Ocean City, Maryland, and Vicinity Water Resources Study

Final Integrated Feasibility Report and Environmental Impact Statement

Appendix D
Restoration of Assateague Island

US Army Corps of Engineers
Baltimore District

June 1998

Ocean City, Maryland, and Vicinity
Water Resources Study

Appendix D: Restoration of Assateague Island

Final Integrated Interim Report
and *Final* Environmental Impact Statement (*FEIS*)

June 1998

NOTE TO READER: In order to allow concerned resource agencies and the public an opportunity to evaluate the project with full and convenient access to the environmental, economic, and engineering documentation prepared for the study, the ***FEIS*** for this project has been integrated into this interim report in accordance with Engineer Regulation 1105-2-100 (December 28, 1990). Sections required for compliance with the National Environmental Policy Act (NEPA) are noted by an asterisk (*) in the table of contents.

This EIS was prepared to address impacts of four components of this study (1) short-term restoration of *the northern end of* ***Assateague Island, (2) long-term sand management, (3) navigation improvements, and (4) environmental restoration in the coastal bays. This appendix documents the findings of the Short Term Restoration of Assateague Island.***

LEAD AGENCY: Baltimore District, U.S. Army Corps of Engineers

We have coordinated with:

- Maryland Department of Natural Resources, Annapolis, Maryland
- National Park Service, Assateague Island National Seashore, Berlin, Maryland
- Worcester County, Snow Hill, Maryland
- Town of Ocean City, Maryland
- U.S. Fish and Wildlife Service, Annapolis, Maryland
- ***Minerals Management Service, Office of International Activities and Marine Minerals, Herndon, Virginia***

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ABSTRACT: This ***final report/EIS*** presents the findings of a study to determine the feasibility of restoring the northern 11 kilometers of Assateague Island. It provides the findings of economic, social, environmental, and engineering analyses that were used to select a recommended plan of action. The potential impacts, if any, to cultural and environmental resources are evaluated herein in accordance with NEPA and Section 106 of the National Historic Preservation Act of 1966.

EXECUTIVE SUMMARY

The watershed area of Ocean City, Assateague Island, and the Maryland coastal bays offers many attractions that draw millions of seasonal visitors and part-time residents, as well as growing numbers of new permanent residents. The area offers a wide variety of recreation activities, from sandy beaches and noisy nightclubs to tranquil nature trails. The coastal bays are home to many birds and fish and provide a variety of recreational opportunities, such as boating, fishing, sunbathing, birdwatching, water-skiing, and other water sports. In addition to tourism, the region benefits economically from a substantial fishing industry based in Ocean City.

Adjacent to Ocean City is the Assateague Island National Seashore and State Park. Assateague Island is a unique national treasure. The importance of this natural resource became apparent in 1965 when Congress designated the island a National Seashore and placed it under the management of the National Park Service. The Park Service has maintained the island in close to its natural state while providing access to millions of visitors attracted to the island's natural setting. Assateague Island offers the peaceful pleasures of camping, canoeing, cycling, surf fishing, crabbing, clamming, birdwatching, and enjoying the island wildlife, including wild horses and deer.

The recent vigorous population growth and development in the area, along with the Corps' construction of the jetties, are jeopardizing the quality of water resources in the coastal bay watershed. Water resources problems include degrading water quality, loss of wetlands, loss of nesting habitat for waterbirds, increasing sediment in the coastal bays, excessive erosion of the Assateague Island National Seashore, navigation difficulties, and increased storm damage. As part of this feasibility study, a comprehensive investigation of the water resource problems is being performed, and solutions that will improve the ecosystem as a whole are being developed. The four components of the project being investigated are (1) short-term restoration of Assateague Island, (2) long-term sand placement, (3) navigation improvements, and (4) ecosystem restoration in the coastal bays.

This document is the first of two being prepared as part of the Ocean City, Maryland, and Vicinity Water Resources Study. This interim report documents the recommendations for the short-term restoration of Assateague Island and includes the documentation necessary to meet the requirements of the National Environmental Policy Act (NEPA). The recommendations and the NEPA documentation for the other three components will be documented in the report to be completed in June 1998. The other three project components are not as far along in the development of solutions, and therefore, are described only briefly in this report, as needed to demonstrate the interconnectedness among the four components.

One of the causes of the water resources problems in the area is the disruption of the longshore transport system caused by the jetties that stabilize the Ocean City Inlet. The jetties were constructed by the Corps of Engineers in 1934, after the inlet formed during a major storm in 1933. Since it formed over 60 years ago, the inlet has functioned as a thoroughfare for boating traffic between the ocean and the coastal bays. In addition to providing access to the coastal bays, the jetties have disrupted the sediment supply between Ocean City and Assateague Island. Prior to the formation and stabilization of the inlet, the sand generally traveled from Ocean City south to Assateague Island. Since construction, the inlet and jetties have prevented a large portion of sand, which would otherwise have reached Assateague, from reaching the island. Consequently, the northern 11 km (6.8 miles) of the island shoreline have been seriously affected. The disruption in the natural longshore transport of sediment between Ocean City and Assateague Island has resulted in adverse physical, biological, and economic impacts to the area. The result is an island that is not being maintained in a natural condition and that lacks the geologic integrity of a healthy barrier island. A substantial portion of Assateague Island, which has always been known for its natural beauty, has also suffered significant aesthetic impacts. The island overwashes frequently, and the shoreline has eroded back towards the mainland at an accelerated rate. This erosion has caused a loss of salt marshes, an infilling and reduction in size of Sinepuxent Bay, and a decrease of habitat diversity on the island. It has also created navigation difficulties near the inlet and through the back bays, and has increased the vulnerability of mainland communities to storm damage.

Due to the lack of an adequate sediment supply, it is expected that northern Assateague Island will continue to be degraded, and a breach will most likely occur on Assateague Island, which could cause additional inlets to form. This could occur during the next substantial coastal storm. An additional inlet would change the dynamics of the area and would create more environmental and economic problems. Most importantly, the Assateague Island National Seashore, a national treasure, would suffer significant loss. In addition, it is expected that considerable losses to wetlands would result, as well as losses to recreational opportunities, damage to property, and hazards to navigation.

Under Section 111 of the River and Harbor Act of 1968, as amended, the Corps of Engineers is authorized to mitigate for shore damage attributable to a Federal navigation project. Through Section 534 of the Water Resources Development Act of 1996, Congress authorized the Secretary to

> *"... expedite the Assateague Island restoration feature of the Ocean City, Maryland, and Vicinity study, and, if the Secretary determines that the federal navigation project has contributed to the degradation of the shoreline, the secretary shall carry out the shoreline restoration feature."*

During this interim study, numerous alternative solutions were evaluated and a plan was identified that would partially mitigate for the impacts caused by the construction of the jetties. The plan involves two parts: (1) a short-term restoration and (2) a long-term restoration. The short-term restoration plan, which would partially mitigate for impacts to Assateague Island during the last 63 years, includes placing approximately 1.4 million m^3 (1.8 million cubic yards) of sand on Assateague Island. The borrow area to be used for the project is Great Gull Bank, an offshore shoal, and possibly a small portion of the ebb shoal. The area of Assateague to be renourished is between 2.5 km (1.6 miles) and 11.3 km (7 miles) south of the inlet. The distance across the beach in that area will be increased to varying widths based on the erosion rates that affect each part of the beach. A low storm berm will be constructed to an elevation of 3.3 m (10.8 feet) NGVD (averaging 0.8 m in height) in the portion of the beach between 2.5 km and 10 km (1.6 miles and 6.2 miles) south of the inlet. The placement will be configured to restore the integrity of the island, and yet to remain sensitive to the Piping Plovers, a threatened and endangered bird found on the island. Positive impacts to the region's environmental, economic, cultural, recreational, or social resources are expected as a result of the implementation of the recommended plan.

Because the jetties and inlet will continue to disrupt the longshore transport, a long-term sand placement plan for the island must also be implemented. The long-term plan is still being developed, and a recommended plan will not be selected until the final report. One potential plan that is being evaluated involves a system of transporting the material from the southern tip of Ocean City, where the beach is widest, across the inlet to Assateague Island, replacing the process that would occur naturally, were the jetties not present. A monitoring and action plan has also been developed to observe and protect the project area against possible negative impacts for a period of at least 5 years after the short-term plan is implemented or until the long-term plan is in place.

The estimated cost for the short-term restoration project, including 5 years of monitoring, is $17.2 million. The long-term plan has not yet been developed. It may involve the construction of a fixed plant that would have a significant first cost, and a relatively low annual maintenance cost, or it could include contracting dredges annually, which would involve no first cost but would have a high annual cost. The estimated first cost for the long-term restoration is between $0 and $10 million; and the estimated annual operation and maintenance cost is between $400,000 and $2 million. Section 534 of the Water Resources Development Act of 1996 states that the Secretary shall allocate costs for the project pursuant to Section 111 of the River and Harbor Act of 1968. It states that the Secretary shall coordinate with affected Federal and State agencies and shall enter into an agreement with the Federal property owner to determine the allocation of project costs. This interim report will provide a basis for that coordination. There are four ways this project could potentially be funded: (1) 100 percent by the National Park Service under the Support for Others program; (2) 100 percent by the Corps of Engineers using Section 111 authority; (3) 65 percent by the Corps and 35 percent by the National Park Service under the ecosystem restoration authority; or (4) some alternative cost-sharing method. The National Park Service, which administers the Assateague Island National Seashore, has agreed to enter into a Memorandum of Agreement with the Corps and to provide lands, easements, and rights-of-way, as needed. The State of Maryland has agreed to provide easements for construction in the State Park. However, additional coordination is necessary to fully define project implementation responsibilities.

[As of June 1998, the Ocean City, Maryland, and Vicinity Water Resources Integrated Feasibility report and Environmental Impact Statement was finalized, as were both the short- and long-term components of the restoration of Assateague Island. The recommended long-term plan is for the "mobile bypassing" of sand via a shallow mobile hopper dredge to remove sand that has been redirected to a number of sites, and then bypassing it to Assateague Island. This dredging will take place each year to more closely mimic natural processes. Sand will be bypassed from the updrift fillet, ebb shoal, the navigation channels and flood shoals. In order to avoid the creation of new problems by taking too much sand from any one source or too frequently from the same source (thus further disturbing the balance of the area), the project will be monitored annually. A team of decision makers led by the Corps, consisting at a minimum of all the project sponsors (the NPS, the State of Maryland, Worcester County, and the Town of Ocean City), will determine each year how much material can be taken from each of the available sources. Their decision will be based on the monitoring results, which will indicate the rate at which the sources are being naturally replenished after dredging.

The authority to implement the Assateague Island components of the project, both short-term and long-term sand management, were provided by Section 534 of the Water Resources Development Act of 1996. This Act directed the Corps to implement the restoration of Assateague Island pursuant to Section 111 of the River and Harbor Act of 1968. In addition, the Act authorized the expenditure of $35 million dollars for both the short- and long-term restoration of Assateague Island. The short-term restoration project is estimated at $17.2 million. At an annual cost of more than $1.1 million for long-term sand management, the project as authorized will carry the project through to fiscal year 2011, assuming the project is fully federally funded. For the 25 year project duration, the estimated long-term sand management cost is $25,243,000, or $43,773,000 fully funded. Therefore, Congressional project reauthorization of the project is recommended. It stated that the Secretary shall coordinate with affected Federal and State agencies and shall enter into an agreement with the Federal property owner to determine the allocation of the project costs. The Corps is currently coordinating with NPS, the State of Maryland, Worcester County, and the Town of Ocean City to define project implementation responsibilities for both the short-term restoration of Assateague Island and the long-term sand management. All of the project sponsors support the recommended project. The NPS, who administers the Assateague Island National Seashore, has agreed to enter into a Memorandum of Agreement with the Department of the Army.

The schedule for these two components of the Assateague Island restoration has also been finalized. This schedule allows 2 years for the construction of the short-term sand management plan, with construction of the long-term plan to begin the year following completion of the short-term plan. The short-term sand management plan is scheduled to begin construction in July 1999; the long-term plan, in summer 2001.]

Ocean City, Maryland and Vicinity
Water Resources Draft Integrated Interim Report and Environmental Impact Statement

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Ocean City, Maryland, and Vicinity
Water Resources Study

Acknowledgments

The Corps of Engineers would like to thank the numerous agencies and individuals who participated in this study. Although it is not possible to identify by name all the individuals who provided assistance in the development of this report, we would like to specifically acknowledge the assistance of the following individuals who provided important insights into the needs of the study area as well as critical technical guidance in the identification of problems and potential solutions. The assistance provided by these individuals was extremely valuable in enabling the Corps of Engineers to complete this report.

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Ocean City, Maryland, and Vicinity
Water Resources Study

DRAFT Integrated Interim Report and Environmental Impact Statement

Restoration of Assateague Island

Section 1

INTRODUCTION

This document is the first of two being prepared as part of the Ocean City, Maryland, and Vicinity Water Resources Feasibility Study. The study was initiated in July 1995, following the completion of the first phase of the study, the reconnaissance phase. The reconnaissance report, dated May 1994, documented the results of a comprehensive investigation of the water resources problems in the Ocean City area. The report included preliminary evaluations of various plans related to environmental restoration, navigation, storm protection, and water resources infrastructure for the study area. Four project components were specifically identified to be investigated further during the second phase. These components are (1) the short-term restoration of the northern end of Assateague Island; (2) long-term sand placement along Ocean City and Assateague Island; (3) navigation improvements; and (4) ecosystem restoration in the coastal bays.

These four components are being investigated together as one project. We realize the importance of investigating the problems in the region as a whole and looking for long-term solutions; however, due to the vulnerability of Assateague Island and the imminent threat of it breaching (which would create an additional inlet), this portion of the project is being accelerated. This first interim report focuses on finding a short-term plan to restore Assateague Island in order to prevent any adverse impacts associated with a breach. The second report will include a long-term plan to ensure that Assateague Island does not continue to degrade. Initial work efforts for the remaining three components during this study have been oriented towards establishing existing conditions, data collection, and preliminary formulation of plans. Therefore, the four components are at different points in the study process.

This report documents the recommendations for the short-term restoration of Assateague Island and includes the documentation necessary to meet the requirements of the National

Environmental Policy Act (NEPA). This report is considered an integrated Environmental Impact Statement (EIS) because the information required for the EIS is included throughout the report. This EIS was prepared to address general impacts of the overall project and specific impacts of the Assateague Island restoration. A separate supplemental EIS addressing the remaining project components, long-term sand placement, navigation improvements, and ecosystem restoration of the coastal bays, will be prepared as part of the second study. The second final report and EIS is scheduled to be completed in June 1998. Since the other three project components are not as far along in the development of solutions, they are described only briefly in this report, as such descriptions are needed to demonstrate the interconnectedness among the four components.

1.1 STUDY PURPOSE

Due to the changing coastal dynamics and the dense population and development, the Town of Ocean City, Assateague Island, and the adjacent mainland areas and bays are experiencing a variety of water resource problems. The coastal environment has been degraded by inlet and shoreline stabilization, intense development, tourism, agriculture, and other man-made factors.

The Corps of Engineers has constructed projects that have impacted the coastal bay area. One of the most significant projects is the stabilization of the inlet in 1934/1935 by the construction of the jetties. From 1933 through 1935, in the aftermath of the hurricane of 1933, the Corps of Engineers constructed the existing jetty system at the Ocean City Inlet. Designed and built to provide safe and effective navigation through the inlet between the coastal bays and the Atlantic Ocean, the jetty system has also disrupted the natural movement of sand along the Atlantic coast. In effect, the system has acted as a sand-trap, interrupting the flow of sand to Assateague Island for more than 60 years. The primary effect of the jetty-induced interruption of sand to Assateague is that the island has been deprived of a volume of sand in the magnitude of 6.6 million m^3 (8.6 million cubic yards). Because of its diminished volume, the island no longer functions as an effective barrier island, and is likely only one substantial coastal storm event removed from breaching along its northern section. In addition, sand deprivation has induced problems throughout the surrounding ecosystem. Not only does sand deprivation diminish the functionality of the barrier island, it also adversely impacts the coastal bays and the mainland west of the island.

The purpose of this study is to identify, measure, and evaluate the impacts to the entire coastal bay region of the problems caused by the continuing sand deprivation of Assateague Island and to investigate the feasibililty of near-term solutions to these problems. Because of the imminent likelihood of a breach of Assateague Island, the uncertainty of the effects that breaching of the island would induce, and the high level of political interest in preserving the integrity of the island, the current investigation has been prioritized relative to the three other project purposes. As such, the focus of the majority of the technical analyses documented in this report was to identify a feasible, short-term, implementable solution to the acute threat to the integrity of the Assateague Island National Seashore induced by the Corps of Engineers jetty system.

The designation of Assateague Island as a National Seashore in 1965 established its identity as a heritage of the American people. It was the intent of Congress in establishing Assateague Island National Seashore that the park provide a protected enclave for the complex plant and animal communities, both terrestrial and aquatic, that characterize the Mid-Atlantic Coast, and that the park fully illustrate the natural processes of change that shape the coastal environment. Congress' action preserved the island from development and placed it under the managerial auspices of the National Park Service. The Park Service has maintained the island in close to its natural state, while providing vehicular access for the many visitors attracted to the island's pristine beach and natural setting. The mission of Assateague Island National Seashore is (1) to preserve these unique coastal resources and the natural ecosystem conditions and processes upon which they depend, (2) to provide appropriate resource-based recreational opportunities compatible with resource protection, and (3) to educate the public as to the values and significance of the area. Since 1965, more than ***65 million people*** have visited Assateague.

The Assateague Island National Seashore holds great significance and value for wildlife and for man. The island provides suitable habitat for a wide variety of listed species, as well as resting and foraging habitat for a variety of migratory species. As the only natural barrier island habitat in Maryland, Assateague also plays an important role in local and regional environmental education. The island is renowned worldwide for its population of feral horses, which provide opportunities for research, and are a major tourist attraction.

Unfortunately, the excessive erosion has negatively impacted this valuable resource. The study area is now significantly less biologically diverse than the rest of the park: open sand constitutes approximately 56 percent of the study area versus approximately 12 percent parkwide, and the study area supports 9 vegetation alliances versus the 22 supported by the park as a whole. Two back-country primitive camping areas, the only public areas of their kind on an Atlantic Coast barrier island, were closed in 1992 when degradation of the north end reached a level where unpredictable overwash threatened campers' safety.

In addition, the Federal investment made to acquire the island is being lost through continued degradation. The Congress of the United States has recognized the significance of Assateague for the American people and, through the Water Resources Development Act of 1996, has authorized the Corps of Engineers to mitigate for damage done to the island by construction of the jetty system

The purposes of this interim report are to recommend a short-term solution of how to restore Assateague Island, and to document the investigation thus far on the other three project components: long-term sand placement along Ocean City and Assateague Island; navigation improvements; and ecosystem restoration in the coastal bays. These four components are interrelated and are being evaluated comprehensively. The overall project goal is to restore the coastal bay ecosystem by restoring coastal functions and wildlife habitat, while protecting and improving the economic resources.

The project partners pursuing this goal with the Corps of Engineers are the National Park Service, the Maryland Department of Natural Resources (MD DNR), Worcester County, and the Town of Ocean City, with MD DNR being the official sponsor of the study.

1.2 STUDY AND PROJECT AUTHORITY

This study was authorized by a resolution of the Committee on Environment and Public Works of the United States Senate, adopted 15 May 1991, which states the following:

"RESOLVED BY THE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS OF THE UNITED STATES SENATE, that the Secretary of the Army is hereby requested to review existing reports of the Chief of Engineers for the Atlantic Coast of Maryland with a view to study, in cooperation with other Federal agencies, the State of Maryland, its political subdivisions and agencies and instrumentalities thereof, the changing coastal environment of the barrier islands, the Ocean City Inlet, and Chincoteague, Sinepuxent, Assawoman, and Isle of Wight Bays and adjacent mainland areas. Included in this study will be the development of physical, environmental, and engineering data on coastal changes and processes to evaluate needed water resources improvements to navigation, flood control, hurricane protection, erosion control, wetlands protection, water supply, and other allied purposes to preserve and enhance the water resources infrastructure which is being severely taxed and degraded by growth, development and other factors."

The project to restore Assateague Island was authorized by the Water Resources Development Act of 1996, adopted September 25, 1996, which states in part:

"PROJECT TO MITIGATE SHORE DAMAGE.-The Secretary shall expedite the Assateague Island restoration feature of the Ocean City, Maryland, and vicinity study and, if the secretary determines that the Federal navigation project has contributed to degradation of the shoreline, the Secretary shall carry out the shoreline restoration feature. The Secretary shall allocate costs for the project feature pursuant to section 111 of the River and Harbor Act of 1968 (33 U.S.C. 426I; 82 Stat. 735)."

1.3 STUDY AREA

The study area, which encompasses approximately 780 km^2 (300 square miles), includes the Town of Ocean City and adjacent areas of Worcester County, including the Ocean City Inlet, Assateague Island, and Assawoman, Little Assawoman, Isle of Wight, Sinepuxent, and Chincoteague Bays. The Maryland portion of the watersheds of the aforementioned bays, which includes the eastern portion of Worcester County, was investigated. Also included were the shoals within 17.7 km (11 miles) offshore of

Assateague Island. Figure 1-1 shows a map of the study area. Figure 1-2 shows a map of the offshore shoals.

1.4 STUDY PROCESS

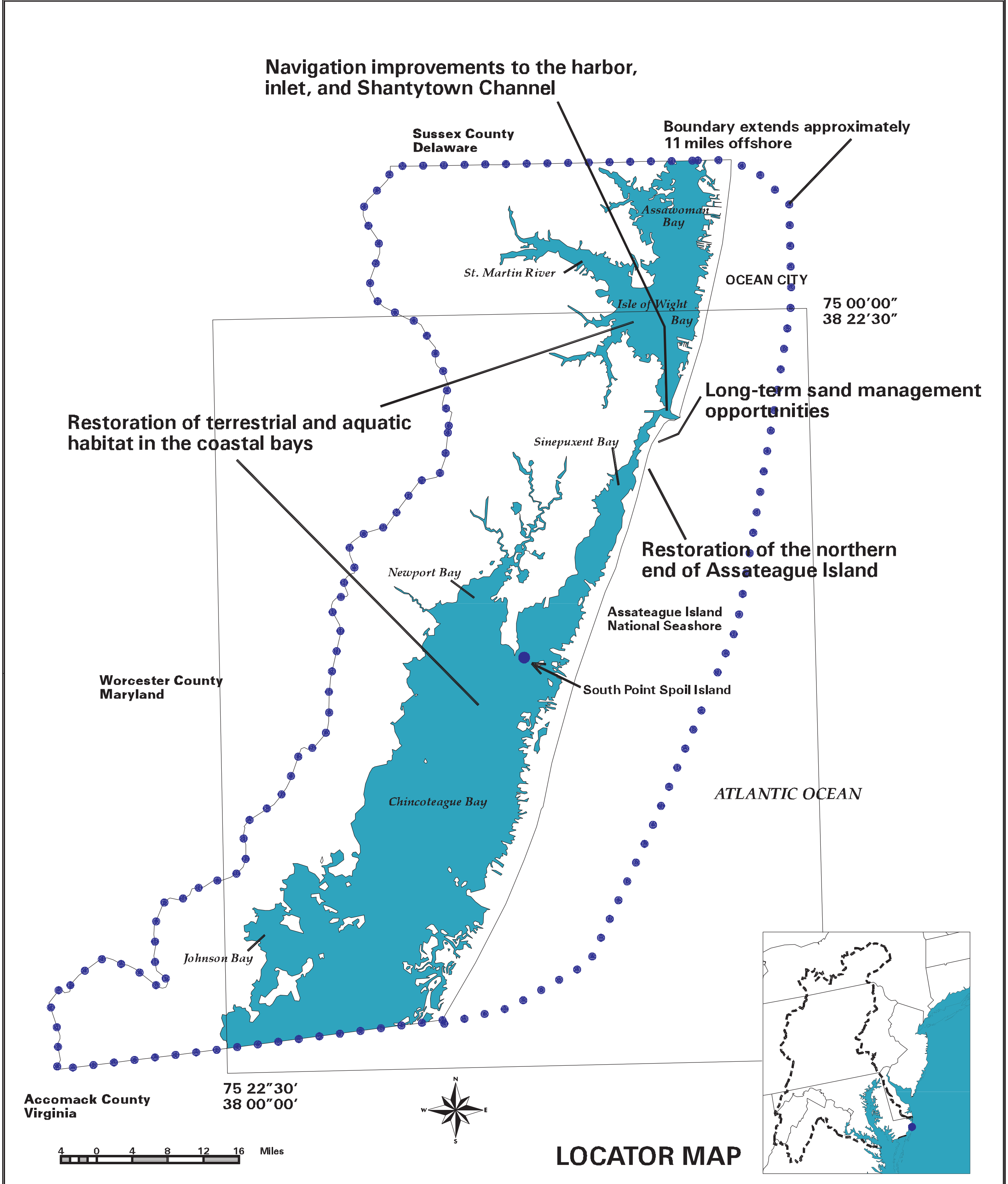
The Corps of Engineers uses a study process having two phases: the reconnaissance phase and the feasibility phase. The reconnaissance phase entails completion of the reconnaissance report, preparation of a project study plan (PSP), and negotiation of a feasibility cost-sharing agreement (FCSA) if a feasibility study is warranted. The reconnaissance phase is a preliminary phase during which problems are identified and potential solutions are determined. If feasible solutions exist and non-Federal sponsors are interested in cost-sharing more detailed investigations, then the study proceeds into the feasibility phase. The feasibility study is cost-shared 50/50 with at least one non-Federal sponsor. Non-Federal sponsors can include state, county, or local governments. The PSP describes the tasks required during the feasibility study and the corresponding costs for those tasks, and is the tool by which the FCSA is negotiated with the non-Federal sponsor(s). During the feasibility phase, new data can be collected through methods such as surveys, soil borings, and hydraulic modeling. More detailed designs and cost estimates are prepared, and the most economically justified (benefits>costs) and environmentally acceptable solutions are recommended.

If Corps of Engineers projects are justified, the pre-construction engineering and design (PED) phase follows, when final engineering and design are performed and construction plans and specifications are completed. Construction follows the PED phase. For traditional Corps-implementable projects, the cost of the PED and construction phases is shared between the non-Federal sponsor and the Federal Government. The cost-sharing varies according to project purpose.

1.5 OTHER FEDERAL AND LOCAL ACTIONS

1.5.1 Corps of Engineers Projects

In 1927 Congress authorized the Corps to construct an inlet, protected by jetties, between the Atlantic Ocean and Sinepuxent Bay at a point about 5 miles south of Ocean City, and to construct navigation channels. However, no inlet was constructed because a 1933 storm created a natural inlet at the southern tip of the present Ocean City. Following inspection of the breakthrough, the District Engineer proposed that the inlet be stabilized, and the Public Works Administration alloted funds for the immediate construction of the north jetty, which was completed in October 1934. Construction of the south jetty was begun in October 1934 and completed in May 1935 under the Emergency Relief Program of 1935. A House of Representatives resolution, dated 3 June 1935, authorized the Corps to review navigation in the area. As a result, the Corps constructed an inlet channel, 10 feet deep and 200 feet wide between the Atlantic Ocean and Sinepuxent Bay; a channel 10 feet deep, 100 to 150 feet wide and 3,000 feet long from the inlet channel to form a harbor with two turning basins of the same depth; and branch channels 6 feet deep into



US Army Corps of Engineers
Baltimore District

Ocean City Water Resources Feasibility Study

Study Area

• • • • • Study Area

Figure 1-1

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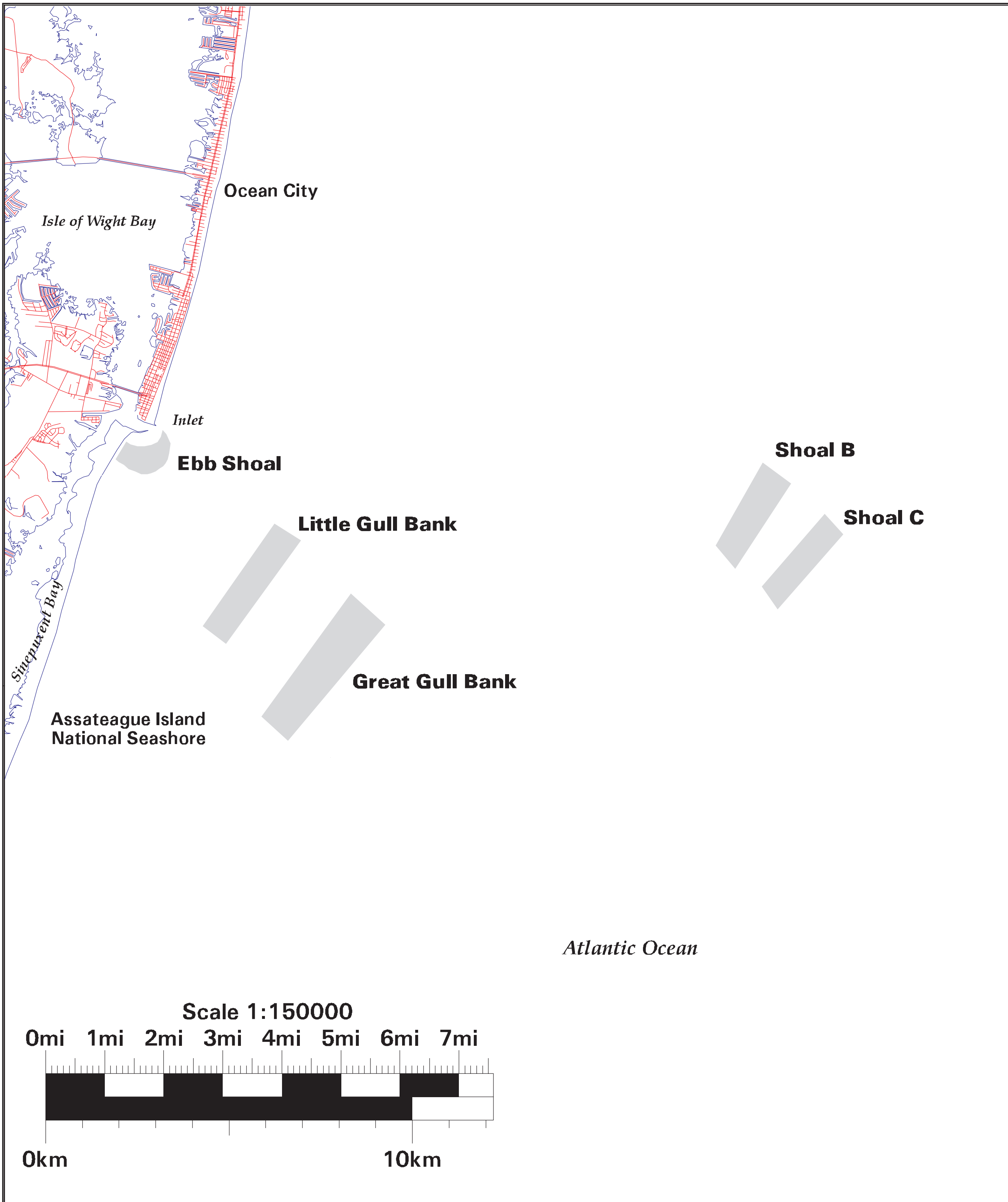

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Ocean City Water Resources Feasibility Study

Offshore Shoals

Approximate Location of Shoal

Figure 1-2

Sinepuxent Bay and Isle of Wight Bay. The resolution also allowed for the raising of the north jetty to an elevation of 9 feet above mean low water; these improvements were completed in 1936. At various times since the construction of the jetties, they have been rehabilitated. The jetties have been raised, sand-tightened, and an adjacent scour hole has been filled in; these most recent rehabilitation projects took place in 1984 and 1985.

In the 1960's, Congress authorized the Corps to study storm protection for the Atlantic Coast of Maryland and Assateague Island. This study led to the construction of the Atlantic Coast Shoreline Protection Project in 1991. The project was designed to provide protection against wave and erosion damage associated with a 100-year storm on the Atlantic Ocean. The project involved the placement of sand on the beach, the construction of vegetated dunes, and the construction of a flood wall. Periodically the beach is nourished, and dunes are maintained as needed.

To address the scouring and deterioration of a bulkhead on the bay side of Ocean City in 1989, the Corps constructed stone toe bulkhead protection and a tie-back system near Chicago Avenue.

See Appendix A2 for a summary of other historical significant engineering and coastal process events.

1.5.2 State and Local Actions

Currently, there are a number of ongoing studies and projects in the study area. The action that is most relevent to this Corps study is the acceptance of the Maryland coastal bays into the U. S. Environmental Protection Agency's National Estuary Program (NEP) in 1995. Under the NEP, a Maryland Coastal Bays Program (MCBP) has been organized by the Maryland Department of Natural Resources; this program is charged with protecting and preserving the coastal bays to ensure ecological and economic prosperity in the region. Over a 3-year period, the MCBP will develop a Comprehesive Conservation Management Plan. The plan will be an in-depth examination of the problems besetting the coastal bays and a set of agreed-upon solutions. Participants in the MCBP include numerous Federal, state, and local agencies; special interest groups; and private citizens. Since the Corps of Engineers is conducting similar work in the area, and data is being shared by both the Corps study and the MCBP, the Corps is an active participant in the program.

Another state and local action worthy of mention is the dredging of non-Federal channels throughout the coastal bays. The state dredges its own channels in Isle of Wight Bay as necessary; there are also numerous private channels to marinas and piers that individuals are permitted to dredge periodically. As this study addresses sediment movement through the Ocean City Inlet into the back bays, it is necessary to consider that this sediment transport affects not only Federal but also state and local channels.

Section 2

EXISTING CONDITIONS and AFFECTED ENVIRONMENT

The study area includes the Atlantic Ocean waters and sea floor of the continental shelf along the Maryland shoreline, the Maryland barrier islands, the coastal bays, and the mainland of the coastal bays watershed (Figure 1-1). The study area is bounded on the west by low hills that separate the coastal bays watershed from the Pocomoke River watershed. The seaward limit of the study area is the eastern side of shoal "C", an offshore shoal about 19 km (12 miles) east of Assateague Island. The northern and southern limits are the Maryland boundaries with Delaware and Virginia, respectively.

On the sea floor lie several large sand shoals that are oriented southwest/northeast. Some of these shoals are being considered as the source of borrow material for beach replenishment at Assateague Island. The sea floor is otherwise largely flat, except in the vicinity of the Ocean City Inlet, where there is an additional shoal known as the ebb shoal at the inlet entrance. The inlet connects the waters of the bays and the ocean and provides a pathway for the waters to mix. Assateague and Fenwick Islands form the Maryland shoreline; although Assateague is an island, Fenwick is actually a spit. Assateague itself is undeveloped and is preserved as open space under the administration of the National Park Service, Fish and Wildlife Service, and the State of Maryland. Fenwick, however, is fully developed as a tourist resort, and contains the town of Ocean City. The two "islands" serve to enclose and protect the coastal bays. The bays are shallow and are bordered on their margins by salt marshes and residential developments. The mainland of the study area has residential development in close proximity to Ocean City and the coastal bays, but is otherwise largely rural, consisting of farms and forest.

An understanding of the natural and human environment of the study area is important to identify and evaluate the problems affecting the area. To that end, this section provides a general overview of the entire study area but focuses in greater depth on the physical environment and biological resources of Assateague Island and the offshore shoals.

This report was compiled using existing information, contacts with scientists and resource agency personnel, and recent research of the Corps of Engineers Coastal Engineering Research Center (CERC). A list of the written references used can be found in Annex F. The CERC reports and some of the records of personal contacts can be found in Appendix A.

2.1 PHYSICAL ENVIRONMENT

2.1.1 Surficial Geology and Sedimentary Processes

Worcester County lies within the coastal plain physiographic province. Unconsolidated sediments consisting of gravel, silt, clay, sand, and shell fragments underlie the entire study area.

This section includes descriptions of the sediment characterizing the study area, as well as how that sediment is moved and how it came to be where it is.

2.1.1.a Sea floor (Including Offshore Shoals Borrow Area)

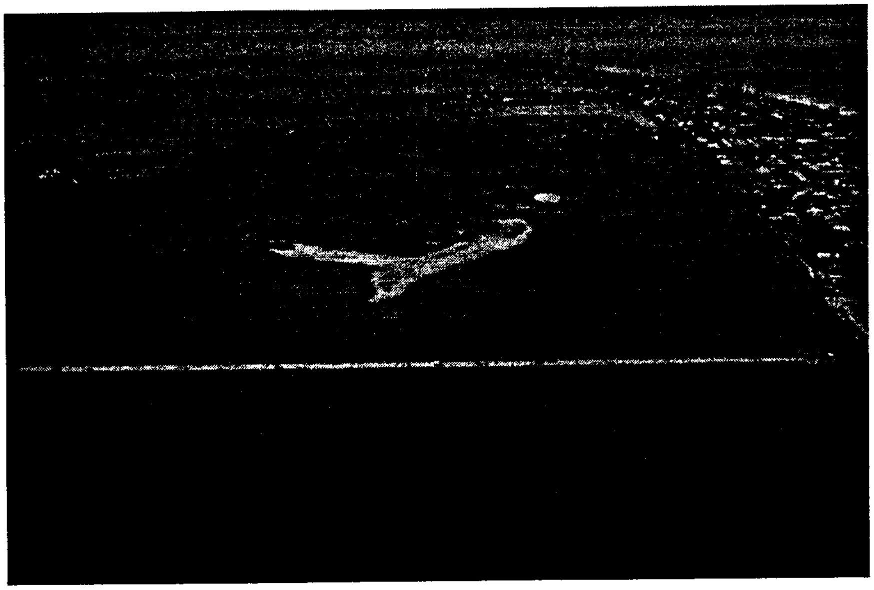
The dominant sea floor sediment type on the continental shelf in the study area is fine to coarse, well-sorted quartz sand. This sediment type is less abundant in the subsurface. The surface sand overlies poorly sorted, very fine to fine sand and mud that is locally exposed at the sea floor surface. The surficial sands of the sea floor are reworked sediments that were originally deposited in stream, bay, barrier island, and shoreface environments. Sand contained in the offshore shoals is generally well-sorted, medium sand. Sediments underlying the offshore shoals are variable, but are often mud and poorly sorted fine sand. Aside from the offshore shoals, sand deposits on the sea floor are generally too thin or of too fine a grain size to use for beach fill purposes.

New submarine shoals form over geologic time on the seaward side of the barrier islands and become isolated as sea level rises and the island retreats. Waves may scour the sea floor to a maximum typical depth of about 9 m (30 feet); this area of the ocean bottom vulnerable to wave scour is known as the shoreface. Waves and currents continue to modify the shoals after their formation. As a result, the shoals are dynamic, and migrate at rates that range from 2 to 120 m (6.5 to 400 feet) per year. Ridges on the shoreface are the most active, and are more vulnerable to wave and current action.

2.1.1.b Inlet

Inlet bottom sediment patterns result from the complex interaction of inlet currents with bay and ocean waves. Sediments in the inlet generally consist of coarse-grained sand due to tides and currents scouring away finer-grained sediments. Sediment carried into the coastal bays by the flood-tide accumulates in the back bays near the inlet in deposits known as flood-tidal shoals or deltas. The islands near the Route 50 bridge west of Ocean City formed by this process (Figure 2-1). Sediment has also accumulated on the seaward side of the inlet; this is known as an ebb-tidal delta or shoal. Inlets typically form during storm events, as did the Ocean City Inlet in 1933. Inlets can form either from the ocean or the bay side of an island. Physical factors such as width and height of the island, magnitude and duration of the storm, depth and size of the back bay, and number of existing inlets determines vulnerability of a barrier island to breaching. Once formed, these inlets typically migrate in a southerly direction for a period of time, and eventually shoal in and close. Without intervention from man, inlets on Fenwick and Assateague Island would open and close naturally in a cycle taking from several years to decades to complete.

Figure 2-1: Formation of Skimmer Island



2.1.1.c Assateague Island

Natural barrier island morphology is the result of a variety of depositional and erosional processes. Major sedimentary environments that can occur on barrier islands proceeding from ocean to bay include the beach, dunes, barrier flats and washover fans, salt marshes, and tidal flats. Figure 2-2 shows a typical cross-section of a barrier island. Figure 2-3 shows a cross-section of a barrier island that experiences frequent overwashes, as does Northern Assateague Island. Northern Assateague Island is sediment-starved, and as a consequence, barrier flats, washover fans, and tidal flats are disproportionately represented at the expense of dunes and salt marsh. The beach can be subdivided into the foreshore and backshore. The foreshore is intertidal and is the termination point for most wave energy. The backshore is transitional between the beach and dunes and is the main site of wave dissipation during storms, but is also an important site of wind removal of beach material. Within the backshore occurs a low terrace feature(s) known as the berm. The berm is formed by sand thrown up and deposited by storm waves. Proceeding landward, the beach grades into dunes, although dunes may not exist in all cases. Dunes are accumulations of wind-blown sand often stabilized by vegetation. On Assateague Island, the prevailing winds capable of forming dunes cause a net transport of sand offshore into the ocean. Under these conditions, only low and open dunes naturally form. Where dunes are present, the dune zone may extend to the intertidal zone on the bayshore or it may grade into a region of barrier flats. These flats are located on the lagoonal side of barrier islands. On Assateague, barrier flats form in areas where dunes are destroyed by overwash and where washover fans coalesce.

Figure 2-2: Cross Section of a Typical Barrier Island

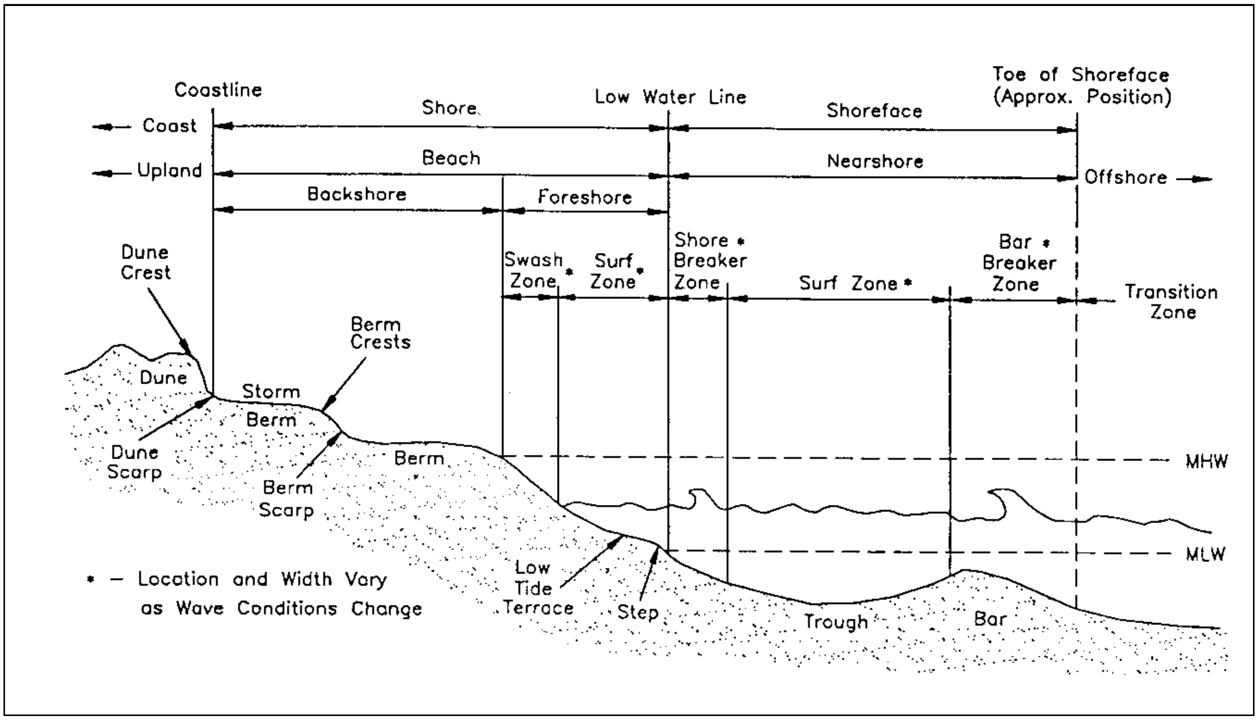
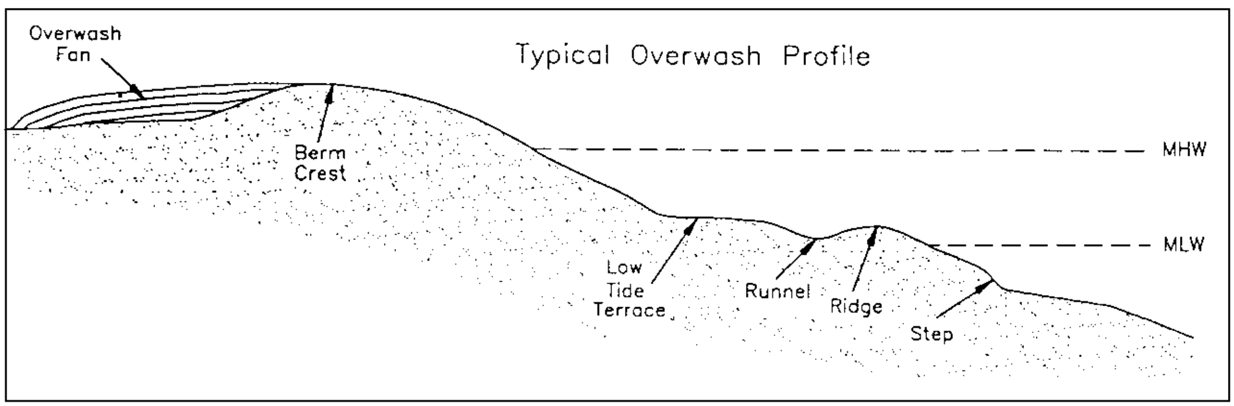


Figure 2-3: Cross Section of Overwash Island



Overwash occurs when storm waves cross the island; it is the means by which sand is deposited above the high tide line. Overwash frequency depends on many factors, including storm frequency and island elevation. On barrier islands, the frequency of overwash at any point typically decreases both with increasing distance from the beach face and with increasing elevation. In areas such as Assateague, where the tidal range is 1 m or less and storm frequency is high, overwash would be a regular event even if inlet stabilization had not occurred. However, prior to inlet stabilization, the height of the island was somewhat greater, and overwash events rarely reached across the island to the bayside. On northern Assateague, from 3 to 10 km south of the inlet, overwash now occurs as many as 20 or more times per year and frequently extends to the bayshore. Overwash maintains the island's width on the northern end within a relatively constant range as the island retreats.

