning Division

Enclosures (3)

Copy Furnished:
CENAD-ET-P

DEPARTMENT OF THE ARMY
U.S. Army Corps of Engineers
WASHINGTON, D.C. 20314-1000

REPLY TO
ATTENTION OF:

28 JAN 2002

CECW-PM

MEMORANDUM FOR Commander, North Atlantic Division (CENAD-ET-P)

SUBJECT: Hereford Inlet to Cape May Inlet and the New Jersey Shoreline Sediment Management Study

1. Reference CENAP-PL memorandum dated 17 January 2002, transmitting Preliminary Analysis of the Hereford Inlet to Cape May Inlet and the Regional Sediment Management – Long- term Nourishment Projects and letter of intent for these studies from the Sate of New Jersey, to Headquarters for review and approval.

2. The Hereford Inlet to Cape May Inlet and the New Jersey Shoreline Sediment Management Study and letter of intent are approved for proceeding into the feasibility phase of planning. The district should plan to convene an in-progress-review meeting early in the study to ensure the study is focused and tailored to meet the specific objectives. Based on results of the in-progress-review, the project management plan may need to be revised to better define the depth of analysis required and/or refine study constraints.

3. Submission of the model feasibility cost sharing agreement is not required, provided no deviations are requested.

FOR THE COMMANDER:

James F. Johnson

JAMES F. JOHNSON
Chief, Planning and Policy Division
Directorate of Civil Works

DEPARTMENT OF THE ARMY
Philadelphia District, Corps of Engineers
Wanamaker Building, 100 Penn Square East
Philadelphia, Pennsylvania 19107-3390

08 MAY 2002

Planning Division

SUBJECT: Hereford Inlet to Cape May Inlet, NJ Feasibility Cost Sharing Agreement

Mr. Bernard J. Moore
Administrator
New Jersey Department of Environmental Protection
Division of Engineering and Construction
1510 Hooper Avenue
Toms River, New Jersey 08753

Dear Mr. Moore:

Enclosed are six (6) copies of the Hereford Inlet to Cape May Inlet, New Jersey Feasibility Cost Sharing Agreement (FCSA). Please obtain signatures and dates on all six copies of the FCSA. Upon obtaining the signatures, return all six signed copies to the District Office. Please do not fill in the date in the first paragraph of the FCSA. Signature authority has been delegated to the Philadelphia District Commander. Upon the Commander's signature, the Hereford Inlet to Cape May Inlet FCSA shall be executed. Copies of the executed agreement will be forwarded to you.

We look forward to working with you on this project. If you have questions please contact Ms. Colleen Rourke at (215) 656-6585.

Sincerely,

Paul Gaudini, P.E.
Acting Chief, Planning Division

Enclosures (6)

CITY OF NORTH WILDWOOD

901 ATLANTIC AVENUE
P. O. BOX 499
NORTH WILDWOOD, NEW JERSEY 08260

(609) 522-5411
FAX (609) 523-8502

JOHN J. HOLMAN
CITY ADMINISTRATOR

November 6, 2002

Dear Resident,

The City of North Wildwood has scheduled a presentation to provide information on the North Wildwood Seawall Project. This Seawall will stretch from Angelsea to 2nd Avenue.

The Army Corps of Engineers will be presenting an update on the plans and specifications and respond to any questions you may have regarding this project.

The meeting is scheduled for Saturday, November 16, 2002 at 11:00 a.m. in the North Wildwood Community Center Building located at 9th and Central Avenue.

All are invited to attend.

Should you be unable to attend this meeting, please do not hesitate to contact me at my office (609-522-2030) or forward any questions you may have so that the City may obtain an answer.

Very truly yours,

John J. Holman
City Administrator

JJH/mel

Cc: Mayor and City Council
Mr. Jeffrey Gebert, Chief of Coastal Planning, Army Corps of Engineers
Janet Harkins, City Clerk

CITY OF NORTH WILDWOOD

901 ATLANTIC AVENUE
P. O. BOX 499
NORTH WILDWOOD, NEW JERSEY 08260

(609) 522-5411
FAX (609) 523-8502

JOHN J. HOLMAN
CITY ADMINISTRATOR

June 3, 2003

Mr. Brian Bogel, Project Manager
U.S. Army Corps of Engineers, Philadelphia District
Wanamaker Building
100 Penn Square East
Philadelphia, PA. 19107-3390

Re: **TOWNSEND INLET – CAPE MAY INLET PROJECT**
Public Presentation, Seawall Project

Dear Mr. Bogel,

The City of North Wildwood is requesting that the U.S. Army Corps of Engineers attend a public meeting to present updates on the North Wildwood Seawall Project. This seawall is a part of the Townsend Inlet to Cape May Inlet project.

The City has preliminarily scheduled this public presentation for Saturday, July 19, 2003 at 10:00 a.m. in the North Wildwood Community Center. Please advise if this time and date is convenient for you and your staff.

Please contact my office for any audiovisual requirements you may need with regard to the presentation.

The City is looking forward to continue working with the Corps towards the successful completion of this project.

If you need any further information please do not hesitate to contact me.

Very truly yours,

John J. Holman
City Administrator
/jjh

cc: Mayor and City Council
Senator Corzine
Representative Lobiondo
Senator Cafiero
Assemblyman Van Drew
Mayor and Council
Mike Preston, Construction Official
Lew Ostrander, City Safety Officer
File: Townsend to Hereford Inlet Project

FRANK A. LOBIONDO
2ND DISTRICT, NEW JERSEY

REPLY TO:
☐ 225 CANNON HOUSE OFFICE BUILDING
WASHINGTON, DC 20515–3002
202–225–6572
FAX 202–225–3318

☑ 5914 MAIN STREET
MAYS LANDING, NJ 08330
609–625–5008
FAX 609–625–5071

1–800–471–4450

Congress of the United States
House of Representatives
Washington, DC 20515–3002

COMMITTEES:
TRANSPORTATION AND INFRASTRUCTURE
SUBCOMMITTEES:
CHAIRMAN
COAST GUARD AND MARITIME TRANSPORTATION
AVIATION
HIGHWAYS AND TRANSIT
ARMED SERVICES
SUBCOMMITTEES:
TERRORISM, UNCONVENTIONAL THREATS AND CAPABILITIES
TACTICAL AIR AND LAND FORCES

January 5, 2004

Mr. Jim Rausch
Director
Army Corps of Engineers
Office of Congressional Affairs
441 G Street NW
Washington, D.C. 20314-1000

Dear Mr. Rausch:

I have received the enclosed information from Barbara Waterman of Wildwood, New Jersey, regarding jetties along Hereford Inlet in North Wildwood.

I would appreciate your assistance in reviewing this matter, and your providing me with any information that will enable me to respond to Ms. Waterman. If you have any questions, or need further information, please contact my staff assistant, Pat Poole, in my Mays Landing district office.

Thank you for your help, and I look forward to hearing from you soon.

Sincerely,

Frank A. LoBiondo

Frank A. LoBiondo
Member of Congress

FAL/pmp
enc

DEPARTMENT OF THE ARMY
PHILA. DISTRICT,CORPS OF ENGINEERS
WANAMAKER BLDG., 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA19107-3390

Planning Division

MAR 1 4 2005

Mr. John Garofalo, Manager
Bureau of Coastal Engineering
New Jersey Department of Environmental Protection
1510 Hooper Avenue
Toms River, New Jersey 08753

Dear Mr. Garofalo:

This letter is in regard to the on-going Corps of Engineers Hereford Inlet to Cape May Inlet General Investigation. The Feasibility Cost-Sharing Agreement (FCSA) for this study was executed in September 2002, and stipulated a non-Federal cost-share of $1,250,000. Through Fiscal Year 2004 the New Jersey Department of Environmental Protection (NJDEP) has provided $307,500, leaving a $942,500 balance for the study. In order to meet the terms of the FCSA and match the Federal funds allocated for FY05, we request the NJDEP to submit $242,500 by March 30, 2005. This funding will be used to determine the existing hydrologic and hydraulic conditions, examine existing environmental and cultural resources, perform economic analyses, geotechnical investigations, identify project alternatives, conduct public outreach and project management.

Thank you for your attention to this matter. If you have any questions, please contact Brian Bogle, Project Manager, at (215) 656-6585.

Sincerely,

Minas M. Arabatzis
Chief, Planning Division

Copy Furnished:
David Rosenblatt, Administrator
Office of Engineering and Construction
New Jersey Department of Environmental Protection
1510 Hooper Avenue
Toms River, New Jersey 08753

U.S. Department of Homeland Security
United States Coast Guard

Commander
Coast Guard Atlantic Area

431 Crawford St.
Portsmouth, Va. 23704-5004
Staff Symbol: Aow
Phone: (757) 398 6230
Fax: (757) 398 6303
Email: jwalters@lantd5.uscg.mil

3170
17 Feb 2005

MEMORANDUM

From: VADM VIVIAN S. CREA
CG LANTAREA

Reply to Attn of: Aow
Walters
757 398 6230

To: Brigadier General Meredith W.B. Temple
U.S. Army Corps of Engineers
North Atlantic Division
302 General Lee Avenue
Brooklyn, New York 11252

Subj: MAINTENANCE DREDGING OF CAPE MAY INLET AND CAPE MAY HARBOR

1. For almost two decades Cape May Inlet has proven to be a perennial challenge for the Coast Guard to operate its ships in and out of Cape May. In previous fiscal years, when the Corps received funding for two annual dredging cycles, the level of dredging activity proved to be barely adequate to ensure our ships could safely enter and leave Cape May on any state of tide. As you are aware, this year's funding included funding to perform one maintenance event and that event occurred in January. For the remainder of this fiscal year, there is no scheduled maintenance and this scenario presents an untenable situation. I also understand that the President's FY06 budget includes dredging maintenance funding for two dredging events for Cape May Inlet. The Coast Guard is now at the juncture when either funding is provided to maintain the inlet continuously to -20 feet, or the two-210 foot medium endurance cutters will depart permanently and seek a safer, more reliable homeport. In January, the Philadelphia District provided superlative service to our fleet in removing a shoal that impeded the return of a deployed cutter and the dispatch of a second cutter. However, without immediate funding relief and implementation of a more aggressive dredging maintenance and hydrographic surveys program, Cape May will cease to be a homeport for the support of deep-water Coast Guard operations.

2. If these ships are relocated, the impact to the Coast Guard and the Nation will be increased costs associated with relocating the cutters and potentially decreased availability of these cutters to perform their primary missions: providing homeland security, providing offshore deep water search and rescue response and enforcement of laws and treaties throughout the eastern seaboard, including living marine resources, counter-drug and anti-migrant operations. Our ability to keep these two cutters homeported in Cape May, and their ability to prosecute Coast Guard missions is directly linked to the water depths provided through the Corps of Engineers dredging maintenance program. The most immediate economic impact to the local community, at a minimum, will be a loss of approximately $4 million.

3. The dredging maintenance situation at Cape May cannot be deferred. To ensure a viable presence for Coast Guard medium endurance cutters, immediate steps must be taken to maintain this waterway. I eagerly await your plan to alleviate the dredging quandary and stand ready to assist you in your efforts to secure funding.

#

Subj: MAINTENANCE DREDGING OF CAPE MAY INLET AND CAPE MAY HARBOR 3170

17 Feb 2005

Dist: U.S. Senator Frank R. Lautenburg
U.S. Senator Jon S. Corzine
U.S. Congressman Frank Lobiondo
Governor Richard J Codey
COMDT (G-C), (G-CI), (G-O)

Copy: CG TRACEN Cape May
CG GP Atlantic City
CG MSO/GP Philadelphia

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

MAY 0 2 2005

REPLY TO
ATTENTION OF

Attention: North Wildwood, Wildwood and Wildwood Crest Residents

This is to inform you that members of the Philadelphia District of the U.S. Army Corps of Engineers will be collecting information/data for the on-going Hereford Inlet to Cape May Inlet, feasibility study. This activity will take place from May 9, 2005 through July 31, 2005.

The purpose of the feasibility study is to evaluate methods to reduce storm damage as well as erosion in North Wildwood and consider reshaping the beach in Wildwood and Wildwood Crest.

The information that will be collected will be used to assist us in developing a plan to provide storm damage protection. During the period of our data collection, Corps of Engineers employees will carry work identification cards and will be provided upon request. The information that will be collected will consist of:

1. Residential and commercial structure inventories including recording the address, property size and type of construction.
2. Residential and commercial first floor elevations to determine the properties' location and vulnerability to storm damage.
3. Photographs of residential and commercial structures.
4. Recording elevations at various locations on the island.

We have established the Point of Contacts for the above data collection as listed below:

- **Mr. Ray Townsend, Administrator**
North Wildwood
1-609-522-6464
- **Mr. Ernie Triano, Mayor**
Wildwood
1-609-522-2444
- **Mr. Kevin Yecco, Borough Clerk**
Wildwood Crest
1-609-522-5176

If you have further questions, please contact the Project Manager, Brian Bogle at 1-215-656-6585, or email: brian.p.bogle@usace.army.mil

Sincerely,

Minas M. Arabatzis
Chief, Planning Division

North Wildwood Public Works
World's Best Beach
Tim O'Leary, Superintendent
511 West Oak Avenue
North Wildwood,N.J.08260
Phone (609)522-4646
Fax (609)522-1141

DATE: November 2, 2005

TO: Brian Bogle, Corps of Engineers

FROM: Tim O'Leary, Supt. N.W.P.W.

RE:Damages to Beach and Outfall Lines

Dear Sir,

Pursuant to your phone call, I have enclosed pictures of said Lines and some of the Beach loss.

Over the past two years at that area shown, the Beach loss amounts to 250 to 300 feet and wiping out all of the remaining dunes. The Outfall Line suffered with the loss of two manholes and approximately 750 feet of pipe. We are in desperate need of Outfall and Beach restoration.

We have seen towns North and South of us receive massive amounts of sand that did not take an impact as we have and we still have not received any help.

The dunes built by me more than thirty years ago with good elevations and stable cape variety dune grass, as well as bayberry bushes, have disappeared. If something is not done about the Outfall Lines, I expect to see the Eastside of town underwater.

Thank you for your attention in this matter.

Tim O'Leary, Supt.
North Wildwood Public Works

Encls (3)
Cc: Mayor and Council
TO:LM

van note - harvey
211 North Main Street, Suite 203
Cape May Court House, New Jersey 08210
609-465-2600 Fax: 609-465-8028
vannoteharvey.com

van note - harvey associates
Since 1894

File: 22034-999-21

November 15, 2005

Hand Delivered

Mr. Kevin Yecco
Municipal Clerk
Borough of Wildwood Crest
6101 Pacific Avenue
Wildwood Crest, NJ 08260

rec'd 11/15/05
11:15 AM
KMY
cc: w/MAP = BRIAN BOGLE, US ARMY CORPS OF ENGINEERS

RE: Storm Sewer Infrastructure
Borough of Wildwood Crest, Cape May County, NJ

Dear Kevin:

Enclosed please find two (2) copies of Storm Sewer Infrastructure Map of the Borough of Wildwood Crest dated January 7, 1994, latest revision September 1996. Please note various storm sewer improvements have been completed in the Borough since the preparation of the enclosed map. In particular the ocean outfall at Cresse Avenue has been abandoned, there are no longer openings in the bay front street end bulkheads at the street surface between Myrtle Road and Cresse Avenue (each street end is now equipped with a single subsurface outfall, 18" – 24" diameter through the bulkhead with a tideflex valve) and the ocean outfalls have been significantly extended as necessitated by accretion. The ocean outfalls have been extended with 24" diameter ductile iron storm sewer main the following approximate lengths:

- Washington Avenue 363 linear feet
- Hollywood Avenue 357 linear feet
- Miami Avenue 449 linear feet
- Atlanta Avenue 450 linear feet
- Fern Road 642 linear feet
- Heather Road 788 linear feet

In addition to the above, various storm sewer improvements have been completed within the Borough roadways. A new infrastructure map will be prepared in accordance with the recently adopted NJDEP stormwater regulations within the next three (3) years.

Feel free to contact me should you have any questions or if I can be of further assistance.

Sincerely,

James W. Verna III, EIT
Van Note – Harvey Associates

enclosure
cc: Ralph Petrella Jr., Borough Engineer

X:\20000 Projects\22034-WWC General Engineering\22034-Yecco storm sewer infrastructure letter 11-15-05.doc

ENGINEERS • ENVIRONMENTAL CONSULTANTS • SURVEYORS
OFFICES IN: NEW JERSEY • PENNSYLVANIA • NEW YORK CITY

State of New Jersey
Department of Environmental Protection

Richard J. Codey
Acting Governor

Bradley M. Campbell
Commissioner

Division of Budget and Finance
P.O. Box 420
Trenton, New Jersey 08625-0420
Telephone #: (609) 292-9230
Fax #: (609) 633-3727

January 6, 2006

Brian Bogle
Project Manager
Coastal Planning Section
US Army Corps of Engineers
100 Penn Square East
Philadelphia, PA 19107-3390

RE: Project 6040 – Hereford Inlet to Cape May Inlet

Dear Mr. Bogle:

Enclosed are two checks, each in the amount of $100,000.00 for a total of $200,000.00, in payment of NJDEP's cost share for the above-referenced project for the first and second quarters of 2006.

If you have any questions, please contact me at (609) 984-7740.

Sincerely,

Elaine L. Temple

Elaine L. Temple
Office of Trust Fund Management

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Recycled Paper

DEPARTMENT OF THE ARMY

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO
ATTENTION OF

Planning Division

0 9 APR 2006

Ed Kaminski
420 Route 9 North
Cape May Courthouse, New Jersey 08210

Dear Mr. Kaminski:

This letter is a follow up to a telephone conversation with Mr. Brian Bogle of my staff regarding the location of utilities within your service area.

The Philadelphia District of the Army Corps of Engineers is conducting a Feasibility study from Hereford Inlet to Cape May Inlet, New Jersey. As part of the study, we need to identify locations of the various utilities that your company owns. Specifically, we are requesting the location of underground and above ground electric utility lines within North Wildwood, Wildwood, Wildwood Crest and Lower Township, New Jersey. If possible please provide the locations electronically as an AutoCAD file or GIS layer (.dwg, .shp). This information will be used to quantify damages to these lines if they are subject to future erosion and wave damage. We have received similar information from utility providers for studies in Cape May City, Avalon, Stone Harbor and Ocean City.

The Philadelphia District understands the need to keep this information confidential and will not publish the location of the utility lines upon request. We appreciate your time and effort in providing this information. If you have any questions please call Mr. Brian Bogle (215)-656-6585, or e-mail: brian.p.bogle@usace.army.mil.

Sincerely,

for Stan Lily

Minas M. Arabatzis
Chief, Planning Division

DEPARTMENT OF THE ARMY

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO ATTENTION OF

Planning Division

MAY 0 3 2006

Mr. John Garofalo, Manager
Bureau of Coastal Engineering
New Jersey Department of Environmental Protection
1510 Hooper Avenue
Toms River, New Jersey 08753

Dear Mr. Garofalo:

This letter is in regard to the Corps of Engineers ongoing Hereford Inlet to Cape May Inlet Feasibility Study.

The Feasibility Cost-Sharing Agreement (FCSA) for this study was executed in September 2002, and stipulated a non-Federal cost-share of $1,250,000. Through Fiscal Year 2006 the New Jersey Department of Environmental Protection (NJDEP) has provided $750,000, leaving a $500,000 balance for the study. In order to meet the terms of the FCSA and match the Federal funds allocated up to and including fiscal year 2006, we request the NJDEP provide $200,000 by June 30, 2006. This funding will be used to conduct the without project hydraulic and economic analyses, perform geotechnical investigations, identify project alternatives, conduct public outreach and project management.

Thank you for your attention to this matter. If you have any questions, please contact Mr. Brian Bogle, Project Manager, at (215) 656-6585.

Sincerely,

Minas M. Arabatzis
Chief, Planning Division

Copy Furnished:

David Rosenblatt, Administrator
Office of Engineering and Construction
New Jersey Department of Environmental Protection
1510 Hooper Avenue
Toms River, New Jersey 08753

William Dixon, Project Engineer
Bureau of Coastal Engineering
New Jersey Department of Environmental Protection
1510 Hooper Avenue
Toms River, New Jersey 08753

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING-100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO
ATTENTION OF

Planning Division

06 FEB 2007

Mr. Dave Rosenblatt, Administrator
Office of Engineering and Construction
New Jersey Department of Environmental Protection
1510 Hooper Avenue
Toms River, New Jersey 08753

Dear Mr. Rosenblatt:

This letter is in regard to the on going Corps' Hereford Inlet to Cape May Inlet General Investigation. The Feasibility Cost-Sharing Agreement (FCSA) for this study was executed in September 2002, and stipulated a non-Federal cost-share of $1,250,000. Through Fiscal Year 2006 the New Jersey Department of Environmental Protection (NJDEP) has provided $950,000, leaving a $300,000 balance for the study. In order to meet the terms of the FCSA and the Federal funds allocated for FY07, we request the NJDEP submit $200,000 by March 2007. These funds will be spent in the 3rd and 4th quarter of this FY on project formulation, plan selection, public outreach and project management.

Thank you for your attention to this matter. If you have questions contact Brian Bogle, Project Manager, at (215) 656-6585.

Sincerely,

for C. Mac Ontosh
Minas M. Arabatzis
Chief, Planning Division

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING-100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO
ATTENTION OF
CENAP-PL-PC

MEMORANDUM FOR Commander, North Atlantic Division, ATTN: CENAD-ET-P

SUBJECT: Herford Inlet to Cape May Inlet Feasibility Study

1. Authorization. The Hereford Inlet to Cape May Inlet General Investigation was undertaken by authority of the New Jersey Shore Protection Study by resolutions adopted within the committee on Public Works and Transportation of the U.S. House of Representatives in December of 1987.

2. Project Area. The study area is located along the Atlantic coast of New Jersey between Hereford Inlet and Cape May Inlet. It is a heavily developed barrier island that is vulnerable to storm damage and serves as a major tourist destination for the region.

3. Project History. The Reconnaissance phase was completed in January of 2002. The Feasibility Cost-Sharing Agreement was executed on 30 September 2002. The Feasibility phase is scheduled for completion in September of 2008.

4. Project Status. Preliminary discussions with local officials indicate that the original borrow area may not be acceptable. This may necessitate additional investigations and outreach to identify source material. CENAP estimates that additional funds of $304,000 will be needed to complete this effort as well as the completion of the Feasibility study phase.

5. Funding Request. CENAP-PL requests that additional Federal funds of $152,000 be provided.

6. Federal Funding Schedule. An increase to the Federal portion of the Feasibility phase cost estimate from $1,250,000 to $1,402,000 is requested.

7. Point of Contact. Questions should be directed to Brian Bogle, Project Manager, Coastal Planning Section, at (215) 656-6585.

FOR THE COMMANDER:

Richard J. Maraldo

RICHARD J. MARALDO, P.E.
Deputy District Engineer
for Programs and Project Management

DEPARTMENT OF THE ARMY
NORTH ATLANTIC DIVISION, US ARMY CORPS OF ENGINEERS
FORT HAMILTON MILITARY COMMUNITY
BROOKLYN, NEW YORK 11252-6700

REPLY TO ATTENTION OF

JAN 11 2008

CENAD-PSD-P

MEMORANDUM FOR Commander, Philadelphia District, ATTN: CENAP-PL

SUBJECT: Review Plan Approval for Hereford Inlet to Cape May Inlet Feasibility Study

1. Reference:

a. EC 1105-2-408, Peer Review of Decision Documents, 31 May 2005.

b. Memorandum, CECW-CP, 30 March 2007, subject: Peer Review Process.

2. The enclosed Review Plan for the Hereford Inlet to Cape May Inlet Feasibility Study has been prepared in accordance with the referenced guidance.

3. The Plan has been made available for public comment, and any comments received have been incorporated. It has been coordinated with the Planning Center of Expertise for Coastal Storm Damage Reduction. The Plan currently does not include external peer review.

4. I hereby approve this Plan, which is subject to change as study circumstances require, consistent with study development under the Project Management Business Process. Subsequent revisions to this Plan or its execution will require new written approval from this office.

Encl

Joseph R. Vietri
Chief, Planning & Policy Community of Practice
Program Support Division
Programs Directorate

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING-100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

AUG 0 6 2008

REPLY TO ATTENTION OF

CENAP-PL-PC

MEMORANDUM FOR Commander, CENAD ATTN: CENAD-PSD-P (Mr. Doukas)

SUBJECT: Hereford Inlet to Cape May Inlet Feasibility Scoping/In Progress Review (IPR) Meeting

1. References.

(a.) 14 March 2008 meeting between Mr. Doukas (CENAD), Mr. Bogle (CENAP) and Ms. Harrington (CENAP), SAB.

(b.) 5 Jun 2008 phone conversation between Doukas and Bogle, SAB.

(c.) Guidance contained in ER 1105-2-100, Appendix H, dated 20 November 2007.

2. Request. Enclosed are nine copies of the read ahead material as described in Reference 1 (c.) for the subject meeting.

3. Background. The Hereford Inlet to Cape May Inlet Feasibility study was authorized under the New Jersey Shore Protection program to investigate hurricane and storm damage reduction within New Jersey's coastal communities. The enclosed material is designed to facilitate the upcoming study milestones including the Feasibility Scoping Meeting, plan selection and feasibility report submittal. The Hereford Inlet to Cape May Inlet Feasibility study is scheduled for completion in fiscal year 2009.

4. Proposed Meeting Date. The District is requesting a meeting between the appropriate parties to be coordinated by NAD, at Philadelphia District Office, within 30 days of the receipt of this memorandum.

5. Point of Contact. The point of contact for this study is Mr. Brian Bogle, CENAP-PL-PC, (215)-656-6585.

FOR THE COMMMANDER:

MINAS M. ARABATZIS
Chief, Planning Division

Enclosures (9)

Copy Furnished: (1)
Cynthia Jester CEMP-NAD

DEPARTMENT OF THE ARMY
NORTH ATLANTIC DIVISION, CORPS OF ENGINEERS
FORT HAMILTON MILITARY COMMUNITY
GENERAL LEE AVENUE
BROOKLYN, NY 11252-6700

REPLY TO
ATTENTION OF

CENAD-PDS 14 August 2008

MEMORANDUM FOR: Chief, CENAD-PDC (Mr. Lawrence Petrosino)

SUBJECT: SUBJECT: New Jersey Shore Protection Study, Hereford Inlet to Cape May , New Jersey - Feasibility Scoping Meeting (FSM)

1. References:

a. CENAP-PL-PC memorandum, dated 6 August 2008, transmitting read-ahead material.

b. ER 1105-2-100, Appendix. G, Amendment #2, dated 31 July 2007 and Appendix H, dated 20 November 2007, provides guidance with regard to FSM briefing materials.

2. Enclosed are eight copies of the read ahead material. As described in reference 1(a), the Hereford Inlet to Cape May Feasibility study was authorized under the New Jersey Shore Protection Program to investigate hurricane an storm damage reduction within New Jersey coastal communities. The enclosed information is intended to facilitate discussion and documentation for the proposed vertical team meeting and assist the district with its remaining tasks in finalizing the draft feasibility report.

3. The Division staff has preliminarily reviewed the Philadelphia District read-ahead information and has no significant comments or concerns at this time. This office requests a meeting between our appropriate staffs at the NAP district Offices within 30 days of receipt of this memorandum.

4. Please contact, Mr. Peter Doukas of my staff at 718.765.7068 should you have any questions or require additional information.

Encl
as

for JOSEPH R. VIETRI
Chief, Policy and Planning Formulation
Programs Directorate

DEPARTMENT OF THE ARMY
NORTH ATLANTIC DIVISION, CORPS OF ENGINEERS
FORT HAMILTON MILITARY COMMUNITY
GENERAL LEE AVENUE
BROOKLYN, NY 11252-6700

REPLY TO
ATTENTION OF

CENAD-PD-CID

28 August 2008

MEMORANDUM FOR: Regional Integration Team, U. S. Army Corps of Engineers 441 G Street NW, Washington D.C. 20314-1000 ATTN: Ms Cynthia Jester (CEMP-NAD)

SUBJECT: SUBJECT: New Jersey Shore Protection Study, Hereford Inlet to Cape May, New Jersey - Feasibility Scoping Meeting (FSM)

1. References:

a. CENAD-PDS memorandum, dated 14 August 2008, requesting a FSM meeting

b. CENAP-PL-PC memorandum, dated 6 August 2008, transmitting read-ahead material.

c. ER 1105-2-100, Appendix. G, Amendment #2, dated 31 July 2007 and Appendix H, dated 20 November 2007, provides guidance with regard to FSM briefing materials.

2. Enclosed are eight copies of the read ahead material. As described in reference 1(b), the Hereford Inlet to Cape May Feasibility study was authorized under the New Jersey Shore Protection Program to investigate hurricane and storm damage reduction within New Jersey coastal communities. The enclosed information is intended to facilitate discussion and documentation for the proposed vertical team meeting and assist the district with its remaining tasks in finalizing the draft feasibility report.

3. The Division staff has preliminarily reviewed the Philadelphia District read-ahead information and has no significant comments or concerns at this time. This office requests a meeting between our appropriate staffs at the NAP district Offices within 30 days of receipt of this memorandum. A call in phone number will be available for the meeting.

4. Please contact, Mr. Patricia Donohue of my staff at 718.765.7080 should you have any questions or require additional information.

Lawrence Petrosino

Encl
as

LAWRENCE PETROSINO
Chief, Civil Works Integration Division
Programs Directorate

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
WASHINGTON, D.C. 20314-1000

CEMP-NAD

OCT 2 2008

MEMORANDUM FOR COMMANDER, NORTH ATLANTIC DIVISION (NAD-PD-CID-S)

SUBJECT: New Jersey Shore Protection Study, Hereford Inlet to Cape May, New Jersey – Feasibility Scoping Meeting (FSM) Package

1. Reference CENAD-PD-CID-S memorandum, dated 28 August 2008, Subject: New Jersey Shore Protection Study, Hereford Inlet to Cape May, New Jersey – Feasibility Scoping Meeting (FSM)

2. Enclosed are the consolidated HQUSACE comments on the subject FSM package for your response. In general the submission lacks some of the information specified in Exhibit H-3 of ER 1105-2-100, such as an outline of the feasibility report and draft report text relative to existing and future without-project conditions. Once responses have been generated, please contact the RIT to schedule a FSM.

3. If you have any questions please contact Ms. Cynthia Jester at 202-761-1379.

Encl

MOHAN SINGH, P.E.
Chief, North Atlantic Division
Regional Integration Team
Directorate of Military Programs

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO ATTENTION OF

CENAP-PL-PC

DEC 12 2008

MEMORANDUM FOR Commander, CENAD ATTN: CENAD-PD-CID-S (Mr. Joseph Forcina)

SUBJECT: Hereford Inlet to Cape May Inlet Feasibility Scoping/ In Progress Review (IPR) Meeting

1. References.

(a.) 2 October 2008 CEMP-NAD Memorandum.

(b.) 14 March 2008 meeting between Mr. Doukas (CENAD), Mr. Bogle (CENAP) and Ms. Harrington (CENAP), SAB.

(c.) 5 June 2008 phone conversation between Doukas and Bogle, SAB.

(d.) Guidance within ER 1105-2-100, Appendix H, dated 20 November 2007.

(e.) 9 December 2008 phone conversation between Doukas and Bogle, SAB.

2. Request. Enclosed are four copies of the 2 October 2008 Memorandum (Reference 1. (a)), and responses to the comments within the October Memorandum.

3. Background. The Hereford Inlet to Cape May Inlet feasibility study was authorized under the New Jersey Shore Protection program to investigate hurricane and storm damage reduction within New Jersey's coastal communities. The enclosed contains the District's responses to the review team comments on the read ahead material that were contained within the October Memorandum. The draft report text relative to the introduction, existing conditions and without project conditions sections of the feasibility study will be provided prior to the Feasibility Scoping/In Progress Review Meeting, as agreed to during reference 1 e.