Prevailing waves produce a southerly current along the Maryland shoreline. This current of water transports sand in a southerly direction in what is known as the longshore transport system, which formed Assateague and Fenwick Islands. These barrier islands were formed by spit growth from sand transported southward from coastal headlands located near Bethany Beach, Delaware, over the last several thousand years. Prior to inlet stabilization, a constant flow of sediment was available to Assateague. Construction of the Ocean City jetties in the 1930's interrupted the southerly flow of sediment and induced sediment starvation of Assateague.

Along the U.S. coast, barriers are migrating landward as sea-level rises. Sea level is currently rising at a rate in excess of 3 mm (0.12 inches) per year (0.3 m [1 foot] per 100 years) in Maryland. This rate of rise could increase substantially if predicted global warming occurs. Barrier landward migration is achieved during storm conditions by inlet dynamics and overwash events. When a new inlet forms, large quantities of sand are carried into the back bays. When this inlet finally closes over time, new salt marshes form on the deposits. Barriers can retreat as a unit landward over the top of salt marsh and back bay deposits, and can retain a somewhat constant sediment volume. However, if the sediment supply is cut off, or if the rate of sea-level rise increases too much, the systematic retreat of a barrier island unit can be jeopardized. Northern Assateague was erosional and was losing sediment volume because of local physical environment conditions and groins at Ocean City even prior to jetty construction; however, the jetties greatly increased the rate of sediment loss (see Appendix A).

2.1.1.d Coastal Bays

Bottom sediments in the coastal bays generally become coarser in an easterly direction across the bays. These sediments include, from most to least coarse, sand, sand/silt, silt, and clay. Sand occurs adjacent to Assateague and Fenwick Islands in inlet deltas, washover deposits, and tidal channel point bars. Deposits from the middle of the bay are silty, and a sand/silt mix occurs along the western shore. Clays occur in low energy areas of the tidal tributaries on the western shore.

The coastal bays are a depositional environment. Sand is transported into the bays through the inlet by tidal processes and from Fenwick and Assateague Islands by washover or wind. Beach nourishment at Ocean City has increased the supply of sand available for deposition in the coastal bays. Reworking and redeposition of sediments from geologic formations underlying the coastal bays and from shoreline erosion also provide a major source of sediment for the coastal bays. Streams draining from the mainland deposit sediment in the bays; however, the sediment yield is low, and in Chincoteague Bay is only about one-tenth that derived from Assateague.

2.1.1.e Mainland

Sediments from modern and ancient barrier island and coastal bay environments comprise the mainland of the study area. These sediments were deposited at times of higher sea level over the last several million years. The ancient barriers are parallel to the modern shoreline and today serve to create areas of steeper slope and sandy soils. The town of Berlin lies on an ancient barrier island as does the West Ocean City area. Finer-grained silts and clays were deposited in ancient back-bay environments. Organic-rich swamp deposits occur in areas of extant and historic wetlands south of Berlin and in the northwesternmost part of the study area. These deposits date back to only about the last 10,000 years.

2.1.2 Soils

Soils are classified into series according to their properties. Soil series typically occur in distinct patterns on the landscape known as associations. The soil series and associations found in an area are important because they influence what flora and fauna can utilize the area. Five soil associations occur in the coastal bays watershed: Fallsington-Woodstown-Sassafras, Mattapex-Matapeake-Othello, Othello-Fallsington-Portsmouth, Pocomoke-Rutlege-Plummer, and tidal marsh-coastal. All of Assateague Island, Fenwick Island, and portions of the mainland shoreline along the bays consist of the tidal marsh-coastal beaches association. These areas are predominantly level or nearly level and are subject to intermittent flooding by tidal water. Coastal beach soils consist largely of sand and typically have poor nutrient content and water-holding capacity. Tidal marsh soils consist of plant remains and mineral sediment; where exposed they are gray or black in color. These soils are saline to brackish. The Fallsington-Woodstown-Sassafras soil association is located west of the mainland tidal marsh-coastal beach soil association. This association is found on the level to steep fields and wooded areas throughout the eastern portion of mainland Worcester County, totaling 40 percent of the county. The soils are primarily sand and fine sand, containing moderate amounts of clay and silt. The surface layer in these areas is generally sandy loam. Soils of the Mattapex-Matapeake-Othello Association include deep well-drained soils that have a high capacity to hold plant nutrients and moisture. They occur over limited areas in the vicinity of Berlin and South Point. Several soil types within the Matapeake, Mattapex, Sassafras, and Woodstown Series are classified as prime farmland in recognition of their importance to agriculture (see Appendix A for list of prime farmland soils).

Hydric soils are soils that are saturated, flooded, or ponded for long enough during the growing season to develop anaerobic conditions in the upper part. Hydric soils are soils that in undrained conditions can support wetlands vegetation. All the soil associations of the study area contain potential hydric soil series. Potential hydric soil series of the study area include Elkton, Fallsington, Othello, Plummer, Pocomoke, Portsmouth, Rutlege, and tidal marsh. Approximately 60 percent of the coastal bays watershed within Worcester County possesses potentially hydric soils. Information on drainage of wetlands will be included in subsequent reports. The actual acreage of soils recognized as hydric is much lower, however, as a substantial proportion of the watershed has been drained for agriculture.

2.1.3 Physiography and Topography

2.1.3.a Assateague Island

The ocean shoreline of Fenwick and Assateague Islands is gently curving, while the bayside shoreline is scalloped and lobate, with ocean waves and currents maintaining the smooth ocean shoreline. Islands and lobes on the bayside of the barriers mark the location of relict tidal inlets and past washover events. Assateague Island is naturally much narrower at its northern end than at its southern end. Over the island's 61-km (38 miles) length it ranges in width from about 270 m (900 feet) at the northern end to about 1.6 km (1 miles) near the Virginia border. This configuration appears to occur as a result of systematic distribution of offshore steepness and curvature, and resultant distribution of wave energy. Berm elevations on the island are controlled by tides and waves, and range from 2.3 to 2.8 m (8 feet to 9 feet) above the 1929 National Geodetic Vertical Datum (NGVD)[1]; maximum elevations on northern Assateague occur on dredged material deposited by the Corps prior to the 1970's. Historically, the ocean side of Assateague and Fenwick Islands was fringed by a series of low and comparatively stable dunes. Historic photos suggest that dune relief may have exceeded 1.5 m (5 feet), and therefore, maximum dune elevation may have been about 4 to 4.5 m (13 feet to 15 feet) (NGVD). Since that time, Assateague's topography has been impacted both by accelerated retreat and by dune-building. Beginning in the 1930's, extensive artificial dunes were built and later planted along much of the U.S. Atlantic Coast, possibly including portions of Assateague Island. The Corps of Engineers erected sand fence to build dunes on northern Assateague in 1962. The National Park Service built dunes on Assateague in the late 1960's and possibly into the 1970's. However, dunes have not been maintained since that time, and sediment starvation has almost completely decimated both constructed and natural dunes from 3 km to 10 km south of the inlet on northern Assateague Island. See Appendix A2 for a chronology of engineering efforts on Assateague Island.

2.1.3.b Coastal Bays Mainland

The Worcester County mainland is characterized by low relief, and the gradient is typically only 0.9 to 1.9 m per km (5 to 10 feet per miles). The low relief landscape promotes waterlogging of the soil in a large proportion of the landscape. The county contains terraces, stream channels, drowned valleys, basin-like depressions, remnant dunes, swamps, and marshes. The highest elevation in the study area is about 18 m (45 feet) above sea level in the vicinity of Berlin.

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[1] The National Geodetic Vertical Datum was developed in 1929 by estimating mean sea level at 29 sites along the North American coast for the preceeding two decades. Zero elevation equals mean sea level at those sites in 1929. Sea level has risen by approximately 0.2 m (8 inches) along the Maryland coastline since that time. Thus, a site with an elevation of 0.2 m NGVD is at about today's mean sea level.

2.1.4 Bathymetry

2.1.4.a Seafloor and Offshore Shoals Borrow Area

Within the study area, water depths reach a maximum of about 23 m (75 feet) in the Atlantic Ocean, and shallow proceeding landward. The major bathymetric features of the seafloor on the Maryland inner continental shelf are a pervasive topography of swales and oblong-shaped ridges (offshore shoals) (Figure 1-2). These occur on the seafloor both within and outside of the study area boundaries. While each shoal is somewhat unique they share many common features. Within study area waters, the offshore shoals crest at 4.5 to 11 m (15 feet to 35 feet) in height above the adjacent seafloor. The offshore shoals in the study area range in length from 3.2 to 8 km (2 miles to 5 miles), and in width from 1.6 to 2.5 km (1 miles to 2 miles). Side slopes are gentle and range from about 0.2° to 7.0°. The seaward flank is steeper than the landward flank. The offshore shoals have a predominant northeast orientation. For this study, Shoal B, Shoal C, Little Gull Bank, and Great Gull Bank were investigated as sand sources for the restoration of Assateague Island (see Appendix B for additional information). Of these shoals, Great Gull Bank is of particular interest to the study. Water depths at Great Gull Bank range from 5.8 m (19 feet) on the crest to 9.2 m (30 feet) in adjacent waters.

2.1.4.b Inlet and Coastal Bays

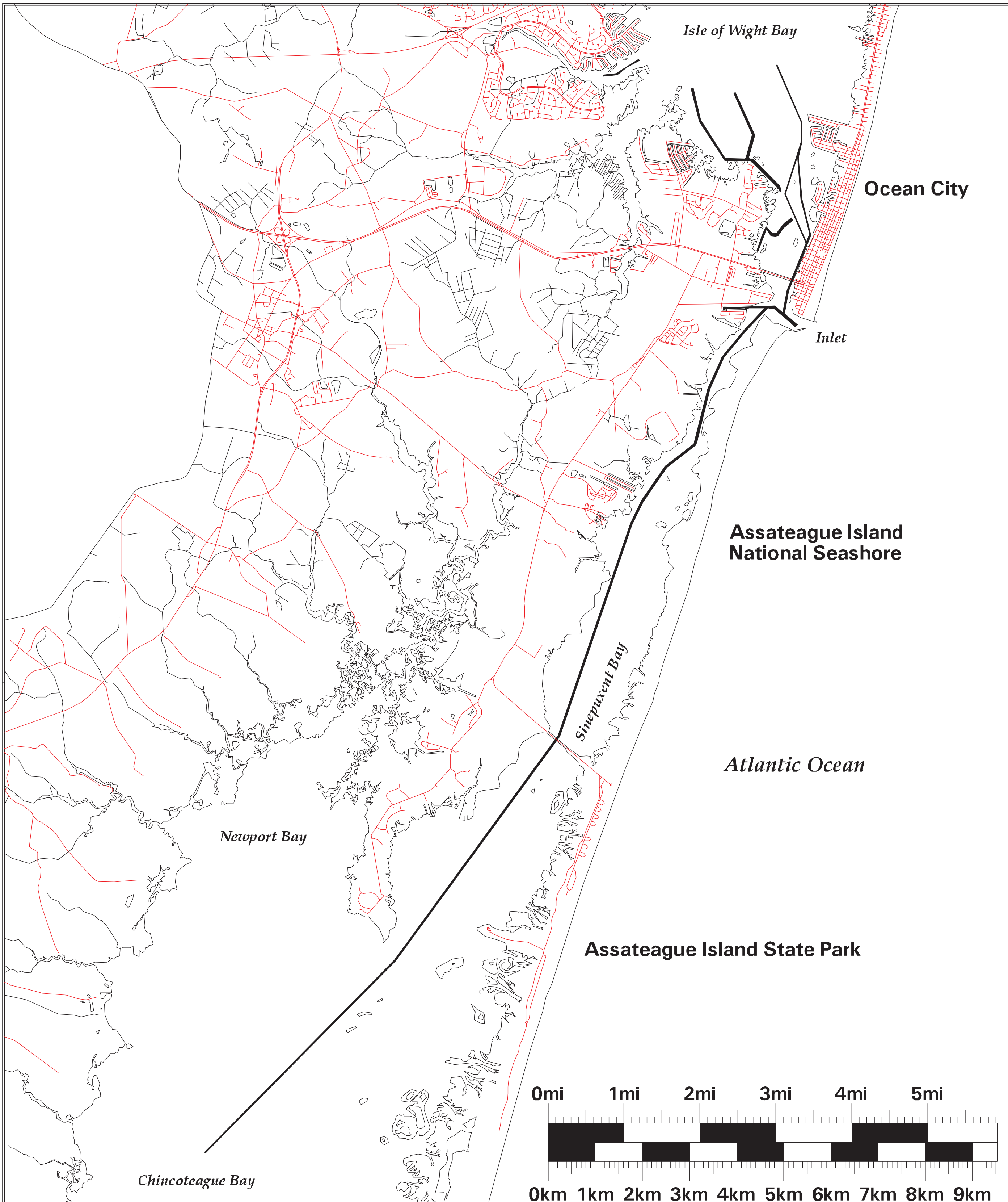
In the inlet throat, a large portion of the channel floor is deeply scoured by the large volume of water transferred during the short duration of the semi-diurnal tides; water depths within the inlet throat locally exceed 7 m (23 feet). The inlet connects to a series of maintained navigation channels in the coastal bays (Figure 2-4), and a portion of the inlet is maintained by dredging for navigation purposes. The navigation channels are discussed in Section 2.8.3. Deeper water also occurs locally in the coastal bays in areas dredged to provide sediment for emergency beach replenishment of Fenwick and Assateague Islands in 1962. Residual holes from that operation are still as deep as 5 to 10 m (16 to 33 feet). Otherwise, water depths in the coastal bays are generally very shallow, with the majority of the bays ranging from 0 to 2 m (0 feet to 7 feet) in depth with average depths of 0.7 to 1.2 m (2.3 to 4 feet).

2.1.5 Hydrology

In this section, a characterization of the salinity, temperature, and movements of the waters of the ocean and bay waters of the study area is provided. The ocean and bay waters of the study area have a semidiurnal tide, which means two high and two low waters occur each day.

2.1.5.a Atlantic Ocean and Offshore Shoals Borrow Area

The mean astronomical tidal range in the ocean waters of the study area is approximately 1 m (3.3 feet). The salinity ranges from about 30 to 33 parts per thousand (ppt). In areas of greater water depth, there may often be a slightly higher salinity on the bottom compared to the surface. Ocean water temperatures generally reach a minimum of about 3° to 5°C (37° to 41°F) in late



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Navigation Channels

Existing Channels

Figure 2-4

February or early March. Homogeneous temperatures characterize the entire water column at that time of year. Continental shelf waters undergo progressive thermal stratification from spring through summer, when the thermocline reaches a depth of 9 (30 feet) to 12 m (39 feet). At coastal locations within the 20 m (66 feet) contour, the stratification is somewhat less intense as the shallower depths permit some turbulent mixing through the water column. Surface water temperatures in the ocean reach a maximum during August and early September of about 21°C (70° F), and rarely exceed 23°C (73° F). Bottom waters below the thermocline are somewhat cooler at this time by up to approximately 10°C (18° F). In autumn, the water column becomes increasingly equalized from the surface downward as it cools. The water circulation in this region of the inner continental shelf is characterized by a general southward movement of the surface and bottom water throughout the year. However, from April to September, the surface water movement may periodically reverse and move northward in association with low spring runoff and the prevalence of south winds.

Waves incident from the west have limited impact on the study area, whereas waves incident from the east are capable of moving sand both alongshore and offshore, influencing both the shape of the shoreline and the beach profile. Waves occur much more frequently from the southeast quadrant than they do from the northeast; however, the waves from the northeast tend to be higher. The predominate southerly littoral drift along this segment of coast is a result of waves from the northeast and east quadrant. The average measured wave height off Ocean City is 0.7 m (2.3 feet). Average wave heights vary seasonally: the lowest monthly average wave occurs in July and August; the maximum monthly average wave height occurs in December, January, and February. The largest measured wave was 4.4 m (14 feet); this occurred during the January 1992 storm. Although not directly measured, hindcasts have determined that wave heights reached 7.5 m (19 feet) during the March 1962 northeaster. See Appendix A of this report for additional information.

2.1.5.b Coastal Bays

The Maryland coastal bays include five bays: Assawoman, Isle of Wight, Sinepuxent, Chincoteague, and Newport. The drainage area for the coastal bays is 45,246 ha (111,801 acres); the majority of this lies in Worcester County, but portions of the watershed also lie in southeastern Delaware and northeastern Virginia. Compared to other estuarine systems such as Chesapeake Bay, the drainage basin for the coastal bays is relatively small compared with the area of open water; the drainage area is only 2.2 times as large as the bay surface area. Freshwater is delivered to the coastal bays by precipitation and tributary streams. The larger streams within the Maryland portion of the watershed are the St. Martin River, Turville Creek, Herring Creek, and Marshall Creek. All tributaries originate in the eastern portion of Worcester County and flow predominantly in an easterly direction.

The tidal range within the coastal bays in the study area is dependent on proximity to the Ocean City Inlet. The mean neap and spring tide range is 1.1 m (3.6 feet) and 1.3 m (4.3 feet), respectively, at the Ocean City fishing pier. The tide attenuates along the coastal bays behind Fenwick and Assateague Islands proceeding away from the inlet. The mean neap and spring tide range at Isle of Wight Bay is 0.7 m (2.3 feet) and 0.8 m (2.6 feet), respectively. At the northern end of Assawoman Bay, the mean tide range is about 0.3 m (1 feet). The mean tide range reaches a minimum of 0.1 m (0.3 feet) in Chincoteague Bay at Public Landing. Due to the low tidal range the coastal bays possess a relatively constant water surface area at the full range of tide. Along the western margins of the bays wind conditions have a greater effect on water levels than do the astronomical tides.

Ocean City Inlet and Chincoteague Inlet are the primary sources of saltwater within the coastal bays, although limited input from overwash also occurs. High salinities of 25 to 32 ppt prevail throughout much of the coastal bays. Salinity generally decreases with distance from the inlets. However, hypersaline conditions may exist during late summer and early autumn due to low freshwater flows and evaporation. Prior to the opening and stabilizing of the Ocean City Inlet, low salinity conditions prevailed in the coastal bays. Shreve and others (1910) noted that "the water of the great lagoon of Worcester County is brackish only in its lower half, becoming fresh on passing north of Ricks Point into Newport, Sinepuxent, Isle of Wight, and Assawoman Bays."

Water temperatures in Chincoteague Bay range from about 0°C (32°F) to 29°C (84°F) during the year, with an average annual water temperature of about 13°C (56° F). Temperature averages for the upper bays are similar, except that temperatures in the tidal tributaries in summer can exceed 32°C (90° F).

Circulation patterns and currents within the coastal bays are dependent on proximity to the Ocean City Inlet and wind conditions. Approximately 85 percent of the tidal prism entering Ocean City Inlet goes north into Isle of Wight and Assawoman Bays, while the remaining 15 percent enters Sinepuxent and Chincoteague Bays. Near the inlet, currents are produced by movement of tidal waters. Currents in excess of 5.8 mph (9.3 km/hr or 5 knots) occur near the inlet, but drop off rapidly moving away form the inlet. Shallow water depths through most of the coastal bays promote thorough vertical mixing of the water column.

2.1.6 Climate

Worcester County has a humid continental climate modified by its nearness to the Atlantic Ocean and Chesapeake Bay. The general atmospheric flow is from west to east. However, alternating pressure systems create variability in weather patterns. Average annual precipitation at Ocean City is 124 cm (49 inches), with about 25 cm (10 inches) of snow occurring annually. Heavy precipitation occurs mostly in the warmer portion of the year from thunderstorm activity. Droughts can occur throughout the year, but are most likely during the summer months. The prevailing winds are from the west to northwest, except during the summer months, when they are southerly. Winds from the northeast, east, and southeast quadrants occur one-fifth of the time. Direct onshore winds can elevate nearshore waves and coastal water levels during storm events, increasing storm damages. Winds from the east and northeast tend to be of the highest magnitude. The average annual temperature at Ocean City is 14°C (57°F). Air temperatures over the coastal ocean typically run 1° to 3°C (5° to 10° F) cooler than temperatures on the coast.

Most coastal storms causing erosion and other damage in the study area are northeasters. These storms can produce damaging storm waves for a duration of up to several days; they occur most frequently between December and April. Hurricanes and tropical storms also impact the study area, although less frequently. Ocean City has been hit by a number of these major storms this century, including hurricanes in 1902 and 1933, the Ash Wednesday 1962 northeaster, the Halloween 1991 northeaster, the January 4, 1992 Northeaster, and the December 1992 northeaster. The winds and waves during the 1933 hurricane were estimated at 160 km/hr (100 mph) and 6 m (20 feet), respectively. The 1962 northeaster caused the greatest storm damage to Ocean City: water covered Fenwick Island for two days at depths of up to 2.4 m (8 feet).

2.2 AIR QUALITY

Maryland is divided into six air quality control areas. The coastal bays and Worcester County are contained in the Eastern Shore area. Ambient air quality is determined by measuring the ambient pollutant concentrations of particulate matter, carbon monoxide, sulfur dioxide, nitrogen dioxide, lead, and ozone, and comparing the concentration to the corresponding standards as determined by the U.S. Environmental Protection Agency. Analysis of the 1994 data from the monitoring station nearest to the coastal bays in Salisbury, Wicomico County, determined that the area is within the level of acceptable ambient air pollution and, therefore, does not have an air quality concern.

2.3 WATER QUALITY

<u>2.3.1 Surface Water</u>

2.3.1.a Atlantic Ocean and Offshore Shoals Borrow Area

No significant water quality problems have been reported from the study area's ocean waters. The State of Maryland has designated all of its coastal waters (i.e., to the 3-mile limit) as Use II, shellfish harvesting waters. No water quality impacts that would threaten this designation have been reported. However, there is an area off 64th Street in Ocean City where shellfish harvesting is prohibited as a precautionary measure due to the discharge of the city's wastewater treatment plant. The restricted area encompasses the oceanside waters between 55th Street and 73rd Street, and extends offshore for 1.5 miles.

2.3.1.b Coastal Bays

Overall water quality in the open water areas of the coastal bays is reasonably good. Water quality problems do occur, however, in a number of the tidal tributaries and in the artificial lagoons. St. Martins River, Newport Bay, Taylorsville Creek, Turrville Creek, ***Trappe Creek***, and Herring Creek are degraded by non-point source pollutants originating primarily from agriculture. These pollutants enter as surface water runoff and groundwater seepage. Concerns about the level of fecal coliform prohibit shellfishing in St. Martins River, Turrville Creek, and Herring Creek. Water quality in manmade canals and lagoons is degraded because of poor circulation. The coastal bays have low flushing rate. This increases the susceptibility of the coastal bays to pollution; shallow depths and strong vertical mixing moderate pollution impacts.

2.3.2 Groundwater

A mutli-layered aquifer system capable of providing large groundwater supplies underlies the study area coast. Overpumping at Ocean City may be inducing saltwater intrusion from the freshwater/salt water mixing zone and from saline water in the deeper parts of the aquifers. The surficial aquifer in the watersheds of the northern coastal bays is probably polluted by agricultural input.

2.4 BIOLOGICAL RESOURCES

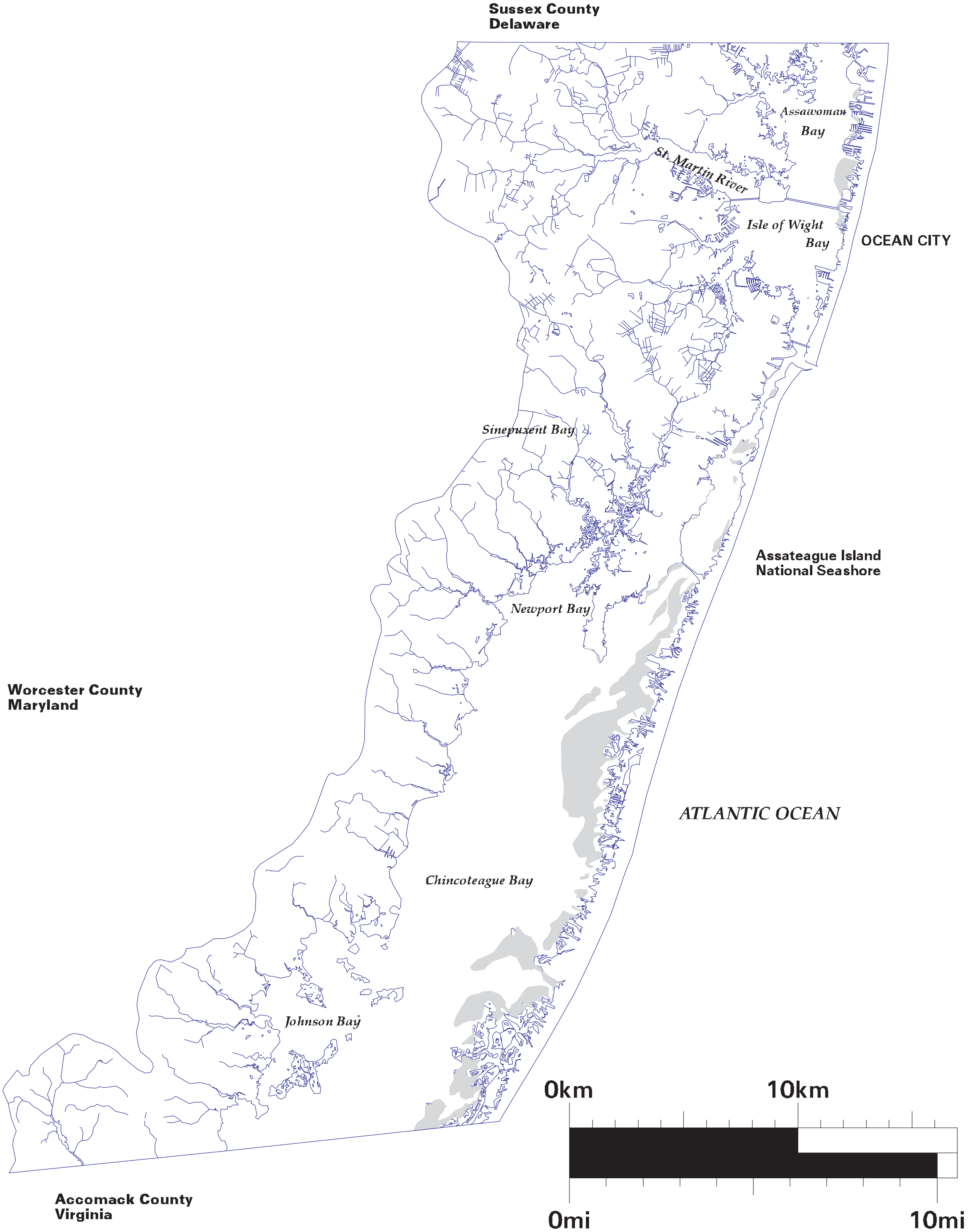
The study area is a composite of ecosystems -- marine, estuarine, terrestrial, and, to a minor extent, freshwater aquatic. Although distinct, the ecologies of these ecosystems are interlinked, and changes in the physical environment or biota of one ecosystem can have a profound impact on the other ecosystems of the study area. They support a diverse assemblage of biological resources.

2.4.1 Plant Communities

The plant communities within the watershed of the coastal bays vary from the lush beds of submerged aquatic vegetation in Chincoteague Bay, to sparse vegetation found on the beaches and dunes of Assateague Island, to the grassland salt marshes on the bay shoreline, to upland and wetland forests on the mainland. Agriculture, forestry, and settlement have substantially impacted wetland and upland vegetation throughout the entire area, however, about half of the watershed is in natural vegetative cover (see Section 2.8.1 for additional information). Important factors controlling the distribution of natural vegetation include land-use history, water availability, and soils. The study area is notable as an area in which many southern upland and wetland plant species occur at or near the northern limit of their ranges. Of particular interest to this report is vegetation found on Assateague Island.

2.4.1.a Submerged Aquatic Vegetation (SAV)

The coastal bays region is the only coastal lagoon system in the mid-Atlantic from Barnegat Bay, New Jersey, to the Albemarle-Pamlico Sound, North Carolina, to have extensive beds of SAV. Two species of SAV have been observed in the coastal bays: eelgrass (*Zostera marina*), which predominates in the deeper subtidal areas greater than 0.6 m (2 feet); and widgeon grass (*Ruppia maritima*), which predominates in shallower subtidal areas to mean low water (MLW). SAV provides a critical food source and nursery ground within the aquatic community for many estuarine organisms. SAV is abundant in Chincoteague Bay, particularly along the western shore of Assateague Island (Figure 2-5). Only limited areas of SAV are noted to occur in the northern coastal bays along the lee of Fenwick Island. Water quality presumably limits the occurrence of SAV in the northern coastal bays.



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Submerged Aquatic Vegetation

Historic and Current SAV Locations

Figure 2-5

2.4.1.b Wetlands

Tidal and non-tidal wetlands occur in the coastal bays watershed. Approximately 16,600 acres of salt marsh occur on the shoreline of the coastal bays. The majority of this is concentrated along the Chincoteague Bay shoreline, including the bayside of Assateague Island. Approximately 2,500 acres of the total salt marsh acreage occurs in the northern coastal bays. Approximately 5,300 acres of forested wetlands occur on the mainland. Prior to extensive development in the region, approximately 4,500 acres of salt marsh historically occurred in the northern bays. Prior to extensive ditching for agriculture, approximately 56,300 acres of forested wetlands may have historically occurred in the watershed of the coastal bays. Additional information on historical wetlands and wetlands losses will be included in a subsequent report.

An important factor controlling the distribution of tidal wetlands vegetation is salinity. The majority of the tidal waters of the coastal bays are brackish. Tidal wetlands that occur where salinities are brackish (0.5 to 30 ppt) include salt and brackish marshes and scrub-shrub wetlands. Tidal marshes perform numerous beneficial functions; these include storm protection and erosion-control for the mainland, nurseries for commercial fisheries species, wildlife habitat, food chain support, nutrient source/sink, and water quality maintenance. The magnitude of the beneficial functions performed by these ecosystems is in large part dependent upon their spatial coverage.

Nontidal wetlands in the study area are predominantly in forest and shrub cover. Non-tidal wetlands possess many important functions, including the ability to sequester and transform pollutants, ameliorate agricultural runoff, provide plant and wildlife habitat, and regulate nutrient exchange between terrestrial and aquatic ecosystems.

Assateague Island

Large salt marshes occur on the bayside of Assateague and on bay islands in areas that breached and healed in the past from the state park south. Prior to the formation and stabilization of the Ocean City Inlet, salt and fresh tidal marsh occurred on the bayside along much of the length of Assateague and Fenwick Islands. Since the jetties were constructed, accelerated retreat and overwash has destroyed the majority of the salt marsh that formerly occurred on the northern end, and only limited areas of salt marsh occur in that area today. Within the northern end of the island from 3 to 10 km south of the inlet occur a number of non-vegetated or sparsely vegetated wetlands on the flats of the bayside and island interior. These areas provide habitat for invertebrate species which in turn provide food for shorebirds and waterbirds. From the state park southward the island also possesses fresh marsh and woodland wetlands in interior areas of the island, in swales between dunes, and in association with ponds. For additional information on the flora of Assateague see Annex A, Part 3.

Coastal Bays Mainland

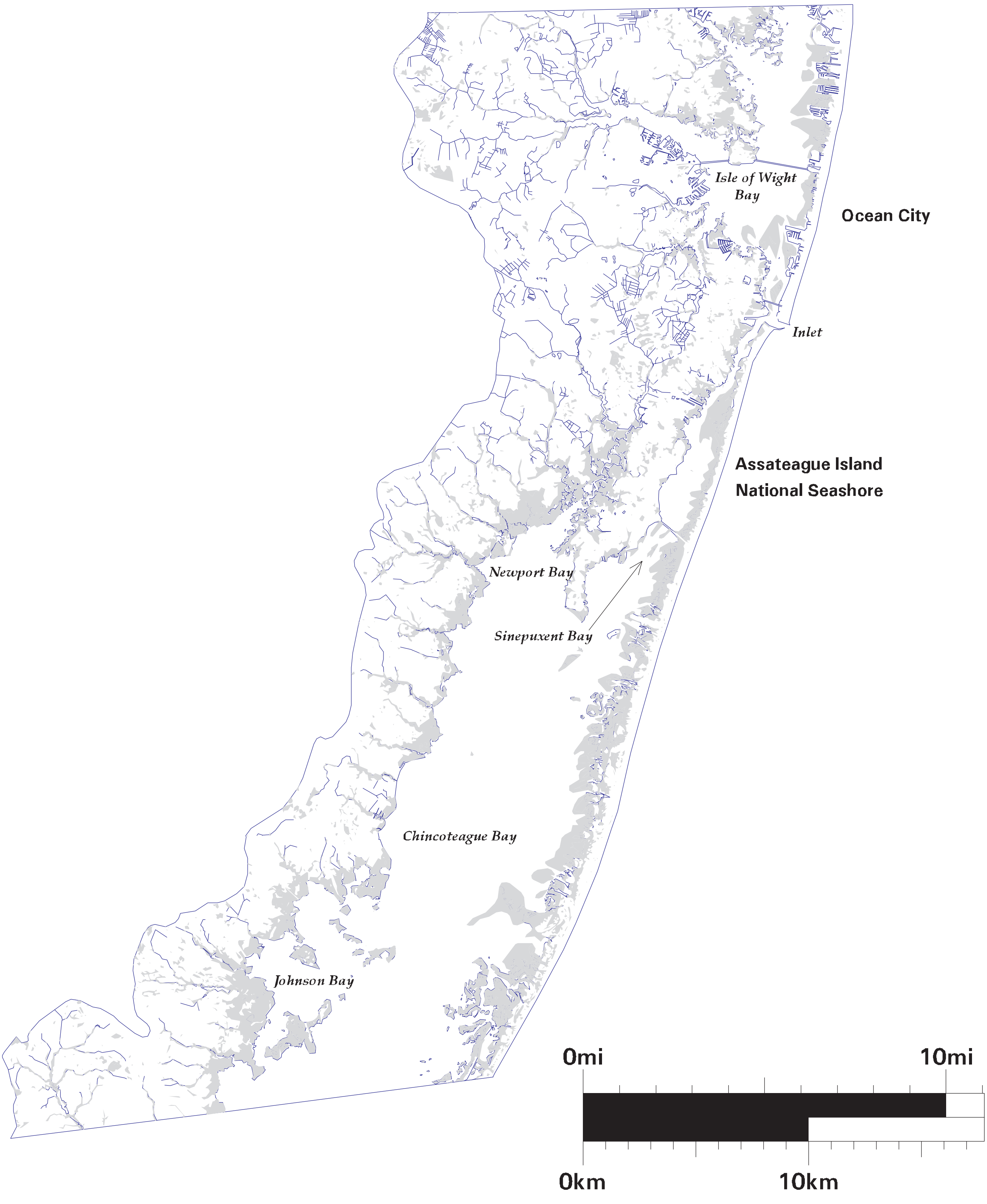
Salt and brackish marshes occur on the mainland shoreline, on bay islands, and along tidal tributaries. Minor areas of tidal forested wetlands occur along the lower reaches of tributary streams. Tidal forest can occur when salinity is less than about 1 or 2 ppt. Nontidal wetlands occur on the mainland above the influence of the tides in broad flat areas and depressions between streams, along streams and valleys, and associated with mill and farm ponds (see Figure 2-6). Non-tidal wetlands in the study area are dominated by temporarily flooded and seasonally-saturated forested wetlands in various successional stages. Existing wetland forest vegetation in the coastal bays watershed is dominated by two major associations: swamp chestnut oak - loblolly pine; and willow oak - loblolly pine. The latter association also occurs on upland habitats. Small areas of wetland forests of the river birch - sycamore, and bald cypress associations occur along streams within the watershed. Non-tidal wetlands possessing vegetation dominated by herbaceous plants and shrubs also occur. These latter wetlands occur along constructed ponds, recently distrubed forested wetland areas, landward of salt marshes, and rarely in one particularly significant natural setting: on the margins of the coastal bays where groundwater seeps out from adjacent higher terrestrial areas. These latter communities are known as coastal fens, and possess notable concentrations of state-rare plant species. Additional information on mainland flora can be found in Annex A, Part 3.

2.4.1.c Upland Habitats

Assateague Island

Factors controlling distribution of barrier island vegetation include soil moisture and quality, climate, salt spray, sand movement by wind, and changes in barrier island geomorphology resulting from overwash and erosion. Of particular importance to this study is overwash. ***Overwash is a natural process, and barrier island vegetation, in general, accommodates this process. However, overwash can also disturb such vegetation, especially during major storm events. The process can move substantial amounts of sand and can deposit up to several centimeters of sand on plants; this can kill or injure plants, and can bury seeds to a depth from which they can't germinate. Saltwater inundation resulting from overwash is also a cause of plant mortality, particularly for woody plants.***

Three general zones of upland vegetation occur on Assateague Island: dune grassland, shrubs, and woodland. Additional information on the vegetative zones of Assateague is included in Annex A, Part 3. Much of the northern end of Assateague from 3 km to 10 km south of the inlet is unvegetated due to the high frequency of overwash events; however, the dune grassland zone is sporadically represented in the area. Shrub zone vegetation occurs in the northernmost 2.5 km of the island and south of 10 km. ***The northern end of*** Assateague was historically dominated by dune grassland vegetation, and possessed minimal woodland areas. Assateague Island's vegetation was substantially impacted by grazing of domestic animals from the 1800's through perhaps as late as the 1940's. Feral animals derived from domestic stock also have had a substantial impact on island vegetation, including the island's famous ponies which continue to be a major factor influencing vegetation.



US Army Corps of Engineers
Baltimore District

Ocean City Water Resources Feasibility Study

Wetlands

Emergent and Palustrine Wetlands

Figure 2.6

Coastal Bays Mainland

Old fields and thickets are common on abandoned farmland, and on road sides and forest edges. Existing upland forests are dominated by successional forests of the willow oak - loblolly pine association. Minor areas of the chestnut oak - post oak - blackjack oak forest association also occur. Additional information on mainland flora can be found in Annex A, Part 3.

2.4.2 Animals

2.4.2.a Benthos

Benthos are bottom-dwelling organisms of aquatic ecosystems. Plants also dwell on the bottom; however, since plants are discussed previously in Section 2.4 they will not be included herein. Benthic macrofauna in marine and estuarine environments are an important food source for many fish species.

Offshore Shoal Borrow Area and Adjacent Seafloor

The sandy seafloor of the offshore shoals and intershoal flats and troughs of the study area ocean waters typically possesses a benthic community with similar numerical abundance, diversity, biomass, and community structure in water depths greater than 8 m (26 feet). Areas with water depths less than 8 m typically have lower benthic species richness than deeper waters.

The offshore shoals tend to possess lower numbers of benthic organisms, species, and biomass in relatively shallow areas (5.8 to 7.6 m) (19 to 25 feet) than in adjacent deeper intershoal areas (7.0 to 9.4 m) (23 to 31 feet). Swales adjacent to the shoals typically contain higher macroinvertebrate abundance, species richness, and biomass than do shoal ridges or flanks. The richer benthic fauna in the swales correlates with the presence of finer sediments and higher organic carbon content. The most common species of the offshore shoals in terms of frequency of occurrence are haustorid amphipods, isopods, bivalves, and polychaete worms (see the Planning Aid Report in Annex A for additional information). Benthic megafauna species occurring on the offshore shoals and adjacent seafloor include lobed moon snails (*Polinices duplicatus*), whelks (*Busycon* spp.), starfish, and various crabs and shrimp. Important commercial species include surf clam (*Spisula solidissima*), whelks/conchs, and horseshoe crabs (*Limulus polyphemus*).

Assateague Island Nearshore

Mollusc species likely to be found in the subtidal zone of the outer beach on Assateague Island include whelks and surf clam. Crabs likely to be found in the subtidal zone of the outer beach include lady crab (*Ovaliped ocellatus*) and horseshoe crab.

The nearshore benthic communities of Assateague Island are dominated by crustaceans such as mole crab (*Emerita talpoida*) and bay possum shrimp (*Neomysis americana*). Mole crab is also common in the intertidal zone. Common species of the upper beach include ghost crab (*Ocypode albicans*) and beach fleas (*Talorchestria* spp.) Additional information on the benthos of the nearshore on Assateague can be found in Annex A, Part 3.

Coastal Bays

Over 100 species of epibenthos and infauna have been identified in the coastal bays. Chincoteague Bay possesses a particularly diverse benthic assemblage. The St. Martins River and artificial canals possess significantly lower species richness than other areas of the bays. The coastal bays provide almost optimal hard-shell clam (*Mercenaria mercenaria*) habitat. In Chincoteague Bay, ribbed mussel (*Geukensia demissa*) dominates the intertidal zones. Mollusc abundance is highest in areas with salt marsh detritus derived from salt marsh and SAV. The coastal bays formerly supported large oyster beds; these beds fell victim to changes in the ecology of the bays accompanying increased salinity conditions resulting from stabilization of the Ocean City Inlet.

Hard-shell clamming yields are high and reliable for both commercial and recreational activities. Small and sporadic yields of soft-shell clam (*Mya arenaria*) also occur in the bays. Blue crab are caught commercially in the coastal bays, but harvests have declined since the 1950's.

Inlet

Benthic organism density, biomass, and species number are generally low in the vicinity of the inlet. The relatively low benthos development in the vicinity of the inlet appears to be due to the presence of a shifting sand bottom substrate associated with high current velocity conditions. In contrast, stable attachment substrate such as rocks, pilings, and other submerged structures are extensively colonized by epifaunal forms.

2.4.2.b Nekton

Nekton are organisms that possess the ability to swim. Nekton include finfish that are caught by commercial and recreational fishermen. Many of these species are important top to mid-level carnivores.

Offshore Shoals Borrow Area and Atlantic Ocean Waters

A wide variety of finfish are present in the ocean waters of the study area, but most of the fishes in the coastal area are seasonal migrants (see Annex A, Planning Aid Report for additional information). Winter is a time of low abundance, as most species leave the area for warmer waters offshore and southward. Spring brings a progressive influx of species that reach a peak in the fall. Spawning often takes place over relatively wide geographical areas. The production of pelagic eggs and larvae by most species further enhances the dispersal of the reproductive effort. As a consequence, the larvae of many species may occur in the vicinity of the borrow sites at different times of the year, but no species appears to concentrate a significant part of its spawning effort here.

There is substantial commercial fishing activity in the waters of the Atlantic Ocean. Important species caught include summer flounder (*Paralichthys dentatus*), dogfish, weakfish (*Cynoscion regalis*), and black sea bass *(Centropristis striata)*. Substantial recreational fishing also takes place in the vicinity of the shoals and fish havens. Commonly caught recreational species include sea bass, tautog *(Tautoga onitis)*, and triggerfish *(Balistes capriscus)*. It appears that some fish species are attracted to the elevated bottom profile and edges of the shoals. The fish havens benefit and attract structure-oriented species. Additional information on finfish of the offshore shoals is included in the Planning Aid Report in Annex A.

Assateague Island Nearshore Waters

Fish species caught by commercial vessels working off Maryland's Atlantic coast include clearnose skate *(Raja eglanteria)*, smooth dogfish *(Mustelus canis)*, weakfish, summer flounder, windowpane flounder *(Scopthalmus aquosus)*, butterfish (*Peprilus triacanthus*), northern kingfish (*Menticirrhus saxatilis*), Atlantic croaker *(Micropogonias undulatus)*, and striped searobin (*Prionotus evolans*).

Nekton of the nearshore must be able to tolerate the currents and turbidity associated with the surf. Bony fish likely to be found in the nearshore of Assateague Island include weakfish, bluefish (*Pomatomus saltatrix*), striped bass (*Morone saxatilis*), northern puffer (*Sphaeroides maculatus*), porcupine fish (*Diodon hystrix*), striped burrfish (*Chilomycterus schoepfi*), and common trunkfish (*Lactophrys trigonis*). Cartilaginous fishes likely to be found in nearshore include spiny dogfish (*Squalus acanthias*), little skate (*Raja erinancea*), barndoor skate (*Raja laevis*), and bluntnose stingray (*Dasyatis sayi*).

Coastal Bays

The coastal bays support both inshore and offshore fisheries. Many fishes use the bays as spawning areas, nursery areas for young, and feeding areas. Some estuarine fish spawn in the ocean waters, while other ocean species spawn in the estuarine habitats or migrate through the coastal bays to freshwater habitats. The coastal bays have historically supported large populations of juvenile finfish. Juvenile stages of more than 115 species of freshwater, estuarine-resident, estuarine-dependent, and marine fishes have been collected in the coastal bays. The most abundant finfish species include bay anchovy (*Anchoa mitchilli*), Atlantic silverside (*Menidia menidia*), spot (*Leiostomus xanthurus*), Atlantic menhaden (*Brevoortia tyrannus*), Atlantic herring (*Clupea harengus*), mullet, silver perch (*Bairdiella chrysura*), striped killifish *(Fundulus majalas*), mummichog (*Fundulus heteroclitus*), pipefish, smallmouth flounder *(Etropus microstomus)*, rainwater killifish (*Lucania parva*), naked goby (*Gobiosoma bosci*), and striped anchovy (*Anchoa hepsetus*). Adults of many recreationally and commercially important species include Atlantic croaker, bluefish (*Pomatomus saltatrix*), spot, summer flounder, weakfish, and shark.

Some of the most significant habitat for finfish in the coastal bays occurs along the fringes of the *Spartina alterniflora* (tall growth form) marshes. These marshes provide excellent foraging and nursery grounds for predominantly juvenile finfish, but sizable adults are found in the vicinity of the marshes as well. Juvenile finfish also occur in large numbers in shallow and well-protected areas remote from development. The main channels of the bays typically possess few juvenile finfish. Sinepuxent Bay in general possesses low finfish species richness and few ***juvenile finfish***. Ocean City and Chincoteague Inlets are of importance since they serve as the pathways between the ocean and coastal bays for fish.

2.4.2.c Plankton

Plankton are small, floating or weakly swimming plants or animals that are of particular importance in marine and estuarine ecosystems. Nutrients supplied from coastal runoff and vertical mixing in the water column support a relatively high abundance of phytoplankton out to about 20 m depth in the ocean. Peaks in phytoplankton populations vary annually, with peak abundances occurring in spring and late summer to late fall. Zooplankton include those species that spend their entire lives as plankton (holoplankton) as well as the eggs and larvae of many fish and invertebrates (meroplankton). Holoplankton abundance is highest in late spring, summer, and fall. Meroplankton are most numerous during late spring and summer. For additional information see the Planning Aid Report in Annex A.

2.4.2.d Birds

The study area includes important wintering, staging, and breeding habitats for more than 200 avian species. Consideration of endangered, threatened, and rare species, including Piping Plover, is included in Section 2.4.3.

<u>Coastal Bays Mainland and Barrier Islands</u>

The area is of notable importance for neotropical migratory bird species, which tend to concentrate in a relatively narrow strip of land along the coastline during migration. Migrants use habitats on Assateague Island and along the shoreline of the coastal bays watershed as stopover areas. Because of the extreme stress imposed on migrants, survival during the period of migration is critical to the maintenance of viable populations. Thirty-two species of neotropical migrants are considered to use the coastal bay areas as important stopover habitat during migration; twelve of these are experiencing significant population decline.

Colonial waterbirds breed on Assateague Island and on natural and dredged material islands in the coastal bays. Additional discussion on colonial waterbirds is included in Section 2.4.3 "Rare, Threatened, and Endangered Species."

The brackish estuarine habitats on the bayside of Assateague Island and the brackish/freshwater impoundments on Chincoteague National Wildlife Refuge are regionally important wintering areas for waterfowl. The open beaches of Assateague Island and intertidal habitats of the coastal bays provide important habitat for shorebirds. Chincoteague National Wildlife Refuge ranked second in diversity of shorebird species from among all 450 sites in ***the Western Hemisphere Shorebird Reserve*** network and, in 1990, the barrier islands of Virginia and Maryland were dedicated as part of the International Shorebird Preserve.

Offshore Shoals Borrow Area and Atlantic Ocean Waters

A number of bird species may be found feeding and/or resting in the waters in the vicinity of the offshore shoals. These include shorebirds such as gulls, terns, scoters, Oldsquaw, and loons, as well as more open ocean species such as Gannet, Black-leeged Kittiwake, storm petrel, and shearwater.

2.4.2.e Mammals

Consideration of endangered, threatened, and rare mammal species is included in Section 2.4.3.

Coastal Bays Mainland

The watershed of the coastal bays provides habitat for approximately 43 species of mammals typical of the Delmarva peninsula. A list of mammals occurring in the terrestrial, wetland, and freshwater aquatic habitats of the coastal bays watershed is provided in Annex A, Part 3.

Assateague Island

Fifteen species of mammals occur within the terrestrial habitats on Assateague. Mammal diversity and density are limited on the northern end of Assateague Island because of the lack of food, cover, and freshwater. Perhaps most notable of these with regard to this study are domestic horse (*Equus caballus*), red fox (*Vulpes vulpes*), and raccoon (*Procyon lotor*). Horses have a significant effect on the vegetation of the island, and may influence island character by eating vegetation that might otherwise promote dune growth. Red fox and raccoon are notable as predators of birds that nest on the island. Red fox and raccoon are more commonly encountered in areas of the island possessing vegetation.

Offshore Shoals Borrow Area

Several species of marine mammals may occur in the vicinity of the offshore shoals, although the bottlenose dolphin (*Tursiops truncatus*) is the only common one. Several other species of dolphin, porpoise, seal, and whale are infrequent visitors to the area.

2.4.2.f Reptiles and Amphibians

Consideration of endangered, threatened, and rare reptile and amphibian species is included in Section 2.4.3.

Coastal Bays Mainland

The habitats of the coastal bays watershed support about 30 reptile and 23 amphibian species, including snakes, lizards, salamanders, skinks, turtles, toads, and frogs. A list of reptiles and amphibians potentially occuring in the terrestrial, wetland, and freshwater aquatic habitats of the coastal bays watershed is provided in Annex A, Part 3.

Assateague Island

Assateague Island supports 23 species of amphibians and reptiles (Annex A, Part 3). Habitat quality and quantity for terrestrial, wetland, and freshwater aquatic reptiles and amphibians on the northern end of Assateague are limited because of the lack of vegetation and habitat diversity.

2.4.3 Rare, Threatened, and Endangered Species

2.4.3.a Plants

Within the study area, 74 species of state-rare plants are known to occur or have occurred (Annex A, Part 3). Many of these are maritime species occurring on Assateague Island, and are listed as state-rare primarily because Assateague Island constitutes the only natural barrier island habitat in the state. Many of the maritime species are common elsewhere along the Atlantic coast of the U.S., and of these only one species -- sea beach amaranth (*Amaranthus pumilus*) -- is Federally-listed. Assateague Island formerly provided habitat for sea beach amaranth, but it has not been seen on the island since the 1960's, and is thought to be extirpated from the state. The state of Maryland is currently investigating reintroducing this species to the island. See the Biological Assessment in Annex A. A list of the rare plant species occurring on northern Assateague Island is provided in Table 2-1. Notable concentrations of rare plant species are known to occur on the mainland shoreline of the coastal bays within coastal fen plant communities (see previous discussion under wetlands).

2.4.3.b Animals

Within the terrestrial, wetland, and freshwater aquatic habitats of the study area, 19 species of state-rare animals are known to occur or have occurred (Annex A). A majority of these are shorebirds and colonial waterbirds that nest on the barrier islands or shorelines of the coastal bays. Of these species, seven are federally-listed, but two of these are considered to be extirpated. The study area is notable in that it includes the only breeding sites in Maryland for the Royal Tern, Gull-billed Tern, and Black Skimmer. In addition, the northernmost breeding site for Brown Pelican along the U.S. Atlantic coast is located on a dredged material island in Chincoteague Bay.

Northern Assateague Island is perhaps most significant from an ecological perspective because it possesses a notable concentration of rare beach-nesting bird species (Table 2-1). The frequent

Table 2-1: Rare Species

	Common Name	Scientific Name	Federal Status	State Status [1]	Occurrence
Plants					
	Seabeach Amaranth	Amaranthus pumilus	Threatened	Extirpated	Historically occurred on Assateague Island
	Seaside Knotweed	Polygonum glaucum		Endangered	Occurs within and south of State Park
Insects					
	White Tiger Beetle	Cicindela dorsalis media		Endangered	Nest on Assateague Island in project area
Birds					
	Piping Plover	Charadrius melodus	Threatened	Endangered	Nest on Assateague Island in project area
	Least Tern	Sterna antillarum		Threatened	Nest on Assateague Island in project area
	Roseate Tern	Sterna dougallii	Endangered	Extirpated	Transient, may have historically nested in the project area
	American Oystercatcher	Haematopus palliatus		Rare/Watch List	Nest on Assateague Island in project area
Sea Turtles					
	Kemp's Ridley	Lepidochelys kempii	Endangered	Endangered	Transient
	Leatherback	Dermochelys coriacea	Endangered	Endangered	Transient
	Green Turtle	Chelonia mydas	Threatened	Threatened	Transient
	Atlantic Loggerhead	Caretta caretta	Threatened	Threatened	Transient, rare nester on Assateague Island
Marine Mammals					
	Fin Whale	Balaenoptera physalus	Endangered	Endangered	Transient
	Right Whale	Eubalaena glacialis	Endangered	Endangered	Transient

[1] Status for birds refers only to breeding status, migrants may have a different rank

overwash is hostile to all but a few plant species, and even these grow only sparsely; much of the island from 3 to 10 km (1.9 to 6.2 mi) south of the inlet lacks any vegetation. These conditions limit the suitability of the area for most species of animals, but provide nearly perfect habitat for beach-nesting bird species. Historically, sparsely vegetated and bare sand barrier island habitat was abundant along the U.S. Atlantic coast, often in association with natural inlets. Development of the barrier islands as resorts, and shoreline and inlet stabilization, have caused a drastic reduction in the availability of natural overwash-prone and bare sand habitat. Among the rare beach-nesting birds occurring in the area, Piping Plover is of particular relevance and importance for this study. Piping Plover is Federally-listed as a threatened species. Assateague Island is of regional significance as a breeding ground for this species; nests and foraging areas are concentrated on the island's northern end (Figure 2-7). Between 14 and 61 breeding pairs nested on northern Assateague annually between 1986 and 1996. Additional information on the Piping Plover can be found in the Biological Assessment in Annex A. A nesting colony of up to several hundred pairs of the state-threatened Least Tern is also located on the nothern end. The northern end of the island also supports populations of the state-endangered white tiger beetle (*Cicindela dorsalis media*). This species occurs on beaches in the northernmost 5 km (3 mi) of the island, with a notable concentration of individuals from 1 to 2 km (0.6 to 1.2 mi) south of the inlet. An area of lesser concentration also occurs from 4 to 5 km (2.5 to 3.1 mi) south of the inlet.

The coastal Atlantic Ocean waters off Assateague Island are not noted for the regular presence of rare animal species; however, transient and migrant whales and sea turtles are encountered in the waters of the study area (Table 2-1). A Biological Assessment focusing on threatened and endangered sea turtles and mammals is being prepared by the Baltimore District.

2.5 RESERVES, PRESERVES, AND PARKS

A number of parks, recreational areas, and wildlife management areas are located within the study area. State-operated facilities include Isle of Wight Management Area, Sinepuxent Wildlife Management Area, E. A. Vaughn Wildlife Management Area, and Assateague State Park. Federally operated facilities include Assateague Island National Seashore and Chincoteague National Wildlife Refuge. These areas provide outdoor recreational and educational opportunities as well as wildlife habitat. Worcester County and Ocean City operate a number of neighborhood parks. Worcester County is also developing a nature-oriented park at Herring Creek.

Three artificial reefs have been established in the Atlantic Ocean waters of the study area. These include the 33rd Street reef established by Ocean City, and fish havens established by the state of Maryland at the southwestern end of Little Gull Bank and on the northwestern portion of Great Gull Bank. Private recreational fishing vessels and commercial party boats frequent Great Gull Bank. Little Gull Bank is not often fished by commercial party boats but is popular with private recreational boats, particularly in the late summer and fall, due to its proximity to Ocean City.

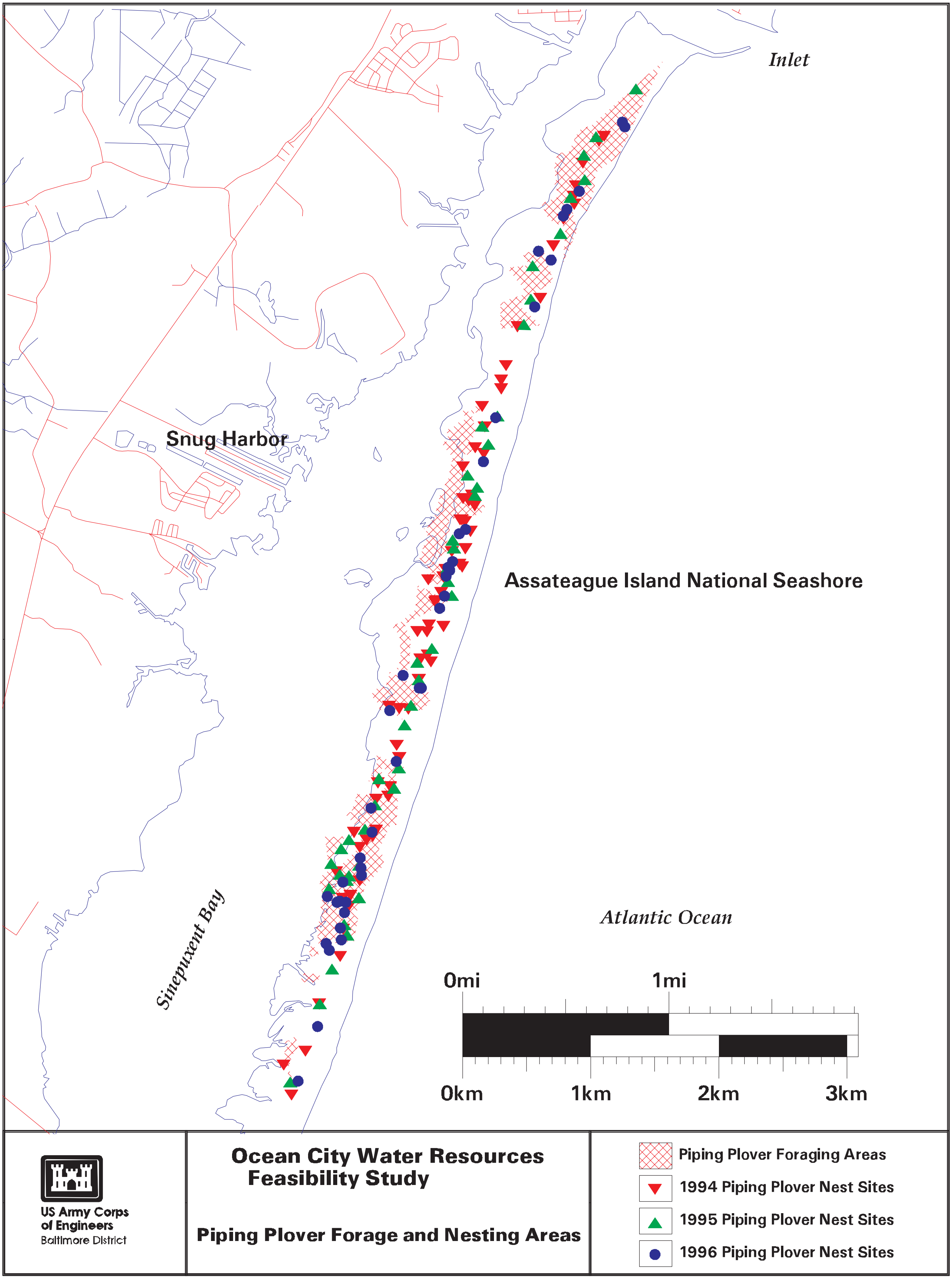

Inlet
Snug Harbor
Assateague Island National Seashore
Atlantic Ocean
Sinepuxent Bay
0mi
1mi
0km
1km
2km
3km
US Army Corps
of Engineers
Baltimore District
Ocean City Water Resources
Feasibility Study
Piping Plover Forage and Nesting Areas
Piping Plover Foraging Areas
1994 Piping Plover Nest Sites
1995 Piping Plover Nest Sites
1996 Piping Plover Nest Sites

Figure 2-7

2.6 CULTURAL RESOURCES

2.6.1. Assateague Island

The Corps of Engineers is required by the National Historic Preservation Act, 36 CFR, Part 800, to determine whether culturally significant historic properties will be affected by any given Federal undertaking, and to minimize those effects through avoidance or mitigation. In accordance with this law and its implementing regulations, the Corps conducted a literature search and Phase I cultural resources reconnaissance for the short-term restoration of Assateague Island. The affected areas that were investigated include the northern 11 km (17.6 miles) of Assateague Island, an area 100 m (330 feet) offshore of the island, and the four offshore shoals that could potentially be used for borrow material.

The northern 1.9 km (3 miles) of Assateague Island is a recent dune formation, and does not contain any significant cultural resources, either on the island or within the 1933 boundaries of the island. There is, however, a recorded shipwreck near the southern terminus of the project on Assateague Island. The Corps is conducting the required investigation to determine whether the shipwreck is a significant cultural resource and to determine whether it will be impacted by the short-term restoration project. Reconnaissance investigations did not identify any shipwrecks in the offshore shoals being evaluated for proposed borrow sites. The Corps is continuing to coordinate with the State Historic Preservation Office. (See Annex D for more detailed information regarding the cultural resources investigation).

2.6.2 Other Study Components

Regarding the other study components, the area of Worcester County has been continously occupied since the earliest prehistoric period (Paleolithic to the present). Prehistoric resources have been found most commonly at the well-drained soils inland from the bays, although extraction of marine resources from the bays can be documented throughout prehistory. During the historic period, the well-drained soils away from the bays attracted farmers, but the bays continued to provide fishing opportunities for the population. Only with the 20th century development of the county for recreational uses has there been extensive settlement and use of the areas immediately adjacent to the bays and to the Ocean City vicinity.

2.7 HAZARDOUS, TOXIC, AND RADIOACTIVE WASTE

The region is lacking industries that typically produce substantial hazardous, toxic, or radioactive contamination. Thus, the study area lacks sites that would be regulated under the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA) or the Resource Conservation and Recovery Act (RCRA). No RCRA or CERCLA sites were found in a records search for the project area. The Baltimore District has determined that no further HTRW investigations are needed. Likely sources of toxic contamination in the region include pesticide and herbicide use in agricultural and residential areas, and atmosheric deposition.

2.7.1 Offshore Shoals Borrow Area

The offshore shoals are composed mostly of coarse-grained sands that are not likely to contain hazardous or toxic contaminants. The Maryland Department of the Environment, Environmental Protection Agency, and Maryland Geological Survey have indicated that testing of these materials for contaminants would not be needed for this project.

2.7.2 Coastal Bays and Harbor and Inlet

Surface sediment in Isle of Wight and Assawoman Bays was often enriched in zinc, copper, nickel, and chromium relative to subsurface sediments. This enrichment may occur because of increased availability of metals from anthropogenic sources (e.g., boats, crab pots). Concentrations of these metals are within the range of other coastal bays not subject to industry.

Because of its proximity to an urban area and heavy boat traffic, and because submerged sediments are fine grained sand with high sulfur contents, the West Ocean City Harbor is a potential source of contaminants. Sediment testing has been recommended by MGS if the channels are to be deepened. Testing will be conducted in accordance with the Corps of Engineers/ EPA Inland Testing Manual. Substances that will be tested for are: metals, priority pollutants, oils and greases and organic compounds. Dredged material is not considered HTRW unless it is on a CERCLA or RCRA site, and as stated above, there are no RCRA or CERCLA sites in the project area.

The sediments in Ocean City Inlet, Isle of Wight Bay, and Sinepuxent Bay are predominantly sands and are not likely to be a significant source of contaminants; consequently no testing is planned in theses area.

2.7.3 Assateague Island

The Corps of Engineers conducted an investigations of potential ordnance and unexploded waste (OEW) at the formerly used defense site (FUDS) on Assateague Island. Investigation were focused on all of Assateage Island because it was believed the island was used as a rocket and bombing range from 1944 through 1947 by the Army and Navy and as OEW burial trenches. Since the island has shifted since the 1940's it is expected that any trenches are now underwater but no underwater investigations were undetaken. Ordnance has occaisionally washed on shore and has been removed from areas outside of the proposed beach replenishment project. The Baltimore District has determined that conditions at the FUDS will not adversely affect the performance of the proposed project and that no further action action is necessary at the FUDS site.

2.8 COMMUNITY SETTING

2.8.1 Land Use

Land use differs in the region as a function of geographic proximity to heavily developed Ocean City. Rapid residential and commercial development occurred in the vicinity of Ocean City beginning in the 1960's. Bayfront areas also attract residential development. Since 1987, approximately 15,900 acres of agricultural land has been converted from active farming to some other use, such as residential; a loss of nearly 13 percent. Sand and gravel mining are permitted in certain agriculturally and industrially zoned areas. Forestry and farming are the predominant land uses in the mainland of Worcester County, and much of the mainland has an open, rural character. Poultry products are Worcester County's agricultural staples with most field crop production geared to producing poultry feed. In contrast to heavily developed Fenwick Island, Assateague Island is publicly maintained parkland, with three governmental agencies sharing management jurisdiction over the island. Land use in the project area is summarized in Tables 2-2 and 2-3.

2.8.1.a Prime and Unique Farmland

Assateague and Fenwick Islands lack farm soils. In contrast, most upland soils within the coastal bays mainland watershed are categorized as prime or unique farmland areas.

2.8.1.b Wild and Scenic Rivers

There are no federally designated wild or scenic rivers within the coastal bays watershed. The only state nominated river for the Maryland Scenic and Wild Rivers Act within Worcester County is the portion of the Pocomoke River from one mile below Whitons Crossing to Snow Hill. However, this river is outside of the coastal bay watershed.

2.8.2 Traffic and Transportation

The main road into the coastal bays region is U.S. Route 50, which connects Washington, D.C., Annapolis, and northern Maryland to Maryland's Eastern Shore and Ocean City. Other main roads are U.S. Route 113, which parallels the shoreline beginning in Delaware and ending on U.S. Route 13 near Pocomoke City; U.S. Route 13, which travels through the southwest corner of Worcester County; and U.S. Route 12, which connects Salisbury, Maryland, to Snow Hill, Maryland. There are three bridges that cross the coastal bays: U.S. Route 90 (connects to Fenwick Island), U.S. Route 50 (connects to Fenwick Island), and U.S. Route 611 (connects to Assateague Island). The Ocean City Airport which was contructed in the 1960's is utilized mainly by operators of small commuter type and private aircraft.

Table 2-2: Summary Characterization of Land Use and Land Cover of the Maryland Portions of the Coastal Bay Watershed (Boynton et al., 1993)

Landuse	**Acres**	**% of Total**
Residential	*7,549.7*	*6.3*
low density	4,483.6	3.7
medium density	752.1	0.6
high density	1,268.4	1.0
open urban land	1,012.6	0.8
forested large lot subdivision	33.0	0.02
Commercial	*1,694.1*	*1.4*
Industrial	*76.2*	*0.06*
Institutional	*194.9*	*0.20*
Extractive	*86.2*	*0.07*
Agricultural	*41,571.4*	*34.7*
cropland	39,286.3	32.8
row and garden crops	180.4	0.09
pasture	261.6	0.2
orchards	45.2	0.04
feeding operations	1,619.0	1.4
other agricultural	178.9	0.1
Forest	*46,188.9*	*38.6*
deciduous	2,607.0	2.2
evergreen	4,742.5	4.0
mixed forest	34,666.3	29.0
brush	4,173.1	3.5
Wetlands	*20,124.7*	*16.8*
Beaches/Bare Ground	*1,394.2*	*1.2*
Water	*828.7*	*0.7*
Total	119,709.0	100

Table 2-3: Land Use Surrounding the Upper and Lower Bays in Percent of Total Acres for Each Subwatershed

Land Use

Subwatershed	Agriculture (%)	Forest (%)	Marsh (%)	Developed (%)
Chincoteague Bay	25	40	31	1
Newport Bay	34	42	14	7
Isle of Wight Bay	40	37	4	15
St. Martin River	66	27	1	6
Assawoman Bay	26	23	25	24
Sinepuxent Bay	19	29	33	9

2.8.3 Navigation

The boating industry is vital to the coastal bay region. There are numerous Federal, state, and locally maintained navigation channels located in the Ocean City Inlet, Ocean City harbor, Sinepuxent Bay, and Isle of Wight Bay. Many of the commercial vessels dock at the Ocean City harbor, whereas the recreational and charter vessels dock at numerous marinas throughout the four coastal bays.

There are numerous Federal, state and locally maintained navigation channels. There are four main Federally maintained channels within the coastal bays: the Ocean City Inlet (10 feet deep and 200 feet wide from the Atlantic Ocean to Sinepuxent Bay); the harbor (150 feet wide from the Sinepuxent Bay through the harbor); Sinepuxent Bay (6 feet deep and 150 feet wide from the inlet to Green Point and thence 100 feet wide in Chincoteague Bay), and Isle of Wight Bay (6 feet deep and 125 feet wide from the inlet channel to a point opposite North Eighth Street in Ocean City, then 75 feet wide into the Isle of Wight).

The Maryland Department of Natural Resources is responsible for marking channels, dangerous areas, shellfish beds, and speed zones. They also service four channels all within Isle of Wight Bay: lower thorofare, George Island (Chincoteague Bay north of Purnell Point), and 87th Street boat ramp. The state and county jointly maintain the local Thorofare Channel (6 foot depth and 100 foot width).

Most of the major commercial navigation facilities are located near the inlet. The average vessel in the fishing fleet drafts 12 feet, is 70-80 feet in length with a beam of 20-30 feet.

The maintained section of the Thorofare Channel serves the needs of local recreational and commercial boaters. The largest vessels using the channel are five commercial passenger vessels which measure as much as 88 feet in length and use the channel most of the year.

Table 2-4: State and Federal Dredging Activity

Channel	***Date Last Dredged***	***Amount Dredged***
Federal		
Harbor	1980	20,000
Inlet	1990	82,450
Isle of Wight	1995	62,000
Sinepuxent	1972	6,000
State/Local		
Lower Thorofare	1992	12,500
George Island (Chincoteague Bay north of Purnell Point	1969	10,00
87 th Street Boat Ramp	1992	11,500

2.9 SOCIOECONOMIC CONDITIONS

2.9.1 Demographics

The strength and rapid growth of the recreation and tourism industry is a primary factor in the recent and projected population growth of Worcester County, which encompasses the study area. The 1995 total population of Worcester County , according to the Maryland Office of Planning, was 37,700, an increase of 7.6 percent since the 1990 census. Approximately 62.2 percent of that number are located within the coastal watershed (east of U.S. Route 113). Total county population is projected to increase to 45,800 by 2015, a 21.5 percent increase over the 20-year period from 1995 to 2015. However, the seasonal population grows to several hundred thousand due to the receational nature of coastal Worcester county. A large proportion of Worcester's newest population is coming from those over the age of 55 as the county becomes a retirement locale for increasingly larger numbers of people. The vast majority of these new citizens are establishing residence in the coastal bay watershed.

To provide a framework for comparison with Worcester County over the 20-year period from 1995-2015 , the projected population increase for the entire Lower Eastern Shore of Maryland (Somerset, Wicomico, and Worcester Counties), is projected at 16.8 percent. For the State of Maryland, the projected increase is 17.6 percent. These data indicate that Worcester County population growth is expected to run about 4 percent ahead of the state growth rate over the next 20 years.

Executive Order 12989, dated February 11, 1994 (*Environmental Justice in Minority Populations)* requires that proponents of Federal projects assess potential impacts of proposed projects on low income or minority populations. Information on minority and low income populations in the project area follows. The The 1994 working age population (16+) of Worcester county was 31,321, of which 20 percent is classified as minority. Unemployment was 7.4 percent for whites and 17.8 percent for minority populations. Approximately 11 percent of the county population in 1994 was below the Federal poverty level.

2.9.2 Economics

The study area is of critical importance for the economy of the state of Maryland. People vacationing in Ocean City also frequently visit Assateague Island and the coastal bays. More than 10 million people visit the Delmarva Peninsula annually, often for the recreational attractions: boating, swimming, and fishing.

Tourism is also the linchpin providing employment opportunities in the study area. Almost 63 percent of the employed labor force in 1993 worked in the retail trade (36.1 percent) or services (26.5 percent) industries. Both of these sectors are driven by the tourism industry. According to data compiled by the Maryland Department of Economic and Employment Development, the total civilian labor force in Worcester County in 1993 was 21,632. The unemployment rate for the same year was 11.4 percent. Because of the dyanmic influence of tourism on the county economy, unemployment rates vary by as much as 15 percent from summer to winter months. The poultry processing industry is also a large provider of jobs in the study area. Two poultry processers, Hudson Foods, Inc. and Perdue Farms, Inc. employed 1350 workers between them in 1993, according to the Worcester County Department of Economic Development.

In comparison to the State of Maryland and the United States in totality, Worcester County income levels are depressed. According to data compiled by Market Statistics, *1994 Demographics USA---County Edition*, 13.5 percent of Worcester County households had an effective buying income under $10,000. Effective buying income is defined as personal income less personal tax and nontax payments. In the state of Maryland in 1994, only 8.4 percent of households were below $10,000. In the U.S., 11.9 percent were below the $10,000 threshold. A similar pattern prevails in the median household, average household and per capita statistics for 1994. Worcester County lags behind Maryland by an average of 25 percent and behind the U.S. by an average of 15 percent in these income categories.

2.9.3 Public Health and Safety

The mainland communities, Assateague Island, and Ocean City are vulnerable to flooding and other storm damage as they are located along the coast.

2.9.4 Visual and Aesthetic Values

The aesthetic features of the study area are varied and contrasting and represent a major factor attracting people to the area. The principal aesthetic features of the region are the Atlantic Ocean, the coastal bays, and their associated shorelines. Assateague Island National Seashore (AINS), because of the road access and its natural environment, is considered one of the best beaches in the United States. The land within the barrier islands is flat but by no means lacking in scenic or aesthetic quality. The physical presence of the ocean and its effect on landforms is impressive. The 37 mile long AINS provides an undeveloped ocean beach. The extensive shoreline wetlands of Chincoteague Bay create a sense of a variety independent of topographic relief. The proximity of the bays and wetlands to the ocean creates a contrast which has been aesthetically pleasing to many residents and visitors to the area.

The aesthetic quality of the study area is influenced by the natural and developed environment. The combination of the two effects are evident in an effective landscaping ordinance adopted in 1984, which has greatly enhanced the previous and recent development. The use of bermed planting areas along the Coastal Highway has improved its aesthetics greatly, as berms are effective at disguising parking lots and other level hard surfaces.

2.9.5 Recreation

The coastal bays provide the water and land-related resources which support a diverse array of recreational opportunities in the study area. These activities provide the basis for a robust recreation-based tourism industry. Water-based recreational opportunities include swimming, saltwater fishing, crabbing, power-boating, sailboarding, parasailing, jetskiing and water skiing. Land-based recreational activities include wildlife viewing and photography, camping, hiking, golf, and sun bathing. All of these activities are dependent on good water quality and the presence of diverse living resources and adequate habitat quality. Most of these activities are supported by privately owned service and recreational facilities in the area.

A number of parks, recreational areas, and wildlife management areas border the coastal bays within the study area. The Isle of Wight Wildlife Management Area is located in Isle of Wight Bay. The Sinepuxent Bay Wildlife Management Area, the ***Assateague State Park***, and the Assateague Island National Seashore and Wildlife Refuge border Sinepuxent Bay. The State Park and the National Seashore are located adjacent to one another in the focus area of the current study. Many of the physical characteristics of these unique seashore parks carry the imprint of the cumulative effect of the interruption of sand flow to Assateague Island for more than 60 years. Although they continue to provide high-quality recreational venues, the realization of the potential problems related to sand-starvation temper optimism about the ability to continue to provide these opportunities in the near-term future.

The management of its water and related land-based resources has been very important in the development of the existing recreational opportunities in the study area. Decisions regarding management of these resources will also determine the future of the recreation-based tourism industry in the study area. Not only do the Assateague parks depend on water and sand management for their viability, the entire study area is dependent on management of the limited volume of sand available.

2.10 FUTURE WITHOUT PROJECT CONDITIONS

2.10.1 Assateague Island

It is predicted that, if nothing is done to restore the sediment supply to Assateague Island, the island will continue to be starved of sediment, the net loss of sediment will increase, and the integrity of Assateague Island as a national treasure will deteriorate. The sediment starved zone is expected to continue to extend southward, and will likely reach to 13 km south of the inlet by the year 2046. The overwash zone area will continue to expand southward and increase in area. These conditions virtually assure that the island will breach. The northern 11 km of the island is extremely vulnerable and any significant storm could breach the island. A breach is imminent. For purposes of this study, though, it was assumed that a breach will occur 7.0 to 7.5 km south of the Ocean City Inlet within the next 10 years. It is feared that if a breach should occur, either it will be filled in quickly using emergency funds, which could adversely affect the environment, or it will not be filled, which could significantly change the dynamics of the bays and inlet.

For evaluation purposes, it is assumed that the inlet will occur in a form similar to the breach that formed in 1962 and will remain somewhat stable in its width. The 1962 breach was 570 m (1870 feet) wide and was subsequently filled by the Corps of Engineers. This event would cause the loss of a portion of Assateague Island National Seashore. Currently, pedestrians may access the entire Assateague Island. However, if a breach were to occur 7 kilometers south of the inlet, access to approximately 920 acres of the island would be limited to boats.

If nothing is done to restore Assateague Island and a breach occurs, as expected, tens to hundreds of acres of barrier island habitat in the vicinity of the new inlet(s) could be converted to marine habitat. Marine habitat exists in greater abundance than barrier island habitat. Additional significant vegetated habitat on the island will likely be converted to bare sand habitat. Impacts of a breach on Piping Plover and other rare species are unknown; rare species habitat quantity and quality could increase or decrease depending on the height and configuration of the post-breach island.

2.10.2 Coastal Bays and Inlet

The coastal bays will continue to gradually fill with sediment transported through the inlet and transported from tributaries. The shoaled areas, such as Skimmer's Island, will continue to expand. The ebb shoal, although it bypasses some sand south to Assateague Island, will continue to grow in size and will most likely block more of the entrance to the inlet.

It is predicted that if a breach occurred, Sinepuxent Bay would be constricted but would not close completely; the tidal prism would most likely serve to maintain a minimal waterway between the Ocean City Inlet and Chincoteague Bay. However, navigation will be difficult without repeated channel maintenance. The presence of an additional inlet will probably reduce tidal flow from

Sinepuxent Bay through the Ocean City Inlet. Sedimentation rates in the vicinity of the harbor and Ocean City Inlet may increase.

A breach will cause substantial changes to the coastal bays ecosystem. Portions of the bay adjacent to the new inlet will be infilled by flood-tidal shoals and overwash deposits. Sinepuxent Bay would decrease in size by tens to hundreds of acres, and lose as much as 10 percent of its area. Hundreds of acres of shallow water habitat in Sinepuxent Bay would be converted to marine or terrestrial habitat. There would be a loss of submerged aquatic vegetation in Sinepuxent Bay, probably in the tens of acres. There would be an increase in salinity of Sinepuxent Bay and Chincoteague Bay, probably by up to a few parts per thousand for much of the year. There would also be an increase in the flushing rate of both of the bays.

If nothing is done to restore or create habitat for colonial waterbirds in the watershed, available nesting habitat will continue to decrease. Dredged material islands that have partially replaced lost habitat on the barrier islands are eroding. New island nesting habitat is not expected to become available. At the present rate of erosion, South Point Spoil, an old dredged material island that provides habitat for an estimated 1,500 breeding pairs of colonial waterbirds, is expected to erode away completely between 2005 and 2010. With the erosion of this island and many similar areas, habitat for colonial waterbirds will continue to decrease in eastern Maryland.

Continued sea level rise at current or accelerated rates is expected to result in the future loss of salt marsh in the northern coastal bays. Loss is predicted because suitable habitat on the mainland shoreline upon which these ecosystems would naturally migrate as sea-level rises has been developed. Impacts of rising sea-level are of less concern in Chincoteague Bay because much of the mainland is rural in character. If nothing is done to restore saltmarsh habitat lost to development prior to the early 1970’s in the northern coastal bays, then the northern coastal bays ecosystem will continue to be impaired by the loss of the important functions and habitat formerly provided by lost saltmarshes there. If nothing is done to compensate for continuing losses due to sea-level rise, then the quality and quantity of the habitat and functions that salt marshes currently provide will diminish further.

If nothing is done to restore forested wetlands, then forested wetlands acreage will remain somewhat constant. Available land on which to restore drained forested wetlands will diminish in supply as population growth and development consume additional farmland. Limited forested wetlands restoration projects, which concentrate largely on providing wildlife habitat, are being conducted by other resource agencies. However, without additional action by the Corps to restore this wetland type, acreage restored or created through these programs will be nominal relative to historic losses. Unless additional avenues are found to restore this ecosystem type on a large scale, the beneficial functions that forested wetlands perform will fail to accrue to the watershed.

2.10.3 Mainland

Currently, due to waves overwashing the island, high water elevations occur behind Assateague Island during storm events. As Assateague Island continues to erode, and specifically if the island breaches, the storm surge over the island or through a breach will be higher.

This estimate of damages in the future without a project condition does not account for future development which may occur on the mainland. According to a 1992 report entitled *Marylands's Coastal Bays, An Assessment of Aquatic Ecosystems, Pollutant Loadings, and Management Options,* future development within the Sinepuxent Bay watershed is projected at over 1,000 additonal hectares by 2005. It is anticipated that most of this development will impact existing forest land, as well as agricultural land. Any future development on the mainland behind Assateague Island should adhere closely to Flood Insurance Administration regulations regarding coastal plain development. Because the Assateague Point resort development adhered to these regulations, flood damage to that community was minimal in the January 1992 storm.

Besides possibly impacting mainland development, the effects of the future without project condition would impact undeveloped lands as well. If a breach occurred, tens of acres of salt marsh could be destroyed along the mainland shoreline. However, over time, new salt marshes would most likely form in adjacent areas.

2.10.4 Offshore Shoals Borrow Area

The future without a project condition of the offshore shoals is expected to be similar to the existing conditions. Although dynamic, the shoals are relatively stable and persistent over time. Additional fisheries enhancement structures will likely be placed at the Great Gull and Little Gull fish havens. Coastal shoals within the Maryland territorial limit may be largely consumed in the future to satisfy the ongoing need for sand to replenish the Ocean City beach.

2.10.5 Ocean City

The Ocean City beaches will continue to be nourished as part of the Atlantic Coast of Maryland Shoreline Protection Project, both routinely and on an emergency basis. Federal, state and local governments will continue to struggle to identify sources of sand to renourish certain areas of the beach whenever an emergency arises.

Section 3

PROBLEMS, NEEDS and OPPORTUNITIES

3.1 INTRODUCTION

During the reconnaissance and feasibility studies, the entire coastal bays watershed was investigated for water resource problems. Numerous environmental problems were identified including the continuing sediment starvation of Assateague Island, loss of wetlands, loss of nesting habitat for waterbirds, degraded water quality in tidal tributaries, absence of subaquatic vegetation in the northern coastal bays, and navigation difficulties. These problems were evaluated during the reconnaissance study, and it was decided that the most important ecosystem problems that the Corps of Engineers could investigate further during this feasibility study are the degradation of Assateague Island, navigation difficulties, and the loss of fish and wildlife habitat. Many local, state, and Federal agencies are investigating other environmental problems that are outside the purview of the Corps.

This study is investigating these problems comprehensively to develop multi-purpose projects that are beneficial to the entire region. The four study components (restoration of Assateague Island, long-term sand placement, navigation improvements, and ecosystem restoration in the coastal bays) are interrelated. We are investigating these problems and determining solutions for each that work together to improve the ecosystem as a whole. The latter three components of the study will be documented in more detail in the second feasibility report, and supplemental NEPA documentation will be prepared as needed. Below is a more extensive description of the Assateague Island erosion problem and a short description of the other problems.

3.2 DEGRADATION OF ASSATEAGUE ISLAND AND NEED FOR SEDIMENT SUPPLY

3.2.1 Problem Statements

The study team established the following problem statements.

1. The jetties at the Ocean City Inlet have created and continue to create a disruption in the longshore transport system, thus causing--

a) the sediment supply to Assateague Island to be greatly reduced. This has resulted in numerous physical and biological impacts to the area around Assateague Island, including the degradation of a functional barrier island.

b) a substantial amount of sediment to be transported through the Ocean City Inlet, resulting in shoaling of the inlet and back bays, and deposition in the ebb shoal. This, in turn, causes navigation difficulties.

2. Ocean City beaches will continue to require sand in the future to maintain the shoreline protection project because of natural shoreline erosion, sea level rise, and emergency needs.

<u>*Problem 1a*</u>: Since 1934, when the Army Corps of Engineers constructed the jetties, the inlet has functioned as a thoroughfare for boating traffic; however, the jetties have disrupted the sediment supply between Ocean City and Assateague Island. Prior to the formation of the inlet, the sand generally traveled from Ocean City to Assateague Island, but the north jetty has greatly reduced the flow of sand to Assateague Island. Consequently, the northern 11 km (6.8 miles) of the island has been eroding and retreating at an accelerated rate. Erosion rates along the northernmost 10 km (6.2 miles) of Assateague Island escalated from a pre-inlet (1850-1929/33) rate averaging -1.5 $\pm$ 1.7 m/years to -2.9$\pm$2.7 m/years in the post-inlet time period (1929/33-1996, see Figure 3-1 for shoreline change over time). The rapid erosion rate caused a loss of dunes and rendered the island vulnerable to overwash. Based on the erosion rates, it has been estimated that Assateague Island has been deprived of approximately 6.6 million m^3 (8.6 million cubic yards) of material since 1933. Erosion of the island has been caused by daily wave action, storm events, and the lack of an adequate sediment supply. The 6.6 million m^3 does not include the material that has naturally eroded over the 60 years; it only includes material lost due to the jetties. (See Appendix A for information regarding how this figure was derived). This disruption in the natural longshore transport of sand between Ocean City and Assateague Island has resulted in numerous physical and biological impacts to the area.

Immediately following stabilization of the inlet, inlet processes began forming the ebb and flood shoals, at the expense of the adjacent beaches. The ebb shoal has grown enormously over the years. On average, the volume of material in the ebb shoal has increased approximately 160,000 m^3/year (208,000 cubic yards/year) since 1933. The volume of the shoal is currently near 10 million m^3 (13 million cubic yards). See Figure 3-2. The ebb shoal significantly impacts the longshore sediment transport process. It has acted as a sink for over 60 years, depriving Assateague Island of the sediment supply it has needed to sustain itself.