4. Proposed Meeting Date. The District is requesting a meeting between the appropriate parties to be coordinated by NAD at the location of their preference upon the review of this material.

CENAP-PL-PC
SUBJECT: Hereford Inlet to Cape May Inlet Feasibility Scoping/ In Progress Review (IPR) Meeting

5. Point of Contact. The point of contact for this study is Mr. Brian Bogle, CENAP-PL-PC, (215)-656-6585.

FOR THE COMMMANDER:

for MINAS M. ARABATZIS
Chief, Planning Division

Enclosures (4)

Copy Furnished: (8)
Cynthia Jester
CEMP-NAD
441 G Street
Washington, DC 20314

DEPARTMENT OF THE ARMY

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO
ATTENTION OF

Planning Division

FEB 0 6 2009

Mr. David Rosenblatt, Administrator
Office of Engineering and Construction
New Jersey Department of Environmental Protection
1510 Hooper Avenue
Toms River, New Jersey 08753

Dear Mr. Rosenblatt:

This letter is in regard to the Hereford Inlet to Cape May Inlet Feasibility Study. The Feasibility Cost-Sharing Agreement for this study was executed in September of 2002.

In order to maintain study development, facilitate the technical review and meet study milestones the District is requesting $154,000 from NJDEP for FY09.

If you have any questions, please contact Brian Bogle, Project Manager, at (215) 656-6585.

Sincerely,

for Minas M. Arabatzis
Chief, Planning Division

Copy Furnished:

Benjamin Keiser, Project Engineer
Bureau of Coastal Engineering
New Jersey Department of Environmental Protection
1510 Hooper Avenue
Toms River, New Jersey 08753

DEPARTMENT OF THE ARMY

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO
ATTENTION OF

Attention: North Wildwood, Wildwood and Wildwood Crest Residents

This is to inform you that the Philadelphia District of the Army Corps of Engineers will be collecting information / data for the ongoing Hereford Inlet to Cape May Inlet feasibility study in your area. This activity will take place during April and May 2010.

The information we collect will be used to develop a plan to prevent storm damage within the study area between Hereford Inlet and Cape May Inlet. During the data collection period consultants from the firm of Michael Baker Jr., Inc., under contract to the Corps of Engineers, will be conducting field surveys of properties within the study area.

The information collected will consist of:

1. Residential & commercial structure inventories including recording the address, property size and type of construction.
2. Residential & commercial first floor elevations to determine the properties' location & vulnerability to storm damage.
3. Photographs of residential & commercial structures.
4. Recording elevations at various locations on the island.

If you have questions, please contact the Project Economist, Robert Selsor, at (215) 656-6569.

Sincerely,

for C. MacIntosh
Minas M. Arabatzis
Chief, Planning Division

DEPARTMENT OF THE ARMY

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO
ATTENTION OF

APR 30 2010

Mr. Dave Rosenblatt, Administrator
New Jersey Department of Environmental Protection
Bureau of Dam Safety and Flood Control
501 East State Street
P.O. Box 419
Trenton, NJ 08625-0419

Dear Mr. Rosenblatt:

The Feasibility Cost Sharing Agreement (FCSA) for the Hereford Inlet to Cape May Inlet feasibility study was signed on 9/30/2002. The cost estimate for the study was $2,500,000. Since the signing of the FCSA the costs of the study have increased due to additional requirements for Federal Water Resource projects. These new requirements include an Agency Technical Review and an Independent External Peer Review (EC 1165-2-209), a Value Engineering study (ER 11-1-321), new requirements within Planning Models and Improvement Program (EC 1105-2-407) and the requirement for a Civil Works Review Board meeting (EC 1105-2-406). Based on these additional requirements the updated cost estimate for the Hereford Inlet to Cape May Inlet Feasibility Study is $3,700,000.

To date, the New Jersey Department of Environmental Protection has provided $1,552,000 and the Federal Government has provided $1,584,142 in study funds. Based on the funds allocated, and the new feasibility estimate, the total amount required to complete the feasibility study is approximately $563,858. Some of the new requirements discussed above are not cost shared at 50% Federal, 50% non-Federal, as in the original FCSA, but are a 100% Federal responsibility. Therefore, the updated non-Federal funding amount necessary to complete the feasibility study is $131,929.

As you indicate that you have budgeted $32,000 this year for the Hereford study, a check in the amount of **$32,000** is requested, and should be made payable to, "**FAO, USAED Philadelphia**". The Funds should be sent to the following address:

Mr. Minas Arabatzis, Chief
Planning Division (CENAP-PL)
U. S. Army Corps of Engineers, Philadelphia District
Wanamaker Building, 100 Penn Square East
Philadelphia, PA 19107-3390

If additional information is required, please contact Mr. Brian Bogle, Project Manager, at (215) 656-6585.

Sincerely,

for C. Mac Intosh
Minas Arabatzis
Chief, Planning Division

CF:
Mr. Ben Keiser, Manager
Bureau of Coastal Engineering
New Jersey Department of Environmental Protection
1510 Hooper Avenue
Toms River, NJ 08753

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO ATTENTION OF

JUN 17 2010

CENAP-PL-PC

MEMORANDUM FOR Commander, CENAD ATTN: (CENAD-PSD-P) (Peter Blum)

SUBJECT: Transmittal of Risk and Uncertainty (R&U) plan for Hereford Inlet to Cape May Inlet.

1. BACKGROUND. The Philadelphia District held a Feasibility Scoping Meeting (FSM) for the Hereford Inlet to Cape May Inlet feasibility study on 23 July 2009. Attendees at the FSM included the Office of Water Policy Review (OWPR), the North Atlantic Division Regional Integration Team (NAD-RIT), North Atlantic Division (NAD), New Jersey Department of Environmental Protection (NJDEP), the non-Federal Sponsor, and key members of the Philadelphia District Project Development Team. One of the recommendations at the meeting from the OWPR, the NAD-RIT and NAD was for the District to pursue one of two paths in order to adequately address Risk and Uncertainty (R&U) inherent in storm damage reduction projects. The first path was to reanalyze the storm damage reduction effort using the recently approved coastal storm damage reduction model, Beach-*fx*. The second path was for the District to enhance its existing modeling effort in order to better address Risk and Uncertainty. The decision on which path to pursue would be based upon the confidence the District has in their 20 years experience in planning, designing and constructing shore protection projects using its current storm damage reduction model, compared to the costs and time delays of executing the new Beach-*fx* model and the needs of the non-Federal sponsor. Based on these criteria, the District decided to pursue an enhanced version of its current model in order to better address Risk and Uncertainty (Enclosure). Subsequent guidance from NAD, provided during the 18 February 2010 In-Progress Review (IPR) meeting, instructed the District to develop their Risk and Uncertainty plan with the current model. NAD also indicated that they would prepare a letter exempting the District from use of Beach-*fx* contingent upon satisfactory review of the District's Risk and Uncertainty analysis.

2. REQUEST. The District is transmitting a draft of its Risk and Uncertainty plan to NAD for review and approval prior to coordinating with the Jacksonville District ATR team. Upon approval by NAD the District will coordinate the Risk and Uncertainty Plan with the ATR team in order to execute the plan outlined in the draft.

Sincerely,

for C. MacIntosh
Mike Arabatzis
Chief, Planning Division

Enclosure

DEPARTMENT OF THE ARMY
NORTH ATLANTIC DIVISION, CORPS OF ENGINEERS
FORT HAMILTON MILITARY COMMUNITY
BROOKLYN, NY 11252-6700

REPLY TO
ATTENTION OF

CENAD-PL

17 November 2010

MEMORANDUM FOR: Chief, CENAD-CID

SUBJECT: Hereford Inlet to Cape May Inlet, Draft Risk and Uncertainty Plan

1. The NAD Planning and Policy Division has reviewed the Draft Risk and Uncertainty Plan for Hereford Inlet to Cape May Inlet. The draft plan is approved and the District should proceed as recommended while addressing the following comments:

   a. The District should update their Review Plan to describe the risk and uncertainty Agency Technical Review (ATR) and provide to the Planning Center of Expertise - Coastal and Storm Damage Reduction (c/o Larry Cocchieri) for approval.

   b. The District should also undertake ATR of the Draft Risk and Uncertainty Plan for Hereford Inlet to Cape May Inlet. Comments should be provided in DrChecks and a memo provided by the ATR team indicating their concerns or concurrence with this approach. The District should provide this memo to NAD.

   c. Pending ATR team concurrence, the District can complete the updated analysis, to include risk and uncertainty and economic risk considerations. The analysis and results would undergo ATR and the Planning Center of Expertise - Coastal and Storm Damage Reduction will determine if an "approved for one time use" model request to HQUSACE, Office of Water Project Review is warranted and will submit the required materials, as appropriate.

   d. NAD has prepared the enclosed transmittal memo to be forwarded to the HQUSACE NAD RIT stating that this approach is the required follow up to the June 2010 Feasibility Scoping Meeting. NAD and the District will proceed with implementing this approach.

2. Please direct any questions to Ms. Amy Guise (NAB Planning Manager) at 410-962-6138.

Encl

for JOSEPH R. VIETRI
Chief, Planning and Policy Division
Programs Directorate

DEPARTMENT OF THE ARMY
NORTH ATLANTIC DIVISION, CORPS OF ENGINEERS
FORT HAMILTON MILITARY COMMUNITY
BROOKLYN, NY 11252-6700

REPLY TO
ATTENTION OF

CENAD-PL

17 November 2010

MEMORANDUM FOR: Chief, CENAD-CID

SUBJECT: Hereford Inlet to Cape May Inlet, NJ, Draft Risk and Uncertainty Plan

1. This memorandum is provided for information regarding issues raised at the Feasibility Scoping Meeting for the subject study. In follow-up, CENAP has outlined an approach to incorporate risk and uncertainty and economic risk considerations into their modeling efforts.

2. The NAD Planning Division / Planning Center of Expertise - Coastal Storm Damage Reduction, has reviewed and approved the Draft Risk and Uncertainty Plan for Hereford Inlet to Cape May Inlet. The draft plan is currently undergoing Agency Technical Review via Jacksonville District. Pending resolution of any Agency Technical Review (ATR) comments, the MSC and District will proceed with implementing the proposed approach to incorporate risk and uncertainty and economic risk considerations into their modeling efforts.

3. Once the analyses are completed, they would undergo ATR and the Planning Center of Expertise - Coastal and Storm Damage Reduction will determine if an "approved for one time use" model request to HQUSACE is warranted and will submit the required materials, as appropriate.

4. The District has updated their Review Plan to describe the risk and uncertainty ATR.

5. Request you furnish this memorandum to HQUSACE and request that any questions or comments be directed to Ms. Amy Guise (NAB Planning Manager) at 410-962-6138.

for JOSEPH R. VIETRI
Chief, Planning and Policy Division
Director, Planning Center of Expertise for
Coastal Storm Damage Reduction

DEPARTMENT OF THE ARMY

PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO
ATTENTION OF

MAY 19 2011

CENAP-PL-PC

MEMORANDUM FOR: Commander, CENAD, ATTN: CENAD-PD-CID-S (Mr. Lawrence Petrosino).

SUBJECT: Documentation of Feasibility Scoping Meeting (FSM) for the Hereford Inlet to Cape May Inlet, NJ Feasibility study.

1. References.

a. Memorandum, CENAP-PL-PC, 12 December 2008, District response to HQUSACE comments regarding Feasibility Scoping Meeting materials.

b. Memorandum, CEMP-NAD, 2 October 2008, Transmittal of HQ comments to CENAD-PD-CID-S.

c. Memorandum, CENAD-PD-CID, 28 August 2008, Transmittal of Feasibility Scoping meeting materials to CEMP-NAD.

d. Memorandum, CENAD-PDS, 14 August 2008, Transmission of Feasibility Scoping Meeting read ahead materials to CENAD-PDC.

e. Memorandum, CENAP-PL-PC, 6 August 2008, Transmittal of Feasibility Scoping Meeting materials to CENAD-PDS.

2. Background.

The FSM read ahead materials were transmitted to North Atlantic Division (NAD) from the District on 6 August 2008, Reference 1.e. The District's August transmittal was then routed through NAD in a memorandum dated 14 August 2008, Reference 1.d, and then on to Headquarters in a memorandum dated 28 August 2008, Reference 1.c. Headquarters then provided comments on the pre-FSM submittal package to NAD in a Memorandum dated 2 October 2008, Reference 1.b., Enclosure 1. The District responded to Headquarters comments in their 12 December 2008 memorandum, Reference 1.a, Enclosure 2, and the FSM was scheduled.

All of the pre- FSM materials submitted to NAD and to the OWPR underwent an Agency Technical Review (ATR) by the Jacksonville District of the Army Corps of Engineers and all comments from the ATR team were input into the Design Review and Checking System (Dr. Checks), Enclosure 3. These materials included the Draft Feasibility report containing the Introduction, Existing Conditions, Without Project Conditions and With Project Conditions up to and including the preliminary selected plan. Comments from the Jacksonville District were entered into the Projnet/Dr. Checks tracking system and closed prior to the FSM.

The FSM was held at the Philadelphia District on 23 July 2009. Opening comments were given by Peter Doukas, of NAD, Wesley Coleman, Chief of the Office of Water Policy Review (OWPR) and Minas Arabatzis, the Chief of Planning Division, Philadelphia District. The Project Manager, Brian Bogle, provided a project overview of the study using the attached Microsoft Power Point slides (Enclosure 4). These slides reviewed the study background, authority, location, problems, opportunities, objectives, constraints, without project damages, plan formulation and identified a preliminary selected plan and documented the study findings to date.

Enclosure 5 contains the District's Memorandum For Record (MFR) of the FSM meeting. This MFR documented the meeting and contains a list of all FSM attendees. All attendees of the meeting received a copy of the District's MFR.

3. District Memorandum For Record (MFR).

The District MFR documented the main discussion points of the FSM meeting. The three main points of discussion at the FSM concerned the Future Without Project Conditions, the status of the Independent External Peer Review, and Model Certification. The Future Without Project Conditions will be examined more closely and presented in the final Feasibility Report. The Independent External Peer Review is being anticipated as a future requirement and is currently being included in the project schedule.

The model certification discussion was based on the fact that a combination of SBEACH and COSTDAM were used for this study instead of Beach-*fx*. Beach-*fx* was certified for USACE storm damage reduction studies on 1 April 2009 and is the only certified corporate model for storm damage assessment, although certification of a model is not a requirement for its use. All modeling for this study were conducted in 2005, 2006, and 2007 with SBEACH/COSTDAM, before Beach-*fx* was available for use as a certified model. Two alternatives were discussed at the FSM in order to incorporate the use of a certified model: (1) even though all modeling is complete for this study, the PDT could run all necessary modeling using Beach-*fx* or (2) the PDT could enhance the existing modeling effort in order to address risk and uncertainty (R&U). The team also will clearly explain the 20+ years of experience with storm damage modeling in this region and describe how the analyses were performed and how the projects, based upon these models, have performed. It was agreed that this explanation would be included in a white-paper that outlined the timeline for the Hereford study versus the development of Beach-*fx* and be presented to FSM attendees and reviewers. This paper would also explain the history of the use of the current SBEACH/COSTDAM model and the resources required to reanalyze this study using Beach-*fx* (Enclosure 6).

4. Path Forward

Alternative (2), enhancing the existing model to incorporate R&U was chosen as the most reasonable and efficient path forward. The R&U plan that was developed by the PDT was forwarded to North Atlantic Division (NAD) on 17 June 2010 (Enclosure 7). NAD approved the R&U plan in an internal memo dated 17 November 2010. The NAD memo required the Jacksonville ATR team to review the District R&U model.

The charge to the Jacksonville ATR team was as follows;

> *"Is the proposed analysis, if added to the current storm damage reduction model process, reasonable enough to incorporate the variability associated with economic and hydraulic systems in order to meet the requirement identified at the Feasibility Scoping Meeting of enhancing the existing effort in order to address risk and uncertainty"*

All comments from the ATR team on the R&U analysis were input into the Projnet/Dr. Checks tracking system and addressed by the PDT. The ATR for the R&U plan was certified on 2 February 2011 (Enclosure 8). A District Quality Control report was certified on the post ATR reviewed final R&U document on 1 March 2011. NAD also required the review of the R&U model by the Planning Center of Expertise for Economics, Norfolk District. Norfolk District is currently reviewing the District Model and will enter all comments into the Projnet/Dr. Checks tracking system. The PCX will also review and certify all model results upon completion of the District's analysis. The results of the R&U analysis will be added to the existing draft feasibility report and be presented at the Alternative Formulation Briefing (AFB).

4. Required Action. It is requested that this memorandum document the completion of the Feasibility Scoping Meeting (FSM) milestone for the subject study and serve as the path forward for the District in lieu of a Program Guidance Memorandum.

FOR THE COMMANDER:

for C. MacIntosh
Minas M. Arabatzis
Chief, Planning Division

Enclosure 1. Pre-FSM submittal (Draft Report)
Enclosure 2. Response to HQ/OWPR comments
Enclosure 3. Jacksonville pre-FSM ATR Comments
Enclosure 4. Microsoft Power Point slides
Enclosure 5. District MFR
Enclosure 6. District white paper
Enclosure 7. District R&U approach
Enclosure 8. ATR comments and Certification of R&U approach

THE BOROUGH OF WILDWOOD CREST

6101 Pacific Avenue, Wildwood Crest, NJ 08260
www.wildwoodcrest.org

CARL GROON
Mayor -
Public Safety

JOYCE GOULD
Revenue &
Finance

DON CABRERA
Public Works &
Recreation

COMMISSIONERS
BOROUGH CLERK
609-522-5176
FAX 609-522-7108

FIRE PREVENTION/
CODE ENFORCEMENT
609-729-5152
FAX 609-729-7089

PUBLIC WORKS
609-522-7446

RECREATION
609-523-0202

TAX ASSESSOR
609-522-3891

TAX COLLECTOR
SEWER COLLECTION
609-522-3843
FAX 609-522-6692

TREASURER
609-522-0401
FAX 609-522-6692

October 6, 2011

Brian P. Bogle, Project Manager
Coastal Planning Section
Planning Division
United States Army Corps of Engineers
100 Penn Square East
Philadelphia, PA 19107-3390

Dear Mr. Bogle:

I wanted to take this opportunity to thank you for your participation at the recent discussion regarding beach accretion in Wildwood Crest. Although no final resolution of the Borough's problems was reached, I certainly appreciate the time and effort provided by everyone involved.

I look forward to further discussions and an alternative to the burden being placed on the taxpayers of the Borough of Wildwood Crest.

Very truly yours,

Carl H. Groon, Mayor

the LOMAX Consulting group

P. O. Box 9 (mailing)
1435 Route 9 North (delivery)
Cape May Court House, NJ 08210, USA

609-465-9857 (P)
609-465-2449 (F)
WWW.LOMAXCONSULTING.COM

MEETING AGENDA
Wednesday, September 28, 2011

PROJECT: Wildwood Crest Oceanfront
Borough of Wildwood Crest, Cape May County, NJ
TLCG File No.: 09-662

ATTENDEES:
Carl Groon, Borough Mayor
Doreen Corino, Esq., Borough Solicitor
James W. Verna III, PE, Borough Engineers Office
Richard Hluchan, Esq.
Richard Weggel, P.E.
Joseph Lomax – The Lomax Consulting Group
Ben Keiser, Bill Dixon, Chris Constantino – NJDEP
Jeff Gebert and Brian Bogle – USACE

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1. Introduction
2. Purpose of the Meeting:
   A. Statement of Borough issues, i.e. economic impact of beach accretion on stormwater management and tourism
   B. Seek near-term and long-term solutions
3. USACE – Coastal sand budget studies and beach management feasibility – Hereford Inlet to Cape May Area
4. NJDEP – Coastal Engineering role in beach management (State program sponsor)
5. Opportunities/approaches to addressing the Borough's beach management issues
6. Next Steps

PROJECTS\Active\09-662\ Correspondence\MEETING AGENDA 9_28_11.doc

CESAJ-PD-PW February 2, 2011

MEMORANDUM FOR THE RECORD

SUBJECT: Hereford Inlet to Cape May Inlet Feasibility Study, Summary of Agency Technical Review of the Proposed Risk and Uncertainty Plan

1. Agency Technical Review (ATR) of the subject Risk and Uncertainty Plan, prepared by Philadelphia District (NAP), was managed by the Coastal Storm Damage Reduction Planning Center of Expertise (PCX-CSDR) in NAD. The ATR was performed by a team composed of staff of the Jacksonville District, in SAD.

2. It is the understanding of the ATR Team that the purpose of the Risk and Uncertainty Plan is to provide methods sufficient to evaluate risk and uncertainty, in lieu of addressing risk and uncertainty by employment of Beach-fx. It was reviewed within that context.

3. The team was composed of a subset of the original team, appropriate for the scope of review of the Risk and Uncertainty Plan, including: economics, plan formulation and coastal engineering. The Charge to Reviewers was as follows: Is the proposed analysis, if added to the current storm damage reduction model process, reasonable enough to incorporate the variability associated with economic and hydraulic systems in order to meet the requirement identified at the Feasibility Scoping Meeting of enhancing the existing effort in order to address risk and uncertainty?

4. Review of the document resulted in a total of 12 comments, with significant comments from all reviewers. The PDT concurred with and resolved all comments. Resolution of comments was based upon the PDT responses provided in DrChecks and by review of draft report revisions. DrChecks reports that provide detailed documentation of the ATR comments and PDT responses are provided in Attachment 1 to this memorandum.

5. The ATR team found that the proposed analysis, if added to the current storm damage reduction model process employing COSTDAM, may be reasonable enough to incorporate the variability associated with economic and hydraulic systems in order to meet the requirement identified at the Feasibility Scoping Meeting of enhancing the existing effort in order to address risk and uncertainty. However, there is an inherent disadvantage adapting a probabilistic model versus employing a life cycle model, such as Beach-fx: the erosion damage function to pile structures is hard-wired in COSTDAM i.e., percentage damage is programmed to be always directly proportional to percent of the eroded footprint (regardless of the depth of the piles) and therefore, this damage function cannot be subject to variability, nor risk and uncertainty.

_____
James M. Baker, Jacksonville District
Agency Technical Review Lead

CESAJ-PD-PW December 7, 2011

MEMORANDUM FOR THE RECORD

SUBJECT: Hereford Inlet to Cape May Inlet Feasibility Study, Summary of Agency Technical Review of the Risk and Uncertainty Economics Model Application

1. Agency Technical Review (ATR) of the subject risk and uncertainty economics model application, prepared by Philadelphia District (NAP), was managed by the Coastal Storm Damage Reduction Planning Center of Expertise (PCX-CSDR) in NAD. The ATR was performed by Dan Abecassis, the ATR team economics reviewer, Jacksonville District, in SAD.

2. There were six economics-related comments and one H&H-related comment. All issues were resolved and all comments closed in DrChecks. A report listing all comments and associated resolutions is enclosed, herein. The review resulted in two specific recommendations that are provided in paragraphs 3 and 4, below.

3. Recommendation 1: The model review documentation for one-time-approval-for-use: needs to be completed to comply with EC 1105-2-412, Quality Assurance of Planning Models, in accordance with the process established by the Coastal PCX. Philadelphia District will need to work with the PCX for the procedural protocols.

4. Recommendation 2: Include Regarding a qualitative assessment addressing the reasonableness of the proportional erosion damage function to pile structures, in the draft report, in response to comment 4293973, relating to damages incurred to structures on pile foundations. The PDT economist has indicated that the depth of the piles to structures on pile foundations is not information readily obtainable, not even from a sampling perspective. It is recognized that one of the limitations of the COSTDAM model is that the calculation for erosion damage to pile structures is hardcoded to compute damages proportional to the footprint (i.e., 10% erosion of footprint equates to 10% damage, 20% erosion, 20% damage, etc.) arriving at 100% damage when the full footprint has been subjected to erosion by the model. The economist has indicated that a qualitative assessment addressing the reasonableness of the proportional erosion damage function to pile structures will be further coordinated with the engineering discipline and provided in the feasibility report. (The limitation of the COSTDAM model for the computation of erosion damages to pile structures should also be documented in the model review appendix). The qualitative assessment will be reviewed during the next ATR.

Enclosure

James M. Baker, Jacksonville District
Agency Technical Review Lead

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET NW
WASHINGTON, D.C. 20314-1000

CEMP-NAD-RIT 3 June 2011

MEMORANDUM FOR THE RECORD

SUBJECT: Hereford Inlet to Cape May Inlet, New Jersey – Feasibility Scoping Meeting Documentation

1. Reference CENAB-PL-P Memorandum for the Record dated 23 July 2009, subject as above.

2. Documentation of the Hereford to Cape May Inlet, New Jersey Feasibility Scoping Meeting (FSM) was completed in July of 2009. Policy compliance review comments were discussed and subsequently resolved during the FSM

3. HQ, the MSC and District have concurred on the outcome of the FSM and understand the following actions will be required prior commencement of the Alternative Formulation Briefing:

a. Certification for one-time use of the SBEACH–COSTDAM methodology for the storm damage and damage reduction benefits analysis.

b. Update the Peer Review Plan to include IEPR.

c. Initiation of IEPR process.

4. Questions regarding this matter should be directed to Catherine Shuman, NAD-RIT Planning Program Manager, (202) 761-1379.

PETE LUISA
Deputy Chief, Civil Works
NAD Regional Integration Team
Directorate of Military Programs

DEPARTMENT OF THE ARMY
NORTH ATLANTIC DIVISION, CORPS OF ENGINEERS
FORT HAMILTON MILITARY COMMUNITY
BROOKLYN, NY 11252-6700

REPLY TO
ATTENTION OF

CEPCX-CSDR

MAR 13 2012

MEMORANDUM FOR: CEMP-NAD, Attention: Ms. Catherine Shuman

SUBJECT: Model Review Plan for the Hereford Inlet to Cape May Inlet, NJ Feasibility Study

1. The National Planning Center of Expertise for Coastal Storm Damage Reduction (PCX-CSDR) has reviewed the Model Review Plan (MRP) for the subject study, which was prepared in accordance with EC 1105-2-412, entitled "Assuring Quality of Planning Models". The subject MRP for an approved model is enclosed for your concurrence.

2. While PCX-CSDR led a model review to ascertain its validity, we are proposing the subject MRP at this time and would be available to discuss any additions or enhancements to it, in which we would carry out, as necessary.

3. For further information, please contact Mr. Larry Cocchieri at 347-370-4571.

Encl

JOSEPH R. VIETRI
Director, National Planning Center of
Expertise for Coastal Storm Damage
Reduction

DEPARTMENT OF THE ARMY

PHILADELPHIA DISTRICT CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO ATTENTION OF

MAR 15 2012

Regulatory Branch
Application Section II

SUBJECT: CENAP-OP-R-2012-79-24
NJDEP #: 0500-07-0006.1, CAF 070001
0515-09-0003.1, CAF100001
WILDWOOD CREST TO NORTH WILDWOOD BEACH SAND BACKPASSING

Mr. Louis J. Belasco, Administrator
City of North Wildwood
901 Atlantic Avenue
North Wildwood, New Jersey 08280

Dear Mr. Belasco:

This is in regard to your application for a Department of the Army permit to perform beach nourishment between 2nd and 7th Avenues in North Wildwood by means of "backpassing" sand from the beach at Wildwood Crest, in Cape May County, New Jersey. The permit application was submitted on your behalf by the Coastal Research Center of Richard Stockton College.

A copy of a public notice of your application is enclosed for your information. You are reminded of your responsibility to obtain State approval from the New Jersey Department of Environmental Protection (NJDEP), including a Section 401 Water Quality Certificate and concurrence that the proposed project is consistent with their approved Coastal Zone Management Program. You should contact the NJDEP Land Use Regulation Program, P.O. Box 439, Trenton, New Jersey 08625-0439, or (609) 292-0060, for additional information. When you receive your State authorization(s), it is requested that copies be furnished to this office.

If you should have any questions regarding this matter, please contact James Boyer of my office by calling (215) 656-5826, by electronic mail to James.N.Boyer@usace.army.mil or by writing to the above address.

Sincerely,

for Frank J. Cianfrani
Chief, Regulatory Branch

Enclosure

Copies Furnished:

NJDEP, Bureau of Coastal Regulation (LURP – Chris Dolphin)
NJDEP, Bureau of Coastal Regulation (LURP – Janet Stewart)
NJDEP, Bureau of Coastal Regulation (LURP – Gail Moore)
NJDEP, Historic Preservation Office (Jesse West-Rosenthal)
USFWS, Pleasantville (Wendy Walsh)
NMFS, Sandy Hook
NMFS, Gloucester, MA
USEPA, Region II
USCG, Fifth District
CENAP-DP-CW (Keith Watson)
CENAP-PL-E (Beth Brandreth)
CENAP-PL-E (Nikki Minnichbach)
CENAP-PL-PC (Jeff Gebert)
CENAP-PL-PC (Brian Bogle)
CENAP-EC-EH (Robert Lowinski)

Mr. Christopher Constantino
NJDEP, Bureau of Coastal Engineering
1510 Hooper Avenue, Suite 140
Toms River, New Jersey 08753

FEMA:	Ms. Megan Jadrosich. U.S. Department of Homeland Security Mitigation Division 26 Federal Plaza, 13th Floor New York, New York 10278-0002
Agent for North Wildwood:	Dr. Stewart Farrell Coastal Research Center 30 Wilson Avenue Port Republic, New Jersey 08241
Agent for Wildwood Crest:	Mr. Ralph Petrella, Jr. Van Note-Harvey Associates 211 North Main Street, Suite 203 Cape May Court House, New Jersey 08210
City of Wildwood:	Honorable Ernie Troiano, Jr. Mayor, City of Wildwood 4400 New Jersey Avenue Wildwood, New Jersey 08262

THIS IS NOT A PAID ADVERTISEMENT

Public Notice

US Army Corps of Engineers
Philadelphia District
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390
ATTN: CENAP-OP-R

Public Notice No. CENAP-OP-R-2012-79-24
Date MAR 1[illegible] 2012
Application No.
File No.
In Reply Refer to: REGULATORY BRANCH

This District has received an application for a Department of the Army permit pursuant to Section 10 of the Rivers and Harbors Act of 1899 (33 U.S.C. 403) and Section 404 of the Clean Water Act (33 U.S.C. 1344).

The purpose of this notice is to solicit comments and recommendations from the public concerning issuance of a Department of the Army permit for the work described below.

APPLICANT: City of North Wildwood

ADDRESS: 901 Atlantic Avenue
North Wildwood, New Jersey 08280

AGENT: The Coastal Research Center
The Richard Stockton College of New Jersey
30 Wilson Avenue
Port Republic, New Jersey 08241

WATERWAY: Atlantic Ocean

LOCATION: The proposed fill or deposition area is situated on the ocean-front beach, immediately southwest of Hereford Inlet, between the jetty at 2nd Avenue and 7th Avenue in the City of North Wildwood, Cape May County, New Jersey. The proposed excavation or borrow area is situated on the ocean-front beach within the Borough of Wildwood Crest, between the southwest municipal boundary adjacent to Jefferson Avenue and the northeast municipal boundary at Cresse Avenue. The truck haul route would be on the ocean-front beach within the Cities of Wildwood and North Wildwood, from Wildwood Crest northeast to the fill area beginning at 7th Avenue. The point of access to the beach area for equipment in North Wildwood would be at 15th Avenue, with staging at the lifeguard parking lot. The point of access to the beach area for equipment in Wildwood Crest would be at Washington and Cresse Avenues, with staging at the Department of Public Works complex on Washington Avenue (west side of the Borough).

ACTIVITY: The applicant is seeking authorization to nourish a portion of their ocean-front beach by removing excess sand from the beach within Wildwood Crest, and transporting that sand by trucks travelling on the intervening beach to the proposed fill site. They propose to carry out a "back-passing" operation, in which they would "harvest" or excavate up to 96,000 cubic yards of sand from the ocean-front beach within Wildwood Crest, and move the sand by truck

through Wildwood to the fill site in North Wildwood. The excavation area would encompass 68.08 acres of beach, which would stretch approximately 2 miles from one municipal limit to the other, approximately 300 feet wide. The excavation would occur in the higher portion of the beach, above the mean higher high water line; only 10.87 acres of it would be below (waterward of) the high tide line (HTL). With a truck capacity of 20-25 cubic yards each, it would take 3,840 to 4,800 round trips to supply the sand to the discharge site. The trucks would travel on the beach above the HTL. Construction access for trucks and equipment in Wildwood Crest would be limited to Washington and Cresse Avenues, with a designated staging area at the Department of Public Works complex on Washington Avenue on the western side of the Borough.

The proposed fill area in North Wildwood would encompass 20.15 acres, with 8.13 acres of fill below the HTL. Of this 8.13 acres, 4.81 would be between the HTL and mean low water line (MLWL), and 3.32 would be placed below the MLWL. A final berm crest elevation of 6.75 feet (NAVD 88) is proposed. The access point for construction vehicles in North Wildwood would be at the lifeguard station at 15th Avenue. Vehicles would be parked at that parking lot overnight, and they would be serviced and fueled there.

There is no specific start date indicated for the proposed project, although it is anticipated that 6 weeks would be required to accomplish the work. Their goal is to complete the work by mid-May. The applicant seeks authorization to maintain the project by means of the indicated borrow, transport and fill activities for a period of 10 years.

The applicant has stated that they are not proposing any compensatory mitigation for the proposed work. It is their position that aquatic impacts would be minimal, with recycling of sand back to where it originated from previous beach nourishment.

The Federal Emergency Management Agency (FEMA), as a federal funding agency for the proposed work, is the lead federal agency for this project.

PURPOSE: The applicant's stated purpose is: a) to restore loss of sand from previous nourishment, specifically from Hurricane Irene as it impacted a 2009 beach fill of 1.4 million cubic yards dredged from Hereford Inlet and pumped onto the beach in North Wildwood; and b) to allow Wildwood Crest to reduce the excess sand accumulation problem on its beach.

A preliminary review of this application indicates that the proposed work is not likely to adversely affect the following federally listed (threatened) species, or their critical habitat pursuant to Section 7 of the Endangered Species Act as amended: the piping plover (Charadrius melodus) and seabeach amaranth (Amaranthus pumilius). As the evaluation of this application continues, additional information may become available which could modify this preliminary determination. Since FEMA is providing federal funding for this project, they are the lead federal agency responsible for compliance with Section 7 of the ESA. That agency has not provided the Corps of Engineers with their determination in this regard.

The decision whether to issue (or modify) a permit will be based on an evaluation of the activity's probable impact including its cumulative impacts on the public interest. The decision will reflect the national concern for both protection and utilization of important resources. The

benefits which reasonably may be expected to accrue from the work must be balanced against its reasonably foreseeable detriments. All factors which may be relevant to the work will be considered including the cumulative effects thereof; among those are conservation, economics, aesthetics, general environmental concerns, wetlands, cultural values, fish and wildlife values, flood hazards, flood plain values, land use, navigation, shore erosion and accretion, recreation, water supply and conservation, water quality, energy needs, safety, food and fiber production, mineral needs and welfare of the people. A Department of the Army permit (or modification) will be granted unless the District Engineer determines that it would be contrary to the public interest.

The Corps of Engineers is soliciting comments from the public; Federal, State, and local agencies and officials; Indian Tribes; and other interested parties in order to consider and evaluate the impacts of this proposed activity. Any comments received will be considered by the Corps of Engineers to determine whether to issue, modify, condition or deny a permit for this proposal. To make this decision, comments are used to assess impacts on endangered species, historic properties, water quality, general environmental effects, and the other public interest factors listed above. Comments are used in the preparation of an Environmental Assessment and/or an Environmental Impact Statement pursuant to the National Environmental Policy Act. Comments are also used to determine the need for a public hearing and to determine the overall public interest of the proposed activity.

Comments on the proposed work should be submitted, in writing, within 15 days to the District Engineer, U.S. Army Corps of Engineers, Philadelphia District, Wanamaker Building, 100 Penn Square East, Philadelphia, Pennsylvania 19107-3390.

The permit area is likely to yield resources eligible for inclusion in the National Register of Historic Places. An investigation for the presence of potentially eligible historic properties may be required by the lead federal agency. FEMA, as the lead federal agency, is responsible for completion of the Section 106 process. The Corps of Engineers will consult with FEMA and other agencies regarding potential impacts to cultural resources within the permit area.

The Magnuson-Stevens Fishery Conservation and Management Act, as amended by the Sustainable Fisheries Act 1996 (Public Law 104-267), requires all Federal agencies to consult with the National Marine Fisheries Service on all actions, or proposed actions, permitted, funded, or undertaken by the agency that may adversely effect Essential Fish Habitat (EFH). A preliminary assessment of the species listed in the "Guide to Essential Fish Habitat Designations in the Northeastern United States, Volume IV: New Jersey and Delaware", dated March 1999, specifically pages 63 and 73, indicates that the proposed work would not have a substantial adverse effect on any managed species, including winter flounder eggs and larvae (*Pseudoleuronectes americanus*), since the proposed discharge (fill) area, as well as the proposed borrow area, are highly dynamic and subject to waves and sand movement. Adults and juveniles could move away from the construction equipment. FEMA is the lead federal agency for compliance with this act. That agency has not provided the Corps of Engineers with their determination in this regard.

In accordance with Section 307(c) of the Coastal Zone Management Act of 1972, applicants for Federal Licenses or Permits to conduct an activity affecting land or water uses in a State's coastal zone must provide certification that the activity complies with the State's Coastal Zone Management Program. The applicant has stated that the proposed activity complies with and will be conducted in a manner that is consistent with the approved State Coastal Zone Management (CZM) Program. No permit will be issued until the State has concurred with the applicant's certification or has waived its right to do so. Comments concerning the impact of the proposed and/or existing activity on the State's coastal zone should be sent to this office, with a copy to the State's Office of Coastal Zone Management.

In accordance with Section 401 of the Clean Water Act, a Water Quality Certificate is necessary from the State government in which the work is located. Any comments concerning the work described above which relate to Water Quality considerations should be sent to this office with a copy to the State.

The evaluation of the impact of the work described above on the public interest will include application of the guidelines promulgated by the Administrator, U.S. Environmental Protection Agency, under authority of Section 404(b) of the Clean Water Act.

Any person may request, in writing, to the District Engineer, within the comment period specified in this notice, that a public hearing be held to consider this application. Requests for a public hearing shall state in writing, with particularity, the reasons for holding a public hearing.

Additional information concerning this permit application may be obtained by calling James Boyer at (215) 656-5826, by electronic mail to James.N.Boyer@usace.army.mil, or by writing to this office at the above address.

for Frank J. Cianfrani
Chief, Regulatory Branch

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

CECW-P

13 April 2012

MEMORANDUM FOR Director, National Planning Center of Expertise for Coastal Storm Damage Reduction (PCX-CSDR)

SUBJECT: Hereford Inlet to Cape May Inlet, New Jersey Feasibility Study; Approval of the Model Review Plan

1. The purpose of the Coastal Storm Damage Assessment Model (COSTDAM) is to quantify damages experienced as a result of costal storms within the Hereford Inlet to Cape May Inlet study area, including storm erosion, wave attack and innundation damages. COSTDAM is a FORTRAN legacy model that was originally developed by the Wilmington District of the Army Corps of Engineers and has had extensive application by the Philadelphia District. The program calculates the damages for each structure on a year by year basis for the life of the project, that are then used to determine without project damages and with-project damages reduced in order to help inform the identification and justification of the National Economic Development (NED) Plan.

2. The Hereford Inlet to Cape May Inlet, New Jersey model review plan is approved. The National Planning Center of Expertise for Coastal Storm Damage Reduction is to implement the review process as described in the plan and in EC 1105-2-412 and submit its recommendation to HQUSACE for coordination with the HQUSACE Model Certification Panel. Given that Beach-fx is the Nationally Certified Economic Model for Coastal and Storm Damage Projects, the PCX-CSDR's recommendation should include a comparison of the outputs of the COSTDAM with what could reasonably considered the results if the feasibility study had used Beach-fx.

APPLICABILITY: This model will be applicable for use on the Hereford Inlet to Cape May Inlet, New Jersey Feasibility Study.

HARRY E. KITCH, P.E.
Deputy Chief, Planning and Policy Division
Directorate of Civil Works

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(201) 624-2136 (fax)

April 13, 2012

Mr. Brian P. Bogle, P.M.P.
Coastal Planning Section
USACE, Philadelphia District
100 Penn Square East
Philadelphia, PA 19107-3390

Re: City of Wildwood, Cape May County, NJ
Beach Programming and Public Access Improvements
Various Blocks & Lots
CAFRA Individual Permit Submittal
Our File: 05-14-T-200

Dear Mr. Bogle:

As a follow up to our March 19, 2012 meeting, please find enclosed the following for a CAFRA Permit for the above-referenced project:

1. One (1) complete copy of Beach Programming and Public Access Improvements Plans.

2. One (1) CD-ROM containing the electronic version of the plans.

If you have any questions or require further information, feel free to contact me at our Wildwood office at our Wildwood at 609-522-5150.

Very truly yours,

REMINGTON, VERNICK & WALBERG ENGINEERS

Marc DeBlasio

Marc DeBlasio, P.E., P.P., C.M.E.

MD:eb

Enclosure

cc: Mayor & Commissioners, City of Wildwood (via email)
Kim Schalek, Salmon Ventures Limited (via email)

S:\Wildwood\05-14-T-\0514T200 Wildwood Transition & Beach Individual Permit\CAFRA\0514T200 12April 13 Ltr. to ACOE.doc

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MACINTOSH

Environmental Resources Branch

FEB 13 2013

Mr. J. Eric Davis, Supervisor
U.S. Fish and Wildlife Service
Pleasantville Field Office
927 North Main Street (Bldg. D1)
Pleasantville, New Jersey 08232

Dear Mr. Davis:

In accordance with the Fish and Wildlife Coordination Act (FWCA), enclosed is preliminary project information for your use in the preparation of a draft Section 2(b) report for the Hereford Inlet to Cape May Inlet Feasibility Study in Cape May County, New Jersey. The information provided includes details on the project area, problem identification and the proposed selected plan for this project. This is still a working document in draft form but we believe it provides the project details you will need in order to complete your draft Section 2(b) report.

This work was previously negotiated, agreed to and paid for under the enclosed SOW. Coordination with Ron Popowski of your staff has indicated that the existing SOW is still valid and no additional funding is required to complete the remaining tasks.

Please review the enclosed information and provide us with your draft Section 2(b) report for inclusion in our Draft Feasibility Report and Environmental Assessment. If you have any questions regarding the enclosed information or need additional details, please contact Ms. Beth Brandreth of the Environmental Resources Branch at (215) 656-6558.

Sincerely,

Charles MacIntosh
Acting Chief, Planning Division

Enclosures

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO ATTENTION OF

13-1482-14WR
HPO-H2013-034

CENAP-PL-E

JUL 02 2013

Daniel Saunders
Deputy State Historic Preservation Officer
Mail Code 501-04B
State of New Jersey
Department of Environmental Protection
Historic Preservation Office
PO Box 420
Trenton, NJ 08625-0420

RECEIVED
JUL 11 2013
HISTORIC PRESERVATION OFFICE

Dear Mr. Saunders,

The US Army Corps of Engineers, Philadelphia District (USACE) is currently preparing a draft Feasibility report and Environmental Assessment for a New Jersey Shore protection study between Hereford Inlet and Cape May Inlet, New Jersey. The *Herford Inlet to Cape May Feasibility Study* is being conducted to address hurricane and storm damage reduction capabilities and environmental restoration initiatives under the General Investigations Program utilizing the New Jersey Shore Protection Study authority.

The study area is a barrier island located in Cape May County, New Jersey. Municipalities on the island include: North Wildwood, Wildwood, Wildwood Crest, West Wildwood and Lower Township. A natural area managed by the US Fish and Wildlife Service and the US Coast Guard Electronics Center are located at the northern boundary of Cape May inlet, within Lower Township. In the early 20th century the study area was two separate island segments consisting of "Five Mile Beach and "Two mile Beach". These two island sections were bisected by Turtle Gut Inlet until the 1920s. At that time Turtle Gut Inlet was closed and a bulkhead was constructed by local interests at the entrance to what was then referred to as Sunset Bay in Wildwood Crest. A marker identifying the approximate location of Turtle Gut Inlet currently stands at Toledo Avenue in Wildwood Crest.

The study area is located between two existing Federal Shore protection projects; Townsend's Inlet to Cape May Inlet and Cape May Inlet to Lower Township. Both projects are in partnership with the State of New Jersey Shore Protection Authority.

The selected plan for this study consists of dune and berm construction using sand obtained from an onshore borrow source located at the southern end of the study area. The plan extends approximately 4.5 miles from Hereford Inlet to Cape May inlet and will encompass the towns of North Wildwood, Wildwood, Wildwood Crest and Diamond Beach. The southernmost beach section which contains the US Fish and Wildlife Property is not included in the plan.

Dimensions of the project area include a +16' NAVD 88 dune, with a 25' crest on a 75' berm that is + 6.5 feet NAVD 88 in elevation from North Wildwood to the northern tip of Wildwood. In Wildwood and Wildwood Crest the project will be a dune only plan with a dune elevation of +16' NAVD 88 on top of the existing berm. Side slopes for the dune will be 1V:5H. The plan includes approximately 64 acres of dune grass, 28,000 linear feet of sand fence, 44 extended crossovers, seven new pedestrian crossovers, seven extended handicap crossovers, six new handicap crossovers, eight existing vehicle crossover extension and five new vehicular crossovers. The sand will be pumped from the southern borrow area using mobile back-passing technology from the Wildwood and Wildwood Crest borrow source to the placement area. Proposed project plans are Enclosure 1.

The USACE has determined that the Area of Potential Effect (APE) for the selected plan includes the beaches and intertidal areas from Hereford Inlet to Cape May inlet, marking the northern and southern limits, and from the existing dunes to the intertidal area marking the eastern and western limits. The limits of construction disturbance for the selected plan are located within the APE (Enclosure 2).

Although there are several recorded historic properties eligible for or listed on the National Register of Historic Places (NRHP) within the vicinity of the APE for the selected plan, the USACE has determined that dune and berm construction along approximately 4.5 miles from Hereford Inlet to Cape May Inlet using recently accreted sand from the intertidal zone from the southern end of Five Mile Island will have *No Effect.*

A cultural resource assessment of the proposed intertidal sand source was conducted by FEMA as part of the Section 106 review for post-Hurricane Irene beach restoration of North Wildwood. An assessment of the beach in the adjacent communities of Wildwood Crest in the south to North Wildwood was conducted to determine the sensitivity of below ground archaeological resources. Several aspects were analyzed including the project's proximity to know archaeological resources, waterways and historic properties as well as the site's environmental characteristics such as spoil analysis and previous ground disturbing activities within the project APE, which is roughly the APE of the selected plan.

Remnants of the *Nancy*, a revolutionary war brig set afire by troops at Turtle Gut Inlet (Site 28CM0013) are located southwest of the APE and site 28CM0008 is currently underneath the existing Wildwood Boardwalk. There are no structures within the project APE; however the Chateau Blue Motes, the Hereford Inlet Lighthouse and the J. Thompson Baker House are all listed on the NRHP, but will not be affected. Also, the Wildwood Shore Resort Historic District runs parallel to the beach and is within the project viewshed but will also not be affected.

The APE is a previously disturbed, engineered beaches. The proposed project will collect, transport and place sand entirely within the previously disturbed areas. No part of the proposed undertaking is located within an archaeologically sensitive area, and no historic properties are within the APE.

We request your concurrence with our conclusion that no historic properties will be affected by the selected plan, pursuant to 36 CFR 800.3(a)(1). Thank you for your cooperation in this review process. If you have any questions concerning our review or if we can be of further assistance, please contact our Cultural Resource Specialist and Tribal Liaison via email at nicole.c.minnichbach@usace.army.mil, or phone (215) 656-6556, or fax (215) 656-6543.

Sincerely,

Peter R. Blum, P.E.
Chief, Planning Division

CONCUR

/km

Daniel D. Saunders
DEPUTY STATE HISTORIC
PRESERVATION OFFICER

DATE

3

United States Department of the Interior

FISH AND WILDLIFE SERVICE

New Jersey Field Office
Ecological Services
927 North Main Street, Building D
Pleasantville, New Jersey 08232
Tel: 609/383 3938
Fax: 609/646 0352
http://www.fws.gov/northeast/njfieldoffice/

LTC Chris Becking
District Engineer, Philadelphia District
U.S. Army Corps of Engineers
Wanamaker Building – 100 Penn Square East
Philadelphia, Pennsylvania 19107 - 3390
Attn: Beth Brandreth

AUG 15 2013

Dear LTC Becking:

Enclosed is a U.S. Fish and Wildlife Service (Service) draft report prepared pursuant to Section 2(b) of the Fish and Wildlife Coordination Act (FWCA) (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) on the U.S. Army Corps of Engineers, Philadelphia District (Corps) Hereford Inlet to Cape May Inlet Feasibility Study, Cape May County, New Jersey. The information presented in this draft FWCA Section 2 (b) report addresses potential beneficial or adverse impacts on fish and wildlife resources from proposed shore protection along the five-mile-long barrier island. This report has been prepared pursuant to the Scope-of-Work and Fiscal Year-2007 and 2008 interagency agreement between the Corps and the Service.

The following comments are provided pursuant to Section 2(b) of the FWCA. Comments are also provided under authority of the Endangered Species Act of 1973 (ESA) (87 Stat. 884, as amended; 16 U.S.C 1531 *et seq.*), and the Migratory Bird Act Treaty of 1918 (40 Stat. 775, as amended; 16 U.S.C. 703-712), and are consistent with the intent of the Service's Mitigation Policy (Federal Register, Vol. 46, No. 15, Jan. 23, 1981).

FEDERALLY LISTED THREATENED AND ENDANGERED SPECIES

The federally listed (threatened) piping plover (*Charadrius melodus*) nests on the beaches of Hereford Inlet including (Stone Harbor Point and North Wildwood from Central Avenue to the intersection of John F. Kennedy Beach Drive and 2nd Avenue), on the U.S. Coast Guard's LORAN site, and on Cape May National Wildlife Refuge; and are known to forage along the beaches of Wildwood Crest and Lower Township. Piping plovers are not listed as "historical" within the project area as erroneously stated on page 2.3 of the Corps' draft feasibility report. On the Atlantic coastal beaches within the project area, piping plovers last nested in North Wildwood and Wildwood Crest in the 1990's, and the Service has no current or historical records of nesting in

Wildwood. Piping plovers nest on sandy beaches above 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 sandpits, and on sites with deposits of suitable dredged or pumped sand.

Coastal development for residential and commercial uses, and the subsequent stabilization of the once shifting and dynamic ecosystem, have resulted in the degradation and alteration of natural beaches to such an extent along the Atlantic coast that many beaches no longer provide suitable habitat for piping plovers. Disturbance by humans and the direct loss of nests have become major contributing factors to the population decline of the piping plover (U.S. Fish and Wildlife Service 1996a).

Dredged spoil deposition has the potential to create piping plover nesting habitat, although this is sub-optimal, provided the material is deposited prior to nesting (U.S. Fish and Wildlife Service 1996a). As a result, piping plovers could expand their nesting range within the project area after nourishment is completed. This occurred in 1997 as a result of Corps - New York District beach nourishment projects in Monmouth County, New Jersey (U.S. Fish and Wildlife Service 2002). Prior to initial beach nourishment in 1994, piping plovers were not documented in that project area for at least a decade.

The project may also create habitat for seabeach amaranth (*Amaranthus pumilus*), a federally listed (threatened) plant (U.S. Fish and Wildlife Service 1996b). Seabeach amaranth is an annual plant, endemic to Atlantic coastal plain beach, primarily occurring 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 materials placed as beach replenishment or dredge spoil. Previous occurrences of seabeach amaranth are known within the proposed project area (*i.e.*, the U.S. Coast Guard's LORAN Unit in 2003-2004) and may become naturally reestablished within the project area during the project life. Colonization of seabeach amaranth in New Jersey occurred in July 2000 after a Corps - New York District beach nourishment project in Monmouth County, (U.S. Fish and Wildlife Service 2002). Prior to the 2000 rediscovery, this species had last been documented in New Jersey in 1913 (U.S. Fish and Wildlife Service 1996b).

Other than the piping plover and seabeach amaranth, the federally and State-listed roseate tern (*Sterna dougallii*) (occasional transient) and State-listed peregrine falcon (*Falco peregrinus*) are known to use the project area. In addition, red knots (*Calidris canutus rufa*), a Federal candidate species, are known to stopover in the project area during spring (northward) and fall (southward) migration where they feed mainly on the spat of mussels and other invertebrates to build fat reserves to complete their migration.

The National Marine Fisheries Service (NMFS) must be consulted regarding Essential Fish Habitat, as required under Section 305 (b)(2) of the Magnuson – Stevens Fishery Conservation and Management Act (16 U.S.C. 1801-1882). The NMFS must also be consulted regarding the ESA due to the potential presence of the federally listed (endangered) kemps ridley sea turtle (*Lepidochelys kempii*), hawksbill sea turtle (*Eretmochelys imbricata*) and leatherback sea turtle (*Dermochelys coriacea*), and the federally listed (threatened) loggerhead sea turtle (*Caretta*

caretta) and green sea turtle (*Chelonia mydas*) within the project area and any borrow areas. Appendix A provides a current list of federally listed (endangered and threatened) and candidate species in New Jersey.

The Service appreciates the opportunity to comment on the proposed plan and is pleased to submit this draft FWCA Section 2(b) report as technical input to the *Hereford Inlet to Cape May Inlet Feasibility Study*. Should you have any questions, please contact Ron Popowski at Ron_Popowski@fws.gov.

Sincerely,

Eric Schrading
Acting Field Supervisor

Enclosure
CC: Ralph Tiner, RO
Karen Green, NMFS
Todd Pover, NJCWF
Dave Jenkins, ENSP
Bill Dixon, NJDEP Bureau of Coastal Engineering

LITERATURE CITED

U.S. Fish and Wildlife Service. 1996a. Piping plover (*Charadrius melodus*), Atlantic Coast population, revised recovery plan. U.S. Department of the Interior, Fish and Wildlife Service, Region 5, Hadley, MA. 245 pp.

_____. 1996b. Recovery plan for seabeach amaranth (*Amaranthus pumilus*) Rafinesque. U.S. Department of the Interior, Fish and Wildlife Service, Region 4, Atlanta, GA. 70 pp.

_____. 2002. Biological opinion on the effects of completion of sections I and II of the Atlantic Coast of New Jersey beach erosion control project Sea Bright to Manasquan, Monmouth County, New Jersey on the piping plover (*Charadrius melodus*) and seabeach amaranth (*Amaranthus pumilus*). U.S. Department of the Interior, Fish and Wildlife Service, Region 5, New Jersey Field Office, Pleasantville, NJ. 124 pp.

DEPARTMENT OF THE ARMY
US ARMY CORPS OF ENGINEERS, NORTH ATLANTIC DIVISION
FORT HAMILTON MILITARY COMMUNITY
302 GENERAL LEE AVENUE
BROOKLYN NY 11252-6700

CEPCX-CSRM 15 May 2014

MEMORANDUM FOR Commander, HQUSACE, US Army Corps of Engineers, (CECW-NAD-RIT/Laura Cameron) 441 G Street, N.W. Washington, D.C. 20314-1000

SUBJECT: Request for Model Approval for Hereford Inlet to Cape May, NJ Feasibility Study

1. Reference is made to:
   a. EC 1105-2-412 Assuring Quality of Planning Models, dated 31 March 2011.
   b. EC 1165-2-214 Civil Works Review dated 15 December 2012.
   c. CECW-P memorandum dated 13 April 2012, Subject: Hereford Inlet to Cape May Inlet, New Jersey Feasibility study, Approval of Model Review Plan.
   d. CEPCX-CSDR memorandum dated 13 March 2012, Subject: Model Review Plan for the Hereford Inlet to Cape May Inlet, NJ Feasibility Study

2. The National Planning Center of Expertise for Coastal Storm Risk Management (PCX-CSRM) previously prepared a model review plan (MRP, reference 1d) for the Hereford Inlet to Cape May, NJ study for Philadelphia District (NAP), which was approved as in reference 1c. The MRP detailed the review of the application of the Coastal Storm Damage Assessment Model (COSTDAM and S-BEACH) and applied to the Hereford Inlet to Cape May Inlet, NJ Feasibility Study.

3. The basis of PCX-CSRM proceeding with the review of the model was due to the fact that outputs of the model would seem to be reasonable based upon its previous application to studies of adjacent areas in the State of New Jersey which were constructed and performed as designed.

4. The purpose of this model is to quantify the damages experienced as a result of coastal storms within the Hereford Inlet to Cape May Inlet study area. This is accomplished through detailed surveying of the study area's housing inventory and coastline and subjecting those parameters to a suite of coastal storms with varying wave heights, durations etc.., and measuring the damage in relation to the position, elevation and construction type from the housing inventory. Variation of the model parameters was accomplished through a risk and uncertainty component of the existing COSTDAM and S-BEACH model linkage. The benefits and costs of alternatives formulated to reduce coastal storm damages in the communities of North Wildwood, Wildwood, Wildwood Crest and Diamond Beach, NJ were documented during the study with ranges of potential Average Annual Damages (AAD) and Average Annual Benefits (AAB) rather than point values.

5. NAP was instructed to determine a way to incorporate Risk and Uncertainty into the COSTDAM model which is linked to the engineering model SBEACH. Both models are described in the MRP. NAP proposed varying the model in order to incorporate Risk and Uncertainty which was addressed in the MRP. Use of the COSTDAM and SBEACH linkage is referred to as "the model." It is being considered for approval for use solely on the Hereford Inlet to Cape May Inlet, NJ Feasibility Study. The model proponent is NAP.

6. COSTDAM was developed by CESAW and applied to many studies over the years which were constructed . A guide for using COSTDAM was included on the MRP. S-BEACH is a geomorphic-based two-dimensional engineering model that simulates beach profile change, including the formulation and movement of major morphologic features such as longshore bars, troughs and berms, under varying storm waves and water levels. S-BEACH was developed by the U.S. Army Corps of Engineers Engineering Research and Development Center (ERDC). It has also been applied to many studies over the years which were constructed. A user's manual for S-BEACH is readily available from ERDC. S-BEACH is an approved engineering model. The application of "the model" to the Hereford Inlet to Cape May, NJ Feasibility study has been reviewed by PCX-CSRM and its application to the study as documented in the feasibility report has undergone additional reviews by Agency Technical Review (ATR), an IEPR panel, as well as HQUSACE.

7. Enclosure 1 contains model review comments from team members of PCX-CSRM and the responses by NAP. The model review also included the risk and uncertainty analysis. Two model reviews had been conducted, with the first, early-on before the model was applied. The first review was conducted by a team from SAJ concluding in February 2011. The second was conducted following approval of the MRP by CECW-P. This review was conducted by Mr. Jeffery Strahan, then an economist from NAO. The second review was concluded in August 2011. All DrChecks comments have been closed out. No opposition to the model resulted from the model review. The final Risk and Uncertainty Analysis is provided as Enclosure 2.

8. The model approval memo also included a requirement in paragraph 2 that "a comparison of the outputs of the COSTDAM with what could reasonably considered the results if the feasibility study had used Beach-fx". A paper on this directive was prepared by NAP and is included as Enclosure 3. Note that the MRP had presented a preliminary comparison of COSTDAM to Beach-fx.

9. The ATR of the Draft and Final Feasibility Reports has been completed in accord with reference 1b, with the most recent review having concluded in May 2014. The ATR team included SAJ members from the model review ATR. No opposition to the

CEPCX-CSRM 15 May 2014

SUBJECT: Request for Model Approval for Hereford Inlet to Cape May, NJ

application of the model to the Hereford Inlet to Cape May, NJ study resulted from the ATR.

10. A Type I IEPR of the Hereford Inlet to Cape May, NJ study was completed by the Battelle Organization with the final report dated 2 December 2013. No comment on objection to the model was received.

11. Therefore, PCX-CSRM is recommending approval of the application of the model to the Hereford Inlet to Cape May, NJ study, based upon reviews completed to date. As this is a Hurricane Sandy-affected study tracking for a Civil Works Review Board in the third quarter of FY14, we are requesting an expedited processing of this request.

12. For further information, please contact me at 917-613-3873, or Mr. Larry Cocchieri, PCX-CSRM Deputy at (347)370-4571.

JOSEPH R. VIETRI
Director, National Planning Center of Expertise for Coastal Storm Risk Management

Encl

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

CECW-P

27 May 2014

MEMORANDUM FOR Director, National Planning Center of Expertise for Coastal Storm Damage Reduction

SUBJECT: Hereford Inlet to Cape May, New Jersey, COSTDAM Model Approval

1. The purpose of the Coastal Storm Damage Assessment Model (COSTDAM) is to quantify damages experienced as a result of costal storms within the Hereford Inlet to Cape May Inlet study area, including storm erosion, wave attack and innundation damages. COSTDAM is a FORTRAN legacy model that was originally developed by the Wilmington District of the Army Corps of Engineers and has had extensive application by the Philadelphia District. The program calculates the damages for each structure on a year by year basis for the life of the project, that are then used to determine without project damages and with-project damages reduced in order to help inform the identification and justification of the National Economic Development (NED) Plan.

2. The use of the COSTDAM model for the Hereford Inlet to Cape May, New Jersey analysis is approved for a single use rather than certified. This approval comes after the feasibility analysis is complete but prior to the Civil Works Review Board. The model review plan was approved in April of 2012 and was on track for approval of the model when Hurricane Sandy impacted the area. This resulted in delays to the study that impacted the submission of the model approval request. The district has implemented the review plan as directed. These reviews have show that the model meets the certification criteria contained in EC 1105-2-412. This approval is based on the decision of the HQUSACE Model Certification Panel which considered the National Planning Center of Expertise for Coastal Storm Damage Reduction assessment of the model. There are no unresolved issues at this time.

APPLICABILITY: This model approval for use is limited to the subject feasibility study.

HARRY E. KITCH, P.E.
Deputy Chief, Planning and Policy Division
Directorate of Civil Works

Printed on Recycled Paper

Section –2 Comments and Responses

TOWNSHIP OF LOWER

2600 Bayshore Road
Villas, New Jersey 08251

Incorporated 1798

(609) 886-2005

MEMORANDUM

TO: William Dixon, Supervising Environmental Specialist &
Christopher Constantino, Environmental Services Specialist

FROM: William Galestok, PP, AICP
Director of Planning

DATE: January 27, 2014

RE: Herford Inlet to Cape May Inlet
Draft Feasibility Study ACOE

Lower Township has the following comments/concerns in regard to the above referenced report:

1. As the MHWL is to be moved landward, the Public Trust Doctrine Rights of the general public are affected. Conflicts between landowners and the general public may result.

2. Considering the overall "sediment budget", will any beach losses, in excess of the newly established MHWL occur. What is the time frame for the new equilibrium to be established in the system.

3. What will be Lower Township's share of the total cost of the project and how will it be calculated?

4. Will ACOE or New Jersey State DEP be notifying individual homeowners along the ocean front?

5. What is the date of the scheduled Public Hearing; and how will the public receive notification?

WJG:las

cc: Mike Beck, Twp. Mayor
Mike Voll, Twp. Manager
Ron Gelzunas, Twp. Solicitor
George Curvan, Twp. Engineer.
Jay Dilworth, Planning Board Chairman
Beth Brandreth, project biologist

Letter from Lower Township, dated 27 January 2014.