Due to the lack of sediment supply, the northern portion of the island has lost its integrity as a barrier island and is highly susceptible to breaching (see Figures 3-3 and 3-4 for aerial photographs of Assateague Island). The northern portion of Assateague Island has a much smaller volume and lower elevation because of this sediment starvation. It overwashes frequently. The rapid erosion, retreat, and overwash have, in turn, destroyed dunes, dune grassland and salt marshes on the island. Bare sand devoid of vegetation now characterizes much of the northern end. As can be seen in the photographs, this barrenness seriously impacts the aesthetics of the island, leaving this unique natural

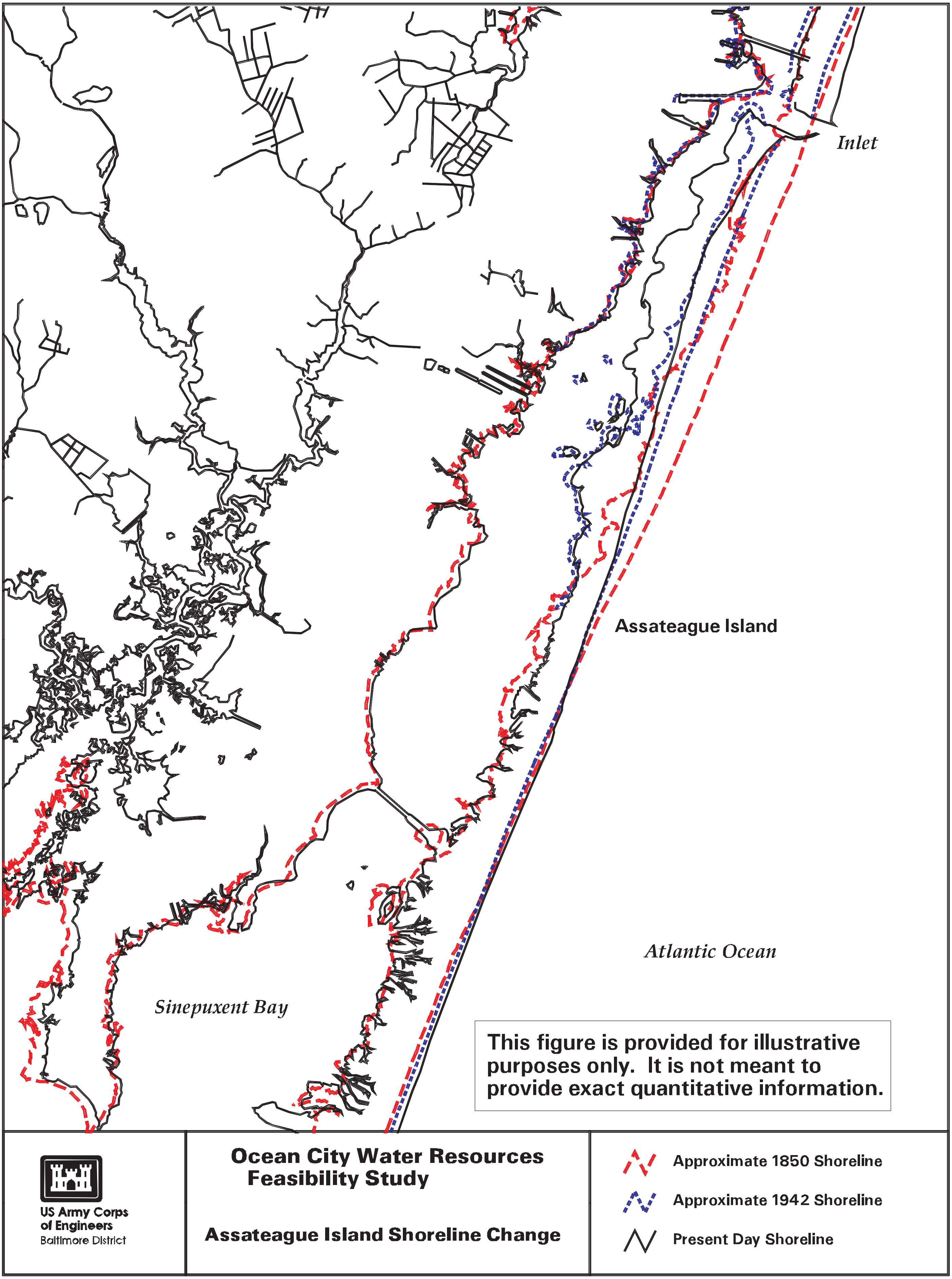
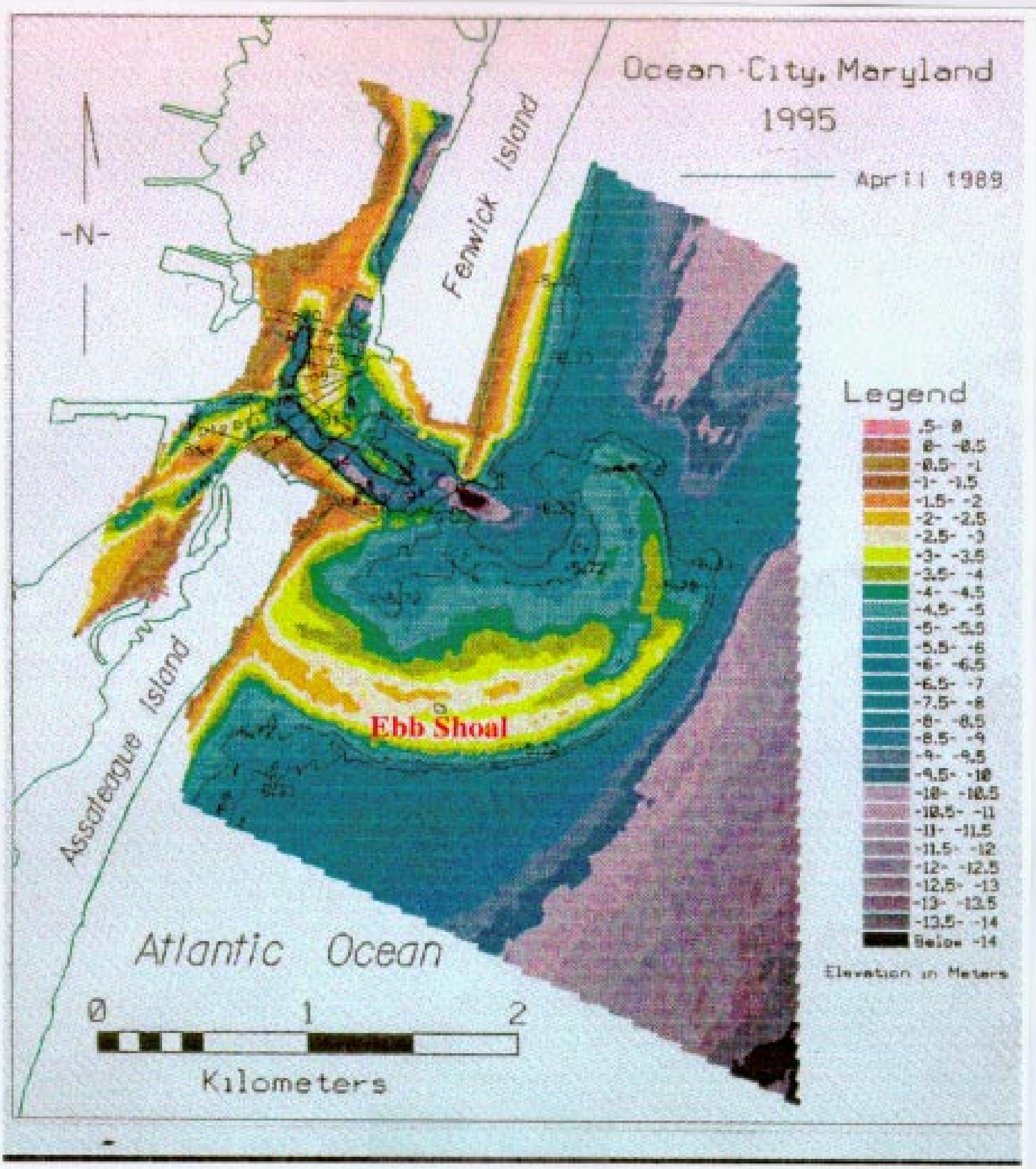

Inlet
Assateague Island
Atlantic Ocean
Sinepuxent Bay
This figure is provided for illustrative purposes only. It is not meant to provide exact quantitative information.
US Army Corps of Engineers
Baltimore District
Ocean City Water Resources Feasibility Study
Assateague Island Shoreline Change
Approximate 1850 Shoreline
Approximate 1942 Shoreline
Present Day Shoreline

Figure 3-1



US Army Corps of Engineers
Baltimore District

Ocean City Water Resources Feasibility Study

Ebb Shoal

Figure 3-2

Figure 3-3: Assateague Island looking 7 km south of Ocean City Inlet

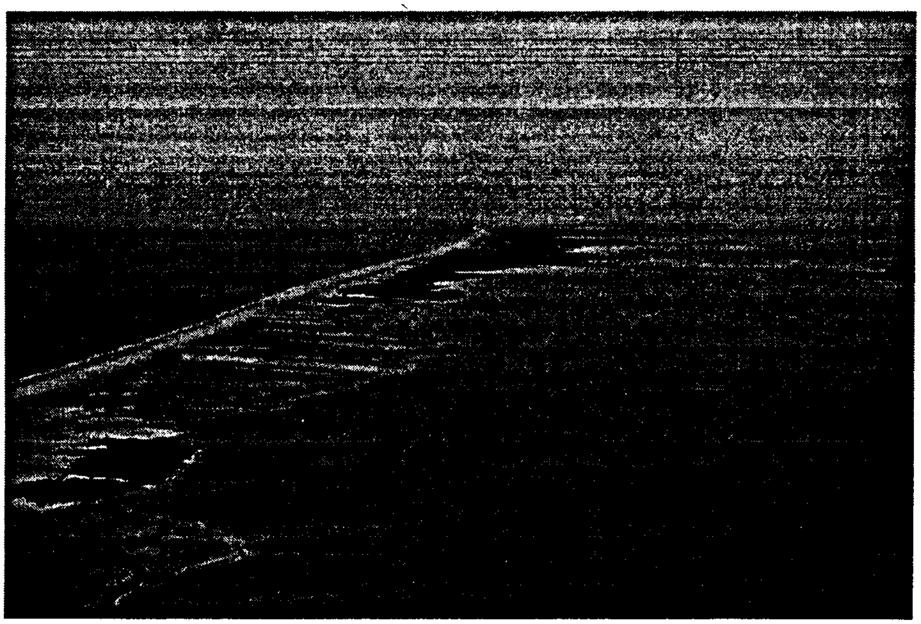
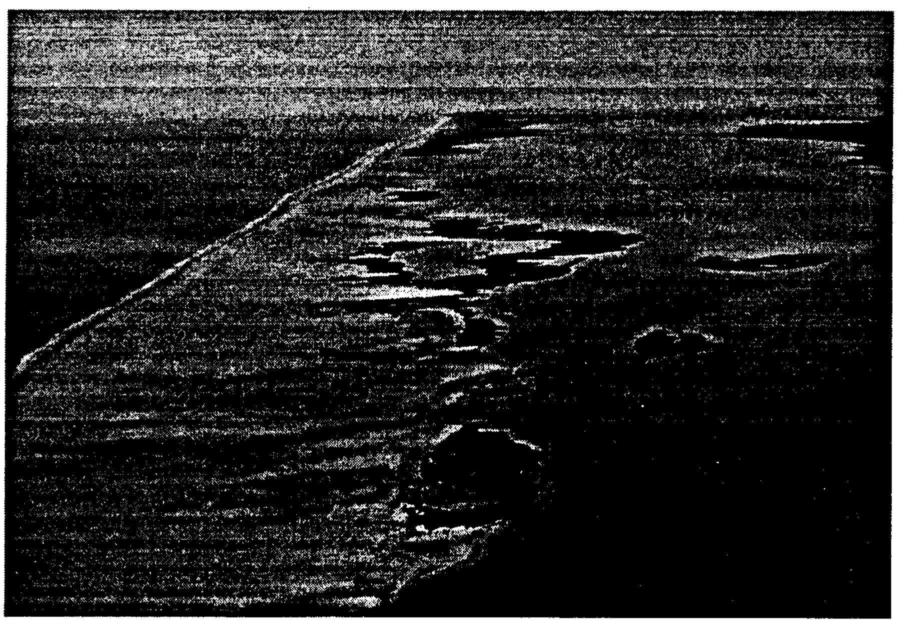


Figure 3-4: Assateague Island looking south towards Rt. 611 Bridge



resource looking destroyed and desolate. A substantial amount of sand has been washed over the island into Sinepuxent Bay, making the bay shallower and reducing the bay's size by about 500 acres. The communities along the shoreline of the mainland behind Assateague Island experience more severe storm damages since the barrier island no longer protects them to the degree it did previously.

Problem 1b: Due to the presence of the jetties, the sand that is not reaching Assateague Island is being transported either to the ebb shoal or through the inlet during flood tide into the back bays (Isle of Wight, Assawoman, and Sinepuxent). A substantial amount of it is settling out and filling up these bays. This is causing numerous navigation problems, mostly for recreational boaters. Nourishing the Ocean City beach adds sediment to the system, and has accelerated shoal growth. The ebb shoal has grown extensively and is a hazard to navigation. It is beginning to block off the entrance to the inlet. Currently the larger boats must travel east out of the inlet, then north out around the large ebb shoal to eventually travel south.

Problem 2: The Corps, along with the state, county, and town, maintains a shoreline protection project along Ocean City that also has a continuous need for sand. The largest problem with the Ocean City beaches is that, at times, an emergency supply of sand is needed to rebuild isolated sections of the beach. It is cost prohibitive to pump material from offshore at these times. Currently, when sand is needed after storms to fill in low areas of the beach, the project managers must identify areas along the beach that have excess sand available for transport. Surveys must be conducted along the entire beach to identify these excess areas, and many times the sand is scarce. The excess sand usually must be transported from a number of small reaches to the low points. The Corps is investigating future sand needs for both Ocean City and Assateague Island and will determine a long-term plan that will address the future needs of both.

3.2.2 Future Without-Project Problems

3.2.2.a Assateague Island

During the past 60 years, the project area has experienced numerous storms; 18 of these have been particularly significant. The cumulative impact of these storms has been to increase the susceptibility of Assateague to degradation as its physical integrity diminishes at an accelerated rate. Large overwash flats have expanded on the island, reducing the diversity of habitat on the island. The physical battering absorbed by the island during storms, along with the natural rate of erosion, and the deprivation of material caused by the jetties, has made the island extremely susceptible to degradation.

As discussed in Section 2, if nothing is done to restore the sediment supply to Assateague Island, the island will continue to be starved of sediment. Storm events will continue to impact the physical integrity of Assateague. Additional breach events seem inevitable, although unpredictable. In the past, significant storms breached the island; however, as the island continues to be starved of sediment, more likely smaller, more frequently occurring storms will create minor or major breaches in the island. In fact, a breach is expected to occur at any time, most likely between 3 km (1.9 miles) and 10 km (6.2 miles) south of the inlet. Within this vulnerable area, the reach from 7.0 to 7.5 km (4.3 to 4.6 miles) is considered to be at greatest risk. It is feared that if a breach should occur, it could be filled in quickly using emergency funds. This could adversely affect the environment through destruction of salt marshes and SAV, the expansion of overwash areas, temporary loss of access to the island, increased storm damage to both the island and the mainland, and temporary navigation difficulties. The other possibility is that it would not be filled, in which case the dynamics of the bays could be significantly altered. The most likely future condition is that the breach will not be filled.

A breach would result in the loss of a substantial portion of Assateague Island National Seashore. The seashore is of national significance because it is readily accessible to millions of Americans by automobile. A breach would impact the unique recreational opportunities for relatively isolated shorebird viewing and nature hiking provided on the northern section of the Assateague National Seashore Island. Currently, pedestrians may access the entire island. However, if a breach were to occur 7 kilometers south of the inlet, access to approximately 920 acres of the national treasure would be limited to boats. In the northern region, the island's function as a healthy barrier island would be further compromised, if not entirely lost. The loss of these opportunities would result in a loss of 7,500 visitor-days on an annual basis. The monetized loss of this opportunity would be $34,000 on an annual basis. (See Annex B for more information on how this value was determined).

The breach would convert tens to hundreds of acres of natural terrestrial barrier island habitat to marine habitat. Natural terrestrial barrier island habitat is of relative scarcity since development has occurred along so much of the U.S. coastline. In contrast, the nearshore marine habitat that would replace it is of far greater abundance, and is available even along developed shorelines. Impacts of a breach on Piping Plover and other rare species habitat are unknown.

3.2.2.b Coastal Bays and Inlet

It is predicted for this study that if a breach occurred, Sinepuxent Bay would be filled in and constricted, but would not close completely; the tidal prism would most likely serve to maintain some flow between the Ocean City Inlet and Chincoteague Bay. These changes will cause substantial short term changes to the coastal bays ecosystem, including disruptions to the food web that will result from short-term loss of SAV beds and mainland salt marsh.

With or without a breach, the coastal bays will continue to fill with sediment being transported through the Ocean City Inlet and over Assateague Island, and navigation problems will only worsen. Most of the post-breach sand accumulation is expected to occur in Sinepuxent Bay, although sand could reach as far north as the Ocean City Inlet. Recreational boaters in Sinepuxent Bay would likely experience channel access difficulties and potentially damaging, shoal-induced groundings. The Federal and some of the state and local channels would have to be dredged immediately following the breach to maintain navigability. As long as the second inlet remained open, the flow through the Ocean City Inlet and Isle of Wight Bay would be reduced and more sediment would settle out. The Federal navigation channel through the inlet and harbor, and possibly Isle of Wight Bay, would have to be dredged more frequently than they currently are.

The ebb shoal, although it bypasses some sand south to Assateague Island, will continue to grow in size and could block more of the entrance to the inlet. This will make it more difficult for boaters to navigate through the inlet, could lead to damage to vessels, and could cause users to wait for higher tides to navigate.

3.2.2.c Mainland

A number of communities located along Highway 611, directly behind Assateague Island, are susceptible to inundation from the effects of storm surge. Four mainland communities landward of Sinepuxent Bay incurred \$3.2 million in damages from the January 1992 storm. The damage is caused by storm surge overwashing Assateague Island and through the Ocean City Inlet. If a breach were to occur, it would allow free communication between the ocean and Sinepuxent Bay, and would permit the exchange of water and sediment for a longer interval than the duration of the storm. Overwash only lasts for the duration of a storm, and does not occur under typical astronomical tide conditions. A breach could significantly affect both the water level and the flow rate in the bay if the water volume transport through the breakthrough throat is comparable to the normal flow through the bay. Breaches generate the largest peak water elevations locally near the breakthrough. Water levels would most likely increase 1.5 to 2.5 m (4.9 to 8.2 feet) directly behind the breach during a storm. The same communities that incurred \$3.2 million in damages are expected to incur at least an additional \$700,000 in damages from a breach of the northern section of Assateague Island during a storm similar to the January 1992 storm. (See Appendix A, Hydrodynamic Model, for information on how the water surface elevations were derived for a future breach. See Annex B for information about how the damages were assessed based on the water surface elevations).

3.2.2.d Ocean City

The Ocean City beaches will continue to be nourished in the future. If a more flexible method of renourishing the Ocean City beaches is not implemented, the Federal, state and local governments will continue to struggle to identify sources of sand to renourish the low areas of the beach whenever a storm occurs, in order to keep the design level of protection.

3.2.3 Needs

There is a need to solve both short-term and long-term problems related to Assateague Island and the disruption in longshore transport. A short-term project needs to be implemented as soon as possible to mitigate for the past erosion on Assateague, to restore the integrity of the island, and to help prevent a breach from occurring in the next few years. A long-term project is needed to prevent similar problems in the future. Even if material is placed on Assateague Island for a short-term solution, the jetties will continue to disrupt the longshore transport, and Assateague will continue to erode at an accelerated rate. If a plan is not implemented to move the material from Ocean City across to Assateague Island, as it should move naturally, the material will continue to enter the inlet and will continue to shoal in the back bays and accumulate at the ebb shoal. This sedimentation and shoaling will continue to change the hydrodynamics of the coastal bays and will cause damage to boats. Assateague Island will continue to be deprived of the sand supply it needs to function as a healthy barrier island.

There is also a need to look at the regional setting and to incorporate both the needs of Ocean City and those of Assateague Island when developing a long-term sand placement plan. The nourishing of the Ocean City beaches is adding to the growth of the ebb shoal and the infilling of the coastal bays. At the same time, Assateague Island is starved despite the abundant sand system. Again, this report is focusing on the short-term restoration of Assateague Island. The long-term plan will be developed and documented in the second feasibility report.

3.3 NAVIGATION

3.3.1 Problem Statement

The study team established the following problem statement:

The commercial waterway users are damaging their boats due to hitting ground and are losing time and revenue waiting for higher tides to navigate in the vicinity of the harbor, inlet, and Shantytown Channel.

Many waterway users are experiencing problems navigating through the Ocean City Inlet, Harbor, and Shantytown Channel (adjacent to the Ocean City Fishing Center). Shoals exist in the bays in the vicinity of the inlet that damage both commercial and recreational vessels and that extend travel time for the vessels navigating the channels. The inlet and harbor include Federal channels that are currently maintained to a depth of 3 m (10 feet). However, deeper draft vessels are attempting to navigate through the inlet and harbor. Shantytown channel is not a Federal channel; the state and the marina owner occasionally dredge the channel.

A number of sources contribute sediment to the shoals in the inlet and bays. Aerial photographs taken from 1933 to the present, and in particular from 1971 to 1993, show growth and migration of shoals in and around the coastal bays that are affecting navigability of the waterways. The root of the problem is flood current transport of material through the Ocean City Inlet, carried north and south into the adjacent back bays, coupled with shoreline erosion along the oceanfront and in areas susceptible to scour in the coastal bays.

It is likely that the beach replenishment for the Atlantic Coast of Maryland Shoreline Protection Project is contributing to the shoaling problems in the coastal bays. The net longshore sediment transport at the Ocean City Inlet is believed to be approximately 110,000 m^3 (140,000 cubic yards) per year to the south. Abundant sediment is available to shoal the channels and other navigable areas both north and south within the coastal bays.

The ebb shoal (just oceanward of the south jetty) is growing in size, prohibiting vessels from taking the direct approach into the inlet. Boaters will have an even more difficult time navigating in the future if the ebb shoal is allowed to extend around the inlet and thus block the approach into the inlet.

In the recent past, maintenance dredging of Shantytown Channel has occurred on a seasonal basis when required, and the work has been performed as a joint venture between the state, county, and the cooperating marina owners utilizing the channel. The channel continues to shoal in regularly, and boat owners are forced to navigate with the tides in order to minimize damage to their vessels while traversing the channel.

3.3.2 Future Without-Project Problems

If improvements are not made to the navigation channels through the inlet, harbor, and Shantytown channel, the commercial boaters will continue to lose revenue due to groundings, having to light-load their vessels, and having to wait for high tides to navigate.

3.4 ENVIRONMENTAL RESOURCES

3.4.1 Problem Statement

The study team established the following problem statement:

The Maryland coastal bays watershed has lost many thousands of acres of fish and wildlife habitat to agriculture, development, and erosion. Ecosystem functions that maintain environmental quality have also been lost. Some of the losses can be directly or indirectly tied to past Corps projects.

Coordination with natural resource agency representatives, coastal bay experts, and local residents was an integral part of the reconnaissance study and this feasibility study. Problems identified included the loss of tidal and non-tidal wetlands, the loss of waterbird nesting habitat, the deterioration of water quality in tidal tributaries, and the near absence of submerged aquatic vegetation in the northern coastal bays. A number of these problems are directly or indirectly related to Corps projects.

In excess of 2,000 acres of salt marsh within the coastal bays have been destroyed by development and filling prior to the early 1970’s and by the accelerated retreat of Assateague Island following jetty construction. Losses were concentrated in the northern coastal bays, where about 40 percent of salt marshes that formerly occurred there have been destroyed.

Tidal marshes perform numerous beneficial functions, including storm protection and erosion control for the mainland, nurseries for commercial fisheries species, wildlife habitat, food chain support, nutrient source/sink, and water quality maintenance. The magnitude of the beneficial functions performed by these ecosystems is largely dependent upon their spatial coverage. The degree to which salt marsh destruction has impaired water quality and affected fish and wildlife populations is not known. However, since tidal marsh acreage in the northern bays has been greatly reduced, it is expected that the magnitude of services performed by these ecosystems has also been greatly reduced.

Approximately 21,000 acres of forested wetlands in the coastal bays watershed has been drained for agriculture. An additional 3,700 acres has been drained for development. These combined losses represent a 44 percent loss of the forested wetlands that once occurred in the study area. Most of the remaining 31,600 acres of land within the watershed that could still potentially be forested wetland have been modified by historic drainage and can be considered partially or completely degraded. In summary, in excess of 90 percent of the forested wetlands in the coastal bays watershed have been destroyed.

Important functions of forested wetlands that have been negatively impacted include their ability to sequester and transform pollutants, ameliorate agricultural runoff, provide plant and wildlife habitat, and regulate nutrient exchange between terrestrial and aquatic ecosystems. For the most part, the functions of forested wetlands are either severely impaired or completely lost when they are drained.

The conversion of Assateague and Fenwick Islands from sparsely inhabited, infrequently visited sites to focal points of human recreation and development has negatively impacted populations of waterbird populations dependent upon remote and barren sand beach nesting habitat. Development and recreational use of the barrier islands has caused a substantial reduction in this habitat type both in the study area and along the U.S. Atlantic coast.

3.4.2 Future Without-Project Problems

If nothing is done to restore or create dredged material island habitat for colonial waterbirds in the coastal bays, available nesting habitat will continue to decrease due to erosion, and populations of a number of rare species may decrease or will at best fail to recover. Continuing loss of nesting habitat to development and shoreline stabilization elsewhere along the U.S. coastline may cause further cumulative detrimental impacts to these bird species, and increases the relative importance and value of nesting habitat that remains in the coastal bays watershed. These species are important elements of the coastal bays ecosystem and are priceless components of America's natural heritage.

If nothing is done to restore saltmarsh habitat in the northern coastal bays, then saltmarsh acreage will continue to decrease. Unless additional avenues are found to restore forested wetlands on a large scale, then only minimal restoration of this ecosystem type will be undertaken by other agencies. The northern coastal bays ecosystem will continue to be impaired by the loss of the important functions formerly provided by the extensive saltmarshes and forested wetlands that once existed there. A number of the functions performed by salt marshes and forested wetlands are critical to maintenance of environmental quality. Good environmental quality, in turn, is critical to maintaining the character of the area as a desirable tourist destination. Salt marsh habitat is also of critical value to the commercial and recreational fishery of Maryland.

Section 4

OBJECTIVES and FORMULATION

4.1 INTRODUCTION

During the reconnaissance phase, planning efforts were directed toward formulating plans to improve water resource problems relating to environmental quality, navigation, storm damages, and water resource infrastructure. It was determined that there was Federal interest in investigating the projects related to ecosystem restoration and navigation. During this study, the Corps is further investigating projects relating to these issues to determine a plan that is feasible from an engineering standpoint and, is environmentally and economically justified.

4.2 FEDERAL OBJECTIVE

The Federal objective of water and related land resource project planning is to contribute to the national economic development (NED) consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders, and other Federal planning requirements. 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.

Water and related land resource project plans are to be formulated to alleviate problems and to take advantage of opportunities in ways that contribute to this objective. Contributions to NED increase the net value of the national output of goods and services, expressed in monetary units (i.e., benefits exceed costs). Contributions to NED are the direct net benefits that accrue in the study area and the rest of the nation. Contributions to NED include increases in the net value of goods and services that are marketed (vendible) and also of those that may not be marketed. Generally, several alternative plans are formulated to address a particular set of water resource problems. These plans are evaluated on four criteria: completeness, effectiveness, efficiency, and acceptability.

In a statement dated 25 June 1990, the Assistant Secretary of the Army for Civil Works directed the Corps to use new approaches to implement the President's goal of maintaining and restoring the health of the environment. One of the suggested ways to do this is to use Federal funds to restore environmental values where a Federal project has contributed to their degradation.

4.3 PLANNING OBJECTIVES, CONSTRAINTS, and FORMULATION

Planning objectives are expressions of public and professional concerns about the use of water and related land resources in a particular study area. These planning objectives result from the analyses of existing and future conditions within the context of the physical, environmental, economic, and social characteristics of the study area. They are used to guide the formulation of alternative plans and to evaluate the effectiveness of those plans.

4.3.1 Short-Term Restoration of Assateague Island

Due to the imminent threat of a breach occurring on Assateague Island, the problems of Assateague Island degradation and the need for sediment supply were separated into two components: short-term restoration of Assateague Island and long-term sand placement. The short-term restoration is being completed on an accelerated schedule and will address problem 1a described in Section 3.2: *The jetties at the Ocean City inlet have created a disruption in the longshore transport system, thus causing the sediment supply to Assateague Island to be greatly reduced. This has resulted in numerous physical, biological, and economic impacts to the area around Assateague Island, including the loss of a functional barrier island.* The long-term sand placement project will address problems 1b and 2 listed in Section 3.2. As mentioned previously, this report is focusing on the short-term restoration project. The other three problem areas are being investigated further and will be documented in greater detail in the second feasibility report. The following goals and objectives were established for the short-term restoration of Assateague Island.

Goal: Restore Assateague Island to mitigate for adverse impacts caused by past Corps projects.

Objectives and Constraints:

1. *Restore the northern end of Assateague Island with a volume of sediment that would adequately mitigate for the impacts caused by the Corps' project* - This objective seeks a means to restore a volume of sediment that would have been within the subaerial and subaqueous portions (to depth of closure, approximately -6.6m, or 21.6 feet) of the island had the longshore transport process not been interrupted by the jetties. It is not possible to include restoration of the longshore transport process in the short-term fix; thus, the objective focuses on placement of a sufficient volume of sand to maintain the island until a long-term solution can be implemented."

2. *Reduce the likelihood of a breach that would result in the formation of additional inlets* - Barrier islands do breach naturally during severe storms; however, Assateague Island is extremely vulnerable to breaching even during a mild storm due to the loss of sediment volume. This objective seeks to reduce the chances of the island breaching during a typical storm.

3. *Promote natural habitat diversity* - The existing habitat on Assateague Island is typical of barrier islands and is not diverse due to the frequent overwash and low elevations. This objective intends that, as much as possible, natural forces will be allowed to shape the character of the island and its biota, and that the project does not intend to preferentially

favor or maintain a particular habitat condition over time. Natural habitats are defined as those habitats indigenous to the study area that arise as a result of natural coastal processes. This objective is linked to restoring a volume of sediment. Ultimately, it is dependent upon establishing an artificial sand transport mechanism that is analogous to the natural system disrupted by the jetties, and which will provide Assateague Island with a sediment budget approximating pre-inlet conditions.

4. *Minimize impacts to the Piping Plovers* - Piping Plover has received the most attention of all the rare species occurring in the project area, and because it is protected under the Endangered Species Act, is likely to be of great interest to agencies and the public. The habitat needs of Piping Plover likely encompass the habitat needs of seabeach amaranth, tiger beetle, and other rare species that occur on the overwash flat habitat of northern Assateague.

5. *Reduce the probability of storm damage/increased erosion in the vicinity of Assateague Island* - The mainland communities behind Assateague Island are more susceptible to damage during storms due to waves overwashing the island. This objective seeks to reduce this damage.

6. *Protect navigation interests* - Because of shoaling, boaters already experience problems navigating the coastal bays; however, if Assateague Island were to breach, the situation would worsen. This objective seeks to protect navigation by reducing the probability of a breach.

7. *Protect and enhance recreational and economic resources* - Recreation on Assateague Island, in the back bays, and on the mainland is vital to the economy, and therefore, the health of the back bays and the watershed is vital to the economy. This objective seeks to protect and improve these resources.

Formulation of Alternatives

<u>Step 1</u>
The first step that the study team took after identifying the problem and objectives was determining an array of eight alternative solutions. These included--

1. No action.
2. No immediate action; repair breach in future.
3. Extend width of shoreline along Assateague Island.
4. Raise profile of Assateague Island.
5. Construct storm berm along Assateague Island.
6. Construct breakwaters offshore of Assateague Island.
7. Remove jetties.
8. Implement no immediate restoration, but implement a long-term sediment supply process.

The Corps, along with multiple agencies, evaluated these eight plans during a second screening. They were evaluated for completeness, effectiveness, efficiency, and acceptability. Alternative #2 was eliminated because it was ineffective in alleviating the problem. It does not meet the objectives of mitigating the damages caused by the Corps jetties or reducing the probability of a breach. Alternative #4 was eliminated because it was unacceptable with respect to the environment. It would directly impact the threatened and endangered species that inhabit the island, and would destroy valuable habitat across the entire island. Alternative #6 was eliminated because the plan is not efficient or effective. Breakwaters would have to be constructed in deep water offshore and would be too costly, and they also would not mitigate for the lost sand. In addition, the plan was unacceptable to the National Park Service. Finally, alternative #7 was eliminated because it would be unacceptable to the state and local entities. The jetties protect navigation and provide direct access to the commercial harbor. Commercial and recreational boating is vital to the local and regional economy. After the initial screening, the following four plans remained:

Step 2

1. No action.
3. Extend width of shoreline along Assateague Island.
5. Construct storm berm along Assateague Island.
8. Implement no immediate restoration, but implement a long-term sediment supply process.

Through coordination with the Coastal Engineering Research Center, it was then determined that plan #3 would be ineffective on its own. For a given volume of sand, the most cost-effective use of that sand for the purpose of reducing the potential for overwash and breach formation is to use it to create added elevation. Therefore, plan #3 was combined with constructing the storm berm, plan #5, to become #3/5. This left only three options:

Step 3

1. No action.

3/5. Construct storm berm and extend width of shoreline along Assateague Island.

8. Implement no immediate restoration, but implement a long-term sediment supply process.

Step 4

Constructing a storm berm and extending the width of the shoreline offered a number of possible height/width variations that needed to be evaluated and compared. It was determined that true mitigation for the effects of the jetties would involve restoring the volume of material that the island has been deprived of since the jetties were constructed in 1934, minus the volume that naturally would have eroded. Plans #3/5a and #3/5b below are variations of this scenario. Since the National Park Service is a project sponsor and the owner of the northern 10 kilometers of Assateague Island, another reasonable time of reference for mitigation purposes is 1965, when Assateague Island was placed under the ownership of the National Park Service, and was established as a National Seashore. Plan #3/5c involves restoring the volume of material lost since 1965, minus the volume that naturally would have eroded. At the time of this analysis, these quantities were estimated to be 5.6 million m^3 (7.3 million cubic yards) and 2.8 million m^3 (3.6 million cubic yards), respectively. However, as additional work was performed on the sediment budget, these figures were adjusted. A discussion of how the volume of material that Assateague Island has been deprived of since 1965 and 1934 was determined is included in Appendix A2. To identify less costly and less intrusive mitigation alternatives for comparison, Plans #3/5d, 3/5e, and 8 were developed as well. Plan #3/5d involves placing a volume of material less than that which the island has been deprived of since 1965, based on environmental considerations. This was originally estimated to be 1.4 million m^3. Plan #3/5e involves replacing only enough material to construct a storm berm. At the time of the evaluation, the length and size of the storm berm had not yet been determined, and so it was estimated to need 173,000 m^3 of material. Later in the study, it was determined that the amount would actually be 285,000 m^3. When these variations were added to the list, the array of alternative plans included the following--

1. No action.
3/5a. Restore the island to "without jetty conditions" (restore 1934 position of island minus natural erosion), and implement a long-term sediment process.
3/5b. Replace the volume of material that the island has been deprived of since 1934 (5.6 million m^3/7.3 million yd^3), and implement a long-term sediment supply process.
3/5c. Replace the volume of material that the island has been deprived of since 1965 (2.8 million m^3/3.6 million yd^3), when the National Seashore was authorized, and implement a long-term sediment supply process.
3/5d. Replace a volume of material less than the amount the island has been deprived of since 1965 based on environmental considerations, and implement a long-term sediment supply process.
3/5e. Replace only enough material to construct a storm berm (173,000 m^3/225,000 yd^3), and implement a long-term sediment supply process.
8. Implement no immediate restoration, but implement a long-term sediment supply process.

Note that plans #3/5a through #3/5e and #8 all include a long-term sediment supply component. The purpose of this report is to recommend a short-term plan, but a long-term plan is critical to the success of Assateague Island. This is discussed further in the following section.

After the initial screening process was completed, these seven alternative plans remained. Figure 4-1 shows the plan formulation process up to this point. A discussion of how these seven alternatives were evaluated and compared is found in Section 5.

Short-Term Assateague Island Restoration

Plan Formulation Flow Chart

Selection of Preferred Plan

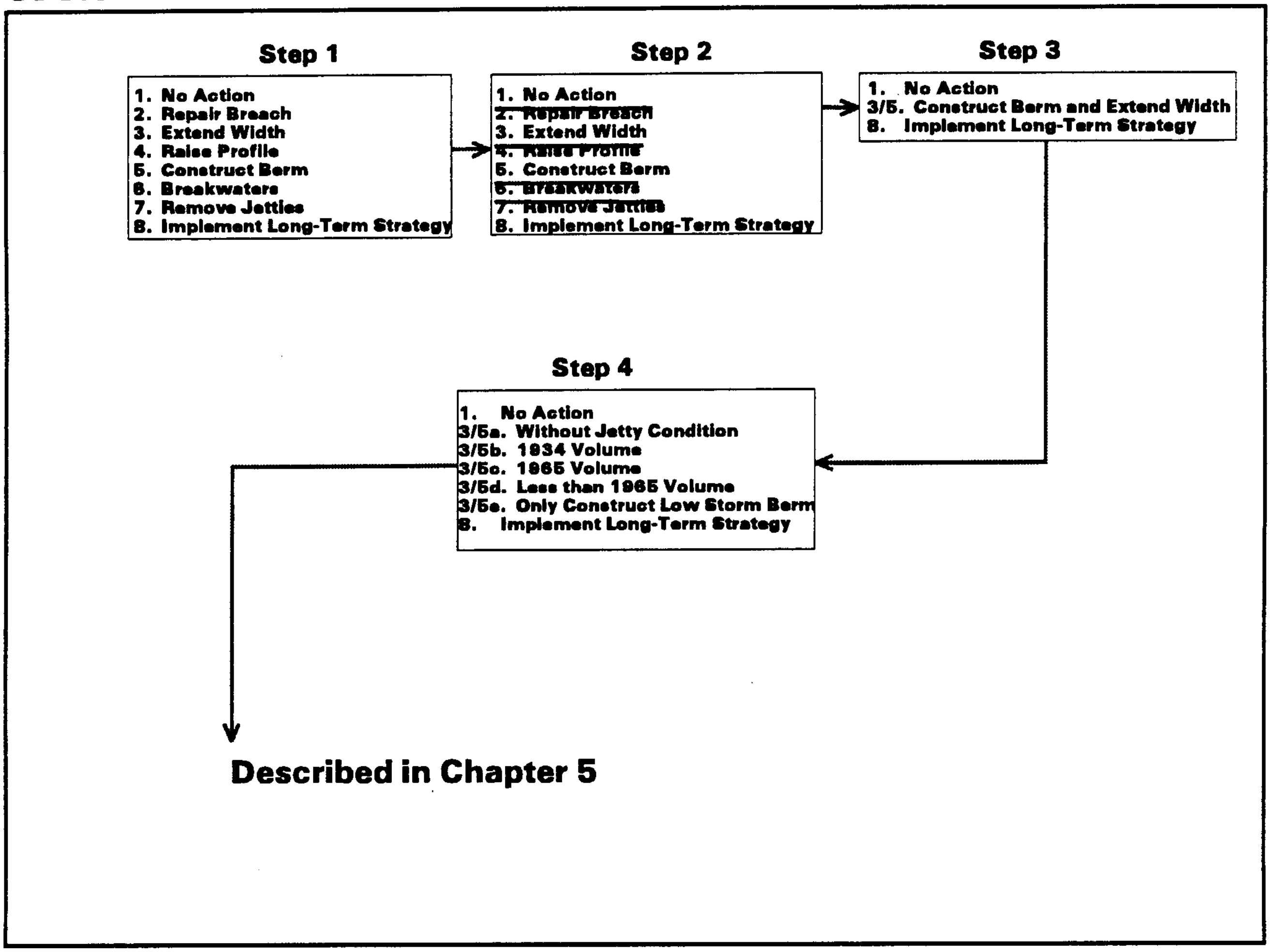


Figure 4-1

4.3.2 Long-Term Sand Management

Sand is a limited resource in the coastal area, and it is vital to the integrity of barrier islands. Since the jetties disrupt the longshore transport between Fenwick and Assateague Islands, the availability of sand in the area is being investigated and long-term plans that could be implemented for the wise use of this resource are being determined. The following goals and objectives were established for this component of the project:

Goal: To restore a sediment transport system that supplies an amount of material to Assateague Island that would naturally be transported to the island if the jetties did not exist. By preventing the movement of sediment through the inlet, the plan should help reduce the shoaling problems in the coastal bays and on the ebb shoal. The plan should also consider the sediment supply needs of the Ocean City beach.

Objectives:

1. Mitigate for future impacts that the jetties will have on Assateague Island, determine a long-term program for restoring and maintaining the flow of sediment to the island.
2. If possible, determine a more efficient or flexible method of renourishing the Ocean City beach, either as a routine measure or under emergency conditions.
3. Reduce shoaling in the back bays and the ebb shoal to improve navigation.

Formulation of Alternatives

This component of the study involves investigating the sediment budget and pathways throughout the entire study area. The study team is evaluating various problems concurrently and is working to determine multi-purpose solutions. When determining a solution for the long-term restoration of Assateague Island, we will consider the sediment needs of Ocean City and the shoaling problems near the inlet and in the back bays. The following is a list of the initial alternative plans identified for the long-term plan:

1. No action.

2. Remove the jetties and fill in the inlet.

3. Construct a fixed plant at the southern tip of Ocean City to transport material to Assateague Island.

3a. Construct booster pumps on Assateague Island
3b. Construct booster pumps on the bay side of the island
3c. Pump the material across the ebb shoal
3d. Pump the material across the inlet and truck it along Assateague

4. Use a punaise to dredge material and place it on Assateague Island.
4a. Purchase a punaise
4b. Rent a punaise
* Must decide where to take material from

5. Use a mobile dredge to dredge material and place it on Assateague Island.
5a. Purchase a hopper dredge
5b. Purchase a clam shell dredge
5c. Use the Corps (Wilmington District) dredge
5d. Contract a dredge routinely
* Must decide where to take material from

Alternatives #3, 4 and 5 involve several types of bypassing and or back-passing scenarios. The systems under consideration include a fixed or semi-fixed bypass plant, a mobile dredge, and a system developed in the Netherlands called a Punaise. These plans are currently being screened for completeness, efficiency, effectiveness and acceptability. Basically, the purpose of most of these systems would be to take material from the southern tip of Ocean City, before it is transported into the back bays or to the ebb shoal, and pass it across the inlet to Assateague Island. Other options include taking the material directly from the ebb shoal or from the back bays and transporting it further south on Assateague Island. Because the ebb shoal traps southerly flowing sand, booster pumps would likely be needed to pump the material far enough south to where it will naturally travel to the south as part of the longshore transport process. Back-passing the material from the southern tip of Ocean City north to the Ocean City beaches is also an option and can be combined with the bypassing plans. Having a back-passing capability could benefit Ocean City in emergency situations, when reaches of the beach have excessively eroded after storms. These alternative plans are currently being evaluated and compared. The costs of the alternative projects will be compared to the benefits or cost savings. Figure 4-2 shows a conceptual sketch of where material could be bypassed or back-passed.

[As of June 1998, the Ocean City, Maryland, and Vicinity Water Resources Integrated Feasibility Report and Environmental Impact Statement was finalized, as were both the short- and long-term components of the restoration of Assateague Island. The recommended long-term plan is for the "mobile bypassing" of sand via a shallow mobile hopper dredge to remove sand that has been redirected to a number of sites, and then bypassing it to Assateague Island. This dredging will take place each year to more closely mimic natural processes. Sand will be bypassed from the updrift fillet, ebb shoal, the navigation channels and flood shoals. In order to avoid the creation of new problems by taking too much sand from any one source or too frequently from the same source (thus further disturbing the balance of the area), the project will be monitored annually. A team of decision makers led by the Corps, consisting at a minimum of all the project sponsors (the NPS, the State of Maryland, Worcester County, and the Town of Ocean City), will determine each year how much material can be taken from each of the available sources. Their decision will be based on the

monitoring results, which will indicate the rate at which the sources are being naturally replenished after dredging.

The authority to implement the Assateague Island components of the project, both short-term and long-term sand management, were provided by Section 534 of the Water Resources Development Act of 1996. This Act directed the Corps to implement the restoration of Assateague Island pursuant to Section 111 of the River and Harbor Act of 1968. In addition, the Act authorized the expenditure of $35 million dollars for both the short- and long-term restoration of Assateague Island. The short-term restoration project is estimated at $17.2 million. At an annual cost of more than $1.1 million for long-term sand management, the project as authorized will carry the project through to fiscal year 2011, assuming the project is fully federally funded. For the 25 year project duration, the estimated long-term sand management cost is $25,243,000, or $43,773,000 fully funded. Therefore, Congressional project reauthorization of the project is recommended. It stated that the Secretary shall coordinate with affected Federal and State agencies and shall enter into an agreement with the Federal property owner to determine the allocation of the project costs. The Corps is currently coordinating with NPS, the State of Maryland, Worcester County, and the Town of Ocean City to define project implementation responsibilities for both the short-term restoration of Assateague Island and the long-term sand management. All of the project sponsors support the recommended project. The NPS, who administers the Assateague Island National Seashore, has agreed to enter into a Memorandum of Agreement with the Department of the Army.

The schedule for these two components of the Assateague Island restoration has also been finalized. This schedule allows 2 years for the construction of the short-term sand management plan, with construction of the long-term plan to begin the year following completion of the short-term plan. The short-term sand management plan is scheduled to begin construction in July 1999; the long-term plan, in summer 2001.]