1. We are still working out these details with the non-Federal sponsor and the District Real Estate Division, but landward movement of the MHW line may impact private property owners if the MHW intersects their private property line. Public Trust rights are critical to the State of New Jersey and public access to the MHW is required for participation in federally funded beach nourishment project.

2. The amount of material to be excavated from Lower Township is low compared to other portions of the project in Wildwood Crest and Wildwood. We anticipate a short term landward migration of the shoreline after excavation, and infilling of the excavated area in between the 4 year nourishment cycles.

3. Traditionally, the share of the local costs will be based on; the volume of material placed in each municipality, the number of crossovers, the number of handicapped access ramps and vehicular crossovers. For the New Jersey shore protection program the costs are split between the federal government and the state government 65% Federal and 35% State for the initial construction and 50% for each periodic nourishment cycle. The local municipality usually pays for 25% of the State's portion for each nourishment cycle and the initial construction.

4. The homeowners along the oceanfront were notified by Lower Township prior to the Public Hearing.

5. The Public Hearing was held in North Wildwood on February 21, 2014.

State of New Jersey

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

DEPARTMENT OF ENVIRONMENTAL PROTECTION
OFFICE OF PERMIT COORDINATION AND ENVIRONMENTAL REVIEW
P.O. Box 420 Mail Code 401-07J Trenton, New Jersey 08625-0420
Telephone Number (609) 292-3600
FAX NUMBER (609) 633-2102

BOB MARTIN
Commissioner

January 30, 2014

Mr. Peter R. Blum
Chief, Planning Division
Philadelphia District, Corps of Engineers
Wanamaker Building, 100 Penn Square East
Philadelphia, PA 19107-3390

RE: Hereford to Cape May Inlet Coastal Storm Damage Reduction Project
North Wildwood, Wildwood, Wildwood Crest, and Lower Township, Cape May County

Comments on Draft Environmental Assessment

Dear Mr. Blum:

The New Jersey Department of Environmental Protection's (NJDEP) Office of Permit Coordination and Environmental Review (PCER) distributed, for review and comment, the Draft Environmental Assessment (EA) for the proposed **Hereford Inlet to Cape May Inlet** Coastal Storm Damage Reduction Project. We received this EA, prepared by the Army Corp of Engineers (ACOE) on December 30, 2013. Based on the information received, we offer the following comments for your consideration.

Cultural Resources

HPO-A2014-170
HPO Project #14-1189-2

Thank you for providing the Historic Preservation Office (HPO) with the opportunity to review and comment on the potential for the above-referenced project to affect historic and archaeological resources. The HPO has previously had the opportunity to comment on the proposed undertaking through consultation with the United States Department of the Army, Corps of Engineers (Corps) under their obligations pursuant to Section 106 of the National Historic Preservation Act, as amended. In a response dated January 15, 2014
1. (14-1078-1/A2014-168), the HPO concurred with the Corps determination that, as proposed, the undertaking will have no effect on historic properties within the project's area of potential effects. As a result, no further cultural resource consideration is necessary prior to permit issuance. However, if project plans change or additional resources are discovered during project implementation, pursuant to 800.13 of the National Historic Preservation Act, further review by the Historic Preservation Office will be necessary.

If additional consultation with the HPO is needed for this undertaking, please reference the HPO project number 14-1189 in any future calls, emails, submissions or written correspondence to help expedite your review and response. If you have any questions, please feel free to contact Jesse West-Rosenthal at (609) 984-0176.

Natural Resources

Endangered and Non-game Species Program:

1. Work should take place outside the nesting area of endangered and non-game species of birds including the piping plover. If work must continue into the nesting season, a biological monitor will be required (under protocol established by USFWS and ENSP). ENSP already monitors this area as part of our regular responsibilities, so an additional monitor might only be needed if nesting activity is detected by ENSP. USFWS may prefer a separate monitor for ANY work done inside the nesting season, beach nesting bird activity or not. Our recommendation, though, is that ENSP handle initial surveys and if activity detected, the USACE/contractor would hire a monitor and coordinate closely with USFWS and ENSP to ensure adequate protective measures are taken for piping plover, least tern and/or black skimmer.

2. To ENSP knowledge, Wildwood and Wildwood Crest do not currently have beach management plans, which are a requirement for projects of this nature. Each town will need to coordinate with ENSP and USFWS to develop and implement a Beach MP.

3. The project notes that it will taper 200' into Hereford Inlet area (where there is current beach nesting bird activity). If there are any plans for snow fence, dune planting or dunes to come into that area, the USACE/contractor must coordinate with ENSP and USFWS to determine the appropriate methods to ensure beach nesting bird habitat is not impacted/impacts are reduced.

4. Section 2.4.12 of the EA discusses potential offshore borrow areas. It is ENSP understanding that this project does not require *any* offshore borrowing areas and is just a back-pass. This section does discuss the possibility of borrowing for a nourishment in North Wildwood "in the near future" and that the borrow area might be the one in Hereford Inlet (pg 102). ENSP would like to be 100% sure that the currently proposed project does not involve borrowing from this site. It seems this EA has been in progress for awhile, so ENSP thinks there is a chance that the fill they are referencing actually already happened, but in any case, ENSP wants to be clear that the comments above are intended to reflect a project that is back-pass in the areas they denote and does not include any borrowing from offshore. If any offshore borrowing is considered, DFW needs to know so that we can address that.

Shellfisheries:
The Bureau is glad to see an alternative method to using offshore borrow areas that adversely affect prime shellfish and marine fish habitat. Shellfisheries doesn't believe that there will be significant impacts to shellfish (surf clams) or to marine fish from the proposed technique, but does not rule out potential impacts to these intertidal/sub-tidal areas that will be used as a sand source.

If you have any additional questions, please contact Kelly Davis at (908) 236-2118.

Bureau of Air Quality Planning (BAQP)

The Bureau of Air Quality Planning (BAQP) has reviewed the Draft Feasibility Report and Integrated Environmental Assessment for the Hereford Inlet to Cape May Inlet and has the following comments:

1) Appendix C – Clean Air Act Calculations
General Conformity Review and Emission Inventory Hereford Inlet to Cape May Inlet Feasibility Study – Table 2 Emission Estimates, this table indicates that NOx emissions are 191.1 tons.

Comment # 1
Please report air emissions on a calendar year basis in accordance with the requirements of the Federal General Conformity regulation (40 CFR Part 90, (Subpart B)).

Comment #2
The BAQP contacted the Army Corps on 1-16-14 regarding an inconsistency in the horsepower hours for the project. Table 1: Project Emission Sources and Estimated Power provides horsepower hours for each piece of equipment and provides the total horsepower hours for the project. The Herford to Cape May Feasibility Study Project Worksheet provides horsepower hours for each piece of equipment and the total horsepower hours for the project, but it is not consistent with the horsepower hours in Table 1. The Army Corps indicated that the horsepower hours in Table 1 are accurate and that the horsepower hours in the Herford to Cape May Feasibility Study Project Worksheet didn't account for the load factors. The Army Corps indicated that this inconsistency would be addressed in the Final Environmental Assessment

If you have additional air quality planning questions, please contact Angela Skowronek at (609) 984-0337

Land Use

The NJDEP Division of Land Use Regulation is currently reviewing a Federal Consistency Determination and expects to complete their review within 60 days of
1. receipt of the application and by approximately February 24, 2014. This determination will include comments from the US Fish and Wildlife Service representatives Todd Pover (609-628-0401) and Carlo Popolizio (609-646-9310). For additional information, please contact Gail Moore at (609) 633-9310.

Thank you for giving the New Jersey Department of Environmental Protection the opportunity to comment on the Draft Environmental Assessment for the proposed **Hereford Inlet to Cape May Inlet** Coastal Storm Damage Reduction Project.

Sincerely,

Ruth Foster, PhD., Section Chief
Office of Permit Coordination
and Environmental Review

C: John Gray, NJDEP-PCER
Jesse West-Rosenthal, NJDEP- HPO
Kelly Davis, NJDEP – DFW
Angela Skowronek, NJDEP – BAQP
Pete DeMeo, NJDEP – Land Use
Gail Moore, NJDEP - Land Use
Dave Rosenblatt, Bureau of Coastal Engineering

Letter from NJDEP-Office of Permit Coordination and Environmental Review dated 30 January 2014.

Cultural Resources

1. The District gave the Historic Preservation Office the opportunity to comment on the draft report and they concurred with the findings that this project would have no effect on historic properties within the projects Area of Potential Effect (APE).

Natural Resources

1. All construction activities are expected to take place outside of the nesting area of any endangered and non-game species of birds including the piping plover. The project does include small taper sections into the Hereford Inlet area and to the border of the USFWS Refuge at Cape May Inlet. Any activities that take place during the nesting season, that has the potential to impact nesting birds or their habitat, will be coordinated under the protocols established by the Endangered and Non-game Species Program (ENSP) and the United States Fish and Wildlife Service (USFWS).
2. All towns that are participating in a federally funded beach nourishment project will be required to have beach management plans, including Wildwood, Wildwood Crest, and Lower Township. North Wildwood currently has a beach management plan.
3. Taper sections will be coordinated with ENSP and USFWS to avoid impacts from dune placement, grass planting and sand fencing.
4. There are no offshore borrow sites proposed for this project as it is currently planned. No offshore borrow areas were considered past the initial stages of plan formulation and the selected plan does not contain an offshore borrow area. The inlet borrow areas were considered at the beginning of the study, but not considered as part of the selected plan. Full coordination will take place with ENSP if offshore sources need to be considered for future re-nourishment cycles. The selected plan contains no offshore sources and all of the material for the dunes and berm will be obtained from the beaches in Wildwood, Wildwood Crest and Lower Township.
5. Concur.

Bureau of Air Quality Planning

1. This number was an error and has been corrected. Based on additional information, the NOx emissions have been revised in the final report and are 86 tons, which is below the critical threshold for the Clean Air Act.

Comment #1. Emissions are reported on a calendar year basis in the final report.

Comment #2. The worksheet has been corrected and load factors were included in the final report's Clean Air Act section.

Land Use

1. The NJDEP requested an extension of the review timeframe. The review timeframe was extended to March 10, 2014.

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

DEC 2 0 2013

REPLY TO ATTENTION OF

Environmental Resources Branch

DEC 26 2013

Daniel Saunders, Deputy State Historic Preservation Officer
Mail Code 501-04B
State of New Jersey
Department of Environmental Protection
Historic Preservation Office
PO Box 420
Trenton, NJ 08625-0420

14-1189-1 PWR
HPO-A2014-168

Dear Mr. Saunders:

The US Army Corps of Engineers, Philadelphia District (USACE) in accordance with Section 106 of the National Historic Preservation Act of 1966, as amended, are requesting your review and comment on the Hereford Inlet to Cape May Inlet Draft Feasibility Report and Integrated Environmental Assessment (EA). The report addresses hurricane and storm damage reduction alternatives for the coastal communities located between Hereford Inlet and Cape May Inlet, Cape May County, New Jersey. The feasibility study is being cost-shared equally by the Federal government and the New Jersey Department of Environmental Protection (NJDEP), the non-Federal sponsor.

The proposed project site is located along the Atlantic Coast shoreline of New Jersey from Hereford Inlet to Cape May Inlet and includes the communities of North Wildwood, Wildwood, Wildwood Crest and a portion of Lower Township. Dune placement activity will take place from 2nd Avenue and John F. Kennedy Boulevard in North Wildwood to the southern border of Lower Township at Raleigh Avenue. The project's northern terminus at 2nd and JFK will have a small tapered berm section that will extend approximately 200 feet northwestward into the Hereford Inlet area. There is no tapered section into the U.S. Fish and Wildlife Service property at the southern border below Lower Township.

The recommended plan in the feasibility report was determined to be berm and dune restoration utilizing sand hydraulically back-passed from the beaches of Wildwood, Wildwood Crest and Lower Township. This plan was developed after evaluating structural and non-structural alternatives to protect property within the study area. The beaches in these areas have historically accreted large quantities of sand, and sand can be dredged from the beach in Wildwood, Wildwood Crest and Lower Township to provide beach nourishment material to reduce storm damage to the entire island in the form of a storm protective berm and dune.

Specifically, the plan includes a dune with a crest elevation of +16ft NAVD 88, fronted by a 75-ft wide berm at elevation +6.5-ft NAVD 88 in North Wildwood. Wildwood, Wildwood Crest and Lower Township will receive a dune only plan at an elevation +16 ft NAVD 88. The design template for both dune configurations includes a 25-ft dune crest width, 1V:5H dune side slopes. The design template extends seaward from the berm crest down to mean low water (MLW) at a slope of 1V:30H, and extends further down to a closure depth of -26 ft following the average existing beach profile shape. The initial sand quantity is approximately 1.3 million cubic yards, which includes overfill factors and advanced nourishment. Periodic nourishment of approximately 305,000 cubic yards is scheduled to occur every 4 years for the fifty year length of the project.

Information on this project was previously sent to your office July 2, 2013. Your office concurred with our *No Effect* determination on August 6, 2013. There have been no significant changes to the project since your previous review. Thank
1. you for your cooperation in this review process. Please provide any additional comments you may have on the project by February 6, 2014. If you have any questions concerning our review or if we can be of further assistance, please contact Nicole Cooper Minnichbach via email at nicole.c.minnichbach@usace.army.mil, or phone (215) 656-6556, or fax (215) 656-6543.

Sincerely,

for C. MacIntosh
Peter R. Blum, P.E
Chief, Planning Division

CONCUR

1/15/14
DATE

Daniel D. Saunders
DEPUTY STATE HISTORIC
PRESERVATION OFFICER

2

Concurrence Letter from the State Historic Preservation office on the No Effect Determination dated 15 January 2014.

1. No response required.

CITY OF NORTH WILDWOOD

Cape May County, New Jersey

RESOLUTION

ENDORSING RESPONSE BY THE CITY OF NORTH WILDWOOD TO THE DRAFT FEASIBILITY REPORT FOR HEREFORD INLET TO CAPE MAY INLET PREPARED BY THE UNITED STATES ARMY CORPS OF ENGINEERS, PHILADELPHIA DISTRICT, 2013

WHEREAS, in the later part of 2013, the United States Army Corps of Engineers, Philadelphia District, released its "Draft Feasibility Report and Integrated Environmental Assessment" (the "Study") for the New Jersey Coastal Reach between Hereford Inlet and Cape May Inlet as part of its long-term coastal protection initiative; and

WHEREAS, a request was made by the Army Corps of Engineers to the impacted communities to prepare a response to the Study on or before February 6, 2014; and

WHEREAS, North Wildwood officials have reviewed the Study on an in-house basis and in a pair of meeting with officials from the City of Wildwood, the Borough of Wildwood Crest and the Township of Lower; and

WHEREAS, as a result of those review meetings, the Mayor, in consultation with the City's Engineering professionals and in consultation with the City's retained professionals from the Coastal Research Center of The Richard Stockton College of New Jersey, has prepared North Wildwood's draft response to the Study, a copy of which is annexed hereto as Exhibit "A;" and

WHEREAS, Council has reviewed the Mayor's draft response and finds that it accurately states North Wildwood's position relative to the Study and, therefore, endorses it and finds further that it should be finalized and forwarded to the Army Corps of Engineers.

NOW, THEREFORE, BE IT RESOLVED, by the Members of Council of the City of North Wildwood, in the County of Cape May and State of New Jersey, as follows:

1) All of the statements of the preamble are incorporated herein by this reference thereto as though the same were set forth at length.

2) The Mayor be, and he hereby is, authorized to finalize the draft response by the City of North Wildwood to the Draft Feasibility Report and Integrated Environment Assessment for Hereford Inlet to Cape May Inlet by the United States Army Corps of Engineers, Philadelphia District, 2013, annexed as Exhibit "A" and to forward same to the Army Corps of Engineers, Philadelphia District, with copies to the Mayor and governing bodies of the City of Wildwood, the Borough of Wildwood Crest and the Township of Lower.

OFFERED BY: RULLO SECONDED BY: BISHOP

****

I, W. Scott Jett, City Clerk of the City of North Wildwood, in the County of Cape May, State of New Jersey, do hereby certify that the foregoing is a correct and true copy of a Resolution adopted by the Mayor and Council of the City of North Wildwood at a meeting duly held on the 4th day of February, 2014.

Dated: February 4, 2014

Signed: W. Scott Jett, City Clerk

APPROVED: Patrick T. Rosenello, Mayor

	Aye	Nayo	Abstain	Absent		Aye	Nayo	Abstain	Absent
Tolomeo	X				Koehler				X
Rullo	X				Bishop	X			
Kane	X				Zampirri	X			
Del Conte	X								

59-14

CITY OF NORTH WILDWOOD
901 Atlantic Avenue
North Wildwood, NJ 08260-5778
(609) 522-2030

Patrick T. Rosenello
Mayor

Kevin Yecco
City Administrator

RESPONSE by the CITY OF NORTH WILDWOOD, CAPE MAY COUNTY, NJ
To the
DRAFT FEASIBILITY REPORT for HEREFORD INLET TO CAPE MAY INLET, NJ
By the
US ARMY CORPS OF ENGINEERS, PHILADELPHIA DISTRICT, 2013

Introduction:

As part of the long term national coastal protection initiative by the US Army Corps of Engineers (ACOE), the Philadelphia District released its "Draft Feasibility Report and Integrated Environmental Assessment" for the NJ coastal reach between Hereford and Cape May Inlets in Cape May County, NJ in late 2013. A request was made to the impacted communities to prepare a response on or before February 6, 2014 to this study. The City of North Wildwood has prepared its response individually following several in-house municipal meetings and a pair of joint meetings with the other three municipal entities located on the barrier island positioned between the two inlets mentioned above.

This project was authorized by the US Congress in 1987, and undertaken following the execution of a 50-50 cost sharing agreement between the ACOE and the State of New Jersey in September 2002. The completed document spells out a multitude of potential impacts and presents solutions to a pair of significant problems unique to this particular barrier island. The ACOE notes that this is the only NJ barrier shoreline with both an erosion and an excess sand accumulation problem. An unusual set of coastal processes combined with the timing of development have generated a wide area where the sand supply is far greater than needed for either recreation or storm protection.

Shore Protection Problems in North Wildwood:

Inlet changes beginning in the late 1990's at Hereford Inlet have generated a sand deficiency for the northern 8-10 blocks of the City of North Wildwood's oceanfront, while allowing large volumes of sand to move south along the shoreline increasing the beach width south of 18th Avenue in North Wildwood, south into Lower Township. Between 1993 and 2004 the North Wildwood beach at 15th Avenue lost 579 cubic yards of sand for each foot of shoreline (CRC 25-year report to NJDEP). The shoreline's zero elevation position retreated 829 feet removing 80% of the beach width. This sand moved into Hereford Inlet creating a significant inlet beach where there had been no sand at the rocks for many years. This was about half the lost volume, with the remainder moving south into Wildwood where the Cresse Avenue cross section's shoreline advanced 411 feet seaward with a 190 cubic yard per foot sand volume increase. Since Cresse Avenue is the boundary between Wildwood and Wildwood Crest, this represents a vast amount of material moved south in 11 years.

As a result of the cumulative changes impacting the City, a large scale plan was executed in 2009 placing 1.45 million cubic yards of sand along the North Wildwood shoreline as a joint NJ State and locally funded project. Storm damage in 2009 and 2010 was restored using FEMA funding as reimbursement to the City for 464,000 cubic yards in 2011. Hurricane Irene was followed a year later by Hurricane Sandy. The Irene losses were satisfied by hauling 94,000 cubic yards of sand from the Borough of Wildwood Crest, north to the zone of erosion using large-capacity trucks. Following Sandy, the City cooperated with restoration work proceeding on

the Stone Harbor shoreline using sand derived from the designated borrow area within the ebb-tidal shoals of Hereford Inlet. This amounted to 155,000 cubic yards of new sand.

Sand Backpassing in 2012:

The City of North Wildwood succeeded in modifying NJ State and Federal ACOE dredging permits issued in 2009 to allow an alternative sand source (the Wildwood Crest berm) and an alternative means of delivering the material to the zone of worst erosion (trucks hauling to between 2nd and 8th Avenues). The Borough of Wildwood Crest already had obtained permits to move sand accumulating excessively on its shoreline landward to enhance the dunes and fill the back beach zone subject to fresh and salt water ponding during rains or spring tides. The berm crest was the alignment for the excavation of up to 2.0 feet of material decreasing both seaward and landward to zero depth, but extending the length of the Borough shoreline. An agreement was reached with the City of Wildwood to allow the large-capacity trucks to haul the sand north along the high tide wet-dry line present each day on the beach.

This methodology was successfully completed between April and mid-May of 2012 where 13 vehicles working one shift, 5 days per week hauled 3,879 loads totaling 94,362 cubic yards placed between 2nd and 7th Avenue and spread to form a new berm with dune restoration north of 3rd Avenue. The entire methodology was prepared following a 2006 pilot study in the Borough of Avalon where sand was harvested from the berm crest in a zone of accumulation and truck hauled to the north end of the island where erosion was a continuing problem. This pilot study was repeated in Avalon under ACOE management in 2012.

Review by the City of North Wildwood on the Proposals within the 2013 Draft Feasibility Study:

First and foremost, the City of North Wildwood endorses the ACOE proposal to undertake a 50-year responsibility to maintain a substantial level of shore protection for the municipality and its citizens. The continued success of this coastal resort town depends on a stable, sand beach and dune system for its very existence and financial viability. The City also endorses the utilization of sand harvesting from the southern segment of the barrier island to either augment the project's goals or be the sole source for sand supplies for the North Wildwood beaches going forward.

The specific points are:

1. The use of "Back Passing" from more southerly beaches to supply sand to zones of erosion in North Wildwood is endorsed unequivocally.
2. The design berm width and elevation are completely acceptable, with the caveat that the ACOE recognize that due to work between 2009 and 2012, the beach width south of 10th Avenue may already be at the ACOE design template limits (except for berm elevation, 6.75 feet).
3. The 2009 project dune elevation was established at 14.75 feet NAVD88 and has been maintained except for where the dune was built seaward of the three piers found in the southern City shoreline. The City also concurs with the ACOE plans to have the dune pass under the two northern piers and marry to a steel bulkhead protecting the Morey's Pier structure at the very south end of the City beach.
4. Raising the dune elevation to 16.0 feet is an option if the ACOE has documented model evidence that raising the entire dune by 1.25 feet is worth the cost and effort for a significant increase in protection. Hurricane Sandy did not breach the dunes between 3rd Avenue and 21st Avenue and only broke through dune south of 21st Avenue because they were placed too far seaward and in harms way (NJDEP permit condition required at the time). Dune loss in the single city block north of 3rd Avenue was due to the complete loss of the berm elevation during the 2009 and 2010 northeast storms. Subsequent replacement proved futile.
5. The City would like a degree of focus on this rapid decrease in shoreline width seen presently north of 3rd Avenue and Hereford Inlet. The 2nd Avenue rock jetty is very short and cannot maintain any beach width on either side of the structure. The 2009 project completely buried the jetty, but inlet tidal

currents and waves quickly stripped sand away. Part of the problem is that the inlet side of the shoreline is utilized by endangered species nesting (piping plovers) so augmentation of the inlet beach would be restricted to the eastern 500-600 feet near the jetty.

6. Public access and emergency vehicle access is already established and needs to be maintained, especially if the dune elevation is increased to 16.0 feet.

Conclusion:

The 2013 Hereford Inlet to Cape May Inlet draft feasibility study presented by the ACOE has a series of solutions proposed that utilize and exploit the unique nature of the Wildwoods barrier island's coastal geomorphology. Recycling a vast sand supply makes economic and practical good sense because repetitively extracting sand from Hereford Inlet ebb-tidal shoals destined for erosion issues in North Wildwood will inevitably acerbate the excess accumulation of sand in Wildwood, Wildwood Crest and Lower Township shoreline segments. North Wildwood endorses this project and will work to assist the ACOE in its implementation.

History has shown that the erosion cycle at the Hereford Inlet segment of North Wildwood lasts about 30 years between maximum excursions of erosion. Keep in mind that in 1986 the beach was over 1,500 feet wide at the NJ Beach Profiles Network 15th Avenue survey site. Therefore history suggests that re-using the sand already available may substitute well for moving material onto the beaches from outside the island beach/dune system.

Respectfully submitted this 4th day of February, 2014

Patrick T. Rosenello, Mayor
City of North Wildwood

City of North Wildwood, Resolution and letter of support dated 4 February 2014.

1. No response required.

2. New surveys will be performed prior to the initial construction to determine areas of need for berm and dune repair in order to construct the beach to the design template.

3. The two northern most piers in North Wildwood can likely fit a +16' NAVD 88 dune underneath them and all efforts will be made to tie into existing shore protection structures.

4. The modeling efforts indicated that the optimum dune elevation is +16' NAVD 88 for the dune in North Wildwood.

5. The District is acutely aware of the rapid erosion of the shoreline in North Wildwood as it was the primary driver for the project early on in the feasibility study. Careful attention will be paid to that section of shoreline and the adjacent inlet, while taking into account the presence or piping plovers and red knots. Terminal structures at the inlet were screened out of the analysis due to their costs and the potential to disrupt natural landward migration of ebb shoal material to the shoreline.

6. Public Access points will be maintained at street ends with pedestrian and vehicular access points over the +16' NAVD 88 dune. Handicapped access points will also be created throughout the length of the project. The exact location of the proposed handicapped and vehicular access points are shown on the current plans and will be further coordinated during the Planning Engineering and Design (PED) and construction phases of the project.

[redacted]
Sent: Monday, January 27, 2014 8:08 AM
To: 'philly@usace.army.mil'
Subject: ACE Report - Hereford Inlet to Cape May Inlet Draft Feasibility Report - Public Comment

Re: Hereford Inlet to Cape May Inlet Draft Feasibility Report and Integrated Environmental Assessment Dated December 17, 2013

Public Comment

Dear Sir:

1. Due to the problems with drainage in the City of Wildwood it does not take much rain for the storm drains on Ocean Avenue to overflow resulting in damage to the surrounding property. The City of Wildwood has been unable to adequately address this problem.

2. I support the plan outlined in the subject report which addresses the flooding problem by eliminating the impact from the clogged outfalls due to continued expansion of the Wildwood beach. In addition the plan for the dunes will contain the ocean during future storms which will also reduce the street flooding and subsequent damage.

Sincerely,

[redacted]

RTER

Email from Wildwood Citizen dated 27 January 2014.

1. We agree that the City of Wildwood has an interior drainage problem and that reducing the amount of sand from in front of the outfall will likely reduce the flooding in the interior sections of the island.

2. We also agree that the construction of a dune and berm will reduce future flooding from oceanfront storms.

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

FEB - 6 2014

Peter R. Blum, P.E.
Chief, Planning Division
Philadelphia District, Corps of Engineers
Wanamaker Building, 100 Penn Square East
Philadelphia, Pennsylvania 19107-3391

Dear Mr. Blum:

This letter is in response to the Hereford Inlet to Cape May Inlet Draft Feasibility Report and Integrated Environmental Assessment (draft EA). The document addressed hurricane and storm damage reduction alternatives for the coastal communities located between Hereford Inlet and Cape May Inlet, in Cape May County, New Jersey.

The selected plan for the project is a dune and berm constructed using sand obtained from an onshore borrow source located at the southern end of Five Mile Island. The plan extends approximately 4.5 miles from Hereford Inlet to Cape May Inlet and will encompass the towns of North Wildwood, Wildwood, Wildwood Crest and Diamond Beach. The sand for the dune and berm will be pumped from the southern borrow area using mobile back-passing technology to hydraulically pump the sand from the Wildwood and Wildwood Crest borrow source to the placement area on a four year nourishment cycle. The initial sand quantity is estimated at 1,362,000 cubic yards, which includes a design quantity of 1,057,000 and advanced nourishment of 305,000 cubic yards.

1. The integrated approach of combining the draft feasibility report with the draft Environmental Assessment resulted in a detailed and thorough analysis of the historical context, existing conditions, and comparative evaluation of the storm damage reduction alternatives. The feasibility report provided an enhanced context for our review of the Environmental Assessment components of the document.

2. The draft EA did not include a discussion of entry points/access paths along the dune. Though access paths are often created perpendicular to the shore, these paths can result in significant dune erosion during intense storms. High force waves gain power as they push through the narrow passages causing increase erosion and flooding. Reduced flooding was seen after Super

Storm Sandy behind dunes that had paths at a 45 degree angle rather than perpendicular to the shoreline. A discussion of dune access paths should be included in the final EA and/or made mention of in your decision document.

Thank you for the opportunity to comment. Should you have any questions concerning this letter please feel free to contact Stephanie Lamster of my staff at 212-637-3465.

Sincerely,

Grace Musumeci, Chief
Environmental Review Section

Correspondence from the Environmental Protection Agency dated 2 February 2014

1. Concur that the integrated Environmental Assessment resulted in a detailed and through analysis of the historical context, existing conditions and plan formulation.

2. A description of the access paths and locations are contained in the plans, but special consideration will be given to the comments in the letter you provided to construct paths at a 45 degree angle.

United States Department of the Interior

FISH AND WILDLIFE SERVICE

New Jersey Field Office
Ecological Services
927 North Main Street, Building D
Pleasantville, New Jersey 08232
Tel: 609/646 9310
Fax: 609/646 0352
http://www.fws.gov/northeast/njfieldoffice

In Reply Refer To:
14-CPA-0088

Peter R. Blum, Chief
Planning Division
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, Pennsylvania 19107-3390

FEB 0 6 2014

Dear Mr. Blum:

The U.S. Fish and Wildlife Service (Service), New Jersey Field Office has reviewed the *Hereford Inlet to Cape May Inlet Draft Feasibility Report and Integrated Environmental Assessment* addressing storm damage reduction for the communities of North Wildwood, Wildwood, Wildwood Crest, and portion of Lower Township. Specifically, dune placement activity is proposed from 2nd and John F. Kennedy Boulevard in North Wildwood south to Raleigh Avenue in Lower Township.

The U.S. Army Corps of Engineers (Corps) proposes to create a 75-foot-wide beach berm at elevation +6.5 North American Vertical Datum (NAVD) and a dune at an elevation of +16 feet NAVD in Northern Wildwood. The remainder of the project would only receive a dune at +16 feet NAVD. For initial construction of the project, the Corps proposes to obtain approximately 1.3 million cubic yards utilizing sand hydraulically back-passed from the beaches of Wildwood, Wildwood Crest, and Lower Township. About 305,000 cubic yards of sand may be required for periodic re-nourishment at 4-year intervals for a period of 50 years.

AUTHORITY

The following comments are provided pursuant to the National Environmental Policy Act (83 Stat. 852; 42 U.S.C. 4321 *et seq.*), the Fish and Wildlife Coordination Act (48 Stat. 401; 16 U.S.C. 661 *et seq.*), Section 7 of the Endangered Species Act of 1973 (ESA) (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*), and the Migratory Bird Treaty Act of 1918 (40 Stat.755; 16 U.S.C. 703-712, as amended), ensuring the protection of federally listed endangered and threatened species, and migratory birds. Additional comments are provided pursuant to the Coastal Barrier Resources Act (CBRA) (16 U.S.C. 3501 *et seq.*).

FEDERALLY LISTED SPECIES

Piping Plover

1. The federally listed (threatened) piping plover (*Charadrius melodus*) was documented nesting on the Hereford Inlet shoreline of North Wildwood during the last 10 years and within the Cape May National Wildlife Refuge (Two-Mile Beach) in 2010. Both nesting areas are in the vicinity of the project area. The likelihood of nesting activity within the project area is very low. However, we cannot entirely rule out possible nesting within the project area, if construction activity occurs during the breeding season (March 15-August 31). Also, because of the proximity of the Hereford Inlet shoreline of North Wildwood to the project area, the Service may require that the Corps hire a biological construction monitor for any work during the breeding season under the protocol established by the Service and the New Jersey Endangered and Nongame Species Program (ENSP) for the protection of nesting piping plovers. Finally, if any nesting activity is detected by the ENSP within the project area, the Corps shall coordinate/consult with the Service and ENSP to ensure adequate protection of piping plovers.

Individual Tier 2 consultation with the Corps remains required prior to construction and for each periodic nourishment cycle. The Corps shall not rely on Service Tier 2 letters for any nourishment cycle that is later cancelled, delayed, or otherwise modified, but shall rather re-submit updated project information to the Service for further individual Tier 2 consultation.

Seabeach Amaranth

2. There are no records of the federally listed (threatened) seabeach amaranth (*Amaranthus pumilus*) occurring within the project area. It is very unlikely that seabeach amaranth will occur in the project area during the initial nourishment but, if detected, we request that the Corps contact this office to coordinate protective measures for this species.

SPECIES PROPOSED FOR LISTING

3. The red knot (*Calidris canutus rufa*) is being proposed for Federal listing under the ESA. The listing process may be completed as early as September 2014. The proposed critical habitat rule may be issued by March-April 2014. Protective measures for the red knot need to be appended or included in the Programmatic Biological Opinion.

Small numbers of red knots may occur in New Jersey year-round, while large numbers of birds rely on Atlantic and Delaware Bay stopover habitats during the spring (mid-May through early June) and fall (late-July through October – sometimes extending into November 15) migration periods. Red knots are generally faithful to their stopover sites. Threats to the red knot include disturbance, reduced food availability at staging areas, and loss of stopover habitat.

During fall migration, red knots have been documented roosting and foraging on North Wildwood beaches from Hereford Inlet south to 26th Street. On the southern end of the project

area, red knots have been documented roosting and foraging from Richmond Avenue south to the U.S. Coast Guard boundary. The Service may requests that, from July 15 to November 15, if a large number of red knots forage at or in the vicinity of the project site, project activities be suspended and an avian biologist be hired to monitor the red knots until they leave. The avian biologist shall determine when project activities may resume in coordination with this office and the Corps. More specific recommendations may be provided in our Tier 2 letter.

COASTAL BARRIER RESOURCE ACT

4. Section 2.4.16 of the Report (page 104) proposes Hereford Inlet as a borrow area for future re-nourishment events and mentions the past use of vibracores to evaluate sand resources within the inlet. According to the official Coastal Barrier Resource System (CBRS) map for Hereford Inlet, proposed sand borrow areas commonly referred as "H" are located within Unit NJ-09 of the CBRS. If the Corps proposes to make Federal expenditures or financial assistance (as defined by Section 3(3) of the CBRA) available for any purpose relating to a future action or project within the CBRS (including funding for the use of vibracores), the Corps is responsible for submitting a formal consultation request to the Service in writing, with an explanation of how the proposed Federal expenditures or financial assistance comply with the provisions of the CBRA and which Section 6 exception the action or project meets. If the activity qualifies for an exception under Section 6 of the CBRA, "the appropriate Federal officer, after consultation with the Secretary, may make Federal expenditures and may make financial assistance available" within the CBRS.

OTHER COMMENTS AND RECOMMENDATIONS

As a condition for receiving Federal assistance for beach nourishment, all municipalities are required to develop a Beach Management Plan approved by the Service and the New Jersey Division of Fish and Wildlife. At the moment, North Wildwood is the only municipality within the project area to have such plan.

The Corps shall require all municipalities within the study area to coordinate with the Service and ENSP prior to placing sand fencing and planting dune-stabilizing native vegetation following each re-nourishment event.

Please contact Carlo Popolizio at (609) 383-3938, extension 32, if you have any questions pertaining to this correspondence.

Sincerely,

Eric Schrading
Field Supervisor

3

Correspondence from the United State Fish and Wildlife Service dated 6 February 2014.

Federally Listed Species

1. **Piping Plover-** Although the District agrees that the likelihood of nesting activity within the project area is low, an individual tier 2 consultation will occur prior to initial construction and before each nourishment cycle. If any nesting activity is detected the Corps will consult with the Service and ENSP to ensure adequate protection of the piping plovers.

2. **Sea Beach Amaranth-** The District agrees that it is unlikely that sea beach amaranth will occur in the project area. If detected, the Corps will contact the USFWS office to determine protective measures for the species.

Species Proposed for Listing

3. **Red Knot** - The Corps will continue to coordinate with the USFWS with regard to the presence and potential impacts of the project on the red knot. If the species becomes listed under the Endangered Species Act, further consultation will be initiated which may include the adoption of protection measures into the project plans.**Coastal Barrier Resources Act**

4. **Borrow Areas**-The Corps does not currently have any plan to borrow from Hereford Inlet for this project. If the Corps develops any future plans for borrowing within this inlet the Corps will submit a formalwritten consultation request to the Service.

Other Comments and Recommendations

The Corps currently requires all municipalities to prepare a Beach Management Plan that is approved by the USFWS and the New Jersey Division of Fish and Wildlife for all Federal beach nourishment projects. Since North Wildwood is the only Municipality that currently has a plan in place, the Corps will require Wildwood, Wildwood Crest and Lower Township to draft a beach management plan.

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
DIVISION OF LAND USE REGULATION
Mail Code 501-02A, P.O. Box 420, Trenton, NJ 08625-0420
TEL: # (609) 777-0454
FAX # (609) 777-3656

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

February 11, 2014

Peter R. Blum, Chief
Planning Division
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

RE: Federal Consistency
File No.: 0500-03-0001.1 CDT 130001
Hereford Inlet to Cape May Inlet - Coastal Storm Damage Reduction Project
North Wildwood, Wildwood, Wildwood Crest, and Lower Township
Cape May County

Dear Mr. Blum:

Pursuant to section 15 CFR 930.41 of the Federal Consistency Regulations, this office hereby requests that the review period to determine consistency with the New Jersey Coastal Management Program-Bay and Ocean Shore Segment for the above project, be extended 15 days, to March 8, 2014, in order for the DEP-OCZM to complete its review. 1.

If you have any questions regarding the above please contact me in writing at the above address or by phone at (609) 984-6216.

Sincerely,

Gail J. Moore
Project Manager
Bureau of Coastal Regulation

Cc: Chris Constantino, Bureau of Coastal Engineering, Toms River

Correspondence from the NJDEP dated 11 February 2014

1. The extension was granted to 10 March 2014.

Dear Mayor Groon, Commissioner Cabrera, and Commissioner Gould,

I do not support the proposed dune project by the Army Corps of Engineers.

1. Not all barrier islands are created equally. Wildwood Crest is very unique compared to other barrier island towns. We are blessed with a wide and growing beach. Our beach is as wide as some entire towns. Surely the width of our beach alone offers more storm protection compared to other more narrow islands. A wider beach must help dissipate wave energy associated with storms and keep the waves further away from the dunes and the town. It doesn't make sense to shorten our beach and bring that wave energy closer. We also have a dune system that the town is consistently improving. How much storm protection is really gained by shortening our beach and raising the dune as opposed to keeping our wider beach with the existing dunes? Because our beach is so unique, we don't necessarily need the same storm protection as other towns.

2. During Hurricane Sandy the majority of Wildwood Crest's flood damage was caused by water coming from the back bay, not from the ocean side of the island. Our wide beach and existing sand dunes helped prevent ocean water encroachment. A sand dune of any height will not stop flood water coming in from the bay. If flood prevention is the concern, then put resources towards solutions to lessen bay-side flooding.

3. One feature of Wildwood Crest that attracts many visitors to our beach is the safe and family-friendly nature of our waters. The gentle gradient of our beach and accompanying sandbars allow for safe bathing conditions. This gradual slope causes more gentle, weaker-breaking waves thus creating safer swimming conditions. Other beaches in New Jersey have a steep drop-off at the water's edge. This creates a stronger shore-break wave that crashes more forcefully into shallow sand, increasing the potential for accidents. The amount of sand needed for the sand dune project must be enormous. Removing a vast amount of sand from the low tide line could severely impact the current gradient of our near-shore waters. Our natural sandbars could be damaged, leaving steep drop-offs and creating dangerous swimming conditions. I'm sure it's assumed that the sand will fill back in as it was, but this can't be guaranteed. No one can predict with certainty how Mother Nature will respond when drastically altered. I don't believe this project is worth the risk of irreparably changing the nature of our beach.

4. Also of concern to me are the access points to the beach. As it now stands, many of the street ends in the Crest have ADA accessible ramps and walkways. Should a

16 foot high dune be built, all of these walkways would have to be replaced. Who would pay for this? And would they still be ADA accessible?

5. One of the selling points to the Army Corps' project is that shortening the beach will abate the outfall pipe problem. Shortening the beach is not a permanent solution to the outfall pipe problem. Assuming that the beach would resume its growth, this would only be a temporary fix. Our town would be better served by investing in a more creative solution to our outfall line situation .

6. I know that Governor Christie and the Army Corps had made it perfectly clear that the aesthetics of a project like this do not matter to them. However, it can't be overlooked that a project of this magnitude will dramatically change our landscape. A shorter beach with a giant sand dune will significantly decrease the recreational area of our current beach. Views of the water and beach from the bike path and street ends will be completely obscured.

7. Wildwood Crest has been blessed with a very wide beach. Other towns struggle annually with beach replenishment. I can't find the logic in voluntarily removing half of our beach, potentially altering the bottom conditions of our waters, drastically altering the landscape of our town all to construct a wall of sand that may or may not protect the island any better than it already is.

Please don't support this project either.

Thank you.

Sincerely,

[redacted]

[redacted]

Wildwood Crest, NJ

Email from Concerned Citizen no date.

1. The large width of the beach in Wildwood is not capable of mitigating for the elevated storm water levels experienced during hurricane and nor'easters. As our modeling has shown in the feasibility phase and feasibility documents, the low nature of the beach and lack of a dune system make North Wildwood, Wildwood & Wildwood Crest susceptible to storm damage at moderately elevated water levels.

2. Damages from hurricane Sandy were reported from ocean and bay sources in the Wildwoods. Hurricane Sandy was approximately a 30 year event in Cape May County. The storm damage models we evaluate for our studies run 7 storm sequences that range from the 5 year event to the 500 year event. These storms have water elevations that exceed the elevations experienced by hurricane Sandy, and overtop the beach and cause damages to houses and infrastructure if our plan is not in place. The project, as authorized, focused on beachfront protection. Additional studies that were authorized as a result of back-bay flooding during hurricane Sandy are currently evaluating how to deal with that flooding issue.

3. The steep drop off at any beach is a function of the sand grain size and the angle at which the sand can be shaped. As sand grain size increases, the angle of the beach increases. The Wildwoods have very fine grained sand, and the material that we will be mobilizing within the project area will all come from the beaches in the Wildwoods, therefore the project should not increase the slope of the beach since the sand grain size will remain similar. Excavating sand from the beach may cause a temporary increase in slope, but this slope will likely not hold that shape and the profile will re-adjust to its normal shape over time.

4. Americans with Disabilities Act (ADA) compliant walkways, pedestrian walkways and vehicular walkways are all part of the construction project and will provide access over the +16 NAVD 88 dune. These costs are factored into the total project cost which is shared 65% Federal and 35% non Federal between the Army Corp of Engineers and the New Jersey Department of Environmental Protection (NJDEP). The local community may have to provide a portion of the NJDEP costs.

5. The project area will likely experience erosion at it's northern end and accretion at the southern end of the project area, similar to what happens now. In order to combat the continued cycle of erosion/accretion, which is a natural part of a coastal system, we plan on excavating sand from in front of the outfalls on a 4 year basis, and placing the material where it eroded from to maintain the shore protection component, and reduce the outfall clogging. All of the projects within the NJ shore protection system in Avalon, Stone Harbor, Ocean City, Atlantic City, Brigantine etc.have a periodic nourishment component that spans 4-6 years to mitigate for the natural erosion that takes place along all coastal shorelines.

6. We do not concur that aesthetics of the project do not matter. Our projects are constructed to mimic natural dune systems.In some locations, the existing dunes within Wildwood Crest are at or exceeded the proposed +16 NAVD 88 design. The Corps dunes are also constructed with native beachgrass that are common to all New Jersey beach communities. Some locations in Wildwood Crest currently have obstructed ocean views due to the wide beach and height of the dunes.

7. The presence of the dune in your community will reduce storm damages from oceanfront waves and storm surge.

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
NORTHEAST REGION
55 Great Republic Drive
Gloucester, MA 01930-2276

FEB 19 2014

Peter Blum, Chief
Planning Division
Philadelphia District
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

ATTN: Beth Brandreth, Project Biologist
RE: Draft Environmental Assessment, Hereford Inlet to Cape May Inlet, Draft Feasibility Report and Integrated Environmental Assessment

Dear Mr. Blum:

We have reviewed the Hereford Inlet to Cape May Inlet Draft Feasibility Report and Integrated Environmental Assessment (DEA) dated December 17, 2013. The DEA presents the findings of the Corps of Engineers' study to determine a hurricane and storm damage reduction plan for coastal communities located between Hereford Inlet and Cape May Inlet in Cape May County, New Jersey. The communities in the project area include North Wildwood, West Wildwood, Wildwood, Wildwood Crest and Lower Township. The selected plan includes the use of a mobile sand back passing system to hydraulically pump sand from the accreting areas of Wildwood and Wildwood Crest in order to construct a dune and berm system in North Wildwood and a dune only system in Wildwood Crest and Lower Township. The initial sand quantity estimate is 1,362,000 cubic yards. A four-year renourishment cycle is anticipated.

As you are aware, the Magnuson Stevens Act (MSA) and the Fish and Wildlife Coordination Act (FWCA) require Federal agencies to consult with one another on projects such as this. Because this project involves essential fish habitat (EFH), this process is guided by the requirements of our EFH regulation at 50 CFR 600.905, which mandates the preparation of EFH assessments and generally outlines each agency's obligations in this consultation procedure. We offer the following comments and recommendations on this project pursuant to the above referenced regulatory process.

Essential Fish Habitat/Fish and Wildlife Coordination Act
The project area has been designated as EFH for a number of federal managed species including summer flounder, winter flounder, bluefish, skates and others. The near shore habitat also supports benthic organism that are prey species for a wide range of NOAA resources including those that are federally managed and those that fall under our FWCA authorities.

The EFH assessment included in the DEA adequately the potential effects of the project on EFH and federally managed species. Adverse impacts to EFH and to other NOAA species may occur as a result of this project, but due to the location of the borrow area within the intertidal and near shore zone, and the dynamic nature of this area, impacts are expected to be temporary and minor.

However, over the 50-year life of this project, changes on project conditions, changes to EFH, to federally managed species or the status of other NOAA resources may occur. Pursuant to 50 CRF 600.920 (j), if new information becomes available, or if the project is revised in such a manner that affects the basis our EFH determination, the EFH consultation must be reinitiated. To ensure that our agencies comply with the requirements of this section of the EFH regulations, we recommend that the Corps contact us prior to the commencement of each renourishment cycle so that we may confirm the basis for the EFH determination remains unchanged. This notification should include the approximate date of the start and duration of the construction and the area affected.

Essential Fish Habitat Conservation Recommendations
Pursuant to Section 305 (b) (4) (A) of the MSA, we recommend the following EFH conservation recommendations be incorporated into the project:

1. Notification should be provided to our office prior to commencement of each renourishment cycle.

Please note that Section 305 (b)(4)(B) of the MSA requires you to provide us with a detailed written response to these EFH conservation recommendations, including the measures adopted by you for avoiding, mitigating, or offsetting the impact of the project on EFH. In the case of a response that is inconsistent with our recommendations, Section 305 (b) (4) (B) of the MSA also indicates that you must explain its reasons for not following the recommendations. Included in such reasoning would be the scientific justification for any disagreements with us over the anticipated effects of the proposed action and the measures needed to avoid, minimize, mitigate or offset such effect pursuant to 50 CFR 600.920 (k).

Endangered Species Act
As noted in the DEA, several species listed as threatened or endangered by NMFS occur seasonally off the coast of New Jersey. The proposed sand bypass will take place in the 1. intertidal zone where water depths are very shallow. Sea turtles, Atlantic sturgeon and listed whales are not present in that area. Therefore, none of these species will be exposed to any direct or indirect effects of the proposed project. Based on this, we do not believe a consultation in accordance with section 7 of the ESA is necessary. As such, NMFS Protected Resources Division does not intend to offer additional comments on this proposal. Should project plans change or new information become available that changes the basis for this determination, further coordination should be pursued. If you have any questions regarding these comments, please contact Julie Crocker of my staff (978-282-8480 or Julie.Crocker@noaa.gov).

We look forward to continued coordination with your office on this project as it moves forward. If you have any questions or need additional information, please do not hesitate to contact Karen Greene at karen.greene@noaa.gov or (732) 872-3023.

Sincerely,

Louis A. Chiarella,
Assistant Regional Administrator
for Habitat Conservation

cc: NJDEP – Land Use -

FWS- Pleasantville- C.Popolizio
EPA – Region II – D. Montella

Correspondence from the United States Department of Commerce dated 19 February 2014

Essential Fish Habitat Recommendations

1. Concur. NMFS will be notified prior to all construction and nourishment activities.

Endangered Species Act

1. Concur. Further consultation in accordance with section 7 of the Endangered Species Act is not necessary.

-----Original Message-----
[redacted]
Sent: Thursday, February 20, 2014 2:35 PM
To: Voigt, Edward C NAP
Subject: [EXTERNAL] Beach Project Concerns

Good Morning,

My name is [redacted] I decided to contact the you because of the recent news about the new beach project currently being discussed on the Wildwood's. First I wanted to take a moment and say how much I commend your hard work and efforts on the island as a whole I have always vacationed in Wildwood 29 years this year and hopefully one day will be able to live and work down there.

On to the reason I decided to write this and maybe this will give some points to bring up during the discussion I wish I could attend the meeting but I am sure it is for residents only. First I understand why the project is needed to a degree. North Wildwood has had problems with erosion near the inlet starting in the early 90's from understanding the yearly coastal research project from Richard Stockton Research Center. This process takes sand from the beachfront of North Wildwood and deposits it onto Wildwood, Wildwood Crest and North Wildwood inlet beaches. From understanding it is a cycle that goes back and forth every few years or so. This process helped cause the flooding issues in Wildwood and some of the Crest because of blocked outfall pipes. I could go on but you already know about these issues. Let me get back to my concerns.

1. · While North Wildwood needs to be protected I don't feel they should take sand from the neighbors. Pump it from the inlet like other beach towns already do. Grow the dunes more and build a bigger berm.

2. · Wildwood floods because of outfall pipes being buried extend them I agree a dune should be built also but don't take away the wide beach which the town has adapted and now many activities are using the wide beach which is helping the revenue source.

3. · If they take away some beach what will protect the piers? Those piers grew as the beach did take away the beach how can they expand and or be protected? How much beach will be a buffer from end of pier to water's edge?

4. · Wildwood Crest has started to already build an impressive dune system which I commend them as well for keeping up with that. Also extend the outfall pipes like Wildwood.

5. · Also on page 48 of the report figure 18 shows Wildwood Crest in the 70s that picture is not correct as the Great White and Great NorEaster roller coasters were built in the 90's and from that picture it looks like it was from 2000/2001 as you can see the outline for the new convention center to be built.

I feel that there are other ways you can handle this but coming from a person who comes to The Wildwoods all the time I do so because of the beach. There is no beach like yours I do not want to have a shorter beach I like having room and space to spread out If I wanted a narrow beach I would go to Ocean City or LBI. They again need to think of how you adapted to the situation of a growing beach and they should not put the piers at risk by making the beach shorter.

Thank you for your time,

cid:image002.jpg@01CEBEB6.38EDD8C0

[redacted]

Correspondence from Concerned Citizen dated 20 February 2014

1. The inlet bordering North Wildwood is already identified as a sediment source for the Avalon and Stone Harbor project, contains numerous shipwrecks, has environmentally sensitive finfish/shellfish and bird habitat and was screen out of the planning process. Pumping sand from the inlet will be more costly than our current backpassing operation and adding more sediment from the inlet may exacerbate the situation in the Wildwood by clogging their outfalls with the additional sand. By using the excess and within the system we can solve the outfall situation and the storm damage situation in the study area.

2. It is against Corps of Engineers policy to maintain or extend outfall pipers for local interior drainage, that is a non-Federal responsibility.

3. The borrow area can be adjusted to reduce the impacts to the piers by shifting the location of the area southward and focusing the harvesting of sand to Wildwood Crest and the southern portion of Wildwood.

4. The dune system in Wildwood Crest is not adequate as a storm damage reduction feature based on the results of the coastal engineering models.

5. The caption in the figure has been modified.

Bogle, Brian P NAP

From: [redacted]
Sent: Thursday, February 27, 2014 11:48 AM
To: christopher.constantino@dep.state.nj.us; Bogle, Brian P NAP; Blum, Peter R NAP; Brandreth, Mary E NAP
Subject: [EXTERNAL] First Ward Dune Project Wildwood New Jersey

1. [redacted] Constanino,It was very nice talking with you today concerning Army Corp. plans to construct a dune in Wildwood New Jersey..However it is my opinion that this would be detremental to my plans in the near and distant future on beach property I own or rent.As long as this property is deeded to myself and others I would have to oppose any plans for this property that were not my own.The property block 270,lot 3.01 is the property above mentioned with D.K. Rentals Inc. a New Jersey corporation operating on same property ,with others, in the first ward ,Wildwood New Jersey.Thank you for your time and kind consideration.[redacted]

Email from concerned citizen dated 27 February 2014.

1. There are multiple properties within Wildwood that may be impacted by the placement of a dune. During the more detailed Planning Engineering and Design (PED) phase the impacts to properties are minimized to reduce the need for easements and takings/relocations.

THE BOROUGH OF WILDWOOD CREST

6101 Pacific Avenue, Wildwood Crest, NJ 08260
www.wildwoodcrest.org

CARL GROON
Mayor -
Public Safety

JOYCE GOULD
Revenue &
Finance

DON CABRERA
Public Works &
Recreation

COMMISSIONERS
BOROUGH CLERK
609-522-5176
FAX 609-522-7108

FIRE PREVENTION/
CODE ENFORCEMENT
609-729-5152
FAX 609-729-7089

PUBLIC WORKS
609-522-7446

RECREATION
609-523-0202

TAX ASSESSOR
609-522-3891

TAX COLLECTOR
SEWER COLLECTION
609-522-3843
FAX 609-522-6692

TREASURER
609-522-0401
FAX 609-522-6692

March 4, 2014

Mr. Peter Blum, PE
ATTN: Environmental Resources Branch
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

RE: Hereford Inlet to Cape May Inlet
Draft Feasibility Report Comments
Wildwood Crest, Cape May County, New Jersey

Dear Mr. Blum:

On behalf of the Borough of Wildwood Crest, we are pleased to provide herewith comments in response to the above referenced U.S. Army Corps of Engineers (USACE) draft feasibility report. These comments are based on a thorough review of the document, multiple meetings with USACE and New Jersey Department of Environmental Protection (NJDEP) representatives, discussions by the Board of Commissioners at various public meetings, and miscellaneous memoranda and e-mail correspondence between our offices.

Based on the Borough's review of the report, it is apparent that the USACE's primary objectives are consistent with those of the Borough, such as reducing storm damage and excessive shoreline accretion. However, the Borough also places a very high value on the aesthetic and recreational qualities of the beach that the public has long enjoyed and that contribute to the economic and cultural vitality of the community. The Borough also desires to minimize both initial costs and the possibility of future costs associated with the maintenance of the USACE improvements.

Therefore, we are providing the following comments on the draft report:

1. We believe that the proposed 16' (NAVD88) dune elevation is unnecessarily high. As has been discussed at meetings with your office and the NJDEP on this subject, the proposed dune height would significantly reduce the public's enjoyment of the beachfront areas by impeding the views of the ocean and making it more difficult to access the beach. The report states that benefits continue to increase with dune heights greater than 16', but that the dune height was limited to 16' in order to be acceptable to the community. The Borough appreciates the rationale of limiting the dune height to accommodate the community's concerns; however, based on extensive feedback from the public, the 16' dune is not acceptable to the community as assumed in the report. Therefore, the Borough requests that the dune be reduced to elevation 12' (NAVD88).

   We would request that the USACE consider reducing the dune height while attempting to achieve the same degree of storm protection by widening the dune and/or establishing an elevated berm in front of the dune to compensate for the reduced height. However, it is our

understanding that the establishment of the proposed 16' elevation was not in strict compliance with National Economic Development (NED) procedures. Therefore, we would request that the reduction of the dune height not be bound by a strict application of a compensating width. That is, if the storm damage protection compensation for a reduction of four (4) vertical feet requires an unacceptably wide dune that would be vulnerable to erosion from moderate storm events, we would request that the width be reduced even if it does not strictly compensate for the reduced dune height.

2. The Borough requests that the USACE consider elevating the berm in front of the dune in order to both protect the dune from periodic erosion from moderate storm events and to provide additional protection from ponding in these areas.

3. It is our understanding, based on previous meetings and correspondence, that the backpassing project will be conducted in such a way as to protect the public safety. Specifically, that the hydraulic excavation process will not create unsafe holes or depressions, but will be graded, *during construction*, to the slopes indicated on the cross sections contained in the report.

   Furthermore, it our understanding that if the excavation of sand in the vicinity of the Borough's outfall structures would result in exposure, or risk of exposure, to forces not considered in the Borough's earlier design of the outfall extensions, that the USACE will include the strengthening of these structures as part of the federal project.

4. In addition to the several ADA-compliant dune crossovers, the Borough requests that all dune crossovers be constructed with slopes not exceeding 12:1.

5. Some of the Borough's existing stormwater outfall pipes extending through the area of the proposed dune may be constructed of materials (or are in a condition) that may not support the additional loads from the proposed dune. Therefore, the Borough requests that the USACE evaluate the existing condition of these structures and replace them as necessary.

6. Since the construction of the dune has the potential to diminish the ability of the Borough's emergency personnel to respond quickly to emergencies, the Borough requests that a vehicular gravel access road, located between the existing bulkhead and the proposed dune, be incorporated into the project along the length of the proposed dune. This would increase the ability of the emergency personnel to respond to emergencies, thereby protecting the public safety.

7. Electronic mail correspondence from Mr. Christopher Constantino, of the NJDEP Bureau of Coastal Engineer, dated February 25, 2014, clarified that damage to the USACE's improvements in Wildwood Crest would be repaired under periodic renourishments, but that these renourishments would be subject to future Water Resources Development Act (WRDA) funding. Please clarify whether future losses of material in the dune would be considered erosion (subject to periodic renourishment) or damage (subject to repair under FCCE funding); or whether it would be eligible for repair under either of these mechanisms.

8. As has been discussed, the report provides significant detail on "without project" damages and benefits of alternative plans for North Wildwood, but does not provide an equivalent level of detail for Wildwood Crest. This additional information has been requested in previous correspondence. The review of these additional details will allow for a better understanding of the costs, benefits, and risks of accepting the USACE's proposed plan.

We look forward to your response to the above concerns, and trust that we can work together to develop a plan that achieves an appropriate balance among the federal, state, and local interests on this important project. We would be pleased to discuss this matter in further detail or to meet with both the USACE and the NJDEP at your convenience.

Very truly yours,

Carl H. Groon, Mayor

Joyce P. Gould
Commissioner

Don Cabrera
Commissioner

:trt

cc: Janelle M. Holzmer, Clerk
Joe Bond, CPWM, Superintendent of Public Works
Ralph Petrella, PE, Van Note-Harvey
James W. Verna III, Van Note-Harvey
Thomas R. Thornton, PE, CME, Hatch Mott MacDonald
Robert C. Mainberger, PE, CME, Hatch Mott MacDonald
Brian Bogle, USACE
Christopher Constantino, NJDEP Bureau of Coastal Engineering

Correspondence from Wildwood Crest dated 4 March 2014.

This correspondence was responded to in a letter from the District to the Municipality on 21 March 2014 contained on the following page.

DEPARTMENT OF THE ARMY
PHILADELPHIA DISTRICT, CORPS OF ENGINEERS
WANAMAKER BUILDING, 100 PENN SQUARE EAST
PHILADELPHIA, PENNSYLVANIA 19107-3390

REPLY TO
ATTENTION OF

CENAP-PL-PC

MAR 2 1 2014

Honorable Carl H. Groon
Mayor, Borough of Wildwood Crest
6101 Pacific Avenue
Wildwood Crest, New Jersey 08260

Dear Mayor Groon,

Thank you for your letter dated March 4, 2014 regarding the Hereford Inlet to Cape May Inlet feasibility study. This study was done in partnership between the New Jersey Department of Environmental Protection (NJDEP) and the U.S. Army Corps of Engineers (Corps). I am writing to respond to the questions and comments you expressed jointly with Commissioner Gould and Commissioner Cabrera on the draft feasibility report for this study.

As noted in your letter, the primary purpose of the study is to provide flood risk management. In response to your specific comments:

Comments 1 and 2. Dune height and berm width. Alternative plans were formulated and a recommendation was made in accordance with our requirements to follow National Economic Development (NED) procedures. Alternative dune heights ranged from +12 ft NAVD88 to +16 ft NAVD 88 with a berm width of 75 ft at elevation +6.5 ft NAVD88. Each alternative was evaluated for completeness, effectiveness, efficiency and acceptability and analyzed for inundation, wave attack and erosion. The recommended NED plan includes the +16 ft dune height. Your suggestion to reduce the recommended dune height from +16 ft to +12 ft would more than double the average annual damages (from $306,000 to $654,000). This additional flood risk ($348,000 in average annual damages) precluded a +12 ft dune plan from being the recommended NED plan.

Your letter also suggests compensating for reduced dune height with a wider dune base and / or establishing an elevated berm in front of the dune. In response, the Corps determined that the recommended NED plan required a 75 ft wide berm at +6.5 ft NAVD88 for Wildwood, Wildwood Crest and Lower Township. This additional beach fill will help stabilize the dune, prevent ponding and ensure the integrity of the project and its eligibility for Federal repair in the event of a declared Federal emergency. However, this addition will not compensate for a lower dune height in terms of reducing the effects of storm surge and dune overtopping.

Comment 3. Excavation process and outfall stabilization. The backpassing will be done in such a way as to protect public safety, avoiding unsafe holes or depression and be graded during construction to the slopes indicated on cross sections shown in the report. Outfalls will be strengthened as needed to consider any change in wave forces attributed to backpassing excavation.

Comment 4. ADA-Compliant Dune Crossovers. All will be constructed with slopes not exceeding 12:1.

Comment 5. Structural integrity of existing outfall pipes. The Corps will analyze the existing conditions and ensure structural integrity with the project in place.

Comment 6. Emergency access with dune in place. The Corps will consider this during the design phase and investigate the possibility of including a vehicular gravel access road between the existing bulkhead and the proposed dune.

Comment 7. Dune erosion. Erosion of the dune would be restored in both scenarios you describe, i.e., as part of a periodic nourishment cycle (if needed) and under emergency repair (FCCE) if damaged in a declared emergency.

Comment 8. Without project damages and benefits of alternative plans. This topic was discussed at a meeting in Wildwood Crest on February 19, 2014. The information we presented at the meeting is summarized in the table below. The data indicate that the average annual storm damage reduction benefit for the recommended NED plan, with the dune crest at +16 ft NAVD88, is $860,000, whereas the average annual benefit for the +12 ft NAVD88 dune plan is $512,000, reflecting the significant damage reduction benefit for Wildwood Crest associated with the recommended plan.

Community	Cell	w/o project	16 ' Dune		12' Dune	
		AAD	AAD	AAB	AAD	AAB
Wildwood Crest	4	$218,000	$74,000	$144,000	$198,000	$20,000
	5	$948,000	$232,000	$716,000	$456,000	$492,000
TOTALS		$1,166,000	$306,000	$860,000	$654,000	$512,000

I hope this information is helpful and I look forward to continuing to work with you in the future. Please call Mr. Brian Bogle at 215-656-6585 or me at 215-656-6540 if you have any additional questions.