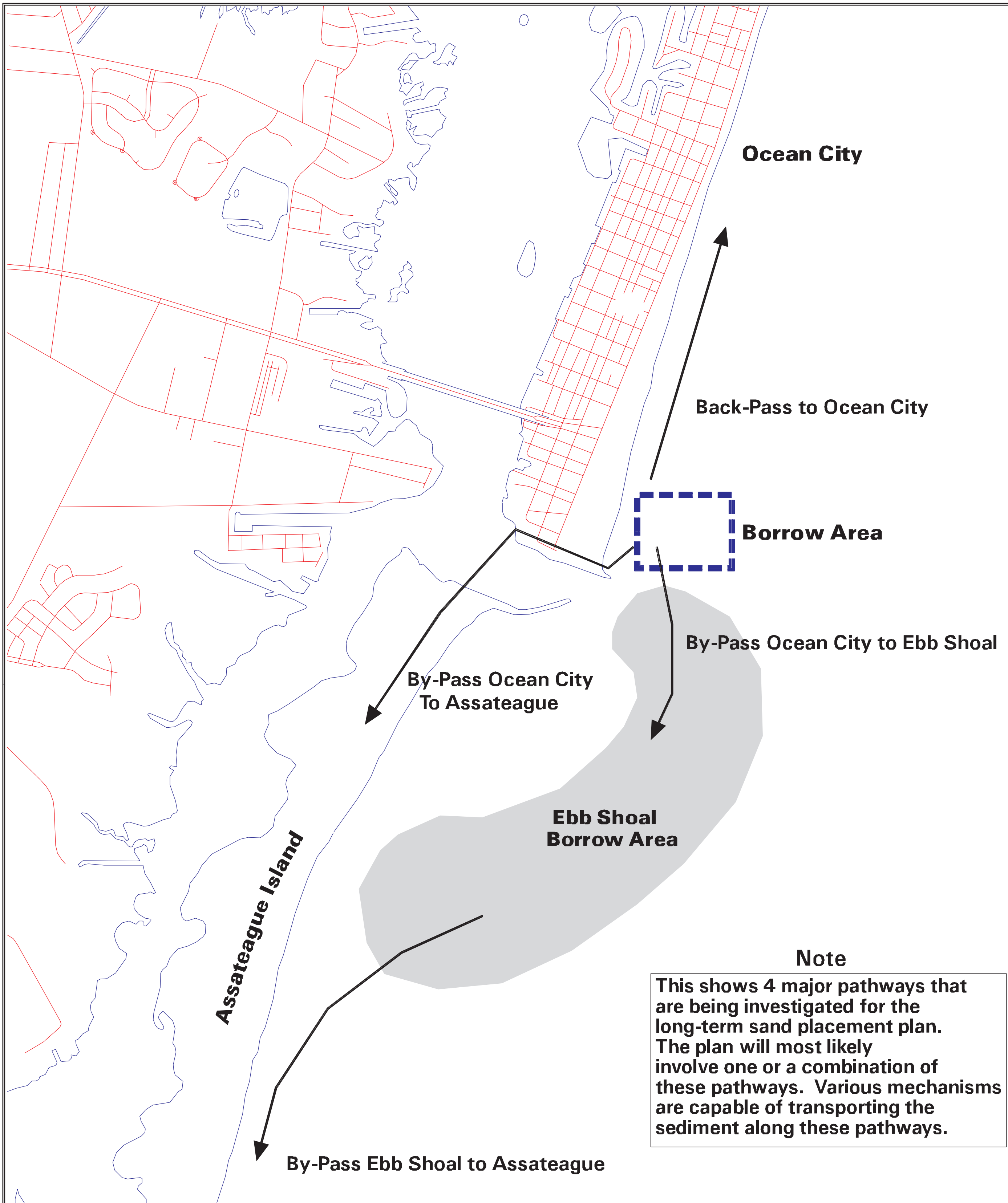
4.3.3 Navigation Improvements

Because commercial waterway users have been experiencing difficulties navigating the Ocean City Inlet, harbor, and Shantytown channel, these problems are also being investigated as part of this study. The following goals and objectives were developed:

Goal: Improve navigation through the inlet, harbor, and Shantytown Channel.

Objectives: The objectives that the study team identified included the following--

1. Establish a safe navigation channel through the inlet, harbor, and Shantytown Channel.
2. Reduce or eliminate the damage being incurred by commercial vessels.
3. Reduce or eliminate the waiting time for vessels to navigate.



US Army Corps of Engineers
Baltimore District

Ocean City Water Resources Feasibility Study

Long-Term Sand Placement Conceptual Solutions By-Pass and Back-Pass Scenarios

Figure 4-2

Formulation of Alternatives

The Corps is still coordinating with the waterway users to determine what the drafts and widths of their vessels are, what the damages are, and how much waiting time the users are experiencing. Once this coordination is completed, designs of various widths and depths of channels will be evaluated. The costs of these potential projects will be compared to the benefits to determine the NED plan.

4.3.4 Ecosystem Restoration

Due to the degradation and loss of fish and wildlife habitat, and the impairment and loss of the ecosystem functions in the watershed, the following goals and objectives for this component of the project have been identified:

Goal: Restore fish and wildlife habitat and ecosystem functions in the coastal bay watershed.

Problems:

First, environmental restoration problems and opportunities identified in the reconnaissance study (see Section 3.4) were revisited. An interagency meeting was held to discuss the following problems:

1. Assateague Island is eroding at an accelerated rate and is being degraded.
2. Water quality is declining.
3. Fish and wildlife habitat and ecosystem functions are being lost.
4. Nesting habitat for colonial waterbirds is being lost.
5. Submerged aquatic vegetation beds are scarce.
6. The number of oyster beds are declining.

These problems were analyzed to determine which ones should be pursued. Problem 1, erosion of Assateague Island, is already being pursued through this study. It was determined that problems 5 and 6 should not be pursued since environmental conditions that cannot be controlled will likely induce failure of these initiatives. It was determined that problem 2 could be combined with 3. This left problem 3 and 4 to be pursued as part of this project. The following objectives were then identified to solve these problems.

Objectives:

1. Replace lost fish and wildlife habitat and ecosystem functions.
2. Provide nesting habitat for colonial waterbirds.

Formulation of Alternatives

After determining that environmental problems dealing with the loss of wetlands and waterbird habitat should be the focus of Corps efforts, an array of alternative solutions was proposed. These included the following:

1. No action.
2. Create/restore/enhance salt marsh along the mainland shoreline.
3. Create salt marsh on newly built dredged material islands.
4. Restore/enhance forested wetlands.
5. Restore/maintain waterbird nesting habitat by restoring/protecting dredged material islands, which are eroding.
6. Create waterbird nesting habitat by building new dredged material islands

At this time, these six plans are being investigated. The Corps is developing plans that could benefit the other project components, such as beneficially using material dredged from navigation channels to create island and wetland habitat. This would benefit both boaters and the ecosystem. The Corps is also considering the restoration of Assateague Island when determining and evaluating these plans, and will avoid any plans that are not compatible with the restoration effort.

Section 5

EVALUATION and COMPARISON OF ALTERNATIVES

Up to this point, the report has focused on the restoration of Assateague Island and has briefly discussed long-term sand placement, navigation improvements, and ecosystem restoration in the back bays. Since the formulation of the latter three components has not been completed, the alternative plans cannot yet be evaluated and compared. This analysis will be documented in the second feasibility report.

5.1 SHORT-TERM RESTORATION OF ASSATEAGUE ISLAND

The restoration of Assateague Island has been investigated primarily because of environmental reasons, and incidentally for economic reasons. Since the project is not economically driven, an NED analysis was not performed, although NED benefits were quantified for certain categories (inundation reduction, recreation, navigation). However, both incremental and cost effectiveness analyses were performed to determine the best plan for restoring the island.

In addition to the project partners--the National Park Service, Maryland Department of Natural Resources, Worcester County, and the Town of Ocean City--the U.S. Fish and Wildlife Service and the Coastal Engineering Research Center played large roles in the development of alternative plans and in the decision-making process.

5.1.1 Evaluation and Comparison of Alternative Plans

As discussed in Section 4, the alternative plans for restoring Assateague Island were formulated, evaluated, and screened, and the remaining plans to be evaluated were--

1. No action.
3/5a. Restore the island to "without jetty conditions" (restore position of the island in 1934 minus natural erosion), and implement a long-term sediment process.
3/5b. Replace the volume of material that the island has been deprived of since 1934 (5.6 million m^3/7.3 million cubic yards), and implement a long-term sediment supply process.
3/5c. Replace the volume of material that the island has been deprived of since 1965 (2.8 million m^3/3.6 million cubic yards), when the National Seashore was authorized, and implement a long-term sediment supply process.
3/5d. Replace a volume of material less than the amount the island has been deprived of since 1965 based on environmental considerations, and implement a long-term sediment supply process.
3/5e. Replace only enough material to construct a low storm berm (173,000 m^3/225,000 cubic yards), and implement a long-term sediment supply process.
8. No immediate restoration, but implement a long-term sediment supply process.

All of the alternative solutions include a long-term restoration component that will be determined as part of the long-term sand placement portion of the study.

The physical, ecological, and economic benefits; impacts; and rough costs for each of the seven alternative plans was determined. Tables 5-1 through 5-7 display the results. Plan #1 is the no-action plan and has the same impacts as the future-without-a-project condition, as described in Section 2 and Section 3 of this report. It includes the occurrence of a breach, followed by degradation of part of the National Seashore, loss of recreation, increased storm damages, navigation difficulties, and loss of SAV beds, to name a few.

Alternatives #3/5a through #3/5e all have similar impacts and provide similar benefits but to varying degrees and with different levels of risk. These restoration alternatives will have both monetary and non-monetary positive impacts, or benefits. Plan #3/5a will restore the northern island in its entirety, whereas Plans #3/5b through #3/5e will restore the island to lesser degrees. Assateague Island is crucial to the coastal bay ecosystem, and without a restoration project, the island will likely breach and impact the area as described in Plan #1.

The benefits of Plans #3/5a through Plan #3/5e include restoring a unique national seashore, a true national treasure, to a more natural condition so that it may be enjoyed for many years to come. These plans would improve habitat diversity on Assateague Island. They would also reduce the amount of overwash and, in turn, reduce shoaling in Sinepuxent Bay and potentially promote SAV bed development. Reducing the probability of a breach from occurring could prevent the adverse impacts associated with the no-action plan. Tens to hundreds of acres of barrier island habitat would not be converted to marine habitat, and tens of acres of salt marshes and submerged aquatic vegetation would not be lost. Part of the National Seashore would not be destroyed, and easy access to approximately 900 acres of the park would not be lost. The project would prevent the loss of about 7,500 visitor days each year to the northern end of the park. The project would also help to maintain a navigable waterway through Sinepuxent Bay by preventing it from shoaling in. In addition, typical storm damage to the mainland communities behind Assateague Island would not worsen. It is estimated that at least $700,000 in additional damages would be incurred by the communities if a storm similar to the January 1992 storm occurred. With any of these plans, these damages could be prevented. Because the benefits are both monetary and non-monetary, a benefit-to-cost ratio cannot be accurately calculated. Table 5-8 is a summary of the alternative plans and displays the level of risk.

The physical, ecological, and economic impacts of each of the alternatives were used to determine whether the plan met the project objectives. The objective of mitigating for the lost volume, which will reduce the likelihood of a breach, had to be met while minimizing the impacts to the Piping Plover, a bird species considered under Federal guidelines to be threatened and under state guidelines to be endangered. Piping Plovers typically nest and breed on sandy beaches where there are minimal dunes and minimal vegetation. On Assateague Island, greater nesting success occurs when birds have unrestricted access to foraging areas on the bay side and in the island interior. Basically, they prefer low-lying areas that overwash. An island that is less likely to breach, however, needs higher elevations to reduce the frequency and magnitude of overwash and to keep it intact. The objectives of reducing storm damages, protecting navigation, and protecting

Table 5-1
Assateague Island Restoration
Evaluation of Alternative #1
No Action

Requirements	Physical Environment	Ecological Impacts	Economic Impacts	Cost	Notes
		Assateague Island			
None	New inlet formation expected by year 2005, 7 km. (4.2 miles) south of present inlet; possibility of additional inlets in near future.	Conversion of Assateague barrier island habitat to marine habitat (10's to 100's of acres)	Loss of recreation on Assateague Island due to lack of access by foot; loss of 7500 visitor days each year while the breach stays open (equals $34,000 per year)	$0	
	Accelerated erosion and increased net loss in volume of sediment	Expansion of non-vegetated overwash habitat on Assateague, loss of other habitat types (100's of acres)	Loss of easy access to 922 acres of a national treasure		
	Acceleration of retreat rate	Change in quantity of Piping Plover and other rare species habitat on Assateague; could be increase or decrease depending on height and configuration of post-breach island			
	Increase in number of islands, total island size shows minimal changes or is reduced by 10's to 100's of acres.				
	Expansion of overwash zone southward				
	Dune loss increases: Northern 10 km. (6.2 miles) aesthetically unpleasing				
		Sinepuxent Bay			
	Sinepuxent Bay decreases in size by as much as 10% due to presence of new inlet and infill by retreat of Assateague Island	Increase in flushing rate of Sinepuxent and Chincoteague Bays (hours and minutes)	Navigation channel impassable; loss of recreational users until breach is filled in, or channel dredged		
		Increase in salinity of northern Sinepuxent and Chincoteague Bays (few ppt)			
		Conversion of Sinepuxent Bay shallow water habitat to marine and terrestrial habitat (10's to 100's of acres)			
		Loss of SAV beds (10's of acres)			
		Mainland			
	Increased wave energy, erosion, and flooding potential on mainland	Loss of existing shoreline salt marsh in vicinity of new inlet following breaching, long-term formation of salt marsh in adjacent locations (10's of acres)	Approx. $3.9 million in storm damages with another Jan '92 storm; this does not include additional damage due to waves from new inlet		

Table 5-2
Assateague Island Restoration
Evaluation of Alternative #3/5a
Restore to Without Jetty Condition

Requirements	Physical Environment	Ecological Impacts	Economic Impacts	Cost	Notes
		Assateague Island			
1. Excavate 2.8 million m^3 (3.6 million cy) of material off the bay side of the island and place on the ocean side	Complete restoration of sediment volume and reduced downdrift future erosion	Increase in vegetative diversity on Assateague, development of dune grassland, shrub-thicket, and salt marshes (1000's of acres)	Very low risk of losing visitor days on Assateague; may improve recreational quality	$95 million first cost; plus cost for long-term sand placement[1]	Using 2 dredges, it will take 5 to 7 years to construct[2]
2. Replace 5.6 million m^3 (7.3 million cy) of material in surf zone	Large reduction in probability of inlet formation	Increase in habitat on Assateague for most wildlife, increase in local wildlife diversity (1000's of acres)	Very low risk of losing a national treasure		Will prove controversial due to severe short-term (few years) environmental impacts
3. Reconfigure south jetty and potentially remove one or more breakwaters	Large reduction in island retreat rate	Substantial reduction in overwash habitat on Assateague and some detrimental impacts to Piping Plover and other rare species of this habitat type (1000's of acres)			
4. Replace 50 acres of saltmarsh	Island size remains same, location changes				
	Reduced overwash frequency				
	High potential for augmented dune formation, more aesthetically pleasing than no-action				
		Sinepuxent Bay			
	Sinepuxent Bay increases in size by about 8%	Water quality detrimentally impacted over short-term from dredging. Long-term water quality remains constant.	Probable increase in recreational boaters due to widening of Sinepuxent Bay		
	Infilling and shoaling of Sinepuxent Bay slowed substantially	Long-term increase in shallow water estuarine habitat (100's of acres) Short-term destruction of SAV beds followed by long-term increase in potential SAV habitat (100's of acres) Long-term increase in benthic and open water bay habitat for commercial fishery species.			
		Mainland			
	Mainland erosion rate decreases or remains constant	Existing shoreline salt marsh maintained	$3.2 million in storm damages during another Jan '92 storm; at least $700k less in storm damages than if no action taken		

Table 5-3
Assateague Island Restoration
Evaluation of Alternative #3/5b
Replace Volume of Material Lost Since 1934 and Implement Long-Term Sediment Supply Process

Requirements	Physical Environment	Ecological Impacts	Economic Impacts	Cost	Notes
		Assateague Island			
1. Replace 5.6 million m^3 (7.3 million cy) of material on the ocean side	Complete restoration of sediment volume and reduced downdrift future erosion	Substantial increase in vegetative diversity on Assateague, development of dune grassland, shrub-thicket, and salt marshes.	Very low risk of losing visitor days on Assateague; may improve recreational quality	$67 million first cost; plus cost for long-term sand placement[1]	Using 2 dredges, it will take 5 to 7 years to construct[2]
	Very large reduction in probability of inlet formation	Substantial increase in habitat on Assateague for most wildlife, increase in local wildlife diversity.	Very low risk of losing a national treasure		Will be controversial due to environmental impacts; might have to mitigate for impacts to piping plovers and other overwash habitat species
	Large reduction in island retreat rate	Severe reduction in overwash habitat on Assateague and severe detrimental impacts to Piping Plover and other rare species of this habitat type.			
	Island width increases approximately 150 to 200 feet; low storm berm constructed				
	Substantially reduced overwash frequency				
	Very high potential for augmented dune formation, more aesthetically pleasing than no action				
		Sinepuxent Bay			
	Sinepuxent Bay size remains somewhat constant	Water quality remains constant.	Protected waterway for recreational boaters		
	Infilling and shoaling of Sinepuxent Bay slowed substantially	Maintenance of existing estuarine habitat.			
		Mainland			
	Mainland erosion rate decreases or remains constant	Existing shoreline salt marsh maintained	$3.2 million in storm damages during another Jan '92 storm; at least $700k less in storm damages than if no action taken		

Table 5-4
Assateague Island Restoration
Evaluation of Alternative #3/5c
Replace Volume of Material Lost Since 1965 and Implement Long-Term Sediment Supply Process

Requirements	Physical Environment	Ecological Impacts	Economic Impacts	Cost	Notes
		Assateague Island			
1. Replace 2.7 million m^3 (3.5 million cy) of material on the ocean side	Partial restoration of sediment volume and moderate reduced downdrift future erosion	Moderate increase in vegetative diversity on Assateague, some development of dune grassland, shrub-thicket, and salt marshes.	Low risk of losing visitor days on Assateague; may improve recreational quality	$32 million first cost; plus cost for long-term sand placement[1]	Using 2 dredges, it will take 2 to 3 years to construct[2]
	Moderate to large reduction in probability of inlet formation	Moderate increase in habitat on Assateague for most wildlife, increase in local wildlife diversity.	Low risk of losing a national treasure		
	Moderate reduction in island retreat rate	Moderate reduction in overwash habitat on Assateague and some detrimental impacts to Piping Plover and other rare species of this habitat type.			
	Island width increases approximately 70 to 90 feet; low storm berm constructed				
	Moderately reduced overwash frequency				
	Moderate potential for augmented dune formation, more aesthetically pleasing than no-action				
		Sinepuxent Bay			
	Sinepuxent Bay size remains constant	Water quality remains constant.	Protected waterway for recreational boaters		
	Infilling and shoaling of Sinepuxent Bay slowed	Maintenance of existing estuarine habitat.			
		Mainland			
	Mainland erosion rate decreases or remains constant	Existing shoreline salt marsh maintained	$3.2 million in storm damages during another Jan '92 storm; at least $700k less in storm damages than if no action taken		

Table 5-5
Assateague Island Restoration
Evaluation of Alternative #3/5d
Replace Less Volume Based on Environmental Considerations and Implement Long-Term Sediment Supply Process

Requirements	Physical Environment	Ecological Impacts	Economic Impacts	Cost	Notes
		Assateague Island			
1. Replace 1.4 million m^3 (1.8 million cy) of material on the ocean side	Partial restoration of sediment volume and some reduced downdrift future erosion	Some increase in vegetative diversity on Assateague, some development of dune grassland, and salt marshes.	Low to moderate risk of losing visitor days on Assateague; may improve recreational quality	$17 million first cost; plus cost for long-term sand placement[1]	Using 2 dredges, it will take 1 to 2 years to construct[2]
	Moderate reduction in probability of inlet formation	Some increase in habitat on Assateague for most wildlife, increase in local wildlife diversity.	Low to moderate risk of losing a national treasure		
	Some reduction in island retreat rate	Some reduction in overwash habitat on Assateague and minimal detrimental impacts to Piping Plover and other rare species of this habitat type.			
	Average Island width increases ***to*** approximately 30 to 40 feet; low storm berm constructed				
	Some reduction in overwash frequency				
	Some potential for augmented dune formation, more aesthetically pleasing than no action				
		Sinepuxent Bay			
	Sinepuxent Bay size remains constant	Water quality remains constant.	Protected waterway for recreational boaters		
	Infilling and shoaling of Sinepuxent Bay slowed	Maintenance of existing estuarine habitat.			
		Mainland			
	Mainland erosion rate decreases or remains constant	Existing shoreline salt marsh maintained	$3.2 million in storm damages during another Jan '92 storm; at least $700k less in storm damages than if no action taken		

Table 5-6
Assateague Island Restoration
Evaluation of Alternative #3/5e
Replace Only Enough Material to Construct a Low Storm Berm and Implement Long-Term Sediment Supply Process

Requirements	Physical Environment	Ecological Impacts	Economic Impacts	Cost	Notes
		Assateague Island			
1. Replace 175,000 m^3 (225,000 cy) of material on the ocean side	Minimal restoration of sediment volume and some reduced downdrift future erosion	Some increase in vegetative diversity on Assateague, some development of dune grassland, and salt marshes.	Moderate risk of losing visitor days on Assateague; may improve recreational quality	$2.2 million first cost; plus cost for long-term sand placement[1]	Using 1 dredge, it will take 1 year to construct[2]
	Some reduction in probability of inlet formation	Some increase in habitat on Assateague for most wildlife, increase in local wildlife diversity.	Moderate risk of losing a national treasure		
	Some reduction in island retreat rate	Minor reduction in overwash habitat on Assateague			
	Island width does not change; low storm dune constructed in island interior	Adverse impacts to Piping Plover and other rare species of this habitat type, due to sand placed in island interior; increased risk to moist flat foraging areas.			
	Some reduction in overwash frequency				
	Some potential for augmented dune formation				
		Sinepuxent Bay			
	Sinepuxent Bay size remains constant	Water quality remains constant.	Protected waterway for recreational boaters		
	Infilling and shoaling of Sinepuxent Bay slowed	Maintenance of existing estuarine habitat.			
		Mainland			
	Mainland erosion rate decreases or remains constant	Existing shoreline salt marsh maintained	$3.2 million in storm damages during another Jan '92 storm; at least $700k less in storm damages than if no action taken		

Table 5-7
Assateague Island Restoration
Evaluation of Alternative #8
No Immediate Restoration but Implement Long-Term Sediment Supply Process

Requirements	Physical Environment	Ecological Impacts	Economic Impacts	Cost	Notes
No initial placement of sand					
		Assateague Island			
	New inlet formation expected	Conversion of Assateague barrier island habitat to marine habitat (10's to 100's of acres)	Loss of recreation on Assateague Island due to lack of access by foot; loss of 7500 visitor days each year while the breach stays open (equals $34,000 per year)	No first cost; only cost for long-term sand placement[1]	
	Dune loss increases: Northern 10 km. (6.2 miles) aesthetically unpleasing; over long-term, minor dunes could form	Expansion of non-vegetated overwash habitat on Assateague, loss of other habitat types (100's of acres)	Loss of easy access to 922 acres of a national treasure		
	Increase in number of islands, total island size shows minimal changes or is reduced by 10's to 100's of acres.	Change in quantity of Piping Plover and other rare species habitat on Assateague; could be increase or decrease depending on height and configuration of post-breach island			
		Sinepuxent Bay			
	Sinepuxent Bay decreases in size by as much as 10% due to presence of new inlet and infill by retreat of Assateague Island	Increase in flushing rate of Sinepuxent and Chincoteague Bays (hours and minutes)	Navigation channel impassable; loss of recreational users until breach is filled in, or channel dredged		
		Increase in salinity of northern Sinepuxent and Chincoteague Bays (few ppt)			
		Conversion of Sinepuxent Bay shallow water habitat to marine and terrestrial habitat (10's to 100's of acres)			
		Loss of SAV beds (10's of acres)			
		Mainland			
	Increased wave energy, erosion, and flooding potential on mainland	Loss of existing shoreline salt marsh in vicinity of new inlet following breaching, long-term formation of salt marsh in adjacent locations (10's of acres)	Approx. $3.9 million in storm damages with another Jan '92 storm; this does not include additional damage due to waves from new inlet		

NOTES:

1. Long-term sand placement method is still to be determined

2. Due to Piping Plover and weather restrictions, construction should only occur between 1 September and early November.

Assateague Island Restoration
Summary of Alternatives

	Alternative	Requirements	Cost	Notes	Risk
1	No Action	None	$0		
3/5a	Restore to "without jetty conditions" (restore 1934 island minus natural erosion) and implement long-term sediment supply process	Excavate 2.8 million m^3 (3.6 million cy) of material off the bay side of the island and place on the ocean side Replace 5.6 million m^3 (7.3 million cy) of material in surf zone Reconfigure south jetty and potentially remove one or more breakwaters Replace 50 acres of saltmarsh	$95 million first cost; plus cost for long-term sand placement[1]	Using 2 dredges, it will take 5 to 7 years to construct[2] Will prove controversial due to severe short-term (few years) environmental impacts	
3/5b	Replace volume of material that the island has been deprived of since 1934 and implement long-term sediment supply process	Replace 5.6 million m^3 (7.3 million cy) of material on the ocean side Island width increases approximately 150 to 200 feet on average assuming material is placed uniformly; low dune/berm constructed	$67 million first cost; plus cost for long-term sand placement[1]	Using 2 dredges, it will take 5 to 7 years to construct[2] Will be controversial due to environmental impacts; might have to mitigate for impacts to piping plovers and other overwash habitat species	
3/5c	Replace volume of material that the island has been deprived of since 1965 and implement long-term sediment supply process	Replace 2.7 million m^3 (3.5 million cy) of material on the ocean side Island width increases approximately 70 to 90 feet on average, assuming material is placed uniformly ; low dune/berm constructed	$32 million first cost; plus cost for long-term sand placement[1]	Using 2 dredges, it will take 2 to 3 years to construct[2]	
3/5d	Replace a volume of material less than the amount the island has been deprived of since 1965 based on environmental considerations, and implement long-term sediment supply process	Replace 1.4 million m^3 (1.8 million cy) of material on the ocean side ***Average*** Island width increases ***to*** approximately 30 to 40 feet assuming material; low ***storm*** berm constructed	$16 million first cost; plus cost for long-term sand placement[1]	Using 2 dredges, it will take 1 to 2 years to construct[2]	
3/5e	Replace only enough material to reduce the likelihood of a breach by constructing a low dune, and implement long-term sediment supply process	Replace 175,000 m^3 (225,000 cy) of material on the ocean side Island width does not change; low dune/berm constructed	$2.2 million first cost; plus cost for long-term sand placement[1]	Using 1 dredge, it will take 1 year to construct[2]	
8	No immediate restoration, but implement a long-term sediment supply process	No initial placement of sand	No first cost; only cost for long-term sand placement[1]		

Risk (rows 3/5a to 8): Potential Impacts to Piping Plovers Reduced (arrow pointing down); Likelihood of Breach Reduced (arrow pointing up)

NOTES:

1. Long-term sand placement is still to be determined; could be by-passing plant

2. Due to endangered species, construction should only occur between Sep. and Oct. Time of construction assumes 2 to 3 months each year; this is conservative and will be further investigated.

recreation and economic resources also rely on an island that does not breach.

The risk of restoring Assateague Island to an elevation that is too high for the Piping Plovers to remain, had to be weighed against restoring it to an elevation that is too low, and will not adequately reduce the likelihood of a breach. This risk was considered when evaluating the seven plans and determining the amount of material with which to restore the island. Basically, as more material is placed on the island, the risk of a breach is reduced, and the chance of providing the benefits is greater. The reduction in breach probability with the increase of volume is not quantifiable because of the many unmeasured, unquantified hydrologic and meteorological factors involved in a storm event capable of breaching the island. In order to postulate breach risk reduction in a quantifiable sense, these factors would need to be assessed. However, as more material is placed on the island, there is also more of a chance for impacting the Piping Plovers. Even if the material is placed at a low elevation, a very large amount of material that widens the island significantly could reduce the overwash frequency and promote vegetation and dune growth, and could also adversely impact the plovers. It was critical that the the two objectives be balanced. Because there is no definitive amount of sand that would neither be too much nor too little, the experience and best professional judgement of the study team members and resource agencies was used.

We then determined which alternatives were meeting which objectives. The most important objective is restoring a volume of sediment to adequately mitigate for the impacts caused by the jetty. However, this objective has to be met within the constraint of minimizing the impacts to the Piping Plover. The table below shows whether or not the objective and the constraint were met for the seven alternatives, along with the approximate first cost. It was decided to set aside some issues in the plan formulation process until one of the seven plans was selected. These issues include what the source of material would be and what the best configuration of the island would be.

Table 5-9 Alternative Plans vs. Objectives and Constraints

Alternative Plan	Meets Mitigation Objective	Within Plover Constraint	Cost
1	No	Yes	$0
3/5a	Yes	No	$95 million
3/5b	Yes	No	$67 million
3/5c	Yes	No	$32 million
3/5d	Yes	Yes	$17 million
3/5e	No	Yes	$2.2 million
8	No	Yes	$0

The Corps and the sponsors all felt strongly that a plan needed to be selected that met both the mitigation objective and the Piping Plover constraint. Besides the fact that Plans #3/5a and #3/5b did not minimize the impacts to the Piping Plovers, they were extremely costly, roughly $95 million and $67 million for first costs, respectively. Although they would fully mitigate for the impacts caused by the jetties since 1934, the team felt that placing more than 5 million m^3 of material on Assateague Island was unrealistic, since the project would take about 7 years to construct. Also, similar benefits could be obtained with Plans #3/5c and #3/5d for a much lower cost. Therefore, Plans #3/5a and #3/5b were eliminated from further evaluation.

Plan #8 would not meet the mitigation objective, would not reduce the likelihood of a breach, and would not provide the desired benefits. Therefore, it was also eliminated. Plan #3/5e would not meet the mitigation objective, but would reduce the probability of a breach if the storm berm could be constructed further back on Assateague Island. This would be necessary for it to be protected from erosion. However, this would adversely affect the Piping Plover habitat. Since it would not meet the mitigation objective and it would adversely affect a threatened species, plan #3/5e was eliminated. This left Plan #1 (the no-action plan), Plan #3/5c, and Plan#3/5d. Plan #3/5c involves placing 2.7 million cubic meters of material on Assateague to mitigate for the sand the island has been deprived of since 1965, the year when the National Seashore was established. The study team and the Steering Committee, comprised of executives from each of the sponsors including the National Park Service, believed that Plan #3/5c would provide an appropriate level of mitigation for the impacts of the jetties. However, it was thought that there was too great a risk of adversely impacting the environment and the Piping Plovers. In addition, it would take about 3 years to construct the project, which we are trying to accelerate, and the cost is roughly $32 million. The team eliminated Plan #3/5c and decided that Plan #3/5d, which involves placing an amount of material less than the amount the island has been deprived of since 1965, based on environmental considerations, should be the selected plan. We agreed that we needed to place just enough material that the risk of a breach was low and the impacts to the Piping Plovers were minimal.

We then needed to determine an exact volume of material for Plan #3/5d. As stated previously, there is no precisely known volume that would guarantee no adverse impacts to Piping Plover yet would guarantee the maximum protection against a breach. The Corps coordinated with resource agencies and experts in various fields to use best professional judgements to determine the amount of sand that would meet our needs. As a starting point, we selected half of the volume that the island has been deprived of since 1965 for Plan #3/5d, 1.4 million m^3 of material. Our next step was to optimize the selected plan. In order to reduce the gap between the recommended plan (#3/5d) and the next larger and smaller plans (#3/5c and #3/5e), we considered three “options” for different volumes for the recommended plan (#3/5d). The first option, Option 1, involved placing 840,000 m^3 of sand. The second option, Option 2, involved placing 1.4 million m^3 of sand (the amount originally selected). The third option, Option 3, involved placing 2.0 million m^3 of material.

Each of the three options described above includes the construction of a storm berm with a 25-m buffer to protect it. The 25-m buffer was determined using the SBEACH model, which was applied using data from numerous storms to determine beach recession. Results showed that a range of 20 to 30 m of beach recession can be expected for storms with a frequency of occurrence of once every year or two. Therefore, the 25-m buffer must be combined with the storm berm in order for the berm to produce the desired benefits. Although simply widening the island will add integrity to it, the storm berm is the feature that will provide the most protection against a breach or destruction of the island. With the berm intact, a myriad of benefits will be realized: the island will be less susceptible to destruction from storms, the unique National Seashore will be preserved, habitat diversity will be promoted, and salt marshes will be protected, for example.

The engineers recommended placing 5 years of erosion protection in front of the storm berm. However, the environmental resource agencies feared that so much protection would make the beach too wide and would not provide the overwash necessary for the Piping Plovers to survive. We agreed to compromise on a maximum of 2 years of erosion protection in front of the storm berm and buffer. Therefore, in order to provide all the benefits of a project, the long-term plan will have to begin within 2 years after the short-term plan is implemented.

Table 5-10 shows the volume, cost, and construction time for each of the three options for the recommended plan, #3/5d. For all three options, the long-term plan will be initiated in Year 3. For Option 1, when this component is initiated, there will be an additional 1 year of erosion volume remaining in the system. This means that 840,000 m^3 is equivalent to the amount of material eroded from the project area in a 3-year period. After 2 years, when the long-term placement is initiated, one year's worth of erosion volume will still remain. Option 2 would have 3 years' worth, and Option 3 would have 5 years' worth.

Table 5-10
Construction Times and Costs for Optional Plans

OPTION	TOTAL COST	YEAR 1	YEAR 2	YEAR 3
Option 1 840,000 m^3 1,080,000 cy	$11,500,000	Complete Construction	No Construction	Initiate long-term plan 1 year of erosion volume remains
Option 2 1,400,000 m^3 1,800,000 cy	$17,100,000	Construction	Complete Construction	Initiate long-term plan 3 years of erosion volume remains
Option3 2,000,000 m^3 2,570,000 cy	$20,300,000	Construction	Complete Construction	Initiate long-term plan 5 years of erosion volume remains

Table 5-11 displays the benefits and costs of each of the options. Option 1 includes construction of the storm berm and the 25-m buffer. However, since this option has less volume, either the storm berm must be placed farther back on the island to provide the 2-years' worth of erosion protection, or the protection in front of the storm berm must be reduced. In the first case, low, moist areas that are prime Piping Plover habitat will be disrupted by the construction of the storm berm. In the second case, the storm berm will not be adequately protected and the potential for a breach is high. Options 2 and 3 are similar in that they provide greater mitigation, reduce

<u>OPTION 1</u>
Volume - 840,000 m^3 (1.08 mil cy)
Cost - $11.5 million

BENEFITS

-Mitigates small portion of volume lost due to jetties (13% since 1933; 26% since 1965); when the long-term plan is initiated, there will be an additional one year worth of volume in the system
-Beach habitat widened 0-11 meters (0-30 feet) initially
-Small potential for increase in habitat diversity
-72 environmental units (EU) - $159,700/EU

COSTS

-Possibly 75% chance of disrupting unique overwash habitat (plover habitat) by having to fill in low moist areas by construction of storm berm

OR

-Little protection in front of storm berm, making the island more vulnerable to a breach, causing:
- emergency repairs
- temporary disruption of habitat - island, salt marshes, SAV
- temporary loss of access to approx. 900 acres of island for recreation
- mainland experiences higher storm damages during storm and until low or breached areas are filled in

<u>OPTION 2</u>
Volume - 1.4 million m^3 (1.8 million cy)
Cost - $17.1 million

BENEFITS

-Mitigates for a portion of volume lost due to jetties (21% since 1933; 42% since 1965); when the long-term plan is initiated, there will be an additional three years worth of volume in the system
-Beach habitat widened 0-29 meters (0-87 feet) initially
-Higher potential for increase in habitat diversity
-Reduces downdrift erosion
-Promotes potential for development of about 100 acres of salt marshes
-Prevents loss of SAV beds
-Allows continued recreation in unique setting
-Provides some protection to mainland
-114 environmental units (EU) - $150,000/EU

COSTS

-Possibly 10% chance of disrupting unique overwash habitat (plover habitat)

Table 5-11
Short-Term Restoration of Assateague Island

Benefit and Cost Analysis

<u>OPTION 3</u>
Volume - 2.0 million m^3 (2.6 million cy)
Cost - $20.3 million

BENEFITS

-Mitigates for a portion of volume lost due to jetties (30% since 1933; 60% since 1965); when the long-term plan is initiated, there will be an additional five years worth of volume in the system
-Beach habitat widened 0-36 meters (0-138 feet) initially
-Highest potential for increase in habitat diversity
-Reduces downdrift erosion
-Promotes potential for development of about 100 acres of salt marshes
-Prevents loss of SAV beds
- Allows continued recreation in unique setting
- Provides some protection to mainland
-115 environmental units (EU) - $176,500/EU

COSTS

-Possibly 20% chance of disrupting unique overwash habitat (plover habitat)

*USFWS did not find this plan acceptable due to risk to endangered species downdrift erosion, lower the potential for a breach, widen the beach habitat, promote the development of salt marshes, and so on. Option 3 is the best solution, purely from a mitigation perspective. However, the USFWS does not find this plan acceptable due to the risk of disrupting the unique overwash habitat.

The team evaluated the three options based on the desired components of this barrier island (see Table 5-12). Values were assigned to the components based on their importance, and then each option was rated from "1" to "5," based on how well it met the objective. Next, the values were summed to derive a total environmental unit. The total cost of the short-term plan was divided by the total environmental unit to determine the cost per environmental unit. As shown in Table 5-12, Option 2 is the most cost-effective plan at $150,000 per unit.

The Baltimore District and the study sponsors feel that a short-term project to restore Assateague Island is justified, at an initial cost of $17,100,000, given the significance of the island and the benefits that will be gained. These benefits include the following:

-Restoring a unique barrier island of national significance to a more natural state.
-Adding integrity to Assateague Island prior to restoring long-term sediment supply.
-Providing 114 environmental units at a cost of $150,000 per unit.
-Reducing likelihood of a minor breach.
-Promoting habitat diversity.
-Reducing future downdrift erosion and preventing overwash areas from expanding, which would otherwise cause the loss of hundreds of acres of other habitat types.
-Increasing beach width varying degrees (maximum increase: 95 feet).
-Promoting potential for development of about 100 acres of salt marshes on the back side of the island.
-Reducing the infilling of Sinepuxent Bay.
-Protecting navigation through Sinepuxent Bay.
-Protecting existing estuarine habitat in Sinepuxent Bay (from tens to hundreds of acres).
-Preventing loss of SAV beds (tens of acres).
-Decreasing or maintaining existing erosion rate of mainland.
-Allowing continued recreation in a unique, natural barrier island setting (preventing loss of 7,500 visitor days, equivalent to $34,000 per year).
-Providing some protection to mainland communities (preventing approximately $700,000 in damage from a storm of the same magnitude as the January 1992 storm).

Therefore, for the short-term restoration of Assateague Island, Alternative #3/5d, Option 2, which will be referred to in the remainder of this report as simply "Alternative #3/5d" or "the recommended plan," has been selected as the best alternative of those investigated.

After selecting the recommended plan, we discussed what plan we would have recommended had we not been constrained by the needs of the Piping Plovers. It was agreed that the same or a similar volume of material probably would have been selected, based primarily on cost and construction time. However, there would have been one difference: the design of the island cross section.

Table 5-12: Assateague Island Restoration
Evaluation of Options for Plan #3/5d

		Components of Barrier Island									
	Option	Sediment supply	Maintain overwash frequency	Low breach potential	Habitat diversity	Low storm damages	Accessible Navigation	Recreational access	Total Environ-mental Units	FIRST COST	Cost per Environ-mental Unit
	Relative Value of Component	8	8	5	5	3	3	3			
1	Replace 840,000 m3	16	32	5	10	3	3	3	72	$11.5 million	$159,700
2	Replace 1.4 million m3	24	28	20	15	9	9	9	114	$17.1 million	$150,000
3	Replace 2.0 million m3	32	16	20	20	9	9	9	115	$20.3 million	$176,500

Notes:
The components are rated on a scale from 1 to 5 for each alternative. This rating is then multiplied by the relative value of the component.

Once it was determined that Plan #3/5d was the most environmentally acceptable and cost-effective plan to meet the objectives, the plan needed to be optimized once again, this time to determine the most cost-effective source of material, placement configuration, and island cross-section. How the borrow source was determined is documented below. The design of the island configuration and cross-section are discussed in Section 6.

5.1.2 Determination of Borrow Source

Once we had determined how much material would be needed to restore Assateague Island, it was necessary to determine where to get suitable material. A geotechnical analysis was performed to arrive at the most appropriate source of beachfill material for the restoration of Assateague Island. The study included an assessment of the physical properties of the native beach sand and potential borrow areas. Economic, environmental, and other appropriate criteria were taken into consideration in the selection process. A general summary of the geotechnical analysis is presented below. Details of the analysis are contained in Appendix B.

The determination of a "composite" gradation to represent the native beach material on Assateague Island was based on gradation data obtained from grab samples taken in November 1995. The beach samples consisted of separate samples for 13 profiles taken at 8 points along each profile. A composite gradation representing samples from the mean high water, midtide, and mean low water locations was selected to represent the "native beach" material for determining the suitability of borrow sources.

Only offshore sources were considered, since the expense of trucking material from a land-based borrow and the potential disruption of the environmentally sensitive island by truck haul operations would leave offshore dredging as the only viable alternative. Many local residents questioned why material could not be taken from the back bays, which are shoaling in. As we explained in numerous public meetings, an extremely large amount of material is needed to restore Assateague Island, and that volume of compatible material cannot be found in the bays. A small amount could possibly be taken from the bays to supplement the offshore borrow source, but it would not be cost effective, since a separate, smaller dredge would be needed to dredge from the shallow bays. Therefore, only offshore shoals were considered. Based on the work done by the Maryland Geologic Survey (Conkwright and Gast 1994 and 1995; Kerhin, 1989; Wells, 1994), four shoal areas were selected for initial consideration because of their proximity to the project. The selected areas included Little Gull Bank and Great Gull Bank shoals, which are relatively close to shore, and shoals designated as B & C, which are further offshore. The location of the shoals is presented on Figure 1-2.

Some existing data on the shoals was available; however, additional information on the sand quality and quantity was needed. Vibracore drilling in the four proposed borrow areas was performed during October and November 1995 by the Corps of Engineers. Thirty-five holes were drilled at spacings of approximately 914 m (3000 feet). The hole locations are shown in Appendix B. The purpose of the drilling was to determine the general characteristics of the proposed borrow areas, and to determine their suitability for use as a beachfill material source. Gradation tests were performed on selected samples obtained from the vibracoring operation.

The proposed borrow areas were divided into subareas for analysis based on general mean grain size differences. Additional adjustments in the areas were subsequently made to eliminate from consideration areas defined as “fish havens.” These areas have been selected as areas where future artificial fishing reefs may be created. Composite gradations representing each subarea were calculated for various elevations, both cumulatively from the surface and for individual vertical increments. Results of the analysis are presented in Appendix B.

Sand material suitable for restoring the beach on Assateague Island can be obtained from portions of Shoal B, Great Gull Bank, and Little Gull Bank. A significant quantity of material from each of these areas has a grain size suitable for use as beachfill. Material from Shoal C has been determined to be too fine for consideration as beachfill.

The initial restoration contract will require placement of approximately 1,400,000 m^3 (1,830,000 cubic yards) of sand. Since this material is available from either Little Gull Bank or Great Gull Bank, these areas were recommended as the initial source of material. Shoal B is significantly farther from shore, would be less cost effective to use, and is considered to be of greater environmental and commercial value to the surf clammers.