Sincerely,

Peter Blum, P.E.
Chief, Planning Division

CC: Christopher Constantino, NJDEP

2

Bogle, Brian P NAP

From: [redacted]
Sent: Monday, March 10, 2014 12:46 PM
To: Bogle, Brian P NAP; christopher.constantino@dep.state.nj.us
Subject: [EXTERNAL] Hereford Inlet to Cape May Inlet draft feasibility study

Gentlemen

On behalf of Seapointe Village, please accept this email as formal comment during the open public comment period regarding the Hereford Inlet to Cape May inlet draft feasibility study.

1. Seapointe Village takes no position regarding the study, and is neutral on dune height as proposed throughout the island, reserving concerns for any changes to dunes on Seapointe Village property.

   Seapointe Village is concerned and objects to the method of borrowing sand from off-shore areas to build the dunes.

   The bathing beaches along the Wildwoods have historically been very safe.

2. Removing sand from these beaches, especially so close to the tide lines, will create a drop off.

3. Seapointe Village is concerned about the effect of this drop off, the change in tides and potential for disturbing and changing the conditions along the bathing beaches of the Wildwoods to the detriment of the bathers.

   Considering the interdependency of the natural attractions of the ocean and beaches and their value as economic drivers, Seapointe Village is opposed to this specific aspect of the feasibility study.

   Thank you.

[redacted]

General Manager

Seapointe Village

[redacted]

Email from Seapointe Village Association dated 10 March 2014.

1. Most of the material to be removed from the beach is in Wildwood Crest and Wildwood. The comparison of the without project model runs and the with project model runs indicate shortening the beach and creating a dune will reduce storm damages project wide.

2. The existing slopes to the beach will be maintained at 1:30 in the offshore to reduce steep drop-offs and pits.

3. The plans currently do not have any material being excavated from Lower Township. Any adjustment to the profiles will be the result of the shoreline reaching equilibrium between Lower Township and Wildwood Crest, not the direct removal of material from the Township.

March 7, 2014

U.S. Army Corps of Engineers
100 Penn Square East
Philadelphia, PA 19107-3390
Attn: Brian P. Bogle
Project Manager, Coastal Planning Section

State of New Jersey
Dept. of Environmental Protection
1510 Hooper Ave
Toms River, NJ 08753
Attn: Christopher Constantino
Environmental Services Specialist

Re: New Jersey Shore Protection Study
Hereford Inlet to Cape May Inlet
Draft Feasibility Request dated December 17, 2013

It was a pleasure speaking with you at the public meeting in North Wildwood on February 21, 2014. Thank you for the opportunity to review the report and allow us to formally comment on some areas of concern. I am writing to follow up and inquire about how we can more fully engage in the discussion.

As I noted at the meeting, we were happy to hear that you are considering adding or increasing the size of the berm in front of the dune based on recent discussions you have had with the municipalities involved. We agree that this is a needed enhancement to the current plan.

1. Our greatest concern relates to the proposed location of the dune which is shown to pass under our four piers at varying distances from the boardwalk. We understand from your comments at the meeting that one of the reasons for this preliminary location was out of consideration for access to the piers. We appreciate this concern and can agree that access is one of the many issues that need to be addressed. However, much more concerning to us is the fact that unlike the protection offered the other public and private facilities on the island, this scheme leaves our four piers (and the two directly to the north) essentially unprotected.

While a berm will afford some measure of protection, one significant nor'easter can remove the largest of berms leaving us unprotected until the beach is replenished. We strongly feel that all six of the island's boardwalk and entertainment/amusement piers are an integral part of the community and require protection at least as substantial as that being provided the rest of the island. It is important that we continue this discussion and look forward to hearing from you regarding how we can most effectively contribute.

Morey's Surfside Pier • Morey's Mariner's Landing Pier • Morey's Adventure Pier • Ocean Oasis Waterpark & Beach Club • Raging Waters Waterpark
3501 Boardwalk, Wildwood, NJ 08260 phone - 609.729.3700 fax - 609.729.0788 www.MoreysPiers.com

New Jersey Shore Protection Study
March 7, 2014
Page 2

2. Additionally, in an effort to clarify the issues that have come up during discussions with the municipalities regarding the various activities that occur on the beach that directly relate to the location of the dune, we have developed a plan of the island delineating the different areas which will be created once the dune project is complete. We are currently sharing this plan with the municipalities and will be happy to forward once we have been able to complete these discussions.

If you have any questions, please do not hesitate to contact me.

[redacted]
Director of Construction

Enclosure
MG/am

cc: Mayor Patrick Rosenello, City of North Wildwood
Mayor Ernie Troiano, Jr., City of Wildwood
Mayor Carl Groon, Borough of Wildwood Crest
Will Morey
Jack Morey

Correspondence from Morey's Pier dated 7 March 2014.

1. The final design will evaluate exact dune locations in order to reduce impacts to the piers and the location of the borrow area relative to the piers. We can also evaluate small changes to the location of the dunes to prevent flooding on certain sections of the piers, and/ or betterments and improvements to the design during the Planning Engineering and Design phase to reduce storm impacts.

2. We look forward to discussing your future recreation plans for the project area.

State of New Jersey

DEPARTMENT OF ENVIRONMENTAL PROTECTION
Division of Land Use Regulation
Mail Code 501-02A
P.O. Box 420
Trenton, New Jersey 08625-0420
www.state.nj.us/dep/landuse

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

MAR 07 2014

Peter R. Blum, Chief
Planning Division
U.S. Army Corps of Engineers
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107-3390

RE: Federal Consistency & Section 401 Water Quality Certificate
File No.: 0500-03-0001.1 (CDT 130001)
Hereford Inlet to Cape May Inlet - Coastal Storm Damage Reduction Project
North Wildwood, Wildwood, Wildwood Crest, and Lower Township
Cape May County

Dear Mr. Blum:

The New Jersey Department of Environmental Protection, Division of Land Use Regulation, acting under Section 307 of the Federal Coastal Zone Management Act (P.L. 92-583) as amended, agrees with the certification that the above referenced project is consistent with the approved New Jersey Coastal Management Program and New Jersey's Rules on Coastal Zone Management N.J.A.C. 7:7E-1.1 et seq., as amended on April 16, 2013. This determination also authorizes a Section 401 Water Quality Certificate for the authorized work.

The proposed project site is located along the Atlantic Coast shoreline of New Jersey from Hereford Inlet to Cape May Inlet and includes work within North Wildwood, Wildwood, Wildwood Crest and a portion of Lower Township. The U.S. Army Corps of Engineers has proposed berm and dune restoration utilizing sand (1,362,000 cubic yards) which will be hydraulically back-passed from the beaches of Wildwood, Wildwood Crest and Lower Township. This sand will then be utilized to provide beach nourishment material to reduce storm damage in the form of a storm protective berm and dune in North Wildwood, Wildwood and Wildwood Crest, with a dune only in Lower Township. The proposed dune will be at elevation +16 NAVD88 with a crest width of 25 feet and a 75 foot wide berm with an elevation of +6.5 feet. Side slopes for the dune will be 1V:5H and 1V:30H for the seaward slope of the berm. To maintain the design template, the ACOE is conditionally authorized to perform periodic nourishments of 305,000 cubic yards of sand every four years following the completion of the initial project.

The proposed project includes the installation of approximately 64 acres of dune grass, 28,000 linear feet of sand fence, 44 extended crossovers, 7 new pedestrian crossovers, 7 extended handicap crossovers, 6 new handicap crossovers, 8 existing vehicle crossover extensions and 5 new vehicular crossovers.

#0500-03-0001.1 CDT130001

This consistency determination is issued subject to compliance with the following conditions.

1. Prior to commencement of work and/or site preparation, all authorizations and/or easements from all owners of property within the project area must be obtained.

2. Prior to commencement of work and/or site preparation, final engineering plans must be submitted to the Division of Land Use Regulation for final review and approval.

3. Federally endangered shorebird nesting areas are located in the northern inlet section of the beach and north and west of the terminal groin in North Wildwood. Therefore, for the protection of these species, no work shall occur within this nesting area between March 15th and August 31st of any given year.

4. Proposed work (i.e., dune taper area) adjacent to the Hereford Inlet area may potentially impact/disturb nesting Piping Plover and Least Terns, therefore authorized work within this area may not be performed during the timing restriction from March 15-August 31 of any given year. Prior to the placement of any snow fence within this area, the permittee must coordinate with ENSP and USFWS to determine the appropriate methods to ensure beach nesting bird habitat is either not impacted or that the impacts have been minimized to the maximum extent possible.

5. Should any habitat for a currently listed Federal or State Threatened or Endangered shorebird species be identified on any portion of the beach within the duration of this Federal Consistency Determination, the ACOE shall cease work and immediately contact USFWS and ENSP to determine whether the borrow and placement areas have become suitable/active habitat for nesting birds. Work may not proceed until this coordination has been completed and the USFWS and ENSP authorize resumption of work. No work is authorized within any nesting habitat that is identified within the life of the project.

6. Should any additional species and/or species habitat be added to the Federal and/or State Threatened and Endangered Species protection list that may occur within the scope of this project, the ACOE shall contact USFWS and ENSP for further evaluation and guidance. In such an event, the Department reserves the right to impose additional timing restrictions.

7. Within 90 days of conducting any four (4) year nourishments the ACOE shall provide DLUR with the information listed below. Future maintenance work authorized by this Federal Consistency determination shall not commence until the ACOE receives written notification from this office that the work may proceed in accordance with existing or modified conditions.

    - An updated list of plover nesting areas and other beach-nesting birds that may be present (e.g., least tern or black skimmer),
    - Locations and numbers of any seabeach amaranth plants discovered,
    - Limits of proposed work, proposed volume of sand, proposed areas of dune maintenance or re-construction,
    - Vehicle access points and travel corridors,
    - Material stockpile and equipment storage areas,
    - Anticipated schedule of activities.

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8. All dune creation areas must be planted with "Cape" American beachgrass or a species listed in the Standards Applicable to Dune Creation and Maintenance (7:7E-3A.3) within the following planting season. Native dune vegetation must be planted in the mid to late spring, annually, to establish vegetative cover on the dune in accordance with the specifications contained in Guidelines and Recommendations for Coastal Dune Restoration and Creation Projects (DEP, 1985) and/or Restoration of Sand Dunes Along the Mid-Atlantic Coast (U.S. Soil Conservation Service, 1992). These documents are available upon request from the Department's Division of Land Use Regulation, PO Box 439, Trenton, New Jersey 08625-0439, (609) 292-0060.

   Dune vegetation should be limited to a variety of the following coastal species: American Beachgrass (Ammophila breviligulata), Coastal Panicgrass (Panicum amarulum), Bayberry (Myrica pennsylvanica), Beach Plum (Prunus maritima), Seaside Goldenrod (Solidag sermpervirens), Beach Pea (Lathyrus japonicus), Sea Oats (Uniola paniculata), Bitter Panicgrass (Panicum amarum), and even Saltmeadow Cordgrass (Apratina patens).

This Federal Consistency is authorized pursuant to all parties following the guidelines set forth, and agreed upon, for the construction of the proposed structures.

Pursuant to 15 CFR 930.44, the Division reserves the right to object and request remedial action if this proposal is conducted in a manner, or is having an effect on, the coastal zone that is substantially different than originally proposed.

Thank you for your attention to and cooperation with New Jersey's Coastal Zone Management Program. If you have any questions regarding this determination, please contact Colleen Keller of our staff at (609) 633-2289.

Sincerely,

David B. Fanz, Assistant Director
Division of Land Use Regulation

3/7/14
Date

C: John Gray, Office of Permit Coordination and Environmental Review
Marty Rosen, Division of Coastal and Land Use Planning
Christopher Constantino, NJDEP Bureau of Coastal Engineering

Correspondence from the NJDEP dated 7 March 2014

1. Concur. All necessary easements will be obtained by the Non-Federal Sponsor prior to construction.

2. Concur. Final plans will be submitted to the Land Use Regulation Program for final review.

3. Concur. If endangered birds are present in the project area, no work in the nesting area will occur between March 15th and August 31st. In addition, the appropriate buffer areas around the nesting sites will be utilized.

4. Concur. If endangered birds are present in the project area, no work in the nesting area will occur between March 15th and August 31st. In addition, the appropriate buffer areas around the nesting sites will be utilized. Sand fence placement will be coordinated with NJDEP and USFWS to minimize impacts to beach nesting birds.

5. Concur. The Corps will notify USACE and ENSP of the presence of any nesting activity, or foraging birds in the project area based on the guidelines established in the 2005 Biological Opinion for buffer zones and seasonal restrictions.

6. Concur. Any additions to the Federal and/or State Threatened and Endangered Species protection list will be coordinated with USFW and ENSP.

7. Concur. The ACOE will provide the DLURP with the information it's requested prior to the beginning of any four year nourishment cycle.

8. Concur. Native dune vegetation will be provided for planting.

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NATURAL & HISTORIC RESOURCES
Office of Engineering and Constructions
501 East State Street
Mail Code 501-01A
P. O. Box 420
Trenton, NJ 08625-0420
Tel. 609-292-9236 FAX 609-984-1908

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

April 9, 2014

John C. Becking, P.E.
Lieutenant Colonel, US Army Corps of Engineers
Philadelphia District
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107

Reference: Hereford Inlet to Cape May Inlet Feasibility Study

Dear Colonel Becking:

The purpose of this letter is to confirm the New Jersey Department of Environmental Protection's (Department) support of the US Army Corps of Engineers (USACE) recommended plan contained in the Hereford Inlet to Cape May Inlet Feasibility Study. The Department is committed to partnering with the USACE Philadelphia District and will continue to provide the staffing and support needed to complete the project.

Sincerely,

Dave Rosenblatt
Administrator

NON-FEDERAL SPONSOR'S
SELF-CERTIFICATION OF FINANCIAL CAPABILITY
FOR AGREEMENT FOR THE CONSTRUCTION OF THE
HEREFORD INLET TO CAPE MAY INLET PROJECT

I, Adrienne Kreipke, do hereby certify that I am the Director of Budget and Finance of the New Jersey Department of Environmental Protection (the "Non-Federal Sponsor"); that I am aware of the financial obligations of the Non-Federal Sponsor for the Hereford Inlet to Cape May Inlet Project; and that the Non-Federal Sponsor has the financial capability to satisfy the Non-Federal Sponsor's obligations under the Project Partnership Agreement for the Hereford Inlet to Cape May Inlet Project, consistent with Article XVII of the PPA.

IN WITNESS WHEREOF, I have made and executed this certification this 9th day of April, 2014.

BY: A Kreipke

TITLE: Director, Budget + Finance

DATE: 4/9/14

Appendix H.

Public Access

H. Public Access

The beach access plan includes pedestrian, handicap, and vehicle access over the project dune. Pedestrian access will consist of modular walkway accesses extending up and over the dune at skewed angles and bordered with sand fencing. Access will be provided at existing access points with spacing of ½ mile or less between each access point, at a minimum. Handicap access will be provided at regular intervals and will consist of timber deck ramps with handrails. Vehicle access will be provided and will consist of a geogrid ramps filled with densified sand. Final locations of access points will be coordinated with the sponsor and local communities during preparation of plans and specifications.

Local communities may have special, site-specific requirements for beach access appurtenances that may require construction of additional access paths or modification of proposed access paths. This is conditionally acceptable to the Corps of Engineers so long as the access plans are fully coordinated with the Corps of Engineers to ensure no loss of project integrity and satisfy minimum access requirements, and coordinated with the Non-Federal Sponsor, the New Jersey Department of Environmental Protection, for adherence to State coastal zone regulations.

Parking

North Wildwood	
Parking Locations Parallel to beach (NWW)	
Streets (within 1/4 mile of access)	
Beach Drive from 2nd -26th; 20 spaces per block maximum	480
Ocean Drive from 2nd -26th; 20 spaces per block maximum	480
Surf Ave from 2nd -26th; 24 spaces per block maximum	576
Parking Locations Perpendicular to beach (1/4 mile landward)	
2-26 Ave (both sides)	?
Subtotal	1,536
Wildwood	
Parking Locations Parallel to beach (WW)	
Streets (within 1/4 mile of access)	
Atlantic Avenue 16 spaces per block maximum	400
Pacific Avenue 16 spaces per block maximum	400
Parking Locations Perpendicular to beach (1/4 mile landward)	
Parking Lots WW	
Juniper - Poplar	175
Poplar - Magnolia	100
Magnolia-Glennwood	100
Glennwood-Maple	100
Convention Center-Ocean Montgomery	75
Convention Center-Middle Lot	500
Convention Center- Bennet Lot	100
Subtotal	1950
Wildwood Crest	
Parking Locations Parallel to beach (WWC)	
Streets (within 1/4 mile of access)	
Ocean, 20 spaces per block maximum	820
Atlantic, 20 spaces per block maximum	820
Seaview, 20 spaces per block maximum	820
Pacific, 20 spaces per block maximum	820
Parking Locations Perpendicular to beach (1/4 mile landward)	
40 blocks from Cresse to Jefferson	?
Parking Lots WWC	
Subtotal WWC	3280
Lower Township	
Parking Locations Parallel to beach (LT)	
Streets (within 1/4 mile of access)	
Atlantic Ave, 20 spaces per block maximum	60
Seaview Ave, 20 spaces per block maximum	60
Parking Locations Perpendicular to beach (1/4 mile landward)	
3 blocks from Jefferson to Raleigh	?
Subtotal	120
Total	**6,886**

Access Points	North Wildwood 2nd - 26th	Wildwood Juniper-Cresse	Wildwood Crest Cresse-Jefferson	I.T- Jefferson - Raleigh
Distance (feet)	6,600	7,705	9,768	1,689
Number of Access Points	25	24	41	4
Average Distance Between Access Points (miles)	0.05	0.06	0.05	0.08

HOUSE DOCUMENT NUMBER 114-107

DEPARTMENT OF THE ARMY
OFFICE OF THE ASSISTANT SECRETARY
CIVIL WORKS
108 ARMY PENTAGON
WASHINGTON DC 20310-0108

DEC - 1 2016

Honorable Paul Ryan
Speaker of the House of Representatives
U.S. Capitol Building, Room H-232
Washington, DC 20515-0001

Dear Mr. Speaker:

In response to a resolution by the Committee on Transportation and Infrastructure of the United States House of Representatives, adopted December 1987 and by the Committee on Environment and Public Works of the United States Senate dated December 1987, and in response to the Disaster Relief Appropriations Act of 2013 Public Law (P.L.) 113-2, the Secretary of the Army recommends a coastal storm damage reduction project for Hereford Inlet to Cape May Inlet, New Jersey. Initial construction will be undertaken under the authority of, and using funds provided in, PL 113-2. The proposal described in the Report of the Chief of Engineers, dated January 23, 2015, recommends authorization of periodic nourishment and any initial construction that will not be completed using PL 113-2 funding. The Secretary of the Army plans to implement periodic nourishment at the appropriate time, considering National priorities and the availability of funds.

The project study was conducted to analyze and formulate plans for reducing coastal storm damages in the coastal communities located between Hereford Inlet and Cape May Inlet, Cape May County, New Jersey, resulting from Super Storm Sandy. The recommended plan is the National Economic Development plan.

The plan consists of dune and berm construction using sand obtained from an on-shore beach borrow source located at the southern end of Five Mile Island (the Wildwoods). It extends approximately 4.5 miles from Hereford Inlet to Cape May Inlet and will encompass the towns of North Wildwood, Wildwood, Wildwood Crest and Lower Township. The plan includes the planting of approximately 64 acres of dune grass, 28,000 linear feet of sand fence, 44 extended crossovers, seven new pedestrian crossovers, seven extended handicap crossovers, six new handicap crossovers, eight existing vehicle crossover extensions and five new vehicular crossovers. The sand will be pumped from the southern borrow area using mobile back-passing technology to hydraulically pump sand from the Wildwood and Wildwood Crest borrow source to the placement area. Initial construction for the project will remove approximately 1,527,000 cubic yards (cy) of sand from the approved borrow zone, which includes a design quantity of 1,136,000 cy and advanced nourishment of 391,000 cy. Periodic nourishment is included in project design to maintain the integrity of the design beach template over the project period of analysis. Nourishment requirements were determined by considering losses resulting from diffusion of the design beach fill

planform and natural background erosion. Following the initial construction, approximately 391,000 cy of material will be back-passed every four years throughout the 50-year period of analysis for the periodic nourishment of the selected plan. The material will be placed in the same borrow area as used in the initial construction. Since the project would not have any significant adverse effects, no mitigation measures (beyond management practices and avoidance) or compensation measures would be required.

Based on October 2015, (FY 2016) price levels, the total nourishment cost is estimated at $107,505,000 composed of the first cost of initial construction estimated $22,321,000 and a total of 12 periodic nourishments estimated at $85,184,000. The cost of lands, easements, rights-of-way, relocations, and dredged or excavated material disposal (LERRD) is estimated at $1,350,000. The total estimated project cost includes monitoring costs estimated to average about $143,000 over the 50-year period for a total of $7,150,000. The operation, maintenance, repair, rehabilitation, and replacement (OMRR&R) costs of the project after construction are estimated at about $155,000 per year.

The New Jersey Department of Environmental Protection (NJDEP) is the non-Federal cost sharing sponsor for all features. Cost sharing is applied in accordance with the provisions of section 103 of the Water Resources Development Act (WRDA) of 1986, as amended by section 215 of WRDA 1999, and is apportioned as follows: 1) Initial construction of the shore protection features are cost-shared at a rate of 65 percent Federal (or $14,509,000) and 35 percent non-Federal (or $7,812,000), which includes LERRD costs; 2). Periodic nourishment is cost shared 50 percent Federal and 50 percent non-Federal. Periodic nourishment costs are expected to be $6,204,000 for year 4 and 8, and $6,454,000 every four years thereafter, except in year 24, which assumes major nourishment is required at a cost of $8,257,000. In addition, nourishment activities include monitoring costs estimated to average about $143,000 over the 50-year period for a total of $7,150,000; 3) The NJDEP would be responsible for all OMRR&R of the project after construction, with an average annual cost currently estimated at $155,000 over the 50-year period of analysis. The non-Federal sponsor will receive credit for the costs of LERRD toward the non-Federal share.

Based on FY 2016 price levels, a 3.125 percent discount rate, and a 50-year period of analysis, the total equivalent average annual costs of the project are estimated to be $2,758,000, including monitoring and OMRR&R. The equivalent average annual benefits are estimated to be $6,461,000 with net average annual benefits of $3,703,000. The benefit-to-cost ratio is approximately 2.3 to 1. The project would reduce overall average annual coastal storm damages by about 41% and average annual damages attributed to wave attack and rapid erosion, by about 69%.

An Environmental Assessment (EA) was prepared in accordance with the National Environmental Policy Act. The recommended plan has been identified as the environmentally preferred plan. Adverse environmental impacts have been avoided and minimized where practicable. The EA resulted in a Finding of No Significant Impact to

the environment, therefore, preparation of an Environmental Impact Statement is not required. No compensatory mitigation is required.

The Independent External Peer Review was completed by Battelle Memorial Institute. The review comments resulted in expanded narratives throughout the report to support the decision-making process and justify the recommended plan. All comments from the above referenced reviews have been addressed and incorporated into the final documents.

The Office of Management and Budget (OMB) advises that there is no objection to the submission of the report to Congress, but that the project would need to compete with other proposed investments for funding in future budgets. A copy of OMB's letter dated January 21, 2016, is enclosed. I am providing a copy of this transmittal and the OMB letter to the Subcommittee on Water Resources and Environment of the House Committee on Transportation and Infrastructure, and the Subcommittee on Energy and Water Development of the House Committee on Appropriations. I am also providing an identical letter to the President of the Senate.

Very truly yours,

Jo-Ellen Darcy
Assistant Secretary of the Army
(Civil Works)

Enclosures

8 Enclosures

1. OMB Clearance letter, dated January 21, 2016
2. Finding of No Significant Impact, signed January 25, 2016
3. Chief's Report, January 23, 2015
4. Letter from Department of the Interior, Nov 17, 2014
5. Letter from the Environmental Protection Agency, Nov 13, 2014
6. Sponsor Letter of Intent, April 9, 2014
7. Project Slides
8. Hereford Inlet to Cape May Inlet Final Feasibility Report and Integrated Environmental Assessment, April 2014 (CD)

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D.C. 20503

January 21, 2016

The Honorable Jo-Ellen Darcy
Assistant Secretary of the Army (Civil Works)
108 Army Pentagon
Washington, DC 20310-0108

Dear Ms. Darcy:

As required by Executive Order 12322, the Office of Management and Budget has reviewed an April 2014 Army Corps of Engineers (Corps) feasibility study of the Hereford Inlet to Cape May Inlet, New Jersey, with a first cost of $21,794,000 (October 2014 price level) and a total cost of $104,966,000 (October 2014 price level). According to the Corps' report, the recommended project addresses wave and inundation damage, as well as erosion and municipal drainage issues, which are not part of the Corps' primary mission areas.

Based on an analysis of costs and benefits, the Corps estimated that the benefit-cost ratio for the project is 2.30 to 1 at a discount rate of 3.375 percent, which is the discount rate that the Corps is required to use for FY 2014 under section 80 of the Water Resources Development Act of 1974 to evaluate and formulate its proposed water resources projects. According to the Corps, the equivalent benefit-cost ratio is 1.90 to 1 at a seven percent discount rate. The coastal storm damage reduction portion of the project has a BCR of 1.58 to 1 at the seven percent discount rate. This is the discount rate that the Administration uses in the Budget to measure the performance of Corps construction projects whose primary purpose is to provide an economic return to the Nation.

The Office of Management and Budget does not object to you sending this report to the Congress. When you do so, please advise the Congress that this project, like all civil works projects, will need to compete with other proposed investments for funding in future budgets.

Sincerely,

John Pasquantino
Deputy Associate Director
Energy, Science, and Water

FINDING OF NO SIGNIFICANT IMPACT (FONSI) FOR HEREFORD INLET TO CAPE MAY INLET STORM DAMAGE REDUCTION PROJECT, CAPE MAY COUNTY, NEW JERSEY

The United States Army Corps of Engineers, Philadelphia District, (Corps) has conducted an environmental analysis of the construction of the Hereford Inlet to Cape May Inlet Storm Damage Reduction Project in accordance with the National Environmental Policy Act of 1969, as amended. The Corps assessed the effects of the recommended plan in the Final Feasibility Report and Integrated Environmental Assessment, dated 28 April 2014, which is incorporated herein by reference:

- Construct a dune and berm extending approximately 4.5 miles from Hereford Inlet to Cape May Inlet using sand obtained from an onshore beach borrow source located at the southern end of Five Mile Island (the Wildwoods). The dune and berm will encompass the towns of North Wildwood, Wildwood, Wildwood Crest and Lower Township;
- Plant approximately 64 acres of dune grass;
- Construct 28,000 linear feet of sand fence, 44 extended crossovers, seven new pedestrian crossovers, seven extended handicap crossovers, six new handicap crossovers, eight existing vehicle crossover extensions and five new vehicular crossovers;
- Pump sand from the southern borrow area using mobile back-passing technology to hydraulically pump sand from the Wildwood and Wildwood Crest borrow source to the placement area;
- Remove approximately 1,527,250 cubic yards (cy) of sand from the approved borrow zone as part of initial construction, which includes a design quantity of 1,136,000 cy and advanced nourishment of 391,000 cy;
- Periodically nourish the beach to maintain the integrity of the design beach template over the project period of analysis. Nourishment requirements were determined by considering losses resulting from diffusion of the design beach fill planform and natural background erosion;
- Back-pass approximately 391,000 cy of material every four years after initial construction throughout the 50-year period of analysis for the periodic nourishment of the selected plan. The material will be taken from the same borrow area and placed in the same location as the initial construction;

The recommended plan was identified as the National Economic Development (NED) plan and is the environmentally-preferred alternative. All practicable means to avoid and minimize adverse environmental effects have been incorporated into the recommended plan. No compensatory mitigation is required.

Consistent with the programmatic Biological Opinion issued by the U.S. Fish and Wildlife Service (USFWS) in December 2005, the hydraulic back-passing of sand from Wildwood and Wildwood Crest for beach nourishment and restoration activities in North Wildwood, Wildwood, Wildwood Crest and Lower Township would not likely jeopardize the continued existence of any species or the critical habitat of any fish, wildlife, or plant, which is designated as endangered or threatened pursuant to the Endangered Species Act of 1973, as amended by P.L. 96-159. As required by the Biological Opinion, the Corps will undergo individual (Tier 2) consultation with USFWS prior to initial construction and each periodic nourishment cycle.

Pursuant to Section 401 of the Clean Water Act, a 401 Water Quality Certificate was obtained from the New Jersey Department of Environmental Protection (NJDEP). Based on the information developed during preparation of the EA, it was determined in accordance with Section 307 (C) of the Coastal Zone Management Act of 1972 that the plan complies with and can be conducted in a manner that is consistent with the approved Coastal Zone Management Program of New Jersey. A Federal Consistency Determination and Water Quality Certificate were received from NJDEP on 7 March 2014.

There are no known properties listed on, or eligible for listing on, the National Register of Historic Places that would be affected by the proposed activity. The plan has been designed to avoid archaeologically sensitive areas, and is therefore not expected to impact any cultural resources. The New Jersey State Historic Preservation Office concurred with this determination in a letter dated 26 December 2013.

General Conformity under the Clean Air Act, Section 176 has been evaluated for the project according to the requirements of 40 CFR 93, Subpart B. The requirements of this rule are not applicable to this project because the total emissions from the project are below the conformity threshold values established at 40 CFR 93.153(b) for ozone (NOx and VOCs) in a marginal nonattainment area (100 tons of NOx and 50 tons of VOCs per year).

Technical and economic criteria used in the formulation of alternative plans were those specified in the Water Resource Council's 1983 Economic and Environmental Principles for Water and Related Land Resources Implementation Studies. All applicable laws, executive orders, regulations, and local government plans were considered in the evaluation of the alternatives. It is my determination that the recommended plan does not constitute a major federal action that would significantly affect the human environment; therefore, preparation of an Environmental Impact Statement is not required.

1/25/16
Date

Michael A. Bliss, PE
Lieutenant Colonel, Corps of
Engineers District Commander

DEPARTMENT OF THE ARMY
CHIEF OF ENGINEERS
2600 ARMY PENTAGON
WASHINGTON, DC 20310-2600

DAEN (1105-2-10a) JAN 2 3 2015

SUBJECT: New Jersey Shore Protection, Hereford Inlet to Cape May Inlet, New Jersey

THE SECRETARY OF THE ARMY

1. I submit for transmission to Congress my report on the study of hurricane and storm damage reduction for coastal communities located between Hereford Inlet and Cape May Inlet, Cape May County, New Jersey. It is accompanied by the report of the district and division engineers. This report is an interim response to a resolution by the Committee on Transportation and Infrastructure of the United States House of Representatives, adopted December 1987 and by the Committee on Environment and Public Works of the United States Senate dated December 1987 and an interim response to PL 113-2, the Disaster Relief Appropriations Act. The resolutions requested the Secretary of the Army 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. Preconstruction engineering and design activities for the Hereford Inlet to Cape May Inlet, New Jersey, project will continue under the study authority cited above. The Corps of Engineers intends to undertake initial construction of the project under the authority of, and using funds provided in, PL 113-2. I am recommending that the Congress authorize periodic nourishment and any initial construction of the project that will not be completed using PL 113-2 funds.

2. The reporting officers recommend authorization of the National Economic Development Plan that consists of a dune and berm construction using sand obtained from an onshore beach borrow source located at the southern end of Five Mile Island (the Wildwoods). The recommended plan extends approximately 4.5 miles from Hereford Inlet to Cape May Inlet and will encompass the towns of North Wildwood, Wildwood, Wildwood Crest and Lower Township. Dimensions of the project are a +16-foot North American Vertical Datum 1988 (NAVD88) dune, with a 25-foot wide dune crest on a 75- foot wide berm that is +6.5-foot NAVD88 in elevation within North Wildwood, Wildwood, Wildwood Crest and Lower Township. Side slopes for the dune will be 1V:5H and slopes for the berm will be 1V:30H. The plan includes approximately 64 acres of dune grass, 28,000 linear feet of sand fence, 44 extended crossovers, seven new pedestrian crossovers, seven extended handicap crossovers, six new handicap crossovers, eight existing vehicle crossover extensions and five new vehicular crossovers. The sand will be pumped from the southern borrow area using mobile back-passing technology to hydraulically pump sand from the Wildwood and Wildwood Crest borrow source to the placement area. Initial construction for the project will remove approximately 1,527,250 cubic yards (cy) of sand from the approved borrow zone, which includes a design quantity of 1,136,000 cy and advanced nourishment of 391,000 cy. Periodic nourishment is included in project design to maintain the integrity of the design beach template over the project period of analysis. Nourishment requirements were

determined by considering losses resulting from diffusion of the design beach fill planform and natural background erosion. Following the initial construction, approximately 391,000 cy of material will be back-passed every four years throughout the 50-year period of analysis for the periodic nourishment of the selected plan. Since the recommended plan would not have any significant adverse effects, no mitigation measures (beyond management practices and avoidance) or compensation measures would be required.

3. The New Jersey Department of Environmental Protection (NJDEP) is the non-federal cost sharing sponsor for all features. Based on a March 2014 price level, the estimated total nourishment cost is $104,030,000, which includes the project first cost of initial construction of $21,600,000 and a total of 12 periodic nourishments at a total cost of $82,430,000. Cost sharing is applied in accordance with the provisions of Section 103 of the Water Resources Development Act (WRDA) of 1986, as amended by Section 215 of WRDA 1999, as follows:

a. Shore protection features are cost-shared at a rate of 65 percent federal and 35 percent non-federal for the initial construction. Thus the federal share of the project first cost is $14,040,000 and the non-federal share is estimated at $7,560,000 which includes the costs of land, easements, rights-of-way, relocations, and dredged or excavated material disposal areas (LERRD). LERRD costs are estimated at about $1,270,000. The non-federal sponsor will receive credit for the costs of LERRD toward the non-federal share.

b. Periodic nourishment will be cost shared 50 percent federal and 50 percent non-federal. It is expected to have costs of $5,950,000 for year 4 and 8, and $6,190,000 every four years thereafter, except in year 24, which assumes major nourishment is required at a cost of $7,920,000. In addition, nourishment activities include monitoring costs estimated to average about $138,000 over the 50-year period for a total of $6,900,000.

c. The NJDEP would be responsible for the operation, maintenance, repair, replacement, and rehabilitation (OMRR&R) of the project after construction, an average annual cost currently estimated at $150,000 over the 50-year period of analysis.

4. Based on a 3.375-percent discount rate and a 50-year period of analysis, the total equivalent average annual costs of the project are estimated to be $2,669,000, including monitoring and OMRR&R. All project costs are allocated to the authorized purpose of shoreline protection. The recommended plan has average annual benefits of $6,252,000. The net national economic development (NED) benefits of the project are $3,583,000 and the benefit to cost ratio (BCR) is 2.3. In addition to providing protection from coastal storms, the dunes and berm create habitat for bird nesting and coastal plant species. The 64 acres of Cape American Beach Grass has the potential to develop into a more diverse plant community in a stable dune system. This project should benefit the piping plover habitat in the North Wildwood by stabilizing the beaches through regular periodic nourishment and improve the overall quality of the beach habitat.

DAEN
SUBJECT: New Jersey Shore Protection, Hereford Inlet to Cape May Inlet, New Jersey

5. Risk and uncertainty has been explicitly factored into the economic analysis of this project. Chapter 6 of ER 1105-2-100, entitled "Risk Based Analysis for Evaluation of Hydrology/Hydraulics and Economics in Shore Protection Studies" specifies the analysis requirements for shore protection projects, the fundamental requirement being that all shore protection analyses adopt a life cycle approach. A risk and uncertainty analysis that incorporated key economic, hydraulic and sea level change parameters was preformed for the feasibility study. This risk and uncertainty plan was peer reviewed by the Jacksonville District of the Army Corps of Engineers and approved by North Atlantic Division. The project is not intended to, nor will it, reduce risk to loss of life during major storm events. Loss of life can only be prevented by residents and visitors following the local evacuation plans that are already in place. These residual risks have been communicated to the NJDEP.

6. In accordance with the Corps of Engineering Circular (EC 1165-2-212) on sea level change, the study performed a sensitivity analysis to look at the effects that different rates of accelerated sea level rise could have on the recommended plan. The plan was formulated using a historical or low rate of sea level rise of 0.013 feet/year. The sensitivity analysis used additional accelerated rates, which includes what the EC defines as intermediate and high rates of 0.023 feet/year and 0.056 feet/year, respectively. The analysis found that the influence of current sea level rise on the project is relatively low as compared to other factors causing erosion (waves, currents, winds and storms). The magnitude of the short-term storm induced erosion during hurricane events have a much greater effect along the New Jersey coastline than those indicated by the natural long term shoreline trends. Adaptive management will be used including monitoring and adding additional volume of sand during periodic nourishments to compensate for significant accelerated sea level rise beyond the current observed rate should it become necessary.

7. In accordance with the Corps of Engineers Circular (EC 1165-2-214) on the review of decision documents, all technical, engineering and scientific work underwent an open, dynamic and rigorous review process to ensure technical quality. This includes a District Quality Control review, an Agency Technical Review (ATR), an Independent External Peer Review (IEPR) (Type 1), and a Corps Headquarters policy and legal review. The IEPR was completed by Battelle Memorial Institute. All comments from the above referenced reviews have been addressed and incorporated into the final documents. Overall, the reviews resulted in improvements to the technical quality of the report.

8. Washington level review indicates that the project recommended by the reporting officers is technically sound, environmentally and socially acceptable, and economically justified. The plan complies with all essential elements of the U.S. Water Resources Council's Economic and Environmental Principles and Guidelines for Water and Land related resources implementation studies and complies with other administrative and legislative policies and guidelines. Also, the views of interested parties, including federal, state and local agencies have been considered. During the State and Agency (S&A) review, comments were received from the U.S. Environmental Protection Agency (EPA) and the Department of the Interior (DOI). Other

agencies indicated they either had no comments or provided none. The EPA reiterated a comment on the draft report concerning the potential for erosion at dune cross over locations due to their alignment. The Corps responded that the final report had addressed the concern, and the seaward side of all of the vehicular and pedestrian crossovers would be constructed at an angle to the dune, not perpendicular, in order to enhance dune resiliency. The DOI commented on the consideration given to borrow from the inlet area and the potential listing of the Red Knot as a threatened species under the Endangered Species Act. The Corps responded that the recommended plan has no borrow from the Hereford Inlet. The Corps has been engaged in Endangered Species Act consultation with the U.S. Fish and Wildlife Service (FWS) regarding the red knot, which was listed as a threatened species following receipt of the DOI S&A comments. The district will coordinate any potential impacts related to this coastal project with the FWS and incorporate protection measures into the project plan as the design phase continues.

9. I generally concur in the findings, conclusions, and recommendations of the reporting officers. Accordingly, I recommend that the periodic nourishment associated with the project to reduce hurricane and storm damages for Hereford Inlet to Cape May Inlet, New Jersey and any initial construction of the project that will not be completed with PL 113-2 funds be authorized in accordance with the reporting officers' recommended plan, with such modifications as in the discretion of the Chief of Engineers may be advisable. The estimated cost of the project is $104,030,000, which includes an estimated total cost for periodic nourishment of $82,430,000 for 12 cycles of periodic nourishment and an estimated total cost of $21,600,000 for initial construction that would be reduced by any initial construction undertaken using PL 113-2 funds. My recommendation is subject to cost sharing, financing, and other applicable requirements of federal laws and policies, including Section 103 of the Water Resources Development Act (WRDA) of 1986, as amended by Section 215 of WRDA 1999. This recommendation is subject to the non-federal sponsor agreeing to comply with all applicable federal laws and policies, including that it will:

a. Provide a minimum of 35 percent of initial project costs assigned to coastal 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 coastal storm damage reduction, plus 100 percent of periodic nourishment costs assigned to protecting undeveloped private lands and other private shores which do provide public benefits, and as further defined below:

1) Provide all lands, easements, and rights-of-way, including suitable borrow areas, and perform or ensure performance of all relocations determined by the federal government to be necessary for the initial construction, periodic nourishment, operation, and maintenance of the project;

2) Provide during construction any additional amounts 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;

b. Operate, maintain, repair, replace, and rehabilitate 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 inspection, and, if necessary, after failure, to perform by the non-federal sponsor, for the purpose of completing, operating, maintaining, repairing, replacing, or rehabilitating 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, except for damages due to the fault or negligence of the United States or its contractors;

e. 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;

f. Assume complete financial responsibility, as between the federal government and the non-federal sponsor 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;

g. 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, repair, replace, and rehabilitate the project in a manner that will not cause liability to arise under CERCLA

h. Participate in and comply with applicable federal floodplain management and flood insurance programs.

i. 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 use of such funds for the project is authorized;

j. Prevent obstructions of or encroachment on the project (including prescribing and enforcing regulations to prevent such obstructions or encroachments) which might reduce the level of protection it affords, hinder operation and maintenance or future periodic nourishment, or interfere with its proper function, such as any new developments on project lands or the addition of facilities which would degrade the benefits of the project;

k. Not less than once each year, inform affected interests of the extent of protection afforded by the project;

l. 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;

m. For so long as the project remains authorized, ensure continued conditions of public ownership and use of the shore upon which the amount of federal participation is based;

n. Provide and maintain necessary access roads, parking areas, and other public use facilities, open and available to all on equal terms; and

o. 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.

10. The recommendation contained herein reflects the information available at this time and current departmental policies governing the formulation of individual projects. It does not reflect program and budgeting priorities inherent in the formulation of a national civil works construction program or the perspective of higher review levels within the executive branch. Consequently, the recommendation may be modified before it is transmitted to Congress as a

DAEN
SUBJECT: New Jersey Shore Protection, Hereford Inlet to Cape May Inlet, New Jersey

proposal for authorization and implementation funding. However, prior to transmittal to Congress, the sponsor, the state, interested federal agencies, and other parties will be advised of any significant modifications and will be afforded an opportunity to comment further.

THOMAS P. BOSTICK
Lieutenant General, USA
Chief of Engineers

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, DC 20240

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Mr. Theodore A. Brown, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works
U.S. Army Corps of Engineers
CECW-P (SA)
7701 Telegraph Road
Alexandria, VA 22315-3860

RE: Proposed Chief of Engineers and the Report of the District Engineer on the New Jersey Shore Protection Project

Dear Mr. Brown:

The U.S. Department of the Interior (Department) has reviewed the U.S. Army Corps of Engineers (Corps), Chief of Engineers Report and District Engineers Report to include the Final Feasibility Report and Environmental Assessment for the New Jersey Shore Protection Project, Hereford Inlet to Cape May Inlet.

General Comments

The Corps is authorized under the Water Resources Development Act 1986 (PL 99-662) and other Federal authorities to provide storm damage reduction, beach restoration, and water quality improvements from Hereford Inlet to Cape May Inlet, Cape May County, New Jersey (study area). Although the study area extends from Hereford Inlet to Cape May Inlet, no activities will be conducted on Hereford Inlet beaches north of the terminal jetty, at the Cape May Inlet, on the Cape May National Wildlife Refuge Two-Mile Beach, or at the U.S. Coast Guard's LORAN facility.

The project area exhibits several different coastal issues. The North Wildwood portion of the project area is prone to moderate to severe erosion, leaving the surrounding community vulnerable to storm damages. The beaches of Wildwood and Wildwood Crest have been accreting large quantities of sand, resulting in human health and water quality concerns due to clogged outfall pipes on the beach. The selected plan being proposed for the project includes "back-passing" sand, using mobile hydraulic dredges located in the surf zones from Wildwood to

"back-passing" sand, using mobile hydraulic dredges located in the surf zones from Wildwood to North Wildwood and changing the beach configuration in Wildwood by increasing berm height and adding a dune.

Specific Comments

The Hereford Inlet is listed as a potential borrow area (sub-areas H-1, H-2, H-3, and H-4) for the initial cycle of beach re-nourishment within the study area. Using Federal funds, the inlet sand was also used by the Corps to re-nourish nearby beaches in Stone Harbor as recently as 2013 and was extensively studied by the Corps with vibracore technology from 1994 to 2007. The Coastal Barrier Resource Act (CBRA) (16 U.S.C. § 3594(a)) specifically prohibits federal expenditures and financial assistance for the following activities within units of the Coastal Barrier Resource System (CBRS): "the construction or purchase of any structure, appurtenance, facility, or related infrastructure", "the construction or purchase of any road, airport, boat-landing facility, or other facility on, or bridge or causeway to, any System unit", and "the carrying out of any project to prevent the erosion of, or to otherwise stabilize, any inlet, shoreline, or inshore area with limited exceptions."

According to the official CBRS map for the area (Stone Harbor Unit NJ-09/NJ-09P dated July 12, 1996), the proposed sand borrow sub-areas of Hereford Inlet are located within System Unit NJ-09 of the CBRS. Therefore, it is necessary to clarify the issue of federally funded vibracore studies and beach nourishment activities and in relation to CBRA, specifically the assessment and removal of sand resources from within a unit of the CBRS for placement outside of the CBRS for beach re-nourishment. According to a previous clarification (enclosed) from the Department's Office of the Solicitor and by then U.S. Fish and Wildlife Service (FWS) Deputy Director Richard N. Smith, federal expenditures are prohibited in such cases (*i.e.*, when the shoreline stabilization project falls outside the CBRS unit).

Additional information is provided in the enclosed memorandum signed by the Federal Emergency Management Agency and the Corps in January 2013 outlining the Federal Interagency Floodplain Management Task Force's (FIFM Task Force) Consensus Recommendations and Actions from a Federal Floodplain Management Policy Analysis. Please note that the FIFM Task Force identified enhancing CBRA compliance across all Federal agencies as a recommended action on page 2 of the memorandum. We recommend that the Corps request a determination pursuant to the CBRA for any proposed activity involving the use of federal funds within Unit NJ-09 of the CBRS (Hereford Inlet).

The FWS developed an online mapper that depicts the approximate boundaries of the CBRS to assist Federal agencies in complying with the provisions of CBRA. The CBRS mapper and additional information on the CBRA consistency consultations process for proposed projects can be found on the FWS's CBRA website at: http://www.fws.gov/cbra.

In the subject report (page 308, Volume 1), the Corps refers to the red knot (*Calidris canutus rufa*) as a "Federally listed Candidate" that "will be present during construction activities . . . and will easily be able to move away from the construction activities to another portion of the beach where they will not be disturbed." We note that a proposed rule to list the *rufa* subspecies as threatened under the Endangered Species Act of 1973 (ESA) (87 Stat. 884, as amended; 16 U.S.C. 1531 *et seq.*) was published on September 30, 2013. The FWS will make a final decision on the 2013 proposal to list the *rufa* subspecies as threatened under the ESA by November 28, 2014. Therefore, the proposed activities by the Corps will occur within documented foraging and roosting habitat of the red knot and may result in harassment of a federally listed species.

Federal regulation pursuant to Section 4(d) of the ESA, prohibit the take of endangered and threatened species, respectively, without special exemption. Take is defined as to harass, harm, pursue, hunt, shoot, wound, kill, trap, capture, or collect, or attempt to engage in any such conduct. Harm is further defined by the FWS to include significant habitat modification or degradation that results in the death or injury to listed species by significantly impairing essential behavioral patterns such as breeding, feeding, or sheltering. Harass is defined by the FWS as intentional or negligent actions that create the likelihood of injury to listed species to such an extent as to significantly disrupt normal behavior patterns, which include, but are not limited to, breeding, feeding, or sheltering.

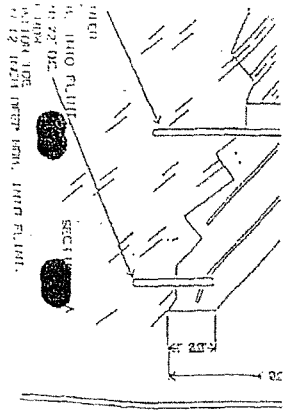
Pursuant to Section 7(a)(1) of the ESA, all Federal agencies shall, in consultation with and with the assistance of the Secretary of the Interior, utilize their authorities in furtherance of the purposes of this Act by carrying out programs for the conservation of endangered species and threatened species.

For any questions regarding these comments, and for further coordination related to the CBRA, fish and wildlife resources, or federally-listed threatened or endangered species, please contact Mr. Carlo Popolizio, FWS, New Jersey Field Office, (609) 383-3938, ext. 32; or email carlo_popolizio@fws.gov.

Sincerely,

Willie R. Taylor
Director, Office of Environmental Policy
and Compliance

Enclosures



In Reply Refer To:
FWS/DHC/BCWR

Memorandum

To: Regional Director, Regions 2, 3, 4, and 5

From: Director

Subject: Interpretation of Section 6 of the Coastal Barrier Improvement Act of 1990

A recent consultation submitted to the Service from the U.S. Army Corps of Engineers pursuant to Section 6 of the Coastal Barrier Resources Act (Act) has required clarification from the Department of the Interior's Office of the Solicitor regarding Federally funded beach nourishment activities (Attachment). More specifically, the issue involves removing sand materials from within a unit of the Coastal Barrier Resources System (System) for placement outside of the unit for erosion control measures.

Section 6 of the Act sets forth several exceptions to the general prohibition in section 5 against Federal expenditures affecting the System. The exception in section 6(a)(6)(G) is for "Nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore, natural stabilization systems" and that are also consistent with the purposes of the Act. The Department's Office of the Solicitor has carefully reviewed this issue and has advised us that section 6(a)(6)(G) applies only to projects for stabilizing the shoreline of a unit of the System; it does not apply to projects to stabilize shoreline outside the System regardless of whether the project might be consistent with the purposes of the Act. Therefore, any proposed Federal action designed to nourish beaches located outside the System using beach material taken from within the System does not meet the criteria for a section 6(a)(6)(G) exception.

If you have any questions regarding this matter please contact Linda Kelsey of my staff at (703) 358-2201.

RICHARD N. SMITH

Attachment
cc: 3012-MIB-FWS/Directorate Reading File
3012-MIB-FWS/CCU
3012-MIB-FWS/AEA Files
3024-MIB-FWS/AES Files
400-ARLSQ-FWS/DHC Files
412-ARLSQ-FWS/DHC/BCWR Files
FWS/DHC/BCWR/LKelsey:bg:06/20/94:(703)358-2201
Q:\DHC\KELSEY\SECT6.MEM

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Washington, D.C. 20240

ADDRESS ONLY THE DIRECTOR,
FISH AND WILDLIFE SERVICE

In Reply Refer To:
FWS/DHC/BCWR

JUN 0 2 1994

Major General Stanley G. Genega
Directorate of Civil Works
U.S. Army Corps of Engineers
20 Massachusetts Avenue, N.W.
Washington, D.C. 20314-1000

Dear General Genega:

It has come to my attention that some clarification is necessary on the issue of Federally funded beach nourishment activities in relation to the requirements of the Coastal Barrier Resources Act (Act). More specifically, the issue involves removing sand materials from within a unit of the Coastal Barrier Resources System (System) for placement outside of the unit for erosion control measures.

Section 6 of the Act sets forth several exceptions to the general prohibition in section 5 against Federal expenditures affecting the System. The exception in section 6(a)(6)(G) is for "Nonstructural projects for shoreline stabilization that are designed to mimic, enhance, or restore, natural stabilization systems" and that are also consistent with the purposes of the Act. The Department of the Interior's Office of the Solicitor has carefully reviewed this issue and has advised us that section 6(a)(6)(G) applies only to projects for stabilizing the shoreline of a unit of the System; it does not apply to projects to stabilize shoreline outside the System regardless of whether the project might be consistent with the purposes of the Act. Therefore, any Corps' proposed action designed to nourish beaches located outside the System using beach material taken from within the System does not meet the criteria for a section 6(a)(6)(G) exception. The Department's Office of the Solicitor has reviewed this issue and this specific correspondence and fully concurs with our position on this matter.

A specific example of where this issue has arisen is relative to the Corps of Engineers proposed action for the use of a sand borrow area (Borrow Area #3) within Unit N01, Little Tybee Island, of the Coastal Barrier Resources System for a beach nourishment project outside of Unit N01. The U.S. Fish and Wildlife Service's Atlanta Regional Director wrote to your agency on April 5, 1994, expressing support for the formal opinion provided to the Corps of Engineers on August 2, 1993, by our Brunswick Field Office regarding your consultation request under the Act. The Atlanta Regional Director also supports the comments provided to your agency on the Joint Public Notice, dated February 14, 1994, and the Draft Environmental Assessment for the Tybee Island, Georgia Beach Erosion Control Project

Section 934 Revaluation Report. This proposed action does not meet the criteria for a section 6(a)(6)(G) exception.

Moreover, the Service believes the proposed project would not be consistent with the purposes of the Act. These purposes are to minimize the loss of human life, wasteful expenditure of Federal revenues, and damage to fish, wildlife, and other natural resources associated with units of the Coastal Barrier Resources System. Use of this site would cause damage to the fish, wildlife, and other natural resources associated with Unit N01, Little Tybee Island.

Taking sand from Borrow Area #3 is likely to cause erosion to the beaches of Little Tybee Island. This area has been identified as important habitat for migratory birds and the federally protected loggerhead sea turtle and piping plover. In addition, the nearshore tidal portions of this site are important spawning, nursery and habitat areas for estuarine larvae, shellfish, and juvenile fish, including Georgia's number one sportfish, the spotted seatrout. Negative impacts to these species include increased turbidity, physical changes in tidal currents or channel locations that could affect migration of these organisms. Furthermore, Little Tybee Island has been designated as a Natural Heritage Preserve to protect the natural, historical, and cultural values for the benefit of the public.

Relative to the Little Tybee Island proposed project, I support the position of our Field and Regional Offices. I strongly recommend that the Corps find an alternative borrow site. The Service has previously stated that Borrow Areas #1 and #2, which are located outside the System and which the Corps identified as possible alternative sites, would be acceptable to the Service, provided adequate testing is done to ensure that these areas contain suitable beach material.

With respect to this issue in general, please clarify this issue for your Divisions and Districts. Thank you for your cooperation on this matter.

Sincerely,

Richard N. Smith

Deputy DIRECTOR

IDENTICAL LETTER SENT TO:
Colonel Wayne W. Boy, Savannah District

Federal Emergency Management Agency

Assistant Secretary of the Army (Civil Works)

TO: Federal Interagency Floodplain Management Task Force Member Agencies

SUBJECT: FIFM Task Force Consensus Recommendations and Actions from a Federal Floodplain Management Policy Analysis

The Federal Interagency Floodplain Management (FIFM) Task Force was formed to promote, support, and encourage Federal agencies to formulate and implement programs and policies that: 1) reduce the loss of life and property caused by floods; and 2) protect and restore natural resources and functions of floodplains. It does this primarily through improving coordination, collaboration, and transparency among the federal agencies in floodplain management efforts; conducting studies of floodplain management activities; and improving alignment of federal programs.

The Task Force has already made progress in carrying out this mission. Specifically, it has:

- Convened a listening session with key stakeholders to identify and refine floodplain management issues and priorities.
- Developed guidance for Federal agencies on unwise use of floodplains.
- Conducted research on policies and programs that promote or interfere with good floodplain management practices.
- Made numerous presentations at floodplain and flood risk management events to exchange information relevant to the work of the Task Force.

The Task Force has also provided a forum for enhanced coordination and action on the part of individual member agencies. For example:

- U.S. Army Corps of Engineers (Corps) and Federal Emergency Management Agency (FEMA) have jointly resolved several policy conflicts, including accounting for the National Flood Insurance Program requirements of 44 CFR 65.12 during Corps evaluation of flood risk management projects in the floodplain. Guidance has been distributed to the field offices of both agencies through jointly signed memorandums.
- The Corps has coordinated its Flood Risk Management and Silver Jackets Programs with FEMA's Community Rating System Program to encourage and assist communities in taking responsible steps to better manage their flood risk.
- FEMA and the U.S. Fish and Wildlife Service (FWS) have updated an existing Interagency Agreement to place Coastal Barrier Resources System (CBRS) boundaries on Flood Insurance Rate Maps (FIRMs) and established a new Interagency Agreement to facilitate a digital conversion of the official CBRS maps and make changes that are necessary as a result of erosion and accretion.

At its meeting on July 27, 2012, the FIFM Task Force identified several opportunities and activities to enhance floodplain management efforts at various levels of government and to help agencies become better stewards of public resources. These activities were developed collaboratively by the Working Group of the Task Force, an interagency group with 19 representatives from the following agencies:

- U.S. Army Corps of Engineers
- Federal Emergency Management Agency
- National Oceanic and Atmospheric Administration
- U.S. Environmental Protection Agency
- U.S. Department of Transportation
- Tennessee Valley Authority
- U.S. Department of the Interior
- U.S. Department of Agriculture
- U.S. Department of Defense
- U.S. Department of Housing and Urban Development
- General Services Administration
- White House Council on Environmental Quality (Advisor)

Some of these activities are recommendations to one or more federal agencies. Others describe actions that the Task Force will take and incorporate into its overall work plan to be carried out over the next 3-4 years. Some activities will involve further action by numerous federal agencies, while others are informational in nature. These opportunities and activities are categorized into four areas and are described below.

Compliance

- **Enhance Coastal Barrier Resources Act (CBRA) Compliance.** Federal agencies operating under CBRA (16 U.S.C. 3501 et seq.), are required to comply with its provisions, which are designed to restrict federal expenditures and financial assistance in the development of coastal barriers designated as part of the CBRS. Section 3506(b) of CBRA also requires that each federal agency affected by CBRA report and certify annually to the Department of the Interior (DOI) that the agency is in compliance with the law. Federal agencies have not issued such certifications in recent years. DOI will issue a memorandum to federal agencies to remind them of their obligations under CBRA and request that they provide DOI with an annual letter certifying their compliance with the law, as appropriate. The Task Force recommends that federal agencies respond to DOI's request to help raise awareness about CBRA requirements and ensure that sufficient policies and protocols are in place to prevent the inappropriate provision of federal financial assistance within the CBRS.

- **Assess and Enhance Executive Order (EO) 11988 Compliance.** A recent study conducted by the Task Force indicated that implementation of *Executive Order 11988: Floodplain Management* may not be consistent across the federal government. Effective and consistent implementation of the EO will save lives and property, reduce the economic and environmental impacts of flooding in communities, and reduce costs to taxpayers across the country. Given the impacts of more extreme precipitation events anticipated as a result of climate change, flood losses will likely increase, thus further highlighting the importance of EO 11988. To address this issue, the Task Force will draft a memorandum for CEQ's consideration and issuance, requesting federal agencies that have adopted regulations and implementing guidance to assess their EO compliance and effectiveness of compliance and to take appropriate action where necessary. The Task Force will work with CEQ to assess responses.

Tools/Technology/Data

- **Modernize Coastal Barrier Resource System (CBRS) Maps.** Many of the maps that delineate CBRS boundaries require updates in light of natural changes to the system that occur over time and to be consistent with current technology. Digitizing and modernizing these maps will help all federal agencies responsible for CBRA compliance as well as developers, surveyors, planners, floodplain managers, realtors and other stakeholders who need to know the exact location of the CBRS unit boundaries. Homeowners, in particular, will have a clearer understanding of whether their property is located within the CBRS, so they can more accurately determine whether they are eligible for federal financial assistance, including flood insurance – avoiding the discovery and cancellation of invalid flood insurance policies after claims are made. The Task Force recognizes the value of the modernization efforts already underway and recommends that they be continued and expanded.

- **Enhance Technical Assistance to Communities in Coastal Areas.** Coastal areas are home to over 160 million people, support 66 million jobs and contribute $8.3 trillion to the U.S. economy. These areas are also prone to a number of natural hazards. As a result, it is critical that we provide coastal communities with the resources they need to make better decisions that reduce flood hazards. The Task Force will be exploring broader use of the Community Rating System as an incentive mechanism for coastal communities to make better floodplain management decisions. In addition, the Task Force plans to assess floodplain management-related technical assistance available to coastal communities and identify gaps that may need to be filled.

- **Enhance Collaboration and Research on Mapping to Support Floodplain Management.** Maps are powerful tools in floodplain management. The Task Force will be working to assess and enhance data collection, distribution, collaboration and research related to mapping to support floodplain management. It will place special emphasis on identifying, quantifying or mapping the natural areas of floodplains and their beneficial uses and values.

- **Improve the Link Between Agencies and Available Floodplain-related Research Capabilities.** There are potential disconnects between agencies responsible for establishing and implementing policies that impact flood risk or floodplains and those agencies involved in scientific research and data collection. The Task Force will evaluate disconnects and establish a more formal mechanism for coordination so the available research becomes more broadly available and research needs are aligned with future research plans.

- **Assess Federal Use of Flood Loss Data and Identify Potential Improvements in Collection, Dissemination and Use.** Federal agencies are often asked to report on flood-related losses. This information is important for understanding the impacts of policies and programs in and around floodplains. Federal agencies collect and use flood loss data differently based on their missions and the needs of their stakeholders. The Task Force will convene key federal agencies to discuss what flood loss data they have, how they calculate flood losses, and how they use these data (e.g., policy questions they try to answer). The Task Force will compile this feedback to create a more comprehensive view of how flood loss data is collected, calculated and used within federal agencies and key, high-level similarities and differences. Based on this feedback, the Task Force will identify approaches for improving the collection, dissemination and/or use of flood loss data to enhance future policy decisions.

- **Study the Benefits of Protecting Natural and Beneficial Functions.** Floodplains provide more value, or services, per acre than any other land type. However, floodplains continue to be degraded by development and other activities that often cause hidden losses, both economic and environmental, for communities and the nation. The Task Force will conduct a review of existing information to assess our current state of knowledge about valuing the natural resources and functions of floodplains. Based on this assessment, the Task Force will identify opportunities to quantify and/or qualitatively describe the benefits that floodplains provide.

Partnerships

- **Improve Silver Jackets Awareness and Participation.** Silver Jackets interagency teams promote valuable collaboration among federal and state agencies with respect to flood risk management. They focus on a common set of priorities and are capable of more easily leveraging resources to solve problems. Involvement by federal agencies other than FEMA and the Corps, however, has been inconsistent. Having stronger support for Silver Jackets teams from all agencies involved in flood risk and floodplain management will provide more resources and opportunities for collaboration to the Silver Jackets teams and promote more innovative and effective approaches to flood risk management. The Task Force will prepare a memorandum to its member agencies and other

interested agencies recommending that they designate a point of contact to coordinate their involvement in the Silver Jackets program.

- **Coordinate Under Presidential Policy Directive 8 (PPD#8) Initiatives.** PPD #8 provides an opportunity to improve floodplain management by providing a partnership venue to ensure assistance is available to integrate mitigation and floodplain management into recovery, mitigation and response policies, plans, programs, and decision making. The FIFM Task Force is developing processes to ensure that it is coordinating closely with the leadership structure of the National Disaster Recovery, Mitigation, and Response Frameworks as developed under PPD #8, specifically as it relates to floodplain management.

Communication

- **Promote the Task Force Role in Resolving Interagency Conflicts.** One reason the Task Force was formed was to identify and address policy or programmatic conflicts among federal agencies that may be resulting in poor floodplain management decisions. The Task Force will more actively promote its role in addressing these issues and opportunities so other members of the floodplain management community are aware of the potential resource the Task Force can offer.

As noted previously, many of the above recommendations will be merged into the Task Force's work plan. Participation by all federal agencies in support of Task Force efforts is encouraged. Please contact any member of the Task Force for further information on the work of the Task Force or its current activities.