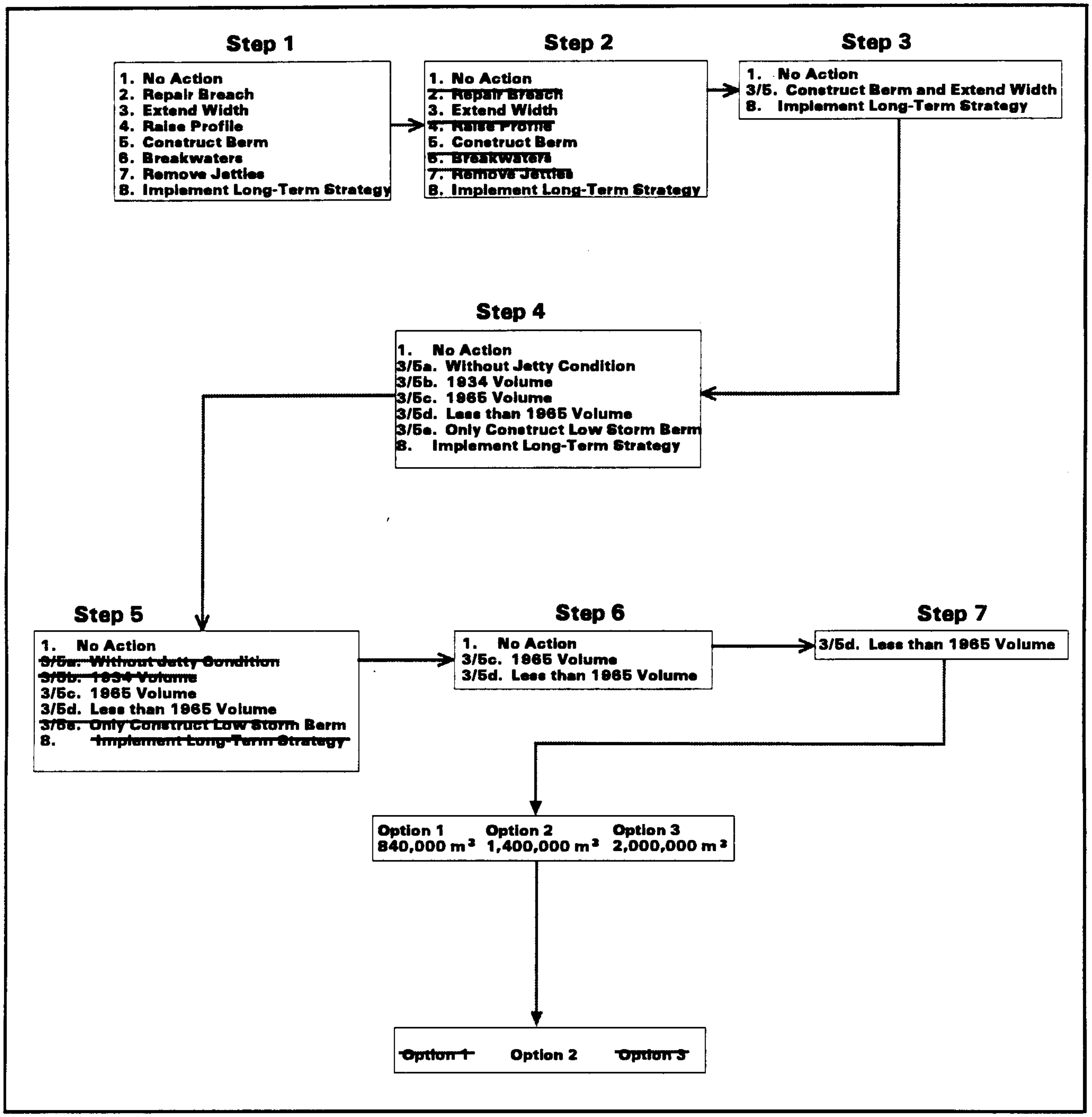
Since either Little Gull Bank or Great Gull Bank could be used as a borrow source, a determination had to be made regarding which shoal would have less of an impact on the environment and the fishermen. On three occasions, we met with the local commercial and recreational fishermen to hear their ideas and comments regarding the two shoals. The commercial fishermen rarely fish off the shoals; however, the shoals are extremely important to the recreational fishermen. The smaller boats fish off Little Gull Bank since it is closer to shore, whereas the larger boats mainly fish off Great Gull Bank. The fishermen agreed that because it is a small percentage of the shoal that we will be dredging , there would be minimal impacts to them and their livelihood. They did agree that the crest should be maintained and they requested that instead of taking a single slice off the side the shoal, that the contractor possibly leave some deeper holes for fish habitat.

Great Gull Bank (Sub area I) has been selected for use for a number of reasons. First, the material from a portion of this shoal more closely matches the gradation of the native material than does that from Little Gull Bank. Second, Great Gull Bank is slightly further offshore than Little Gull Bank, and its mining would have minimal influence on shore erosion. An evaluation of the effects of removing material from Great Gull Bank was made, and it showed that a small change in the sediment transport trends of the shoreline would be expected. The small changes may have a beneficial effect by reducing the shoal-induced gradients in the nearshore wave climate, resulting in a less erosive shoreline in the area shoreward of Great Gull Bank. (See Appendix A for this analysis.) In contrast, mining Little Gull Bank would pose a slightly greater risk to the shoreline. Finally, the fishermen agreed that if Great Gull Bank were used, both the small and large boats could fish off Little Gull Bank during construction. As stated earlier, the smaller boats prefer Little Gull; they would be less likely to travel further offshore to Great Gull if Little Gull Bank were being used for construction. The cost difference of pumping material from either of the two shoals was considered, and the difference was insignificant. The average distance from the two shoals to the furthest points they would need to pump on Assateague Island is within a tenth of a mile. Therefore, cost was not considered a deciding factor. Final design level drilling (vibracoring) will be accomplished in this area of Great Gull Bank during the plans and specifications stage with hole spacings at approximately 300-m (1000-foot) intervals.

The ebb shoal is also under consideration as a sand source. As shown in Figure 3-2, the ebb shoal has grown greatly in the past few years and has begun to close off the oceanside entrance to the inlet to adversely impact navigation. Boaters now must navigate east out of the inlet, then north around the ebb shoal, before heading south. It may be possible to take between 100,000 and 500,000 m^3 (130,000 and 650,000 cubic yards) of material from the ebb shoal to improve navigation. Because we have not completed the sediment pathways work, we are hesitant to say where exactly the material could be taken from. By the time the second feasibility report is completed, however, we will have finished the sediment budget and pathways work and will have enough information to make a decision regarding the source(s). Figure 5-1 shows the entire plan formulation process.

Short-Term Assateague Island Restoration Plan Formulation Flow Chart

Selection of Preferred Plan



Selection of Source Material

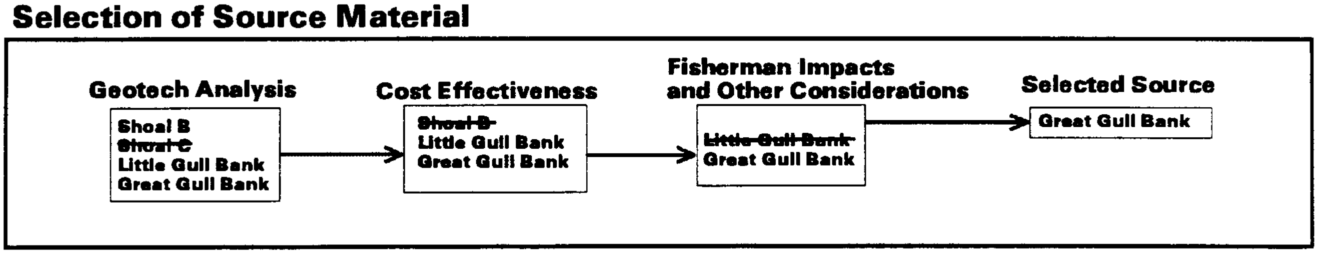


Figure 5-1

Section 6

DESCRIPTION OF RECOMMENDED PLAN

6.1 PHYSICAL DESCRIPTION OF PLAN

After deciding that 1.4 million cubic meters of material should be placed on Assateague Island, the plan had to be optimized by selecting the best cross-section for the island, the best location to place the material on the island, and the best borrow source.

6.1.1 Developing the Island Cross-Section

The first critical design parameter that had to be considered was the elevation to be created during the process of placing sand on the island. The main reason for increasing the elevation of the island is to reduce the frequency and magnitude of overwash, and therefore, reduce the potential for breaching along the island's severely eroded north end. At present, much of north Assateague Island is void of any relief above the existing average berm height [average 2.5 m (8.2 feet)], and the island is overwashed as much as 20 times per year. There are several areas that are particularly low in elevation and possess well-defined overwash channels. The low relief and the presence of these channels make the island susceptible to breaching, as has happened in the past. The most cost-effective means for reducing the potential for breaching is to provide additional elevation to the island, in the form of a storm berm feature.

However, environmental factors and desires of the local cost-sharing partners pose constraints on the design, and must be considered. The restoration must be done in such a way as to avoid any significant adverse impact on threatened and endangered species, such as the Piping Plover, that presently exist on the north end of the island. Design of the elevation feature required a resolution between two conflicting goals: the need to increase the elevation of the island to reduce the likelihood of a breach and the need to minimize the increase in elevation to avoid alterations to the existing plover habitat. Therefore, designed the cross-sectional shape of the project had to be achieved in a way that balances the engineering and environmental concerns.

Given the constraint of minimizing impacts to threatened and endangered species, the study team determined that the short-term restoration must maintain an overwash frequency that, at a minimum, is sufficient to preclude the growth of woody vegetation. More preferable still for Piping Plover would be to maintain an overwash frequency sufficient to maintain only sparse vegetative cover by herbaceous plants. A number of wildlife biologists, plant ecologists, and coastal geomorphologists were contacted for information concerning the frequency of overwash likely to promote these two conditions,. None of the individuals contacted had knowledge of the existence of any data that directly compared overwash frequency to vegetative distribution along the mid-Atlantic coast, although data on vegetative distribution versus an index of frequency of sand-burial by overwash is available. Instead, best professional judgment of these individuals provides a means by which to establish an acceptable frequency of overwash to (a) preclude the growth of woody plants or (b) maintain sparse herbaceous vegetation. To preclude the growth of woody vegetation, an overwash frequency of one event per every two years is probably sufficient. To maintain sparse herbaceous vegetative conditions, a greater frequency of overwash is probably required. It was decided to raise the elevation of the island in the critical areas to limit overwash to a minimum frequency of one event per year and to inherently provide a limited degree of breach protection.

The primary tool used in the design process was the Storm-induced BEAch CHange Model (SBEACH). The model was applied to compute wave run-up, overwash, and storm-induced beach erosion for without- and with-project conditions. The design procedure is summarized in the following paragraphs and described in detail in Appendix A.

Profile data, aerial photography, and sediment samples were collected in September 1995. Using these data, existing beach conditions along the northern end of Assateague Island were characterized in terms of vegetation cover, beach profile shape, maximum profile elevations, and risk of breaching. Profile line AI-6 [approximately 2.5 km (1.6 miles) south of the inlet] was chosen to be representative of nearly all the profiles in the critical overwash region. The critical overwash region was determined to be the area 3 to 10 km (1.9 to 6.2 miles) south of the inlet.

Next, the degree of current run-up and overwash conditions were determined based on observations from National Park Service (NPS) personnel. Their observations indicate that much of the northern portion of the island overwashes frequently. Nearly all spring tide conditions produce some overwash, and many storms produce substantial overwash. An analysis was then done using the SBEACH model to assess the typical tide and storm conditions that now produce the frequent overwash, including a qualitative validation of the model.

Input to the SBEACH model is the initial profile shape, information to characterize the wave and water level conditions (time series of wave height period, and water level), and the median diameter of the sand. The time series of synoptic wave and water level data extracted from the Ocean City wave and water level database were used as hydrodynamic input. Profile AI-6 was used as the input beach profile. Based on an analysis of sediment samples taken during the beach surveying in September 1995, a median diameter, D50, of 0.30 mm (0.01 inches) was chosen to represent the size characteristics of the foreshore sediments.

Five mean tide events that were considered to represent typical mean tide and wave conditions were simulated. Wave periods were fairly short except for one 12-second case. The maximum run-up values computed using *root-mean-squared* (H_{rms}) heights were less than or equal to 2.1 m (6.9 feet) for four of the cases, and 2.4 m (7.9 feet) for the 12-second wave case. H_{rms} values can be thought of as more of an average wave height. Run-up results using the average of the highest 10 percent of the waves ($H_{1/10}$) showed run-up exceeding 2.5 m (8.2 feet) only for the 12-second wave period case. Recalling that the existing average berm height is about 2.5 m, these calculations are consistent with NPS observations that the berm rarely overwashes during typical tide conditions.

Five spring tide events were also simulated. The wave heights were generally higher than for the mean tide events, about 1.1 m (3.6 feet) on average. One spring tide event is also characterized by long wave periods, 13 seconds. The run-up elevations computed using the H_{rms} model reach

2.6 m (8.5 feet) for two of the cases. Results using the $H_{1/10}$ model show that three events reach an elevation of 2.8 to 3.0 m (9.2 to 19 feet) and the other two reach an elevation of 2.5 m (8.2 feet). This indicates that for berms with maximum elevations of 2.5 to 2.6 m (8.2 to 8.5 feet) or less, overwash will occur for many spring tide conditions. This predicted response is also consistent with observations by the NPS staff.

In addition to the mean and spring tide simulations, 19 storm events were simulated from the period January 1991 through January 1996. These events included both tropical and extratropical storms, or "northeasters." The Halloween storm of October 1991 and the January 1992 storm are included in this set. Run-up results using H_{rms} values indicated that more than half of these events [those producing run-up elevations exceeding 2.6 m (8.5 feet) NGVD] would produce substantial overwash along most of the north Assateague Island shoreline. This is also consistent with observations made by the NPS staff. Appendix A includes a more detailed discussion of predicted beach response to the Halloween storm and the January 1992 storm.

At this point, the accuracy of the SBEACH model to calculate run-up and overwash for the different wave and tide conditions was deemed adequate, if only in a qualitative sense. The next step was to determine the degree of elevation needed that would still allow overwash to occur for a 1- to 2-year event. Considering both wave and water level conditions at the height of the storm, the March 1994 and September 1992 storms seem to best represent events that can be expected on average once each year.

Analysis of the run-up elevations for these storms, as well as the Halloween storm, led to the selection of a design elevation of 3.3 m (10.8 feet) NGVD. The engineered feature would have a top crest width of 5 m (16.4 feet) and side slopes of 1:20. The cross-shore footprint of this feature is approximately 45 m (147.6 feet). The feature will be referred to here as a “storm berm” rather than a “dune” because of its low relief. This storm berm would not be very visible on the natural beach because of its gentle slope and low relief.

Constructing this feature as described above is estimated to limit substantial overwash to a frequency of at least once every year. An unusually severe northeaster, such as the January 1992 storm or a tropical storm, has a chance of occurring at any time and can produce significant overwash. This feature will provide some breach protection, although at a reduced level, while at the same time minimizing impacts to the plover habitat.

Once the storm berm cross-section was determined, the location of the feature had to be considered. The goal is to have the storm berm survive and provide a lasting degree of breach protection without adversely impacting the existing habitat. The chance of survival will be increased when a more natural supply of sand can be restored to Assateague Island through long-term management strategies. In the interim, the storm berm must be designed to survive on its own under the present erosional pressures that characterize north Assateague. Long-term erosion rates and the occurrence of storms had to be considered in locating the exact position of the storm berm on the existing profile.

To account for the erosive nature of frequent as well as infrequent storms, some additional beach width should initially be added to act as a buffer and to protect the storm berm. A rigorous analysis was conducted (see Appendix A3) using the SBEACH model to simulate both frequent and infrequent historical storms to evaluate the desired width for a protective buffer. It was determined that a minimum 25 m (82 feet) natural berm at elevation 2.5 m (1.6 feet) NGVD should be included to act as a storm erosion buffer. At this point, the design cross section considers the elevation needed to reduce the frequency of overwash to approximately a 1-year frequency, with the need to protect the storm berm from frequent storms, while providing a limited degree of breach protection.

The next step in the design process was to consider the background, or long-term erosion trends associated with longshore sand transport processes. The same wave forces and limitations in sand supply that are presently producing high erosion rates along certain portions of north Assateague Island will immediately begin to work on the constructed storm berm and buffer. During the lag in time between construction of the storm berm and restoration of a continuous supply of sand to the island, the losses associated with longshore processes must be factored into the design. An additional buffer was recommended, with the added width to be determined based on the rate of shoreline recession presently being experienced locally. The actual position of the constructed berm on the existing beach profile will depend on the amount of fill to be placed locally to construct the storm berm and erosion buffer.

6.1.2 Where to Place the Material Along the Island

The first step in deciding where along Assateague Island the material should be placed was to determine what area was adversely impacted by the construction of the jetties. An even/odd analysis conducted as part of this study indicated that the downdrift effects of the jetty extend a distance of approximately 10 to 12.5 km (6.2 to 7.8 miles) south of the inlet. Refer to Appendix A2 for a detailed discussion of the overall sediment budget.

The present day erosion rate along the ocean shoreline of Assateague Island reaches a maximum of approximately -9 m (-29.5 feet) per year at approximately 7 km (4.3 miles) south of the inlet. However, a strong erosional zone extends from approximately 3 to 12.5 km (1.9 to 7.8 miles) from the inlet. North of 3 km, the island currently appears to be accretional. Consequently, it was decided to construct the widest buffer at approximately 7 km south of the inlet and taper into the existing shoreline at approximately 3 and 11.3 km south of the inlet. The northern boundary of the beach fill (3 km south of the inlet) was chosen to mitigate the present-day “strong” erosional zone. The southern boundary of the beach fill (11.3 km south of the inlet) was chosen as the average of the alongshore impact distance indicated by the odd (10 km) and even (12.5 km) analysis (See Appendix A2). It is expected that the beach fill will be transported past 11.3 km by the net southerly transport direction.

Next, the location and extent of the storm berm had to be determined. The elevations along the northernmost 2 to 3 km (1.2 to 1.9 miles) of the island had recently been increasing and vegetative succession had been occurring. It was decided that since this area of the island is building on its own, constructing the storm berm at elevation 3.3 m (10.8 feet) in this area was not necessary nor, from a habitat perspective, desirable. During a field visit in mid-September

1996, the formation of small dunelet features in the interior of the island at elevation 2.7 to 3.4 m (8.9 to 11.1 feet) NGVD was observed in the northern 3 km. Shrubs and trees were present on the back side of the island, and there was very little evidence of overwash. In addition to these recent field observations, studies of the sediment budget indicate this area of the island is currently accretional. For these reasons, it was decided to start the storm berm at a distance approximately 2.5 km south of the inlet and extend it to the existing dunes approximately 10 km south of the inlet near the beginning of the State Park. This area will continue to be monitored, and an exact determination of the northern storm berm tie-out will be accomplished during the plans and specification phase.

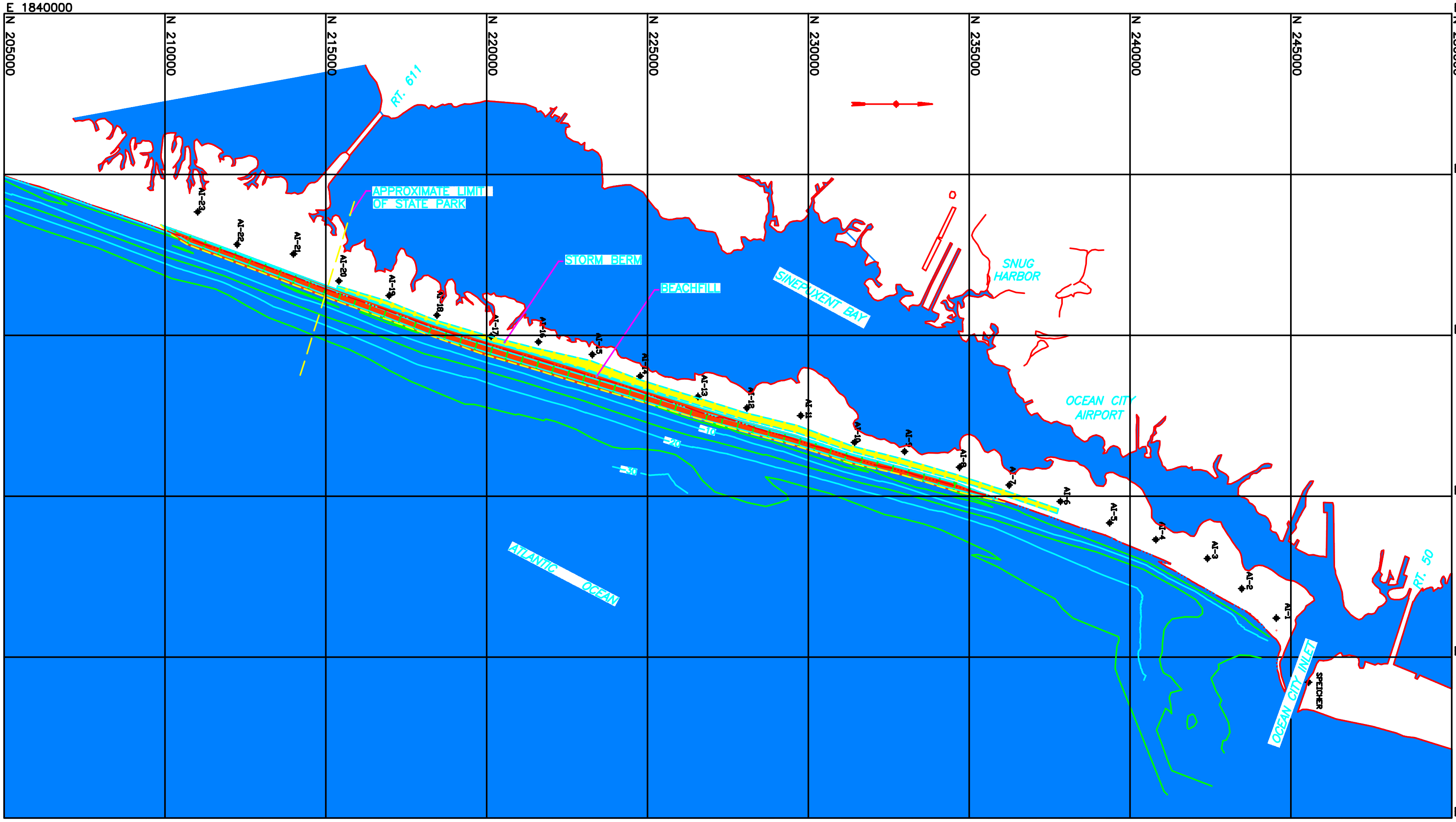
Originally, it was proposed to offset the storm berm a distance of 70 m (230 feet) from the natural berm in the widest location and to taper to a minimum distance of 25 m (82 feet) at the terminus of the fill on both sides. The reasoning was to account for 5 years of erosion (5 years x 9 m/year = 45 m) plus the 25 m storm erosion buffer until the long term sand placement strategies (i.e. sand bypassing) could be implemented. However, the NPS and environmental resource agencies were concerned about the maximum buffer proposed to be placed in front of the storm berm. Specific concerns were that this configuration would limit overwash to the point that vegetation would establish. This of course would be detrimental to the Piping Plover. At present, the SBEACH model is not able to adequately assess the impact of added buffer width and foreshore profile shape on run-up elevation, because of the limitations in the run-up algorithms used in the model. Consequently, it was decided to allow for two years of background erosion and the minimum width required to account for the frequent storms. However, until the natural supply of sediments can be restored, it was agreed to reestablish this elevation if erosive forces lowered it significantly (see the proposed monitoring plan, Annex E). The maximum width fronting the storm berm was thus determined to be 43 m (9 m/year x 2 years plus 25 meters) tapering to a minimum of 25 m at 2.5 km and 10 km south of the inlet. Plates 6-1 through 6-4 show a general plan and plan views of the proposed island restoration.

Construction of the beach and storm berm will involve the placement of 1.4 million m^3 (1.8 million cubic yards) of beachfill oceanward of a "construction baseline." This line will be established to control the project alignment. At present, control has been established at 26 locations along the northern 13 km of the island, which has been used for present estimates of project placement. However, for ease of construction, this line may require adjustments to remove irregularities.

The general beachfill construction template will be as shown on Plate 6-5 and will consist of a horizontal berm at elevation +2.5 m (+8.2 feet) NGVD, a 1-vertical on 20-horizontal slope from elevation 2.5 m to elevation -0.5 m (-1.6 feet) NGVD and a 1-vertical on 12-horizontal slope from elevation -0.5 m NGVD to its intersection with the existing sand surface. Through past experience with beach replenishment projects at Ocean City, Maryland, this template should closely conform to the natural configuration of pumped sand on a beach and will require a minimum amount of mechanical grading.

The horizontal berm component of the beachfill construction template will vary as necessary to meet the specified fill requirements for each reach. Currently, the project is divided into 20 one-half km reaches. Plate 6-5 shows a typical restoration section as well as the construction berm width for each reach. The largest fill reaches will be in the area of maximum erosion (7 km south of inlet) and will gradually taper into the existing shoreline at the project terminus on either side. At the widest beachfill location, the constructed berm will increase 48.8 m (160 feet). After the constructed berm reaches equilibrium, the island will be 29.3 m (96 feet) wider than it is presently. The beachfill material necessary to construct the project will be obtained from Great Gull shoal as discussed in the next section. The storm berm will be constructed by pumping the required amount of sand in the approximate location of the berm and then mechanically grading the material to its final configuration as required using conventional earth moving equipment. Table 6-1 shows the quantities of sand required for each reach for the storm berm and beachfill.

Immediately after construction, the forces of the tide and waves will act to adjust the profile into an equilibrium shape. This is expected to occur during the first winter season. Plate 6-5 also shows the estimated seaward shift of the shoreline after the beachfill equilibrates, as well as the storm berm setback distance for each reach. It should be noted that it is the position of the natural berm after profile equilibration from which the storm berm setback is measured. Shoreline erosion will continue in the placement area at the same rate (about 5 m/yr (16 feet/yr) as prior to construction. By the end of the third year following construction only, about half of the project area shoreline will still lie seaward of the shoreline position at the time of construction. On average, the shoreline will have returned to its pre-construction position. By the end of year 4 the shoreline throughout the majority of the project area will have eroded to about 5 m (16 feet) west of its position at the time of construction. Following construction, longshore transport will move the placed material southward at a rate of approximately 190,000 m^3/yr (248,000 cubic yards/yr). A percentage of the placed material carried downdrift will be available for deposition on the island during overwash events, and may measurably increase island width south of the placement area over a distance of up to 12 km (7.5 miles) over a period of several years. After approximately 7 years it is expected that the fill material will have been effectively removed from the placement area beach and nearshore if no long-term solution is implemented. However, it is expected that a long-term solution will be implemented after year 4. It is expected that this solution will be designed to slow both the erosion rate and rate of loss of material to the longshore transport system to natural pre-jetty rates (3 m per year [10 feet per year] and 150,000 m^3 per year [196,000 cubic yards per year] respectively). Material placed to form the constructed storm berm on Assateague will be subject to deflation by prevailing winds from the west/northwest immediately following construction. Much of the sand will be transported in an offshore direction. However, it is expected that localized increase in storm berm height will occur and low discontinuous dunes may form.



GENERAL NOTES:

1. HORIZONTAL CONTROL IS BASED ON THE MARYLAND STATE PLANE COORDINATE SYSTEM (NAD 83, FEET).
2. VERTICAL CONTROL IS BASED ON THE NATIONAL GEODETIC VERTICAL DATUM (NGVD, FEET) 1929, ADJUSTED 1977.
3. MEAN HIGH WATER (MHW) SHORELINE ALONG ATLANTIC OCEAN IS BASED ON PROFILE DATA COLLECTED IN SEPTEMBER 1995.
4. ALL OTHER SHORELINES WERE OBTAINED FROM VARIOUS SOURCES AND ARE APPROXIMATE LOCATIONS ONLY.

SCALE IN FEET

1000 0 2000 4000

SCALE IN KILOMETERS

1km 0 1km 2km

REV	DATE	DESCRIPTION	BY

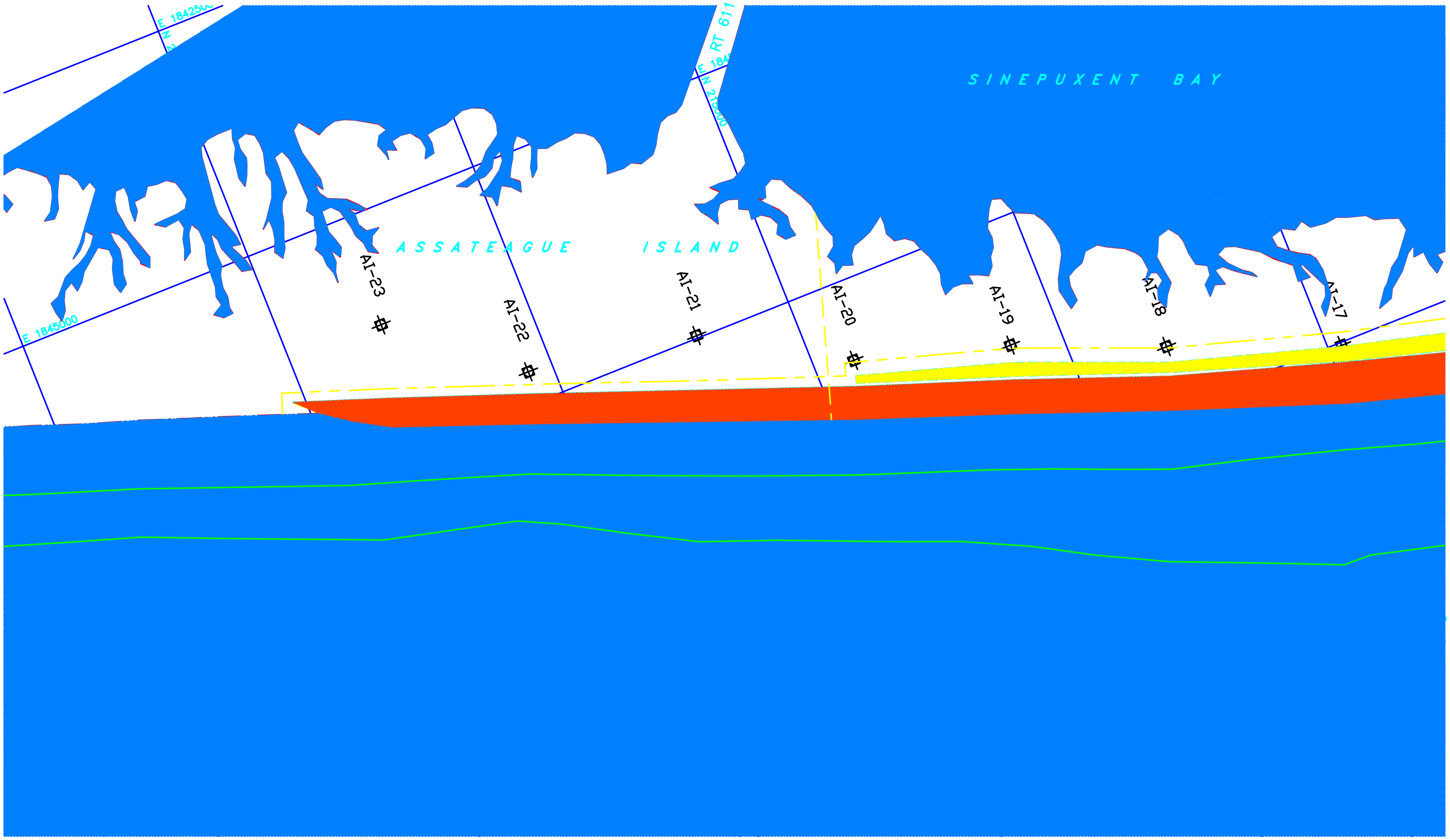
U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ASSATEAGUE ISLAND
GENERAL PLAN

DRAWING NUMBER

PLATE 6-1

SCALE: DATE: SHEET



LEGEND

LIMIT OF WORK

MEAN HIGH WATER

PROPOSED STORM BERM

PROPOSED BEACH FILL (CONSTRUCTION CONFIGURATION)

POINT	NPS DESIGNATION	EASTING	NORTHING	ELEVATION
AI-17	NPS-4.5	1850030	220138	8.71
AI-18	NPS-4.75	1849373	218457	7.33
AI-19	GPS-5	1848763	216967	6.37
AI-20	NPS-5.25	1848310	215408	9.89
AI-21	NPS-5.50	1847472	213996	7.19
AI-22	NPS-5.75	1847175	212245	16.42
AI-23	GPS-6.	1846163	211014	5.16
AI-24	NPS-6.25	1845380	208620	5.43
AI-25	NPS-6.5	1844674	206570	6.6
AI-26	NPS-6.75	1844007	204864	7.11

SCALE IN FEET: 400 0 400 800

SCALE IN METERS: 100m 0 100m 200m 300m

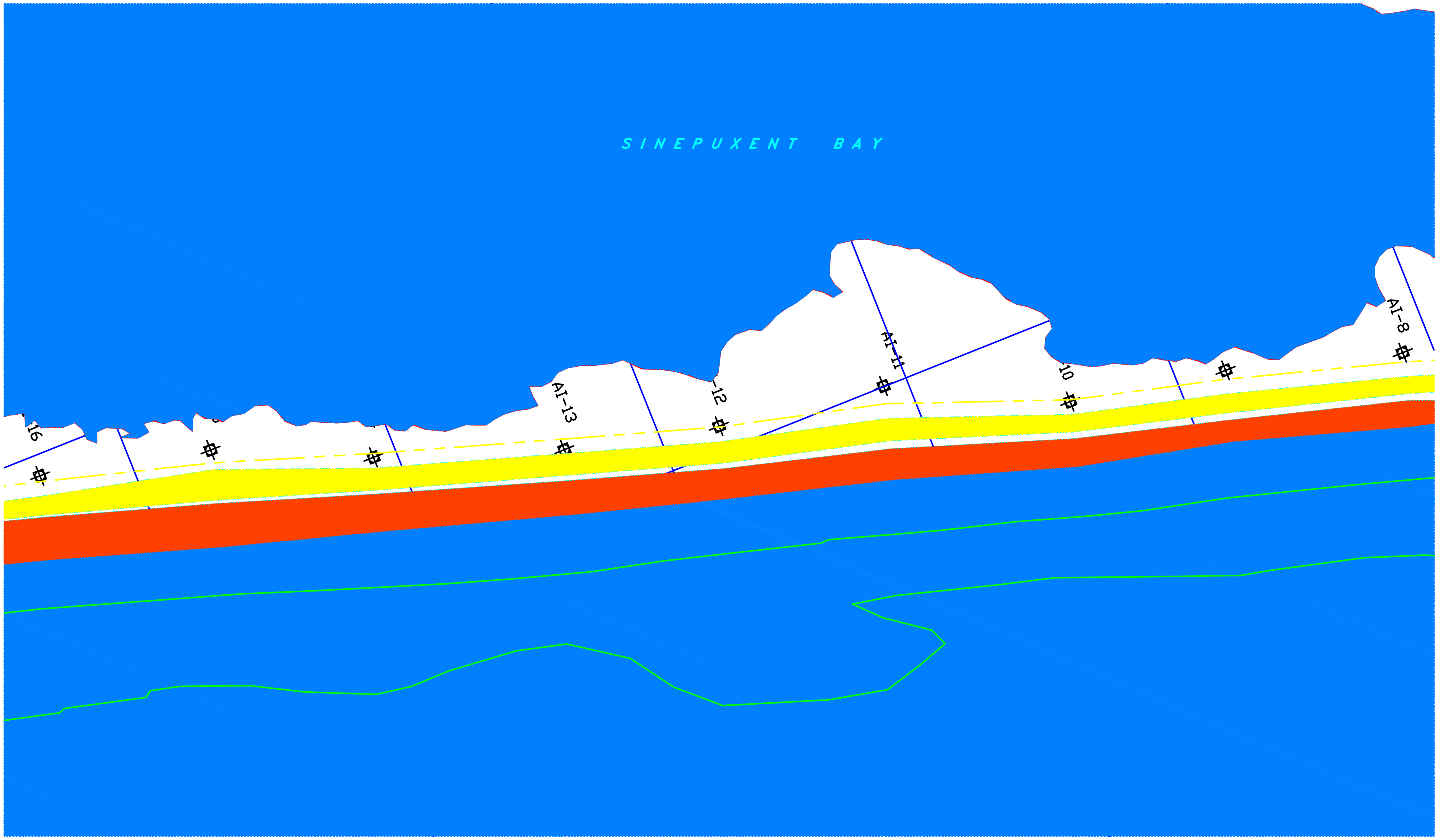
REV | DATE | DESCRIPTION | BY

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ASSATEAGUE ISLAND
PLAN VIEW

DRAWING NUMBER | PLATE 6-2

SCALE: | DATE: | SHEET



LEGEND

LIMIT OF WORK

MEAN HIGH WATER

PROPOSED STORM BERM

PROPOSED BEACH FILL
(CONSTRUCTION CONFIGURATION)

POINT	NPS DESIGNATION	EASTING	NORTHING	ELEVATION
AI-8	NPS-2.25	1854102	234698	5.1
AI-9	NPS-2.5	1853612	232991	5.86
AI-10	NPS-2.75	1853326	231436	5.69
AI-11	GPS-3	1852494	229763	5.17
AI-12	NPS-3.25	1852257	228090	3.88
AI-13	NPS-3.5	1851902	226568	5.88
AI-14	NPS3.75	1851268	224770	9.45
AI-15	GPS-4	1850598	223287	4.47
AI-16	NPS-4.25	1850206	221608	8.3

SCALE IN FEET
400 0 400 800

SCALE IN METERS
100m 0 100m 200m 300m

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
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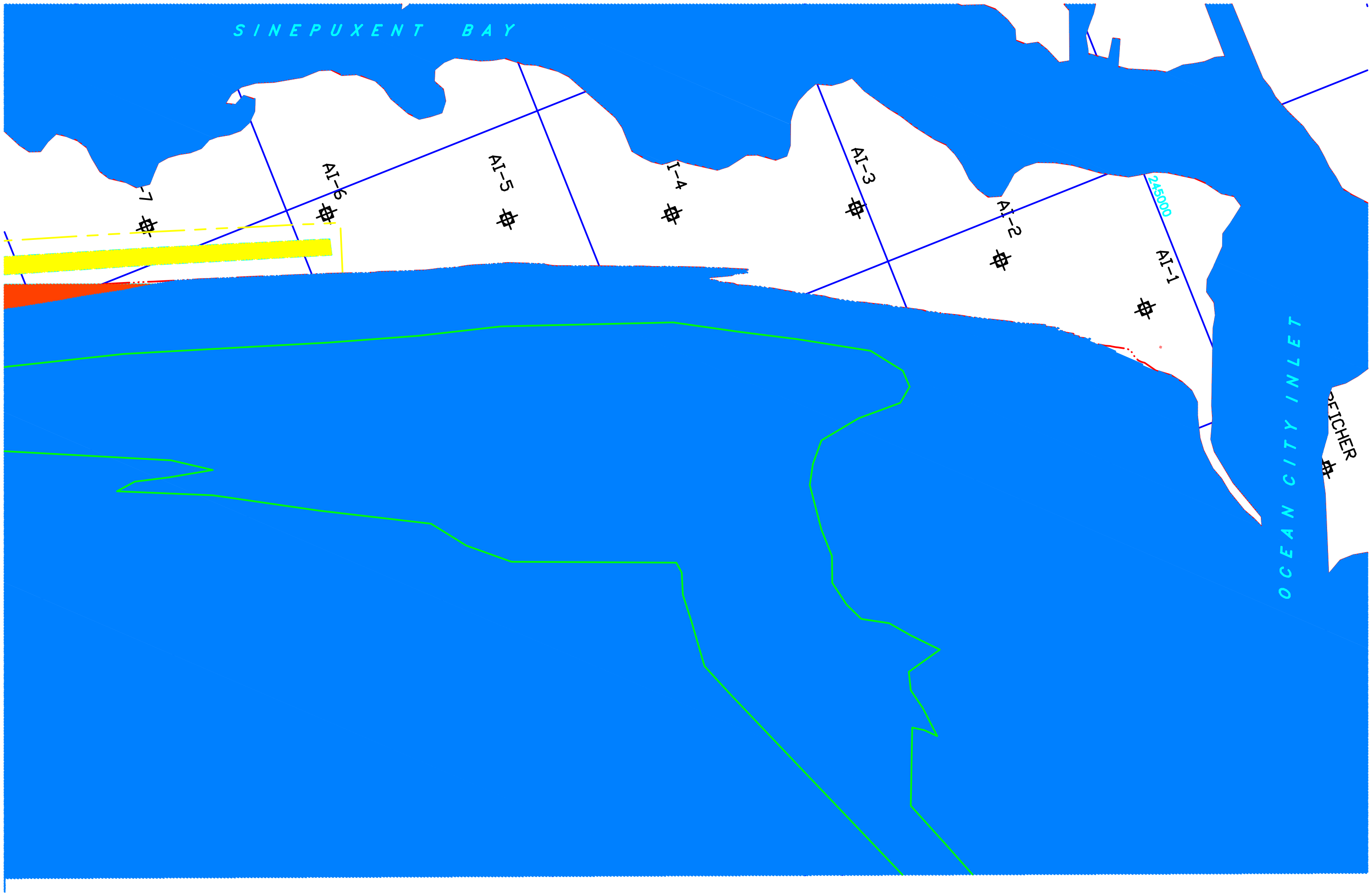
BALTIMORE, MARYLAND

ASSATEAGUE ISLAND
PLAN VIEW

PLATE 6-3



LEGEND

- LIMIT OF WORK
- MEAN HIGH WATER
- PROPOSED STORM BERM
- PROPOSED BEACH FILL (CONSTRUCTION CONFIGURATION)

POINT	NPS DESIGNATION	EASTING	NORTHING	ELEVATION
AI-1		1858074	243451	
AI-2	NPS-0.5	1857876	243472	9.96
AI-3	GPS-1	1856933	242406	5.17
AI-4	NPS-1.25	1856351	240802	5.91
AI-5	NPS-1.5	1855830	239368	10.03
AI-6	NPS-1.75	1855165	237834	7.01
AI-7	GPS-2	1854656	236242	5.28

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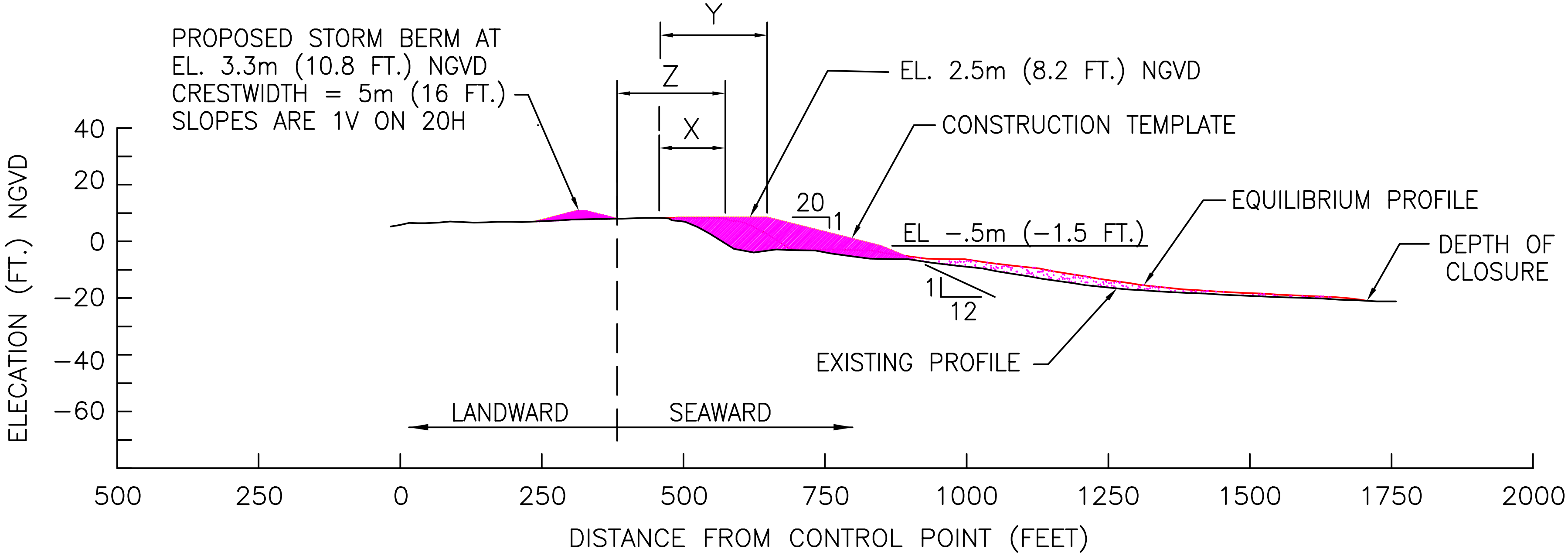
ASSATEAGUE ISLAND
PLAN VIEW

DRAWING NUMBER | PLATE 6-4

SCALE: | DATE: | SHEET



PROPOSED ASSATEAGUE ISLAND RESTORATION
BERM WIDTH AND SETBACK TABLE

LINE NO.	STATION (feet)	STATION (kilometers)	CONSTRUCTION BERM WIDTH Y m (ft)	EQUILIBRIUM BERM WIDTH X m (ft)	STORM BERM SETBACK Z m (ft)
1	500				
2	1700	.518			
3	3300	1.006			
4	4950	1.509			
5	6600	2.012			
6	8250	2.515			25.0 (82)
7	9900	3.018	0		27.1 (89)
8	11550	3.520	1.5 (5)	4 (13)	29.0 (95)
9	13200	4.023	7.6 (25)	4 (13)	31.1 (102)
10	14850	4.526	7.6 (25)	8.2 (27)	32.9 (108)
11	16800	5.121	19.8 (65)	7.3 (24)	35.0 (115)
12	18450	5.624	19.8 (65)	14.3 (47)	36.9 (121)
13	20100	6.127	39.6 (130)	18.6 (61)	39.0 (128)
14	21750	6.629	39.6 (130)	25.3 (83)	41.1 (135)
15	23550	7.178	48.8 (160)	29.3 (96)	43.0 (141)
16	25200	7.681	48.8 (160)	28.7 (94)	39.3 (129)
17	26850	8.184	36.6 (120)	27.7 (91)	35.7 (117)
18	28500	8.687	36.6 (120)	19.5 (64)	32.3 (106)
19	30150	9.190	30.5 (100)	16.8 (55)	28.7 (94)
20 *	31800	9.693	21.3 (70)	13.7 (45)	25.0 (82)
21	33450	10.196	12.2 (40)	11.0 (36)	
22	35100	10.699	9.1 (30)	8.2 (27)	
23	36630	11.165	9.1 (30)	5.5 (18)	
24	38280	11.668	0		
25	39930	12.171			
26	41580	12.674			

* APPROXIMATE LIMIT OF STATE PARK

REV	DATE	DESCRIPTION	BY

U.S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
BALTIMORE, MARYLAND

ASSATEAGUE ISLAND
TYPICAL RESTORATION SECTION

DRAWING NUMBER
PLATE 6-5
SCALE: DATE: SHEET

TABLE 6-1
QUANTITY ESTIMATES FOR ASSATEAGUE ISLAND BEACHFILL

LINE NO.	STATION (kilometers)	STATION (feet)	STORM BERM QUANTITIES UNIT VOLUME yd3/ft	VOLUME yd3	CUM. VOL. yd3	BEACHFILL QUANTITES UNIT VOLUME yd3/ft	VOLUME yd3	CUM. VOL. yd3	TOTAL QUANTITIES yd3
1		500	0	0	0	0	0		0
2	0.518	1700	0	0	0	0	0		0
3	1.006	3300	0	0	0	0	0		0
4	1.509	4950	0	0	0	0	0		0
5	2.012	6600	0	0	0	0	0		0
6	2.515	8250	9.1	9.1	9.1	0	0		9
7	3.018	9900	11.2	16747.5	16756.6	0	0	0	16757
8	3.520	11550	11	18315	35071.6	15.5	12788	12788	47859
9	4.023	13200	17.2	23265	58336.6	15.1	25245	38033	96369
10	4.526	14850	15.1	26647.5	84984.1	29.3	36630	74663	159647
11	5.121	16800	22.7	36855	121839.1	26.7	54600	129263	251102
12	5.624	18450	18.7	34155	155994.1	51.2	64268	193530	349524
13	6.127	20100	23.5	34815	190809.1	64.7	95618	289148	479957
14	6.629	21750	22.3	37785	228594.1	88.8	126638	415785	644379
15	7.178	23550	22.1	39960	268554.1	103.3	172890	588675	857229
16	7.681	25200	16.1	31515	300069.1	102.9	170115	758790	1058859
17	8.184	26850	10.1	21615	321684.1	99.7	167145	925935	1247619
18	8.687	28500	9.9	16500	338184.1	69.5	139590	1065525	1403709
19	9.190	30150	7.8	14602.5	352786.6	60	106838	1172363	1525149
20 *	9.693	31800	2.1	8167.5	360954.1	49.5	90338	1262700	1623654
21	10.196	33450	0	0	360954.1	40.2	74003	1336703	1697657
22	10.699	35100	0	0	360954.1	30.3	58163	1394865	1755819
23	11.165	36630	0	0	360954.1	20.2	38633	1433498	1794452
24	11.668	38280	0	0	360954.1	0	16665	1450163	1811117
25	12.171	39930	0	0	360954.1	0	0	1450163	1811117
26	12.674	41580	0	0	360954.1	0	0		1811117

6.2 MONITORING AND ACTION PLAN

Due to the uncertainty of how the island will respond to the placement of 1.4 million m^3 of sand on the beach, the USFWS thought it critical to develop a Monitoring and Action Plan. The purpose of the plan is to document physical evolution of the project and related changes in key physical and biological resources of northern Assateague Island in order to evaluate the project's overall performance in meeting stated objectives. Data will be collected and analyzed and will be used to determine whether follow-up corrective action is warranted. For each of the two key issues--breach potential and Piping Plover impacts--multiple indicators of project performance provide the basis for decision making. We are recommending that the immediate restoration of Assateague Island be monitored for at least 5 years, until a long-term project is implemented. At that point, a new monitoring plan will be established. The draft monitoring and action plan is in Annex E. The total cost for the 5 years of monitoring is estimated to be $1,627,500. Currently, the National Park Service budgets for and spends approximately $275,000 monitoring the Piping Plovers each year. In the spirit of interagency cooperation, the National Park Service plans to continue this action and share the information with the Corps for the Monitoring and Action Plan. Therefore, the remaining amount of the monitoring plan to be paid for by this project is $1,352,500, without escalation. Of this amount, $725,000 is estimated for collecting wave and tide data. This same data is currently being collected for the Atlantic Coast of Maryland Shoreline Protection Project. Potentially, this information could be shared and used for the Monitoring and Action Plan. This option is currently being coordinated between the Corps and the State of Maryland.

6.3 OPERATION AND MAINTENANCE

A significant purpose of the short-term restoration is to "buy time" and set the stage for the long-term project. Therefore, little operation and maintenance is required for the short-term restoration of Assateague Island. The purpose of this project is to restore the island to a more natural state, not to create or maintain a specific cross-section or island configuration. We are constructing the low, wide storm berm to elevation 3.3 m (10.8 feet) NGVD to provide some protection against storms. Almost immediately, the material will start shifting. Some areas will probably increase in elevation and some will decrease.

We do not anticipate the need for maintenance or corrective action; however, the team realizes the risks being taken in constructing a project in a dynamic area. The performance of the project will be evaluated through the monitoring plan. At this time, it is envisioned that if corrective action does need to be taken, that it will most likely be undertaken as a one-time action after 2 or 3 years. Not knowing what type of action would be required, it is difficult to determine how much it would cost. Assuming that the action would require construction equipment to move sand around over a period of a few weeks, the cost of this one-time corrective action is estimated to be $70,000. Maintenance of the project will be performed by the project sponsor, National Park Service.

6.4 CONSTRUCTION AND COST ESTIMATE

As stated previously, Great Gull Bank will be used as the borrow area for the beachfill. The project would be constructed in two phases. Project construction would start in the southern end and work toward the northern end. Construction in the National Seashore where the Piping Plover nest will be limited to two months per year due to environmental and weather conditions. The first phase of construction could start in July 1998, if funds are available, and continue through October 1998. During this phase, work would be limited to the area south of the Piping Plover nesting area, including the State Park, until on or about September 1, 1998. This date will be adjusted based on when the Piping Plover nesting season is completed that year. The second phase of construction could start on or about September 1, 1999 to be completed by October 31, 1999.

Two Island Class hopper dredges with pump-out capability will be used to dredge sand for the restoration. Work will be done over two fall work seasons during the period of late August through mid October. Each dredge is capable of producing 219,073 m^3 (286,520 cubic yards) of sand per month. Sand will be dredged off the shoal and pumped into the vessel, which has an effective hopper capacity of 1,444 m^3 (1,888 cubic yards). Each hopper dredge will transect the borrow area until the hopper is full. The hopper dredge will then travel to a pumpout point located about 600 m (2000 feet) offshore of Assateague Island where a barge with a booster pump will be waiting. The barge-mounted booster pump will pump the sand in a slurry from the hopper dredge to the beach through a steel pipeline. The pipeline will lie on the seafloor oriented perpendicularly to the shoreline and will be marked with buoys. The hopper dredge will then return to the borrow area and resume dredging. Approximately 1,055 transits from the borrow area to the pump-out point will be made between the two hopper dredges. Bulldozers will then be used to create areas to trap and shape sand as it exits the pipeline to form the berm and dune. Bulldozers will access the project area from the state park. Pumping of sand will be done for a maximum distance of up to 1,220 m (4,000 feet) north or south of where the pipeline crosses up onto the beach. Beach nourishment will be completed in sections of 2,450 m (8,000 feet). Once a 2,450 m section of the project is built, the barge and booster pump would be moved to a new pumpout point to continue the project. A minimum of three pump out points will be established. Using the two dredges simultaneously it will take a minimum of 3 months to complete the dredging.

The estimate in Table 6-2 reflects the full funding cost for this short-term project at October 1, 1996 price levels. The initial construction cost is estimated to be $15,383,000, including contingency and escalation, for the preparation of plans and specifications, construction management, and lands and damages. Contingency amounts for construction cost items are based on uncertainties within individual project elements. Monitoring is estimated to cost on average, $282,000 per year, including escalation, for the 5-year plan. The total project cost for the short-term restoration is estimated to cost $17.2 million. A detailed cost estimate is included in Appendix C.

Table 6-2: Total Project Costs

(including escalation and contingency)

Beach Replenishment	$12,960,000
Lands and Damages	$295,000
Planning, Engineering, and Design	$547,000
Construction Management	$1,876,000
5-year Monitoring Plan	$1,410,000
Potential O&M	$70,000
Total Project Cost	$17,158,000
Rounded	$17,200,000

A number of plans for the long-term restoration of Assateague Island component of the project are still being evaluated. However, it is important to show some range of costs for the long-term plan since it will accompany the short-term plan. Some of the alternative plans being investigated would have a large first cost and a smaller annual operation and maintenance cost, such as a fixed bypass plant. Other plans, such as contracting a mobile dredge, will have little to no first cost and will have higher annual costs. We still have a great deal of work to do on this component of the project, but it is estimated that the long-term restoration project would have a first cost in the range of $0 to $9 million, and an annual operation and maintenance cost of $400,000 to $2 million per year.

Section 7

IMPACTS to PROJECT AREA

This section includes a detailed consideration of impacts to the project area of the selected alternative for the short-term restoration of Assateague Island. Consideration of impacts to the project area of the long-term sand placement; navigation; and coastal bays environmental restoration components are provided at only a general level of detail. Selected alternatives for these other project components have not been determined at this time, and any impacts that will result are somewhat speculative. Detailed consideration of the impacts of the other project components will be included in the second report and supplemental EIS.

7.1 SHORT-TERM RESTORATION IMPACTS

Impacts of the alternative plans under consideration for the short-term restoration of Assateague Island to the physical environment, biological resources, society, and economy were evaluated to select the preferred alternative. Tables 5-1 through 5-7 provide a summary of these impacts. This section (7.1) focuses only on impacts of the selected alternative, which are summarized in Table 7-1. Impacts that are likely to be substantial and issues of particular concern to society are addressed at length. Those categories for which impacts are likely to be negligible or minimal are only briefly addressed to reduce the length of this document. Additional information is available by contacting the Baltimore District, Corps of Engineers.

The discussion of environmental impacts of the short-term restoration is based on CERC hydrodynamic and beach response modeling, and a sediment budget study (Appendix A); consultation with environmental resource agency personnel, members of academia, and the general public (Annex A, Part 7); and existing information. It is assumed in this section that a long-term restoration project will follow the immediate restoration component within 4 to 6 years. Impacts of the long-term restoration are discussed in Section 7.2.

Direct, indirect, and cumulative impacts of the short-term restoration component have been considered. Direct impacts would occur at the project sites at the time of construction. Dredging sand from Great Gull Bank, transporting sand to Assateague Island, placing sand on the ocean shoreline of Assateague Island to form the berm, and placing and shaping sand on Assateague to construct the low storm berm will cause a number of direct environmental impacts. Any subsequent corrective actions taken under the monitoring and action plan will also cause direct environmental impacts. Indirect impacts would occur after the project is constructed and may be removed in distance from the project location. Indirect impacts would occur as natural processes modify the dredged area of the offshore shoal and redistribute the sand that is placed on Assateague Island. Cumulative impacts 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 actions. In general, beach nourishment is considered a desirable method of erosion control because (1) nourishment is unlikely to

Table 7-1
Impacts

CATEGORY		CLASSIFICATION OF IMPACT 1						Location of Additional Information 5
		Direct			Indirect			
		Type of Impact 2	Range of Impact 3	Duration of Impact 4	Type of Impact 2	Range of Impact 3	Duration of Impact 4	
Physical Environment								
	Surficial Geology, Soils, and Sedimentary Processes	C	WS	Y	C	WS	Y	Appendix A
	Physiography and Topography	C	WS	Y	*	WS	Y	
	Bathymetry	C	L	Y	C	L	Y	Appendix A
	Hydrodynamics	*	N/A	N/A	*	N/A	N/A	Appendix A
	Air Quality	*	L	M	N/A	N/A	N/A	
	Water Quality	*	L	M	*	N/A	N/A	
Biological Resources								
	Wetlands	*	N/A	N/A	B	WS	Y	
	Submerged Aquatic Vegetation	*	N/A	N/A	B	WS	Y	
	Upland Vegetation	*	N/A	N/A	B	WS	Y	
	Benthos	A	WS	M/Y	A	WS	Y	Annex A, Part 4
	Nekton	C	WS	M/Y	C	WS	Y	
	Plankton	*	WS		*	WS		
	Birds 6	*	N/A	N/A	C	WS	Y	
	Mammals 6	*	N/A	N/A	B	WS	Y	
	Reptiles and Amphibians 6	*	N/A	N/A	B	WS	Y	
	Rare, Threatened, and Endangered Species	*	N/A	N/A	C	WS	Y	Annex A, Parts 5 and 6
	Prime and Unique Farmland	N/A	N/A	N/A	N/A	N/A	N/A	
	Wild and Scenic Rivers	N/A	N/A	N/A	N/A	N/A	N/A	
Community and Socioeconomic Setting								
	Cultural Resources	*	N/A	N/A	*	N/A	N/A	Annex D
	Hazardous, Toxic, and Radioactive Waste	*	N/A	N/A	*	N/A	N/A	
	Navigation 7	B	L	Y	B	L	Y	Annex B
	Storm Damages	*	N/A	N/A	B	WS	Y	Annex B
	Health and Safety	*	N/A	N/A	*	N/A	N/A	
	Noise	*	L	M	*	N/A	N/A	
	Visual and Aesthetic Value	A	L	M	*	N/A	N/A	
	Recreation	A	L	M	B	L	Y	Annex B
	Environmental Justice	*	N/A	N/A	*	N/A	N/A	

1 Impacts with-project assumes that no breach occurs prior to implementation of long-term restoration (5 or 6 yrs)

2 A = Adverse
B = Beneficial
* = Negligible
C = Change that is neither + or -
N/A = Not Applicable

3 L = Local
WS = Wide Spread
N/A = Not Applicable

4 D = Day
M = Months
Y = Years

5 #.#.# = Report Section
A = Appendix
PAR = Planning Aid report by FWS
BA = Biological Assessment
contact Balt. District USACE

6 Does not include endangered/threatened species

7 Assumes portion of ebb shoal is dredged

adversely affect areas beyond the problem area, (2) if the design fails, the results of the engineering are soon dissipated, and (3) placement of sand does not alter the suitability of the system for recreation.

7.1.1 Physical Environment

7.1.1.a Surficial Geology and Sedimentary Processes

Great Gull Bank

Direct Impacts

It is expected that dredging would remove approximately 3 percent of the volume of Great Gull Bank. This excavated volume will not be replaced in the foreseeable future by natural processes and can be considered a permanent loss. Sand underlying the material to be removed is similar in grain size to the sand to be removed; so the post-project shoal surface sand is expected to be similar in character to the pre-project surface. A detailed dredging plan will be developed in collaboration with the U.S. Fish and Wildlife Service (USFWS), National Marine Fisheries Service (NMFS), and Mineral Management Service (MMS). Minor slumping of material from adjacent areas into the excavated areas may occur during dredging.

Indirect Impacts

The surface of the excavation will slope gradually into the existing surface, so no substantial post-construction movement of material by slumping is expected. However, currents and waves will modify the excavated area after dredging, and over time, the depression is likely to be partially filled in by material transported from adjacent shoal areas.

Assateague Island

Direct Impacts

Sand added to Assateague will be compatible with existing beach material. Creation of the low storm berm on northern Assateague will reduce overwash frequency from many events per year to an average of one event per year.

Indirect Impacts

Immediately following placement on Assateague, sand comprising the constructed berm along the shoreline will be eroded by waves and tides. Movement of sand following beach nourishment is difficult to predict with certainty. However, it is possible to predict a number of probable general trends. Sand eroded from the constructed berm will be introduced into the longshore transport system and will begin moving subtidally in the nearshore. Sand will generally travel in a southerly direction. Downdrift accumulation of sand in the nearshore will occur for several years following project construction. An increase in the rate of sand transport over pre-project rates will eventually extend 15 to 18 km (9.3 - 11.2 miles south) of the placement area. The rate at which material is transported southward will be within the range of historic transport rates, however. Beyond 15 to 18 km south of the placement area, accumulation of sand in the nearshore from the restoration will be negligible. Some sediment from the constructed berm may be moved northwards to the southern side of the south jetty during periods of the year when longshore transport is northerly. A minor proportion of this material will be deposited within the ebb shoal.

The majority of material transported via the longshore transport system will remain in the nearshore zone. However, some material will be added to the beach and will increase island width. This increase in width will not be detectable beyond 15 to 18 km south of the placement area. During storm events, overwash will move some of the sand that has been added to the beach in the placement and downdrift impact area and will deposit it on the island interior. In addition, some of the material will be transported seaward from the placement area beyond the depth of closure during storm events. Shoreline erosion and longshore transport is expected to occur at pre-project rates. The placement area shoreline will retreat to its pre-project position within about 4 years following project construction (Table 7-2). Placed material will persist within the subtidal portion of the project area for a somewhat greater period of time. However, it is expected that the placed volume of material will be effectively removed from the beach and nearshore of the placement area within about 7 years.

The constructed low storm berm will evolve following construction. Because construction will occur in late summer and early fall and the dune will not be planted, the natural establishment of dune-protecting vegetation in the months following construction would be discouraged by cooler temperatures. Prevailing winds from the west/northwest in the fall, winter, and spring months after construction will deflate the unvegetated sand surface causing a net offshore transport of sand from the low storm berm. This loss of material will cause a reduction in height of the low storm berm along most of its 8.5 km (5.3 miles) length. Reduction in height of the storm berm from the design height will serve to increase the frequency of overwash in most of the placement area to an average of somewhat greater than the design frequency of one event per year. However, the frequency of overwash is expected to remain less than the extreme frequency at which it presently occurs. If the project fails to perform according to expectations, post-construction modifications as outlined in the monitoring and action plan will be undertaken. Although a general trend of reduction in storm berm height is expected, localized discontinuous dunes may form within the placement area to a height greater than 3.3 m (10.8 feet) NGVD due to the increased volume of material available for dune building. Localized augmentation of existing dunes and growth of new dunes downdrift of the placement area may occur for up to 15 to 18 km (9.3 - 11.2 miles) downdrift of the placement area.

7.1.1.b Physiography and Topography

<u>Assateague Island</u>

Direct Impacts

Assateague Island will be widened from its existing dimensions as indicated in Plates 6-1 through 6-5. (See table on Plate 6-5). Construction will alter the topography of the ocean side of the island to fit the construction template. No direct impacts will occur to the interior or bay side of the island. Island height will be increased by a maximum of approximately 0.8 m (2.6 feet) from the existing maximum elevation of 2.5 m (8.2 feet) on the natural berm to the 3.3 m (10.8 feet) NGVD crest of the low storm berm. Placement of sand will increase the beach width and cause seaward translation of the beach intertidal zone.

Table 7-2
Predicted Erosion Rate of Placed Materials

Table 7.2: Predicted erosion of placed material on northern Assateague Island.

These rates are a maximum and provide a conservative estimate of project longevity.
These rates do not include probable reduction in shoreline change rates in southern placement area that will occur as material is received from the north.

	Distance south of inlet (nearest 0.5 km)	Additional berm width (equilibrium) (m) [1]	Floating average shoreline change rate (m/yr) [2]	Berm Width in Meters at End of Year 1	Berm Width in Meters at End of Year 2	Berm Width in Meters at End of Year 3	Berm Width in Meters at End of Year 4	Berm Width in Meters at End of Year 5
	3	0	1	1	2	3	4	5
	3.5	4	-0.5	3.5	3	2.5	2	1.5
	4	4	-1.9	2.1	0.2	-1.7	-3.6	-5.5
	4.5	8.2	-3.5	4.7	1.2	-2.3	-5.8	-9.3
	5	7.3	-5.1	2.2	-2.9	-8	-13.1	-18.2
	5.5	14.3	-5.6	8.7	3.1	-2.5	-8.1	-13.7
	6	18.6	-5.9	12.7	6.8	0.9	-5	-10.9
	6.5	25.3	-6.6	18.7	12.1	5.5	-1.1	-7.7
	7	29.3	-8.3	21	12.7	4.4	-3.9	-12.2
	7.5	28.7	-7.2	21.5	14.3	7.1	-0.1	-7.3
	8	27.7	-7	20.7	13.7	6.7	-0.3	-7.3
	8.5	19.5	-6.2	13.3	7.1	0.9	-5.3	-11.5
	9	16.8	-4.8	12	7.2	2.4	-2.4	-7.2
	9.5	13.7	-4.5	9.2	4.7	0.2	-4.3	-8.8
	10	11	-4.7	6.3	1.6	-3.1	-7.8	-12.5
	10.5	8.2	-3.6	4.6	1	-2.6	-6.2	-9.8
	11	5.5	-3	2.5	-0.5	-3.5	-6.5	-9.5
	Average	14.2	-4.6	9.7	5.1	0.6	-4.0	-8.5

[1] Data from chart on Plate 6-5

[2] Shoreline change rate over period 1989 - 1996. Each entry is average of rates over 0.5 km centered at the point of interest.

Following project construction, if the constructed storm berm elevation decreases below 2.6 m (8.5 feet) elevation (see Monitoring and Action Plan in Annex E), it will be assumed that an unacceptable risk of breaching may be present, and the need for corrective action will be evaluated. Actions taken under the plan to restore the height of the constructed low storm berm at 2.6 m (8 .5 feet) NGVD elevation may require movement of sand from the beach and/or island interior to reconfigure the storm berm. There are currently no plans to repair any breaches that may form.

Indirect Impacts
The island width and configuration of the project would evolve as material placed on the island is moved by wind and wave action. As the material is moved by wave and tide action, the maximum width of the island would be reduced. It is expected that the equilibrium width would be reached within several months (Table on Plate 6-5). The design width lies within the range of historic widths recorded for the island and would not substantially change the characteristic configuration of the barrier island. Island width would not be controlled or maintained to any specifications after the initial placement of sediment. Shoreline erosion is expected to occur at pre-project rates, and the placement area shoreline will retreat to its pre-project position within about 4 years following project construction.

The low storm berm will evolve following construction; this is discussed in Section 7.1.1.b. Where conditions permit along a minor portion of its length, the design elevation (3.3 m [10.8 feet] NGVD) is expected to persist after construction. The majority of the low storm berm is expected to persist at an elevation somewhat greater than the height of the natural shoreline berm (about 2.6 m [8.5 feet]) but lower than the initial storm berm height at construction. Localized formation of discontinuous dunes, with crests at greater than 3.3 m NGVD, within the placement area is expected. Augmentation of existing dunes and growth of new dunes is expected up to 15 to 18 km (9.3 to 11.2 miles) south of the placement area.

7.1.1.c Bathymetry

Great Gull Bank
Direct Impacts
During dredging, the 93 ha (230 acres) borrow area on Great Gull Bank will be lowered from existing depths of 6 to 9 m (19.7 feet - 29.5 feet) to an average 9 m (29.5 feet) depth. Dredging will thus result in a deepening of the borrow area by 3 m (10 feet). A detailed dredging plan will be developed in collaboration with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and Minerals Management Service. Material may be removed to enhance local bathymetry by creating deeper areas, such as holes or trenches, that might serve to attract fish; however, this has not yet been determined. The sidewalls of the depression will be gradually sloped, and slumping during dredging will be minimal. The remainder of the shoal and the shoal crest will be left at its existing height, and the overall shape and gentle slopes of the shoal will be maintained.

Indirect Impacts
Over time, it is likely that some infilling of the borrow area will occur as natural processes transport material from adjacent areas of the shoal to the borrow area. The project will avoid disturbing the existing crest directly during dredging; however, because crest height is partly a function of volume, the reduction of volume of material in the shoal may result in some lowering (less than 1 m [3.3 feet]) of the shoal crest over time.

<u>Sinepuxent Bay</u>
Direct Impacts
None are expected since no project activity will occur within the bay.

Indirect Impacts
Reduction in the rate of overwash deposition from Assateague Island will have a positive impact on Sinepuxent Bay by reducing the rate of infilling in the bay. The total size of the bay will remain approximately stable during the few years following project construction, rather than diminishing in size as would be expected without a project. Water depths within the bay will remain more stable, rather than the bay becoming progressively more shallow over time.

7.1.1.d Hydrodynamics

Direct Impacts
None are expected because ocean circulation and wave activity will not be affected.

Indirect Impacts
Dredging of the shoal would have a negligible impact on wave action both offshore and in the nearshore (see Appendix A for additional information). No impacts are expected to the shoreline of Fenwick or Assateague Islands.

7.1.1.e Surface Water Quality

<u>Great Gull Bank</u>
Direct Impacts
There will be short-term turbidity impacts to the area of the offshore shoal being dredged, ***but little surface turbidity.*** The coarse grain size of the sand being dredged would allow any sand that is stirred up to rapidly resettle on the bottom. All work will be performed in accordance with the State of Maryland Water Quality Certificate to minimize detrimental impacts.

Indirect Impacts
No long-term impacts are expected since dredging will occur only during project construction. No long-term increase in the rate of sediment resuspension from the offshore shoal surface is expected.

Assateague Island

Direct Impacts

It is expected that there would be increased short-term turbidity in the project area when material is placed to construct the shoreline berm. Strong wave action in the nearshore zone creates a dynamic environment where bottom sediments are frequently stirred up naturally. However, material added during construction of the shoreline berm is similar in character to native beach sand in the project area and would be expected to settle out of suspension very rapidly. The material to be placed from Great Gull Bank includes only a very small component (approximately 0.5 percent by weight) of fine-grained sediments (silts and clays finer in grain-size than 4 ϕ). For these reasons, the direct impacts of the short-term restoration to water quality are expected to be minor. All work will be performed in accordance with the State of Maryland Water Quality Certificate to minimize detrimental impacts.

Indirect Impacts

No long-term impacts are expected since fine grained sediments will be rapidly winnowed away within a short period of time following placement. And sediment transported within the nearshore will be within historic rates.

Sinepuxent Bay

Direct Impacts

None are expected since no project activity will occur within the bay.

Indirect Impacts

None are expected since the project will not induce hydrodynamic change within the bay. During storm events overwash into the bay will be reduced. However, this is not expected to cause any noticeable turbidity reduction. Wave action within the bay itself during storm events will resuspend bay bottom sediments, and obscure any reduction of suspended sediment delivered via overwash.

7.1.1.f Air Quality

Emissions during sand placement will be produced by dredges, bulldozers, trucks, small construction vehicles, and workboats. Coordination with the Maryland Department of the Environment (MDE) has indicated that air quality impacts are expected to be localized, temporary, and insignificant and within the Ozone and NO_X limits for this non-attainment area. The MDE has concurred with these findings and has indicated that the project is expected to be in conformity with the State of Maryland implementation of the 1990 Clean Air Amendments (see Annex A, Part 7).

7.1.1.g Noise Impacts

Noise during construction will be produced by dredges, bulldozers, trucks, small construction vehicles, and workboats. Noise impacts are expected to be temporary and insignificant. Construction will not occur during the times when the Piping Plover is most sensitive to disturbance, and noise is not expected to significantly impact the ponies or other wildlife.

Construction will not occur during the period when the project area is most frequented by tourists.

7.1.2 Biological Resources

PLANT COMMUNITIES

7.1.2.a Submerged Aquatic Vegetation

Direct Impacts
None are expected since no project activity will occur within the bay.

Indirect Impacts
Reduced overwash frequency will likely have a positive impact in SAV beds by promoting SAV development in Sinepuxent Bay. Tens of acres of SAV beds may develop as a result. These beds may persist as long as the reduction in overwash frequency is maintained following project construction.

7.1.2.b Wetlands

Direct Impacts
None are expected. Construction of the low storm berm or shoreline berm will not fill any salt marsh or moist interior flats, and equipment will be deployed along the oceanside of the island.

Indirect Impacts
It is anticipated that the reduced frequency of overwash would promote limited development of up to several tens of acres of salt marsh on the bayside of Assateague. Prevention of a future breach would also protect tens of acres of salt marsh on the mainland shore from the increased wave energy and erosive impacts of a breach. However, prevention of a breach would also prevent the formation of flood-tidal shoal deposits that could provide additional substrate for salt-marsh development. In the narrow part of the island where a breach is considered likely, there is a potential that the formation of tens of acres of new salt marsh may be prevented. As a consequence of these trade-offs, the net long-term impact of the immediate restoration project to salt marsh will be minimal. The increased volume of sediment available for transport onto the island during overwash events may cause a minor reduction in the area of moist interior flats. If this occurs to the extent that Piping Plover habitat is jeopardized (discussed in the monitoring and action plan in Annex E), an interagency committee will decide whether mitigation measures should be undertaken. Mitigation may include altering the height of the constructed storm berm in order to increase the frequency of overwash.

7.1.2.c Upland Vegetation

Direct Impacts
The constructed storm berm will bury a swath of non-vegetated to sparsely vegetated beach 50 m (150 feet) in width by 8.5 km (5.3 miles) in length where the storm berm is constructed. The total

area to be buried is 42.5 ha (105 acres). The area will be buried to a maximum depth of about 1 meter (3.3 feet) near the center of the storm berm, with lesser depths extending east and west of the line of maximum depth. Since only minimal vegetation occurs in the placement area, adverse impacts to island vegetation will be insignificant.

Indirect Impacts
In the months and years following sand placement, localized development of sparse dune grassland vegetative cover is expected in association with reduced frequency of overwash and development of discontinuous dunes. Initial vegetation establishment will probably be slowed by the lack of seeds and propagules in the upland habitat of the placement area and island interior. Increased vegetative cover and habitat diversity on northern Assateague will be limited since an overwash frequency sufficient to limit vegetation coverage will be maintained by the project design and/or monitoring and mitigation plan (Annex E).

ANIMALS

7.1.2.d Benthos

<u>Great Gull Bank</u>
Direct Impacts
Dredging will destroy relatively nonmotile benthic organisms. Underlying sands lacking benthic populations will be exposed and will become the new shoal surface.

Indirect Impacts
The substrate remaining at the shoal after dredging will consist of sediment of the same character as the pre-project surface substrate. Colonization of the borrow area by benthic organisms is expected within several months to a year following dredging. Because the existing benthic community is thought to be low in species richness, faunal density, and biomass, the community that recolonizes would be expected to achieve levels at least as great as pre-project conditions (see Planning Aid Report in Annex A, Part 4).

<u>Assateague Island</u>
Direct Impacts
Deposition of sand to increase berm width will smother and destroy existing relatively nonmotile benthic infauna in the beach and nearshore zone. Construction of the storm berm and movement of bulldozers between the beach and constructed storm berm will disturb and destroy fauna of the upper beach over the entire placement area between the western edge of the constructed storm berm and the shoreline. These impacts are not expected to be significant to the regional foodweb. Beach fauna are adapted to the dynamic environment of barrier island beaches and are expected to colonize the new beach and constructed storm berm from adjacent areas to levels characterizing the pre-project beach within a period of several months following project construction. Nearshore fauna are expected to colonize the new seafloor within a period of several months to several years following project construction.

Indirect Impacts
Habitat zones of the beach and nearshore will initially shift seaward following project construction, but will then retreat landward as shoreline erosion occurs. Beach nourishment impacts are most notable when the grain size of added material is different from the existing material and when added material has substantial proportion of fine-grained sediments. The sand from Great Gull Bank to be placed on Assateague was selected because it contains minimal fine-grained sediments and is compatible with existing beach sand. As a consequence, only minimal and temporary adverse impacts to benthos are expected. Resident near-shore benthic communities are well adapted to disturbance from shifting sediments. Therefore, repopulation of the beach and near shore of Assateague by benthos to pre-project levels is expected within several months to several years following placement of the material as the material comes into equilibrium with the physical environment. This shoreline will return to its current position within about 4 years (Table 7-2). Minor impacts will continue to occur for several years due to the restoration of historic longshore transport rates in the nearshore and to the impacts of a large volume of shifting sediments.

Material transported via the littoral transport system southward beyond the placement area on Assateague will have minimal impacts to benthos since benthos of the near shore are adapted to the shifting substrates of this high energy environment. Nearshore bottom sediments are predominantly sandy along the Assateague shoreline. The sand that will be added to the system contains minimal fine-grain sediments and is highly compatible with existing beach and nearshore sand; therefore, impacts that could occur from alterations in sediment character are expected to be minimal. Although downdrift impacts to benthos are not expected to be significant, detectable impacts may extend as far south as 15 to 18 km (10 to 11.2 miles) south of the project area.. Areas of finer grained bottom sediment do occur offshore and south of the placement area. Minor benthic impacts may occur if storm events transport placed sand into these areas.

7.1.2.e Nekton

<u>Great Gull Bank</u>
Direct Impacts
Direct impacts to the offshore shoal include a short-term increase in turbidity during dredging and a resulting disturbance of fish, some of which are expected to temporarily relocate. In addition, some entrainment and subsequent destruction of nekton is expected during dredging. These impacts are expected to be insignificant.

Indirect Impacts
The dredging plan would maintain the shoal crest and general shape of the shoal. It is anticipated that maintaining the general shape and crest height of the shoal would serve to minimize impacts to fisheries and nekton (see Planning Aid Report in Annex A, Part 4).

<u>Assateague Island</u>
Direct Impacts
As island width increases in the placement area, there will be a conversion of marine habitat to terrestrial habitat. Impacts to nekton resulting from this habitat loss are expected to be minimal

since nearshore marine habitat is regionally abundant. In addition, a short-term increase in turbidity during placement may cause nekton to relocate from the placement area.

Indirect Impacts
The seaward shift of nearshore habitats and introduction and transport of a large volume of sediments in the littoral zone may cause minor impacts to the food web. Impacts will be limited because of the compatibility of the placed material with the existing material and similarity of sediment transport rates with-project to historic conditions.

7.1.2.f Birds

This section only includes birds not recognized to be endangered, threatened, or rare by the Federal government or the State of Maryland. Potential impacts to these special status species are considered in *7.3.3 Rare and Endangered Species*.

<u>Assateague Island</u>
Direct Impacts
Impacts to shorebirds will be minimal due to geographic and/or time of year restrictions that protect habitat within the National Seashore during nesting season. The birds are less vulnerable to disturbance at other times of year. During placement, gulls and other scavengers will congregate around the pipeline exit. Since placement in Year 1 will occur away from nesting grounds during the breeding season, and after the nesting season is over in Year 2, minimal impacts to nesting shorebirds are expected. It is expected that migratory birds will temporarily relocate to other parts of the island during construction.

Indirect Impacts
Increased elevation and reduced overwash frequency will likely increase the proportion of the northern end of the island having sparse vegetative cover (as opposed to bare sand). This change will increase habitat diversity on the island and favor species preferring more cover. These changes may cause a minor detrimental impact to species preferring bare sand substrate for nesting purposes.

7.1.2.g Terrestrial Mammals

Direct Impacts
Mammals may avoid the placement area during construction. Habitat quality in the placement area is low, and avoidance of the area will cause no detrimental impacts to mammals.

Indirect Impacts
The proposed beach replenishment will cause a minor increase in vegetative habitat diversity on the northern end of the island. This will cause a minor increase in the availability of food and cover for mammals on the northern end. Minor positive or nonsignificant impacts to mammal populations, including the ponies, are expected.

7.1.3 Rare, Threatened, and Endangered Species

7.1.3.a Piping Plover and Rare Beach-Nesting Bird Species

Direct Impacts

It is assumed in this consideration of potential project impacts that Piping Plover habitat needs encompass the habitat needs of other rare beach-nesting bird species. Direct impacts to Piping Plover and other rare beach-nesting bird species will be minimized through a time-of-year restriction on construction. Construction activities will be restricted in the National Seashore where Piping Plover nest and forage during the period from mid-March until about the first of September. This restriction should preclude detrimental impacts to Piping Plover during courtship, nesting, and brood-rearing seasons. Extensive coordination with the U.S. Fish and Wildlife Service and MD. Department of Natural Resources (MDDNR) has been undertaken (see Annex A, Part 7) to ensure that the project design is well thought out and carefully constructed with regard to Piping Plover. If post-construction modifications are deemed necessary as per the Monitoring and Action Plan (Annex E), then the interagency working group will ensure that remedial actions are implemented in a manner that causes minimal direct impacts to Piping Plover.

Indirect Impacts

Indirect impacts to Piping Plover and other beach-nesting bird species that could occur as a result of augmented dune growth, vegetative succession, and infilling of moist interior flats include increased predation, obstruction of chick walkways, and loss of valuable foraging areas. These risks have been minimized both through project design and by including the Monitoring and Action Plan (Annex E) as a component of the project. The constructed storm berm elevation has been designed to maintain an overwash frequency that will limit vegetation development. It is expected that the constructed storm berm will lose elevation over much of its length during the several months following its construction in the fall. This reduction in height of the storm berm from the design height will serve to further increase the frequency of overwash. This should nearly ensure that vegetative succession on the storm berm and island interior are minimal, and should maintain the character of the island such that impacts to Piping Plover are minimal. If the project fails to perform according to expectations, post-construction modifications as outlined in the monitoring and action plan will be undertaken to improve habitat conditions on the island for Piping Plover (Annex E). The monitoring and action plan establishes a protocol for timely intervention to maintain habitat suitability on northern Assateague for Piping Plover. (See Biological Assessment in Annex A for further discussion.)

7.1.3.b Sea Beach Amaranth

Direct Impacts

Since sea beach amaranth is not known to occur on the island now, no direct impacts are expected. This issue is addressed in more detail in the Biological Assessment in Annex A.

Indirect Impacts

The project may improve conditions for the proposed reintroduction of this plant to the island. Overwash conditions currently maintain much of the northern end in a non-vegetated condition.

The reduction in overwash frequency with the project is expected to allow some growth of vegetation; this may improve conditions for the reintroduction of sea beach amaranth. This issue is addressed in more detail in the Biological Assessment in Annex A.

7.1.3.c Sea Turtles

Direct Impacts

Direct impacts to sea turtles could be avoided either by restricting dredging from the end of March through November or by selective use of, or modifications to, dredging equipment. Unfortunately, weather conditions (primarily northeasters) make it unsafe to dredge from October through March; therefore, it is not possible to complete the project during the time of year when turtles would be absent from the project area. The need to protect Piping Plover (see discussion in 7.1.3.a) restricts activity on Assateague Island from spring through mid-summer, so it is not possible to dredge even during the time of year when ocean water temperatures are somewhat cooler and fewer sea turtles would be present. Project modifications to protect sea turtles, such as modifications to equipment and dredging methods, are more practicable than modifications to protect Piping Plovers. As a result, the project would be constructed when sea turtles are present with provisions undertaken to protect them. It is expected that these provisions will include modifications of the dredging gear to include a Waterways Experiment Station (WES) designed turtle deflector, as well as dredging practice modifications, crew training, and the use of NMFS approved observers. As part of the consultation requirements under the Endangerred Species Act the Baltimore District is preparing a Biological Assessment for submission to the NMFS. Coordination with NMFS has indicated that properly used approved sea turtle deflectors are likely to eliminate significant adverse impacts to sea turtles in the project area, and seasonal restrictions to protect the turtles will not be necessary.

Indirect Impacts

None are expected since no significant long-term impacts to the physical environment or biological resources of the offshore shoals borrow area or nearshore waters of Assateague are expected. The suitability of Assateague Island as a nesting ground will not be significantly altered, and no impacts to migratory patterns will occur.

7.1.3.d Whales

Direct Impacts

It is unlikely that any whales will be in the project area during dredging or placement of material. The hopper dredges will make a combined total of approximately 1,055 transits between the borrow area and the pump-out point. In order to prevent whales from being struck by the hopper dredge when it transits from the borrow area(s) to the pump-out point, a spotter will watch for whales and direct the vessel's course to avoid striking any. This issue will be discussed further in the Biological Assessment currently being prepared by the Baltimore District. At this time it is expected that impacts to whales are unlikely to be significant.

Indirect Impacts
None are expected since no significant long-term impacts to the physical environment or biological resources of the offshore shoals borrow area or nearshore waters of Assateague are expected. No impacts to migratory patterns will occur.

7.1.3.e White Tiger Beetles

Direct Impacts

Construction traffic and related disturbance by heavy equipment to move and configure the storm berm could cause mortality of a substantial portion of the white tiger beetle larvae within the project area. However, the greatest concentration of tiger beetles occurs north of the project area and should not be directly impacted. This undisturbed area will serve as a refugium from which tiger beetles can recolonize the remainder of the island following construction.

Indirect Impacts

It is expected that the relatively flat beach with frequent overwash that was designed to meet habitat requirements of the Piping Plover will also likely meet the habitat needs for the state-endangered white tiger beetle. Given that a recent survey of the island has not been completed and that little is known about habitat requirement of the tiger beetles, designing the project for Piping Plover was considered to be the best strategy to protect the tiger beetle.

7.1.4 Hazardous, Toxic, and Radioactive Wastes (HTRW)

There are no known HTRW sites in the study area; therefore, no HTRW impacts are expected. The Baltimore District has determined that there will be no effects from the FUDS site on Assateague Island.

7.1.5 Reserves, Preserves, And Parks

7.1.5.a Great Gull Banks Artificial Reef

Direct Impacts
No dredging will occur in the fish haven on Great Gull Bank in order to minimize impacts. Dredging will generate turbidity; however, sediments are expected to rapidly settle out of suspension because of the coarse grain size of the material, and minimal impacts are expected to the fish haven. Construction equipment may cause disturbance to nekton and may cause them to relocate from the project area during dredging. Permanent loss of sand is expected to have negligible impact on the offshore shoal.

Indirect Impacts
No long-term impacts are expected since dredging will occur only during project construction. No substantial alterations to the character of the offshore shoal are expected; the surface and

overall configuration of the shoal will only be slightly altered from pre-project conditions, and hydrodynamic conditions will not be altered.

7.1.5.b Assateague Island State Park

Direct Impacts
We have coordinated extensively with the Maryland Department of Natural Resources, and impacts to the State Park have been considered throughout the planning process. The project will benefit the State Park by increasing its beach. The additional material will also help to reduce detrimental impacts to park facilities and to existing constructed dunes, which are occurring as a result of sediment starvation.

7.1.5.c Assateague Island National Seashore (AINS)

This report extensively discusses *Direct Impacts* and *Indirect Impacts* to the AINS in other sections. The National Park Service is a project sponsor and has been thoroughly involved in designing the project. The project will serve to maintain the geological integrity of the island and to reduce the probability of a breach until a long-term solution can be implemented.

7.1.6 Land Use And Traffic Impacts

The proposed restoration at Assateague Island would occur along the beach and would not change land use in the area during or after construction. Project activities are not expected to cause any significant increase in road uses or changes in traffic. Therefore, no significant adverse impacts are expected.

7.1.7 Socioeconomic Impacts And Environmental Justice

7.1.7.a Socioeconomic Impacts

Implementation of the beach replenishment will not significantly impact key, macroeconomic elements of the local or regional economy. The project's scope is such that it will not affect the long-term population, employment, or income trends in the study area. It is possible that implementation of the proposed action will, by stabilizing the northern section of Assateague Island, prevent negative impacts to property values on the mainland behind the island, and reduce costs incurred by boaters from increased channel shoaling in Sinepuxent Bay. The extent and magnitude of such effects is not, however, expected to alter economic activity in the study area.

Population trends are not expected to be impacted by project implementation. Physical changes are localized and not likely to effect current population trends. No relocations of existing households are required. No existing population centers will be affected. It is not expected that residents will be inclined to relocate because of the project.

The impact of the proposed project on local or regional employment distribution is not expected to be significant. The project will not, in and of itself, spur growth in the major industries in the study area, nor will it stimulate significant growth in other, less dominant industries. Tourism and agriculture will continue to thrive with or without the project.

The impact of the proposed project on income in the study area will not be significant. The project will not change the median household income, which currently lags significantly behind the state-wide figure.

The beach replenishment proposed for Assateague Island may produce a minor and temporary increase in employment during construction and perhaps a slight increase in use of temporary lodging. Any lodging requirements are likely to be met by existing facilities because construction will not occur during periods of peak lodging usage by tourists. The proposed dredging and placement will be accomplished by a small construction crew operating dredges, bulldozers and trucks. These workers, if they do not live locally, will likely spend money in the area for food and lodging. Therefore, socioeconomic impacts are expected to be slightly positive.