David L. Miller
Associate Administrator, Federal Insurance and Mitigation Administration
Co-Chair, FIFM-TF

Date: 1/24/13

Jo-Ellen Darcy
Assistant Secretary of the Army (Civil Works)
Co-Chair, FIFM-TF

Date: Jan. 28, 2013

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION 2
290 BROADWAY
NEW YORK, NY 10007-1866

NOV 13 2014

Peter R. Blum, P.E.
Chief, Planning Division
Philadelphia District, Corps of Engineers
Wanamaker Building, 100 Penn Square East
Philadelphia, Pennsylvania 19107-3391

Dear Mr. Blum:

This letter is in response to the New Jersey Shore Protection Study, Hereford Inlet to Cape May Inlet, Final Feasibility Report and Integrated Environmental Assessment (EA). The document addressed hurricane and storm damage reduction alternatives for the coastal communities located between Hereford Inlet and Cape May Inlet, in Cape May County, New Jersey.

The selected storm damage reduction plan will entail backpassing sand obtained from the beaches of Wildwood, Wildwood Crest and Lower Township to create a dune and berm. These locations are experiencing beach accumulation that is impacting municipal outfall systems that drain storm water to the ocean. The excess sand will be used to form a continuous dune and berm within North Wildwood, which is experiencing beach erosion, as well as Wildwood, Wildwood Crest and Lower Township. The sand for the dune and berm will be transported using a mobile back-passing technology to hydraulically pump the sand from within the intertidal zone. The plan includes periodic nourishment every four years. The sand for nourishment efforts will be sourced from the approved borrow zone.

In our review, we did not notice whether our comment regarding the orientation of entry points/access paths along the dune was addressed so we are reiterating our recommendation. Access paths are often created perpendicular to the shore, resulting in significant dune erosion during intense storms and greater inland impacts. High force waves gain power as they push through the narrow passages causing increased erosion and flooding. Reduced flooding was seen after Super Storm Sandy behind dunes that had paths at a 45 degree angle rather than perpendicular to the shoreline. EPA continues to maintain that this modification could enhance the resiliency of the beaches and we recommend the inclusion of this information in the decision document for the project.

Thank you for the opportunity to comment. Should you have any questions concerning this letter please feel free to contact Stephanie Lamster of my staff at 212-637-3465.

Sincerely,

SLamster for GM

Grace Musumeci, Chief
Environmental Review Section

DEPARTMENT OF THE ARMY
U.S. ARMY CORPS OF ENGINEERS
441 G STREET, NW
WASHINGTON, DC 20314-1000

REPLY TO
ATTENTION OF

Planning and Policy Division

DEC 22 2014

Ms. Grace Musumeci
Chief, Environmental Review Section
United States Environmental Protection Agency
Region 2
290 Broadway
New York, NY 10007-1866

Dear Ms. Musumeci:

This letter is in response to your comments on the Hereford Inlet to Cape May Inlet Shore Protection Project provided in a letter dated November 13, 2014. We value and appreciate your commentary on the proposed project.

In regards to the orientation of the proposed entry points/access paths along the dune, we apologize if the response contained in our report was unclear. The plans contained in the report show the seaward side of all of the vehicular and pedestrian crossovers would be constructed at an angle to the dune, not perpendicular in order to enhance dune resiliency during storm events. The information is specifically contained in Volume 3, Appendix G-2, page 16 of the report.

Again, we thank you for the commentary that you have provided. If you would like to discuss these issues further, please contact the review manager, Lee Ware, at (202) 761-0523.

Sincerely,

Theodore A. Brown

Theodore A. Brown, P.E.
Chief, Planning and Policy Division
Directorate of Civil Works

Printed on Recycled Paper

XXX

State of New Jersey
DEPARTMENT OF ENVIRONMENTAL PROTECTION
NATURAL & HISTORIC RESOURCES
Office of Engineering and Constructions
501 East State Street
Mail Code 501-01A
P. O. Box 420
Trenton, NJ 08625-0420
Tel. 609-292-9236 FAX 609-984-1908

CHRIS CHRISTIE
Governor

KIM GUADAGNO
Lt. Governor

BOB MARTIN
Commissioner

April 9, 2014

John C. Becking, P.E.
Lieutenant Colonel, US Army Corps of Engineers
Philadelphia District
Wanamaker Building
100 Penn Square East
Philadelphia, PA 19107

Reference: Hereford Inlet to Cape May Inlet Feasibility Study

Dear Colonel Becking:

The purpose of this letter is to confirm the New Jersey Department of Environmental Protection's (Department) support of the US Army Corps of Engineers (USACE) recommended plan contained in the Hereford Inlet to Cape May Inlet Feasibility Study. The Department is committed to partnering with the USACE Philadelphia District and will continue to provide the staffing and support needed to complete the project.

Sincerely,

Dave Rosenblatt
Administrator

Hereford Inlet to Cape May Inlet, New Jersey

Coastal Storm Risk Management Feasibility Study

Feasibility Report and Integrated EA

U.S.ARMY

US Army Corps of Engineers

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Initial Study Authority

This report is an interim response to the Senate Resolution adopted on December 17th 1987 by the Committee on Environmental and Public Works states:

"That the Board of Engineers for Rivers and Harbors, created under Section 3 of the Rivers and Harbors Act, approved June 13, 1902, be, and is hereby requested to review existing reports of the Chief of Engineers for the entire coast of New Jersey, with a view to study, in cooperation with the State of New Jersey, its political subdivisions and agencies and instrumentalities thereof, the changing coastal processes along the coast of New Jersey. Included in this study will be the development of a physical, environmental, and engineering database on coastal area changes and processes, including appropriate monitoring, as the basis for actions and programs to prevent the harmful effects of shoreline erosion and storm damage; and, in cooperation with the Environmental Protection Agency and other Federal agencies as appropriate, develop recommendations for actions and solutions needed to preclude further water quality degradation and coastal pollution from existing and anticipated uses of coastal waters affecting the New Jersey coast. Site specific studies for beach erosion control, hurricane protection, and related purposes should be undertaken in areas identified as having potential for a Federal project, action, or response."

Additional Study Authority

- Disaster Relief Appropriations Act (Public Law 113-2)
  - Hereford Inlet to Cape May Inlet Included in the Second Interim Report to Congress
  - Authorizes initial project construction
  - Does not authorize periodic nourishment cycle – additional project authorization required for nourishment cycle

Project Purpose

To determine a hurricane and storm damage reduction plan for coastal communities located between Hereford Inlet and Cape May Inlet, Cape May County, New Jersey

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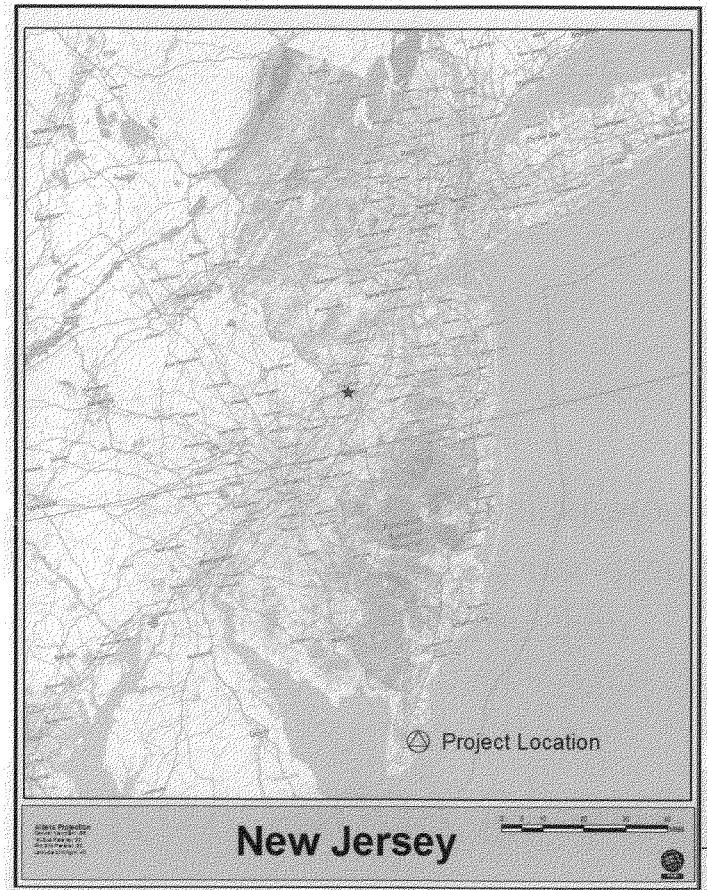
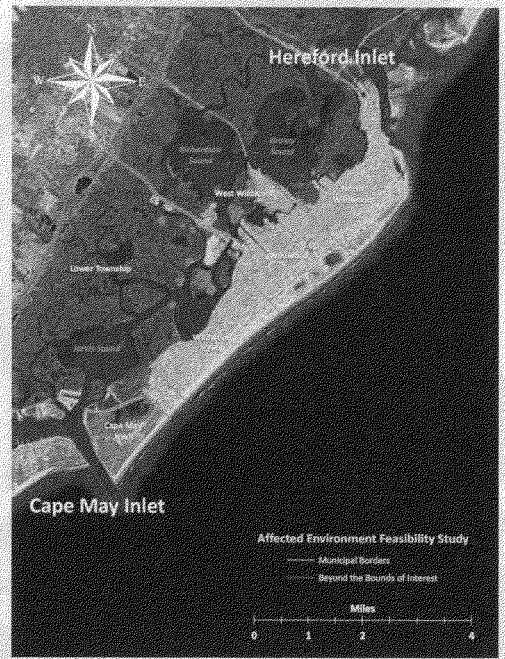
Key Study Sponsor & Partners

- Non-Federal Sponsor - State of New Jersey, Department of Environmental Protection
  - ► NJDEP Commissioner -Bob Martin
  - ► NJDEP- BCE Administrator- Dave Rosenblatt
- Key Stakeholders
  1. North Wildwood
  2. Wildwood
  3. Wildwood Crest
  4. Lower Township





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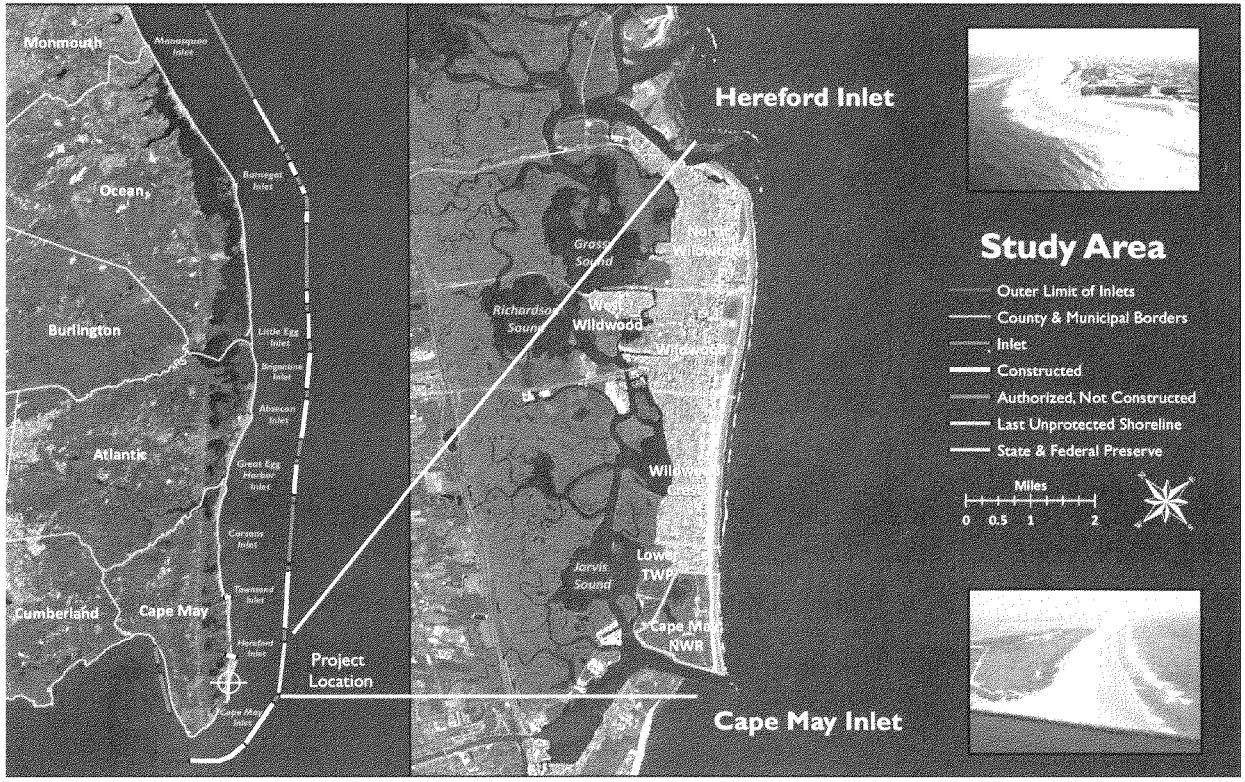
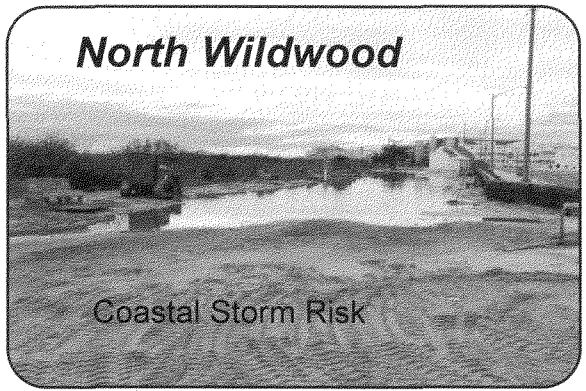
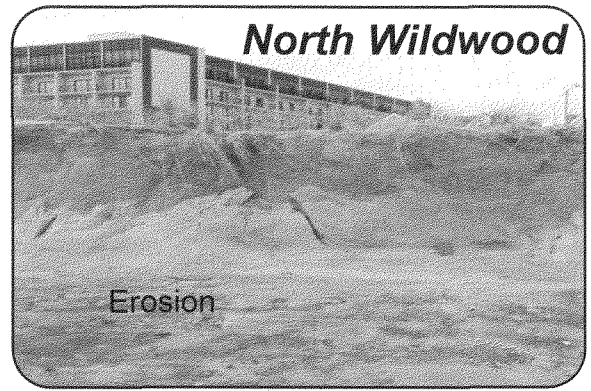
Hereford Inlet to Cape May Inlet Study Area

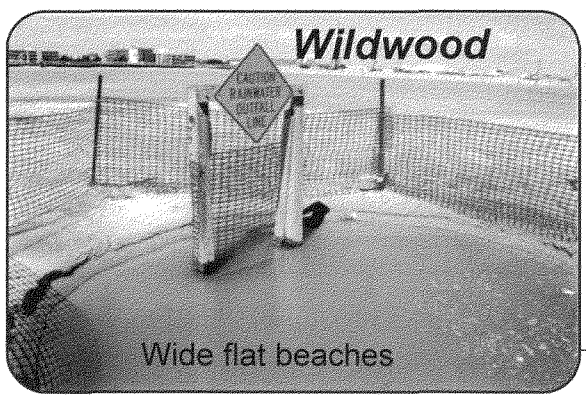
Last ocean front component of the NJ shore protection system

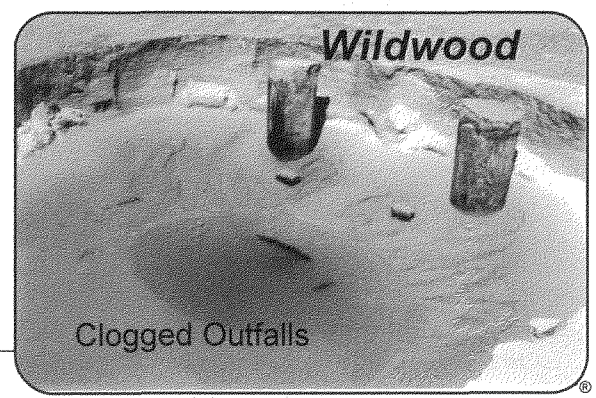


Problems


North Wildwood
Coastal Storm Risk


North Wildwood
Erosion


Wildwood
Wide flat beaches


Wildwood
Clogged Outfalls

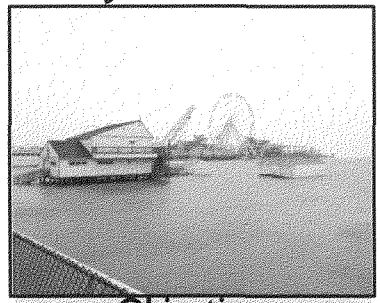
Problems /Opportunities /Objectives

Problems

- Erosion, flood, and wave damage.
- Storm water drainage issues.
- Drainage maintenance costs.
- Impacts to recreation.
- Health and safety.

Opportunities

- Protect homes and infrastructure.
- Reduce health and safety issues.
- Mitigate damages caused by beach growth.
- Restore natural storm water flow.



Objectives

- Restore beaches.
- Regional Sediment Management.
- Reduce environmental and cultural impacts.
- Utilize excess sand to reduce maintenance.
- Satisfy non-Federal and Local Sponsors.

~ Constraints ~

- Comply with USACE Regulations
- Ensure the Economic Feasibility of the selected plan
- Use of natural dune elevations, berm elevations, side slopes
- Balancing the sediment distribution
- Ensure Environmental Protection
- Maintain storm damage reduction and recreation
- Consideration of public health, safety and social well-being

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Plan Formulation

Initial Screening

Non-structural Alternatives	Structural Alternatives
No Action	Berm & Dune Restoration using Backpass Technology
Regulation of future development	Berm & Dune Restoration from an Inlet Source
Permanent evacuation	Groins
	Excavate Sand from in Front of Outfalls
	Extend Outfalls
	Combine Outfalls
	Bulkhead around Piers
	Seawall
	Elevate Amusements
	Remove Amusements
	Hereford Inlet Channel Maintenance
	Geotextile tubes

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Recommended Plan

- Construction of beach berm and dune from Hereford Inlet to Cape May Inlet, via Hydraulic Back-Passing System
  - Berm Description
    - Elevation - +6.5 NAVD 88
    - Width – 75 feet
  - Dune Descripton
    - Elevation - +16 NAVD 88
    - Width at Crest – 25 feet

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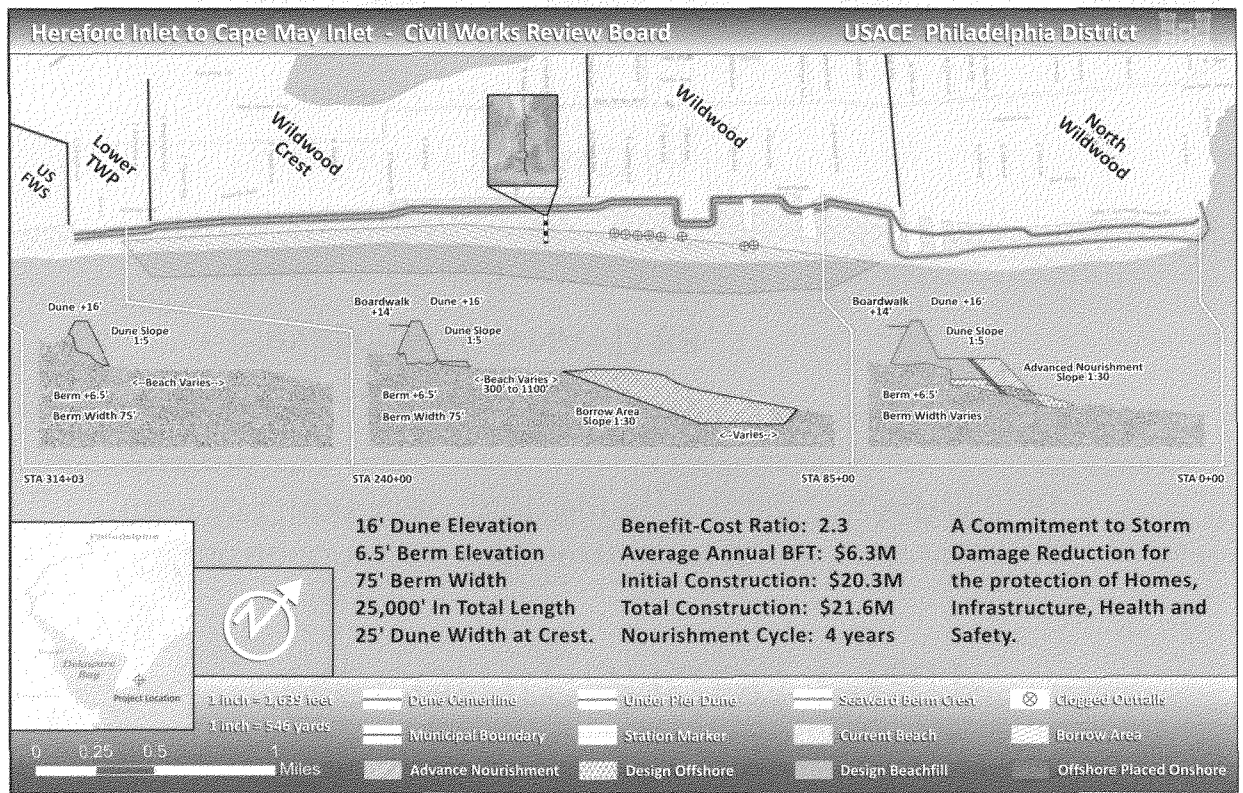
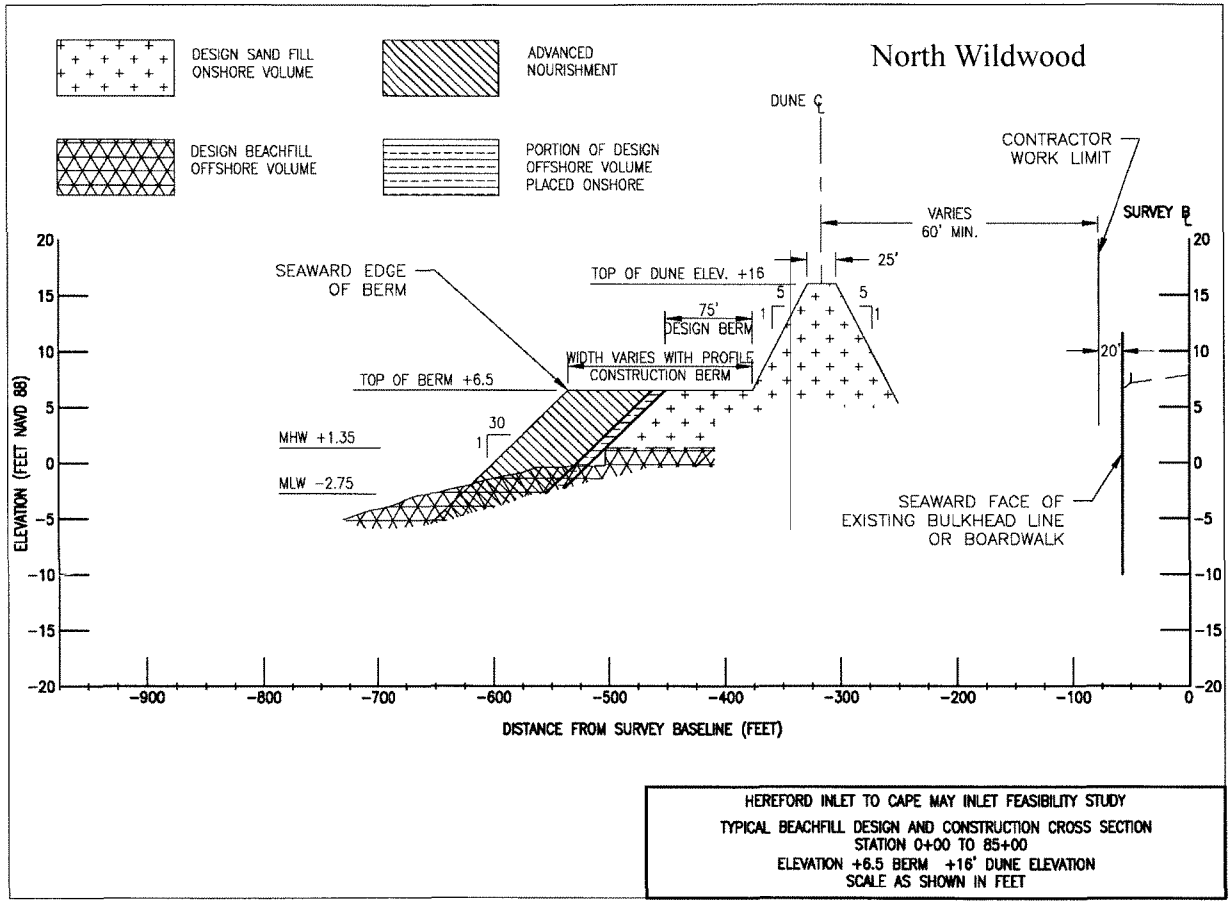
Recommended Plan

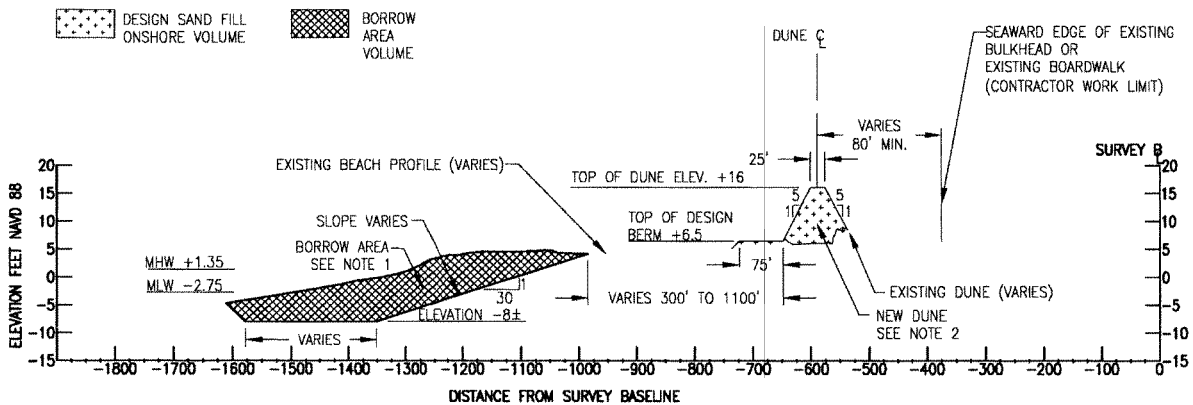




HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY

TYPICAL BEACHFILL DESIGN AND CONSTRUCTION CROSS SECTION
STATION 0+00 TO 85+00
ELEVATION +6.5 BERM +16' DUNE ELEVATION
SCALE AS SHOWN IN FEET

Wildwood/Wildwood Crest



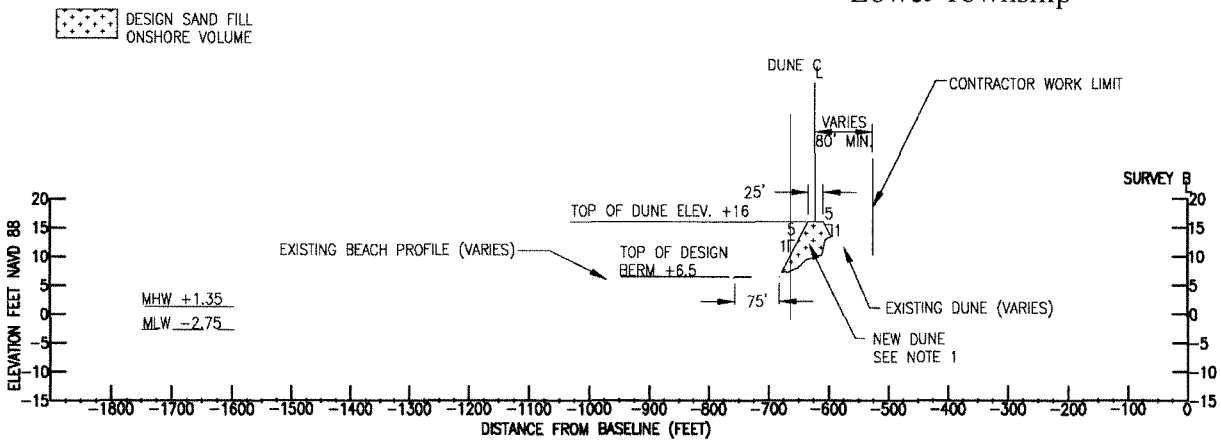
NOTES:
1. EXACT LIMITS OF BORROW AREA MAY VARY FROM THAT SHOWN HERE, BASED ON EXISTING BEACH CONDITIONS AND DREDGING EQUIPMENT SELECTED AT TIME OF CONSTRUCTION.
2. CENTERLINE OF NEW DUNE IS LOCATED ALONG THE SEAWARD EDGE OF THE EXISTING DUNES IN ORDER TO MINIMIZE SAND VOLUME REQUIRED
3. NEW DUNE VEGETATION IS NOT SHOWN.

HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY

TYPICAL DESIGN CROSS SECTION STATION 85+00 TO 240+00
BEACH BORROW AREA WITH ELEVATION +16 DUNE

SCALE AS SHOWN IN FEET

Lower Township



NOTES:
1. CENTERLINE OF NEW DUNE IS LOCATED ALONG THE SEAWARD EDGE OF THE EXISTING DUNES IN ORDER TO MINIMIZE SAND VOLUME REQUIRED.
2. NEW DUNE VEGETATION IS NOT SHOWN.

HEREFORD INLET TO CAPE MAY INLET FEASIBILITY STUDY
TYPICAL DESIGN CROSS SECTION
STATION 240+00 TO 314+03
ELEVATION +16 DUNE
SCALE AS SHOWN IN FEET

Economic Summary

▪ Discount Rate (FY15)	3.375%
▪ Period of Analysis	50 years
▪ Price Level	October 2014
▪ Base Year	2016
▪ Estimated Total Cost	$104,966,000
▪ Initial Construction Cost	$21,794,000
▪ Total Renourishment Cost	$83,172,000
▪ Periodic Nourishment (cycles 1,2)	$6,004,000
▪ Periodic Nourishment (other cycles)	$6,246,000
▪ Major Rehabilitation (year 24)	$7,991,000
▪ Interest During Construction	$349,000

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Economic Summary Cont'd.

- Total Avg Annual NED Benefits $6,309,000
- Total Avg Annual Costs $2,693,000
- Net Benefits $3,616,000
- Benefit-Cost Ratio at 3.375% 2.3
- Benefit to Cost Ratio at 7% 1.9

Benefit Breakdown

- Storm Damage Reduction $4,132,000
- Local Costs Forgone $1,375,000
- Recreation $699,000
- Benefits During Construction $103,000

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Cost Apportionment Table

Item	Federal Cost	Non-Federal Cost	Total Cost
PED	$1.4M	$0.5M	$1.9M
LERR&D		$1.3M	$1.3M
Flood Damage Reduction	$14.0M	$7.6M	$21.6M
Renourishment	$41.2M	$41.2M	$82.4M
Total	**$56.6M**	**$50.6M**	**$107.2M**

Environmental Considerations

- Environmental Assessment (EA)
  - FONSI was prepared
  - Red Knot is close to the study area
    - Listed as threatened in November 2014
    - NAP is consulting with FWS

Public Review

- Date of Public Notice – 20 Dec 2013
- Public Meeting Dates – 4 Public Meetings/ Workshops/Hearings in Feb 2014
- ~ 100 to 150 comments from concerned citizens, engineering firms working for the municipalities, the mayor and council
  - Support of the plan
  - Concerns with dune height
  - Concerns with impact of dune on tourism, real estate and recreation

Project Implementation

- PPA Execution Date – 4 December 2015
- Contract Award Date – 29 July 2016
- Construction Completion Date – 15 Jun 2017

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CWRB Summary
21 August 2014

- CWRB Decision: The project was approved for State and Agency review at the 21 August 2014 CWRB.
- OMB Attendees: The OMB Examiner was in attendance.

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