7.1.7.b Environmental Justice Impacts

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

7.1.8 Recreation Impacts

Implementation of the beach replenishment proposed for Assateague Island is expected to have a positive impact on recreational opportunities and the quality of recreational experience in the localized area of project impact. The project is expected to reduce the incidence of shoaling and sand migration in Sinepuxent Bay behind Assateague Island. This will prevent the navigation channel in the bay from more severe clogging and minimize or eliminate probable boat damages. The project may also benefit users of the marinas at resort developments on Sinepuxent Bay. These recreational boaters will not lose access to the channel that could occur with migration of large volumes of sand with a breach of the island. Also, the probability of shoal-induced groundings of recreational boaters will be reduced. Another positive impact will be that users from channels north of Sinepuxent Bay are not likely to lose access to the channel with project implementation.

7.1.9 Cultural And Historical Impacts

Cultural Investigations by the Baltimore District have indicated that there are no significant cultural resources in the offshore shoal area or in most of the area on Assateague Island. Therefore no significant impacts to cultural and historic resources are expected in these areas. However, investigations have indicated that historical site WO154 “Dune Wreck” is within the southernmost project. The District is performing a Phase II cultural investigation at this site.

7.1.10 Irretrievable Uses of Resources

During beach replenishment, some resources will either be expended in construction activities or impacted by those activities. The most significant resource in the project area that will be expended is the sand from the offshore borrow areas. Because of the north to south drift of the longshore current, sand that erodes from the project area will drift in a southerly direction out of the project area and will be retained within the coastal ecosystem as beach, ocean, or bay bottom mostly outside of the project area.

7.1.11 Impacts to Prime and Unique Farmland

Most upland soils within the coastal bays mainland watershed are categorized as prime or unique farmland areas. However, the type of activities being proposed for the mainland will probably impact wetland or filled wetland soils, and no significant adverse impacts to farmland are expected.

7.1.12 Impacts to Wild and Scenic Rivers

There are no federally designated wild or scenic rivers within the project area. Consequently, no impacts are expected.

7.2 LONG-TERM RESTORATION OF ASSATEAGUE ISLAND

At this time the long-term project has not yet been determined; however, it is expected that some type of by-passing/back-passing system will be the selected project. A by-passing system is considered to be the most likely solution since it will serve to correct the disruption in the longshore transport system that is the root of both the problems at Assateague Island and navigation problems in the harbor, inlet, and shoals. It has not been determined yet whether the plan will involve permanent or mobile structures and equipment.

The restoration of sediment flow at historic rates by the use of a by-pass system should restore the geological integrity and biological character of Assateague Island. Vegetative habitat diversity will increase and some low dunes may form. It is possible that these changes may cause minor detrimental impacts to Piping Plover and other beach-nesting bird species. However, it is expected that a substantial portion of the northern end of the island will remain low and vulnerable to overwash, allowing disturbance to restore unvegetated habitat periodically. In spite of this potential impact, this course of action is preferable to routine beach nourishment of the island, which requires substantial interference with the island on a regular basis. Construction, operation, and maintenance will be coordinated with the U.S. Fish and Wildlife Service, National Marine Fisheries Service, and National Park Service to minimize impacts to rare species.

Minor short-term detrimental noise, air, and water quality impacts resulting from construction of a by-passing project will occur. The system may require the presence of a pipeline and pumps on the northern 3.2 km (2 miles) of Assateague for several to many years. This presence may be required because of the severity and nature of disruption to the longshore transport system that has occurred over the more than 60 years since jetty construction.

In addition to the possible requirement of a pipeline and pumps on this portion of Assateague, the long-term project may require the presence of equipment in the vicinity of the south jetty at Ocean City. Detrimental impacts to the aesthetic quality of the area will be minimized through coordination with the town of Ocean City and the National Park Service.

A by-passing system will provide a long-term benefit to navigation by reducing input of sediment to the flood and ebb-tidal shoals, which will presumably shrink in size. The expected shrinkage of the flood-tidal shoals in the vicinity of the Route 50 bridge will result in a reduction of nesting habitat for shorebirds and colonial waterbirds, including a number of endangered and threatened bird species. This habitat loss could be offset by creation of new islands or restoration of existing islands elsewhere in the study area using material dredged from the Federal, state, or private navigation channels.

Impacts to the economy and recreational appeal of Ocean City will be minimized through careful coordination with the town. Means to minimize these impacts may include a combination of site selection, system design, and time of year restrictions.

7.3 RESTORATION OF SALT MARSH AND FORESTED WETLANDS

Construction activities for tidal and non-tidal wetland restoration may include excavation, transport, placement, and grading of fill; filling or alteration of existing drainage ditches; shoreline stabilization using rubble or geotubes; removal of undesirable vegetation mechanically or with herbicide; application of fertilizer; and planting of vegetation. These actions may cause minor short-term detrimental impacts to water quality because of increased turbidity, release of materials stored in fill, or runoff of fertilizer and herbicide. These impacts will be minimized by construction sequencing and best management practices. Construction activities may also temporarily disturb fish and wildlife. Fish and wildlife may temporarily relocate from the area to adjacent habitats during construction, but are expected to return upon completion of the projects. Impacts to rare, threatened, and endangered species will be avoided by careful site selection and or other means as necessary, such as time-of-year restrictions. Long-term impacts resulting from the restoration of lost habitat and environmental quality functions will be highly favorable to the coastal bays ecosystem.

Although specific sites for salt marsh restoration have not been selected at this time, it is expected that any sites that are identified will be on the shoreline of the northern coastal bays. If salt marsh is restored on fill, then the restoration will cause the loss of upland that might otherwise be used for other purposes. Restored salt marsh may cause local increases in nuisance insect populations, including mosquitoes and biting flies.

Although specific sites for forested wetlands restoration have not been selected at this time, it is expected that any sites that are identified will be on farmland or on land marginal for development within the watersheds of the St. Martins River, Manklin Creek, Turville Creek, Herring Creek, or

Newport Bay. If forested wetlands are restored on farmland, then the restoration will cause the loss of farmland. However, potential sites for restoration will be focused on farmland that is only marginally productive with high water table levels, so impacts to agricultural productivity are expected to be minor. If other lands that are marginal for development are selected, then no detrimental impacts to society are expected. Engineering required to restore hydrology will take into account the requirement to avoid detrimental impacts to the hydrologic conditions of adjacent properties. Restored forested wetlands may cause local increases in mosquito populations.

7.4 CREATION OF HABITAT ISLANDS

Construction activities for island creation may include excavation, transport, placement, and grading of dredged material and fill; shoreline stabilization using rubble or geotubes; application of fertilizer; and planting of vegetation. Island creation will cause the permanent loss of benthic and open water habitat that the island replaces. This impact will be minimized through a site selection process that identifies and avoids environmentally significant areas as sites for island creation. Islands will be placed where there will be the least detrimental impact on the aquatic ecosystem and minimal disruption to the physical environment. Siting of bird habitat islands will also include considerations to minimize vulnerability to human disturbance and predators, but with protection, colonial birds can nest in harmony with man and can serve as a tourist attraction. Islands will be sited to avoid or minimize impacts to commercial and recreational uses of the coastal bays. The impact of the loss of benthic and open water habitat will be non-significant because of the relative abundance of benthic and open water habitat in the coastal bays. Construction may cause minor short-term detrimental impacts to water quality because of increased turbidity, release of materials stored in fill, or runoff of fertilizer and herbicide. These impacts will be minimized by construction sequencing and best management practices. Construction activities may also temporarily disturb fish and wildlife. Fish and wildlife may temporarily relocate from the area to adjacent habitats during construction, but are expected to return upon completion of the area of the projects. Impacts to rare, threatened, and endangered species will be avoided by careful site selection and or other means as necessary, such as time-of-year restrictions. The islands will be designed to provide local habitat enhancement to compensate for the loss of benthic and open water habitat.

Although specific sites for habitat island creation have not been selected at this time, initial screening results indicate that Isle of Wight Bay is a likely area. The relative proportion of island area that will be devoted to waterbird habitat and salt marsh has also not yet been determined, but it is expected that some or all of the created islands will include both. The benefits to populations of colonial waterbirds that are expected to result from creation of nesting habitat should exceed any negative effects that construction of the island might have on the aquatic ecosystem. Creation of salt marsh will also provide a significant positive contribution to the ecosystem of the coastal bays.

7.5 RESTORATION OF WATERBIRD NESTING HABITAT ON EXISTING DREDGED MATERIAL ISLANDS

At this time the South Point Spoils island (Figure 1-1) appears to be a promising candidate for restoration because it is highly significant as a nesting site for a variety of colonial waterbirds. The viability of the site as a nesting ground is threatened by erosion. Restoration of this dredged material island may prove somewhat controversial because the island is surrounded by SAV, and SAV beds are considered to be of great ecological significance. Although a specific project to restore the island has not been selected at this time, two measures are most likely. The restoration project could either stabilize the shoreline of the island and maintain it at its current size, or restore a previous island footprint. If the island is stabilized, short-term localized impacts to the environment would occur as discussed in section 7.4 above. Additional impacts would result, however, from the need to cross over and work within existing perennial SAV beds. Any work undertaken would need to be carefully coordinated with other resource agencies. If the project consists of restoring the island to a previous footprint, then long-term impacts will include the loss of SAV beds. If this latter option is pursued, it will be proposed only if it is determined that the relative gain in waterbird nesting habitat that will accrue is of substantially greater ecological significance than the relative loss of SAV.

7.6 NAVIGATION

Increasing channel depth and width may induce changes in the inlet dynamics and the hydrodynamics of the coastal bays. An enlarged channel may alter the flow and current regime of the inlet, which may in turn affect local current patterns and erosion. However, most of the Ocean City Inlet is already wide and deep and there are only a few isolated shallow areas that would need to be dredged to widen or deepen the channel. Therefore, the hydrodynamics in and around the inlet would most likely change only slightly with a navigation project. On the ocean side, impacts of modifying the inlet on the ebb-tidal shoal and northern Assateague Island are of concern. On the bay side, alterations in the tidal regime, salinity, and flushing characteristics of the bays could occur. These impacts will be minimized through numerical hydrodynamic modeling of the potential plans by CERC to exclude those that may cause significant detrimental impacts.

Past maintenance and dredging operations of the inlet channel and harbor have utilized Assateague Island and Ocean City beaches for dredged material placement. An analysis of the quality and amount of the material to be removed will be required to determine whether beach nourishment is a viable option. This will likely continue in the future and will positively impact the restoration of Assateague Island. Dredged material could also be utilized for the creation or rehabilitation of islands in the coastal bays.

The deepening and widening of the inlet and channel could increase navigation in the coastal bays causing subsequent indirect and cumulative detrimental impacts to water quality and benthic habitat, and increase recreational fishing.

7.7 CULTURAL AND HISTORICAL IMPACTS OF NAVIGATION AND ENVIRONMENTAL RESTORATION PROJECTS

The remainder of the study area has a long history of use by humans from the Paleolithic Period to the present, but most of the cultural activity has been restrained to well-drained, upland portions of the county. All future project areas will be reviewed against known and predicted site locations, and cultural resource surveys will be conducted if necessary. It is considered that, in general, impacts to cultural resources in the remainder of the project will be limited.

7.8 CUMULATIVE IMPACTS

Cumulative impact assessment requires consideration of impacts beyond the site-specific direct and indirect impacts evaluated previously in this section. It should expand the geographic boundaries to consider the effects over an ecological community which extends beyond the immediate site of the proposed action. It is in this context that this section is written.

The project will restore a measure of geological integrity to Assateague Island that will reduce the potential for damage and breaching. This will contribute to the continued maintenance of Assateague as an undeveloped barrier island by the National Park Service; this is of particular importance given the relative scarcity of undeveloped barriers along the Atlantic coast. No additional infrastructure such as roads and lodging will be required at Assateague as a result of the proposed project. The project is not expected to change the number of people using the project area. However, visitation at Assateague is likely to increase as the population of the eastern United States increases and there are fewer undeveloped areas like Assateague to enjoy.

The most significant ecological change requiring consideration herein is perhaps that the acreage of unvegetated beach suitable as nesting habitat for beach-nesting birds (i.e., Piping Plover, terns, Black Skimmer, and other species) may decrease. This change is important both within the coastal bays and along the entire Atlantic coastline since development, inlet stabilization, and heavy recreational use have caused a substantial loss of natural, open sand beach that beach-nesting birds can utilize. However, the risk of detrimental cumulative impacts that could occur by additional loss of unvegetated beach nesting habitat has been minimized both by project design and by incorporation of the Monitoring and Action Plan (Annex E) into the project. This is expected to maintain the availability of a significant area of this habitat type on northern Assateague.

Cumulative impacts to the offshore shoals within the project area are expected to be negligible because of the relatively small volume of material that will be taken for this project, and because of the minimal impacts these shoals have incurred to date. However, consideration of cumulative impacts to the habitat value of offshore shoals off the Maryland coast, as well as to the irretrievable consumption of the mineral resources they contain, will require greater scrutiny in the near future in the state of Maryland. Offshore shoals within Maryland waters north of the Ocean City Inlet outside of the project area are being heavily utilized as sources of sand for the nourishment of the Ocean City beach. Sand resources within Maryland state waters available for use by Ocean City could conceivably be depleted between the years 2010 and 2025. The increasing use of offshore shoals along the Atlantic coastline as sand sources for beach nourishment, as well as for sources of sand and gravel for construction, necessitates comprehensive consideration of long-term management of these non-renewable features in the near future.

Cumulative impacts relating to navigation and beneficial use projects such as island and wetlands creation are expected to be mostly positive. Activities under consideration are not expected to greatly increase the human use of the project area, increase the need for infrastructure such as roads or lodging, or increase congestion on land or on the water. The bird habitat and salt marsh island creation projects are expected to increase habitat for fish and wildlife and provide support to the coastal bays ecosystem.

7.9 ENVIRONMENTAL COMPLIANCE

For an activity or site to be environmentally acceptable, the location, design, and operation must be in compliance with a number of environmental protection statutes and executive orders. Table 7-3 outlines the statutes and executive orders that are potentially applicable to the project, including the level of compliance. The multiple organizations involved in the project and the ongoing and open communication surrounding decisions have helped ensure complete compliance with potentially applicable statutes and regulations.

The proposed action complies with applicable cultural resources statutes, including the state Archaeological and Historic Preservation Act and the National Historic Preservation Act. The assessment included evaluation of archaeological and historic resources, economic and social impacts, and interaction with coastal planning regulations. The Maryland State Historic Preservation office has been consulted, and coordination is ongoing. No significant impacts to cultural resources are expected.

The technical impact assessment documented in this report demonstrates that the project complies with applicable components of the Anadromous Fish Conservation Act; Clean Air Act; Coastal Barrier Resources Act; Coastal Zone Management Act; Estuary Protection Act; National Fishing Enhancement Act; Outer Continental Shelf Lands Act, Marine Protection, Research, and Sanctuaries Act; and the Rivers and Harbors Act. The proposed action will be in full compliance with the Clean Water Act when the State of Maryland issues a water quality certificate or if Congress authorizes the project and the EIS. At the present time, the Corps intends to apply for a water quality certificate. The project also complies with all components of NEPA.

No significant impacts are expected to any rare, threatened, or endangered species; the project will comply with the Endangered Species Act and the Marine Mammal Protection Act. Through the intensive coordination process, the project complies with the Fish and Wildlife Coordination Act. In compliance with the Endangered Species Act, a Biological Assessment for the Piping Plover was prepared. The USFWS completed a Biological Opinion dated May 23, 1997 on the effects of the project on Piping Plover and sea beach amaranth and concluded that implementation of the project, as currently proposed, is not likely to jeopardize the continued existence of these species. The USFWS opinion provided a list of nondiscretionary reasonable and prudent measures to minimize incidental take of Piping Plover which must be undertaken to ensure compliance with the Endangered Species Act. These are provided within the text of the Biological Opinion which is contained in Annex A, Part 7 of this report. A Biological Assessment for sea turtles and whales was prepared by the Baltimore District. The Baltimore District and NMFS are engaged in the consultation process required under the Endangered Species Act. A Biological Opinion has not yet been issued by NMFS, however no significant impacts to listed threatened or endangered sea turtles or whales are expected.

A number of executive orders are applicable to the project. The impact evaluation process demonstrates that the project complies with Executive Orders number 11593), Protection and Enhancement of the Cultural Environment; number 11514, Protection and Enhancement of Environmental Quality; and number 12088, Pollution Control Standard, and the Prime and Unique Farmlands CEQ Memorandum.

The nature and design of the project explicitly incorporate compliance with Executive Orders number 11988, Floodplain Management, and number 11990, Protecting Wetlands.

This project will comply with Executive Order number 12898, Environmental Justice in Minority Populations and Low-Income Populations. A Public Notice was sent out as part of the 1994 Reconnaissance study prepared by the Baltimore District and two newsletters have been distributed during the preparation of this feasibility study. An additional newsletter will be distributed at the end of the study to inform citizens of the results and recommendations of the study. The Public Notice stated that any person who has an interest may request a public hearing. No significant impacts are expected to occur to any minority or low income communities in the project area. Furthermore, the Working Group has involved the residents of Worcester County in the decision-making process via a series of public meetings. The fishermen who use the shoals that would provide borrow material met Corps representatives three times. As a result of these exchanges of information, it was determined that there would be no significant negative impacts to this group. Any impacts would be short term and minor.

Through coordination with the applicable state and Federal agencies, it was determined that no National Point Discharge Elimination System permit or Federal wetlands permit will be required for the project. The project will be in compliance with the Coastal Zone Consistency Act and the Clean Air Act Amendments.

Table 7-3: Compliance of the Proposed Action With Environmental Protection Statutes and Other Environmental Requirements.

Federal Statutes	Level of compliance[1]
Anadromous Fish Conservation Act	Full
Archeological and Historic Preservation Act	Full
Clean Air Act	Full
Clean Water Act	Full[2]
Coastal Barrier Resources Act	Full
Coastal Zone Management Act	Full
Comprehensive Environmental Response, Compensation and Liability Act	N/A
Endangered Species Act	Partial
Estuary Protection Act	Full
Federal Water Project Recreation Act	Full
Fish and Wildlife Coordination Act	Full
Land and Water Conservation Fund Act	N/A
Marine Mammal Protection Act	Full
Marine Protection, Research, and Sanctuaries Act	Full
National Historic Preservation Act	Partial
National Environmental Policy Act	Full
Outer Continental Shelf Lands Act (OCSLA)	Full
Resource Conservation and Recovery Act	N/A
Rivers and Harbors Act	Full
Watershed Protection and Flood Prevention Act	N/A
Wild and Scenic Rivers Act	N/A
Executive Orders, Memoranda, etc.	
Protection and Enhancement of Environmental Quality(E.O 11514,1977)	Full
Environmental Justice (E.O. 12898)	Full
Protection and Enhancement of Cultural Environment (E.O. 11593)	Full
Floodplain Management (E.O. 11988)	Full
Protection of Wetlands (E.O. 11990)	Full
Prime and Unique Farmlands (CEQ Memorandum, 11 Aug 80)	N/A
40 CFR 122.26 (B)(14), 19 Nov 1990	N/A

1 Levels of Compliance

a. Full Compliance: having met all requirements of the statute, E.O. or other environmental requirements for the current stage of planning.

b. Partial Compliance: not having met some of the requirements that normally are met in the current stage of planning.

c. Non-Compliance: violatio n of a requirement of the Statute, E.O. or other environmental requirement.

d. Not-Applicable: no requirements for the statute, E.O. or other environmental requirement for the current stage of planning.

2 Compliance will be complete after the State of Maryland issues water quality certificate.

Section 8

PROJECT IMPLEMENTATION

In accordance with the Water Resources Development Act of 1996, the Corps of Engineers is authorized to carry out the restoration of Assateague Island pursuant to Section 111 of the River and Harbor Act of 1968, as amended. The Corps shall coordinate with the affected Federal and State agencies and shall enter into an agreement with the Federal property owner to determine the allocation of the project costs. The sharing of project responsibilities will be defined in a Memorandum of Agreement (MOA) to be signed by the Assistant Secretary of the Army for Civil Works and the National Park Service.

A Project Management Plan (PMP), which describes the tasks, funding, and schedule through the preconstruction, engineering and design (PED), and construction phases, has been prepared. Since detailed design was accomplished during this feasibility phase, the PED phase will only consist of preparation of the plans and specifications, and a project report. No Design Memorandums are required. Funding for the PED phase will be fully Federal. Following the PED phase, the project will proceed to construction. Based on the availability of funding, construction could begin in July 1998.

8.1 LOCAL COOPERATION

The National Park Service, the Federal property owner of most of the project area, has agreed to enter into an MOA with the Corps prior to construction. There are 17 other property owners affected by the project. There are 16 private properties, as well as a portion of the State Park. The National Park Service has agreed to acquire the private properties prior to construction and the State of Maryland has agreed to provide easements for construction on their State Park property. The National Park Service has agreed to operate and maintain the project as described in Section 6-3.

The MOA that will be prepared with the National Park Service will include the following items of local cooperation and participation:

1. Provide all lands, easements, rights-of-way, and relocations, as determined by the Federal government to be necessary for the construction of the project, including any necessary monitoring and corrective actions.

2. Assure maintenance and repair during the useful life of the project as required to serve the project's intended purpose.

3. Ensure continued public ownership or continued public use of the shoreline upon which the amount of Federal participation is based, and ensure its administration for public use during the economic life of the project.

4. Ensure that any water pollution that could endanger the health of bathers will not be permitted where the beach is used for recreational purposes.

5. Provide and maintain necessary roads, parking, and other public-use facilities open and available to all on equal terms.

Section 9

PUBLIC INVOLVEMENT and AGENCY COORDINATION

Public involvement and agency coordination for the Ocean City Water Resources Study was designed to be an integral part of the planning process. The purposes of the public involvement program included informing the public and decision makers as required by NEPA; gathering useful information; coordinating with citizens, interest groups, and agencies; assessing support for the project; providing a mechanism for citizen input to the planning process; and explaining the use of tax dollars to the taxpaying public. Public involvement participants included the project partners; natural resource management, regulatory, and planning agencies; citizen and interest groups; and the general public. Project cost-sharing sponsors are the Town of Ocean City, Maryland Department of Natural Resources (DNR), National Park Service (NPS), and Worcester County.

The public involvement program developed for this study was a continuation of a comprehensive program completed during the reconnaissance phase of the project. During the reconnaissance phase activities; a broad scoping process was used to identify potential water resource problems and solutions. The reconnaissance public involvement program included a series of public meetings and workshops, as well as meetings with interest groups, focus groups, and agency representatives. The product of the scoping efforts was a list of approximately 30 problems relating to water resources in the Ocean City area. Potential corrective plans were developed and evaluated for the problems identified, a determination was made about Federal interest in correcting the problems, and a cost estimation for a feasibility level study was prepared. Four of the 30 water resource problems were characterized as being in the Federal interest and are addressed in the feasibility study. The problems selected as Federal-interest projects include the short- and long-term restoration of Assateague Island, navigation improvements, and ecosystem restoration in the coastal bays

Similar to the reconnaissance level public involvement program, feasibility level activities were organized into several stages, corresponding with the stages and tasks of other study activities. Each stage provided different opportunities for public participation and resulted in specific products. Both the study team and other participants were committed to an extensive public involvement program that included formal and informal meetings, correspondence, and conversations.

The stages of the public involvement program, including project initiation, development of preliminary and detailed plans, and completion of the planning process, were modified during the feasibility study to provide the flexibility needed in a project with four separate components. Meetings and other public involvement activities often included both preliminary discussions on issues involving the three normally scheduled projects and decision-making discussions on the short-term restoration. Because of the complexity of the project, a variety of communication techniques were employed throughout the study.

Public involvement activities at the initiation of this phase of study included a newsletter, a public information workshop, and publication of the Notice of Intent in the Federal Register. The newsletter reviewed the reconnaissance study accomplishments and provided information on the feasibility phase. The public workshop on May 9, 1996, was attended by approximately 100 people and provided information on the status of each of the study components. A second newsletter was prepared to provide information on the status of the project as well as to address concerns and specific questions raised at the meeting. Issues and concerns identified by the meeting attendees, especially sedimentation in the back bays, were subsequently incorporated into the project planning process.

Since the first public workshop, efforts have concentrated on smaller, more focused group activities. In addition to the regular monthly study team meetings, which include representatives from five Federal, state, and local agencies, focus group meetings have been convened as necessary to discuss issues or questions identified, such as how to add material to the northern end of Assateague Island without negatively impacting Piping Plover habitat, and whether removing sedimentary material from offshore shoals would harm the area fishery or change the wave action along the beach.

The Corps will continue to meet with many agencies, interest groups, and members of the public during the development of recommended alternatives for the remaining three components of the feasibility study. Following development, review, and revision of preliminary plans incorporating the participation of the smaller groups, public information meetings will be held to present those plans for review and comment. After addressing pertinent comments, a last public meeting will be held to present the recommended plan and to invite final comments. In addition to these public meetings, newsletters presenting information on the preliminary and recommended plans will be distributed, and copies of the draft and final study reports will be made available by mail and in local libraries.

The intent of the public involvement program was (1) to identify the several publics with an interest in the project or that might be impacted by the project, (2) to encourage constructive interaction with the study team, (3) to elicit the ideas, issues, and concerns important to each group; and (4) to incorporate those ideas, issues, and concerns into the planning process. Strong and consistent agency coordination was critical throughout the study, and included formal written communication, spirited interaction at study team meetings, assistance with presentations, and participation at public meetings and workshops. Extensive informal communication among agencies also took place as questions were raised and answered during phone conversations and in impromptu discussions. Each interaction, meeting, and conversation was important to the plan formulation process.

A summary and a copy of the letters, comments, and records of other communications are included in Annex A.

9.1 *COOPERATION/COORDINATION WITH MINERAL MANAGEMENT SERVICE*

During the sand source identification phase, it was determined that the active participation of the Mineral Management Service (MMS), an agency of the U. S. Department of Interior, would be necessary. When sand and gravel from the Outer Continental Shelf (OCS) are being considered for use in association with any project, the MMS must be consulted early in the design process to fulfill its stewardship responsibilities and ensure compliance with any legal requirements governing removal of those minerals. The MMS's role in such projects relates to its delegated legal responsibilities under the Outer Continental Shelf Lands Act (OCSLA), for management and conservation of federally owned OCS mineral resources.

In the past, the law required that rights to OCS minerals, such as sand and gravel, be awarded to the party offering the highest cash bid in a competitive lease sale. However, MMS's newly expanded authority (Amendment to OCSLA - P.L. 103-426) provides that they may now work directly with state and local governments to negotiate noncompetitive leases for use of sand, gravel, and shell resources for shore protection or other qualifying public works projects.

In addition, the new law requires that any Federal agency proposing to utilize OCS resources enter into a Memorandum of Agreement (MOA) with the MMS. The purpose of the MOA is to ensure timely cooperation and coordination, to address overlapping environmental requirements, and to specify terms and conditions for removal of the identified resource. For example, the MMS is required to evaluate environmental effects associated with the issuance of a noncompetitive lease for use of federally owned OCS sand.

Several meetings between representatives of the Corps and MMS have been conducted to facilitate this cooperation. Ongoing activities will include draft report and EIS review and consultation meetings to ensure that all the potential MMS concerns are addressed.

Section 10

SUMMARY and CONCLUSIONS

The watershed area of Ocean City, Assateague Island, and the Maryland coastal bays offers many attractions that draw millions of seasonal visitors and part-time residents, as well as growing numbers of new permanent residents. The area offers a wide variety of recreation opportunities and activities, from sandy beaches and noisy nightclubs to tranquil nature trails and fascinating interpretive programs. The wide open bays are home to many birds and fish and provide a variety of recreational opportunities, such as boating, fishing, sunbathing, birdwatching, water-skiing, and other water sports. In addition to tourism, the area and the State of Maryland benefit economically from a substantial fishing industry that is based in Ocean City. Commercial fishermen catch clams, marlin, tuna, sea bass, and flounder. Local marinas also offer facilities for permanent, seasonal, and transient recreational boaters. Tourists can enjoy day-long charterboat outings or fish for part of a day on a "headboat." Small rental boats are also available for navigating through the coastal bays. On land, visitors have fun on the boardwalk, on amusement rides, or by enjoying the numerous restaurants and hotels.

In a more natural setting, quieter amusements are available at the National Seashore and State Park on nearby Assateague Island. Assateague Island is a unique national treasure. The importance of this natural resource became apparent in 1965 when Congress designated the island a National Seashore and placed it under the management of the National Park Service. The Park Service has maintained the island in close to its natural state while providing access to millions of visitors attracted to the island's natural setting. Assateague Island offers the peaceful pleasures of camping, canoeing, cycling, surf fishing, sunbathing, crabbing, clamming, birdwatching, and enjoying the island wildlife, including wild horses and deer.

Unfortunately, extensive population, development, large-scale agricultural operations, and other human-induced factors are jeopardizing the quality of water resources in the coastal bay watershed. Water resources problems include degrading water quality, loss of wetlands, loss of nesting habitat for waterbirds, increasing sediment in the coastal bays, excessive erosion of the Assateague Island National Seashore, navigation difficulties, and increased storm damages. As part of this study, a comprehensive investigation of the water resource problems is being performed, and solutions that will improve the ecosystem as a whole are being developed. The four components of the project being investigated are (1) short-term restoration of Assateague Island, (2) long-term sand placement, (3) navigation improvements, and (4) ecosystem restoration in the coastal bays.

One cause of some of the water resource problems is the disruption of sediment movement caused by the jetties that stabilize the Ocean City Inlet. The jetties were constructed by the Corps of Engineers in 1934, after the inlet formed during a major storm in 1933. Since its formation over 60 years ago, the inlet has functioned as a thoroughfare for boating traffic between the ocean and the coastal bays. In addition to providing access to the coastal bays, the jetties have disrupted the sediment supply between Ocean City and Assateague Island. Prior to the formation and stabilization of the inlet, the sand generally traveled from Ocean City south to Assateague Island. Since their construction, the jetties have prevented a large portion of the sand that would have otherwise reached Assateague from reaching the island. Consequently, the northern 11 km (6.8 miles) of the island shoreline have been seriously affected. The disruption in the natural longshore transport of sediment between Ocean City and Assateague Island has resulted in adverse physical, biological, and economic impacts to the area. The result is an island that is not being maintained in a natural condition, and that lacks the geologic integrity of a healthy barrier island. The island overwashes frequently, and the shoreline has eroded back towards the mainland at an accelerated rate. This has caused the loss of salt marshes and subtidal habitat on the bay side of the island, the infilling and reduction in size of Sinepuxent Bay, and a decrease of habitat diversity on the island. It has also created navigation difficulties through the inlet and back bays and has increased the vulnerability of mainland communities to storm damages. Since the degradation of Assateague Island was determined to be an urgent problem, this interim study was accelerated so that a project could be implemented expeditiously.

Under Section 111 of the River and Harbor Act of 1968, as amended, the Corps of Engineers is authorized to mitigate for shore damage attributable to a Federal navigation project. Through Section 534 of the Water Resources Development Act of 1996, Congress authorized the Secretary to

> *"... expedite the Assateague Island restoration feature of the Ocean City Maryland, and vicinity study, and, if the Secretary determines that the Federal navigation project has contributed to the degradation of the shoreline, the Secretary shall carry out the shoreline restoration feature."*

The future without project condition scenario for Assateague Island was investigated, and these future conditions were found to be unfavorable for many reasons. Due to the lack of an adequate sediment supply, it is expected that northern Assateague Island would continue to be degraded, and a breach would most likely occur on Assateague Island, which could cause additional inlets to form. This could occur during any substantial coastal storm. An additional inlet would change the dynamics of the area and would create more environmental and economic problems. Most importantly, the Assateague Island National Seashore, a national treasure, would suffer significant loss. In addition, it is expected that considerable losses to wetlands would result, as well as losses of recreational opportunities, damage to property, and hazards to navigation would result.

Numerous alternative solutions were evaluated based on completeness, efficiency, effectiveness, and acceptability. A plan was developed that would partially mitigate for the past impacts caused by the construction of the jetties. The study team and the sponsors utilized the best environmental, economic, and institutional data and criteria available to determine and develop this short-term plan. The short-term restoration plan includes dredging approximately 1.4 million cubic m(1.83 million cubic yards) of sediment from Great Gull Bank and placing it on Assateague Island between 2.5 km (1.6 miles) and 11.3 km (7 miles) south of the south jetty. The distance across the beach in this area will be increased to varying widths based on the erosion rates that affect each part of the beach. A low storm berm will be constructed to an elevation of 3.3 m (10.8 feet) NGVD (averaging 0.8 m in height) in the portion of the beach between 3 km (1.86 miles) south of the inlet and approximately 10 km (6.2 miles) south of the inlet. The placement will be configured to restore the integrity of the island, and yet still be sensitive to the Piping Plover, a threatened and endangered bird found on the island. Positive impacts to the region's economic, cultural, recreational, and social resources are expected as a result of the implementation of the recommended plan. A monitoring and action plan has also been developed to observe and protect the project area against possible negative impacts for a period of 5 years after the short-term plan is implemented and until a long-term plan is established. The National Park Service will be responsible for maintenance of the project, which is expected to be minimal.

This initial phase of the project, the short-term restoration of Assateague Island, partially mitigates for the impacts on Assateague Island during the last 63 years. We are also currently developing long-term plans for preventing the future impacts that the inlet and jetties will continue to have on Assateague Island and the surrounding area. Some of the alternative plans being evaluated for the long-term restoration are (1) constructing a fixed by-passing plant, (2) dredging in and around the inlet on a routine basis and placing the material on Assateague Island, and (3) removing the jetties. The evaluation of these plans is currently underway, and the selected plan will be documented in a draft feasibility report, scheduled for completion in September 1997. The primary goal of the long-term sand placement component of the project is that it restore, as much as possible, the natural longshore transport process. All of the long-term Assateague Island restoration plans (except no action) will require the short-term component to be constructed initially; therefore, the short-term plan will not preclude the long-term plans. The importance of a long-term plan is recognized; however, the approval of this short-term plan does not commit the Federal government to the implementation of a long-term plan. The practicality of constructing the short-term project is tied to the feasibility of the long-term project. The schedule allows adequate time for evaluation of the long-term plan prior to a decision for construction of the short-term project.

The estimated cost for the short-term restoration project, including 5 years of monitoring, is $17.2 million. As mentioned previously, the long-term plan has not yet been developed. It may involve the construction of a fixed plant that would have a significant first cost, and a relatively low annual maintenance cost, or it could include contracting dredges annually, which would involve no first cost but would have a higher annual cost. The estimated first cost for the long-term restoration is between $0 and $10 million; and the estimated annual operation and maintenance cost is between $400,000 and $2 million. Section 534 of the Water Resources Development Act of 1996 authorizes the Corps of Engineers to restore Assateague Island pursuant to Section 111 of the River and Harbor Act of 1968. It states that the Secretary shall coordinate with affected Federal and State agencies and shall enter into an agreement with the Federal property owner to determine the allocation of the project costs. This report will provide a basis for that coordination. There are four ways this project could potentially be funded: (1) 100 percent by the National Park Service under the Support for Others program; (2) 100 percent by the Corps of Engineers using Section 111 authority; (3) 65 percent by the Corps and 35 percent by the National Park Service under the ecosystem restoration authority; or (4) some alternative cost-sharing method. The National Park Service, who administers the Assateague Island National Seashore, has agreed to enter into a Memorandum of Agreement with the Corps and provide lands, easements, and rights-of-way, as needed. The State of Maryland has agreed to provide easements for construction in the State Park. However, additional coordination is necessary to fully define project implementation responsibilities.

[As of June 1998, the Ocean City, Maryland, and Vicinity Water Resources Integrated Feasibility Report and Environmental Impact Statement was finalized, as were both the short- and long-term components of the restoration of Assateague Island. The recommended long-term plan is for the "mobile bypassing" of sand via a shallow mobile hopper dredge to remove sand that has been redirected to a number of sites, and then bypassing it to Assateague Island. This dredging will take place each year to more closely mimic natural processes. Sand will be bypassed from the updrift fillet, ebb shoal, the navigation channels and flood shoals. In order to avoid the creation of new problems by taking too much sand from any one source or too frequently from the same source (thus further disturbing the balance of the area), the project will be monitored annually. A team of decision makers led by the Corps, consisting at a minimum of all the project sponsors (the NPS, the State of Maryland, Worcester County, and the Town of Ocean City), will determine each year how much material can be taken from each of the available sources. Their decision will be based on the monitoring results, which will indicate the rate at which the sources are being naturally replenished after dredging.

The authority to implement the Assateague Island components of the project, both short-term and long-term sand management, were provided by Section 534 of the Water Resources Development Act of 1996. This Act directed the Corps to implement the restoration of Assateague Island pursuant to Section 111 of the River and Harbor Act of 1968. In addition, the Act authorized the expenditure of $35 million dollars for both the short- and long-term restoration of Assateague Island. The short-term restoration project is estimated at $17.2 million. At an annual cost of more than $1.1 million for long-term sand management, the project as authorized will carry the project through to fiscal year 2011, assuming the project is fully federally funded. For the 25 year project duration, the estimated long-term sand management cost is $25,243,000, or $43,773,000 fully funded. Therefore, Congressional project reauthorization of the project is recommended. It stated that the Secretary shall coordinate with affected Federal and State agencies and shall enter into an agreement with the Federal property owner to determine the allocation of the project costs. The Corps is currently coordinating with NPS, the State of Maryland, Worcester County,

and the Town of Ocean City to define project implementation responsibilities for both the short-term restoration of Assateague Island and the long-term sand management. All of the project sponsors support the recommended project. The NPS, who administers the Assateague Island National Seashore, has agreed to enter into a Memorandum of Agreement with the Department of the Army.

The schedule for these two components of the Assateague Island restoration has also been finalized. This schedule allows 2 years for the construction of the short-term sand management plan, with construction of the long-term plan to begin the year following completion of the short-term plan. The short-term sand management plan is scheduled to begin construction in July 1999; the long-term plan, in summer 2001.]

Section 11

RECOMMENDATION

In conducting this interim study, I have investigated the possibility of restoring Assateague Island to mitigate for the adverse impacts caused by the construction of the Ocean City Inlet jetties by the Corps of Engineers in 1934. This investigation has been conducted as authorized by a resolution of the Committee on Environment and Public Works of the United States Senate, adopted May 15, 1991.

As part of this study, I have given consideration to the relevant aspects of public interest, including environmental, social, economic, and engineering concerns. The northern 11 km (6.8 miles) of Assateague Island have been sediment starved due to the disruption in the longshore sediment transport caused by the existence of the jetties. This starvation has caused excessive erosion of Assateague Island, a loss of salt marshes, a loss of subtidal habitat, increased storm damage, and navigation difficulties. If no action is taken to restore the island, it will most likely breach, creating an additional inlet. This would cause even more environmental and economic problems. The proposed project represents a cost-effective plan that restores the environment. Positive impacts to the region's economic, cultural, recreational, and social resources are expected as a result of the implementation of the recommended plan.

On the basis of these evaluations, and with the support of various resource agencies, State and local government, and citizens, I recommend that the Corps of Engineers mitigate for the impacts caused by the Corps navigation project. Through the Water Resources Development Act of 1996, Congress has authorized the Corps of Engineers to pursue this project under the authority of Section 111 of the River and Harbor Act of 1968, as amended. I recommend that 1.4 million m^3 (1.8 million cubic yards) of material be dredged from Great Gull Bank and placed on Assateague Island in the area between 2.5 km and 11.5 km (1.6 and 7 miles) south of the Ocean City Inlet. The beach will be widened various distances based on the varying erosion rates. A low storm berm will be constructed to elevation 3.3 m (10.8 feet) NGVD (averaging 0.8 m in height) between 2.5 km (1.6 miles) south of the inlet and approximately 10 km (6.2 miles) south of the inlet. The estimated cost for the short-term restoration project including monitoring for 5 years is $17.2 million. Section 534 of the Water Resources Development Act of 1996 states that the Secretary shall allocate costs for the project pursuant to Section 111 of the River and Harbor Act. It also states that the Secretary shall coordinate with affected Federal and State agencies and shall enter into an agreement with the Federal property owner to determine the allocation of the project costs. The National Park Service, who administers the Assateague Island National Seashore, has agreed to enter into a Memorandum of Agreement with the Corps, maintain and repair the project as needed, and provide lands, easements, and rights-of-way, as needed. The State of Maryland has agreed to provide easements for construction in the State Park. Additional coordination between the Corps and the National Park Service will occur to fully define the implementation responsibilities.

The recommendations contained herein reflect the policies governing formulation of individual projects and the information available at this time. They do not necessarily reflect program and budgeting priorities inherent in local and state programs, or the formulation of a national Civil Works water resources program. Consequently, the recommendations may be modified at higher levels within the executive branch before they are used to support funding.

RANDALL R. INOUYE, P.E.
Colonel, Corps of Engineers
Commander and District Engineer

ANNEX A

SUPPLEMENTAL NEPA DOCUMENTATION

ANNEX A

SUPPLEMENTAL NEPA DOCUMENTATION

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ANNEX A

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SECTION 404(b)(1) EVALUATION

ASSATEAGUE ISLAND RESTORATION

WORCESTER COUNTY, MARYLAND

MAY 1997

I. Project Description

a. Location

The project area includes northern Assateague Island, Great Gull Bank, the ebb-shoal of the Ocean City Inlet, and the waters of the Atlantic Ocean separating these features (Figures 1-1 and 1-2). The area is shown on National Ocean Service Chart No. 12211, and on the U.S. Geological Survey Ocean City, Berlin, and Tingles Island 7.5' quadrangle topographic maps.

b. General Description

The proposed action is a beach nourishment of Assateague Island utilizing sand dredged from Great Gull Bank. Sand may also be dredged from the ebb-shoal of the Ocean City Inlet. Approximately 1,400,000 m^3 (1,800,000 yd^3) of sand will be placed along northernmost Assateague Island's ocean shoreline. The majority of this sand will be placed on the beach immediately seaward of the existing berm along a reach from 2.5 km to 11.3 km (1.6 to 7 miles) south of the Ocean City Inlet (Plate 6-1 through 6-4). This will increase island width. Approximately 10% of the sand will be used to construct a low storm berm setback from the berm along the reach from 3 km to 10 km (1.9 to 6.8 miles) south of the inlet. The storm berm will serve to increase island height.

c. Purpose

The purpose of the project is to restore a volume of sediment that has been lost to Assateague Island because of interruption of the longshore transport system at Ocean City by the Corps of Engineers jetties. This will serve to partially restore the geological integrity of the island and reduce the likelihood of the island breaching. The restoration design is constrained by the need to minimize detrimental impacts to the rare species that occur on the northern end of the island.

d. General Description of Discharge Material

(1) *Characteristics of Fill Material* - The material consists of sand.

(2) *Fill materials*
1,400,000 m^3 (1,800,000 yd^3) of fine to coarse grain sand (average is medium sand with grain-size of approximately 1.62 ϕ with a standard deviation of 0.80 ϕ) will be used for the restoration. Approximately 1,225,000 m^3 (1,600,000 yd^3) of the sand will be used to construct the berm which will increase island width; 285,000 m^3 (370,000 yd^3) of the sand will be used to construct the low storm berm which will increase island height.

(3) *Source of Material* - Sand for the immediate restoration of Assateague Island will be dredged entirely or primarily from Great Gull Bank . Great Gull Bank is an offshore shoal located about 8 km (5 mi) east of Assateague Island in the Atlantic Ocean. The shoal is oblong in shape and is oriented southwest/northeast. The shoal covers an area of approximately 4,900 ha (1,980 acres). Maximum length and width are about 6 km (20,000 feet) and 1.8 km (6,000 feet) respectively. The shoal contains 42,800,000 m^3 (56,000,000 yd^3) of sand. Of this total volume, approximately 6,890,000 m^3 (9,000,000 yd^3) is suitable for beach nourishment purposes. Sand will be dredged from an oblong-shaped area along the eastern margin of the southwestern quadrant of Great Gull Bank. The borrow area on Great Gull Bank is approximately 93 ha (230 acres) in size, with maximum dimensions of 3,050 m (10,000 feet) and 500 m (1,500 feet) respectively parallel to the long and short axes of the offshore shoal. Approximately 3 m (10 feet) of sand will be dredged from the borrow area on Great Gull Bank. It is also possible that the ebb-tidal shoal of the Ocean City Inlet will be used as a borrow source. If the ebb shoal is utilized, sand that has accumulated over the last several years either at the northern tip of the shoal or along the outer edged will be used. A maximum of 500,000 m^3 (650,000 yd^3) of sand may be dredged from the ebb shoal.

e. Description of the Proposed Discharge Site

The discharge site is the ocean shoreline of northern Assateague Island, and extends from 2.5 to 11.3 km (1.6 to 7 miles) south of the Ocean City Inlet (Plate 6-1 through 6-4). This area is world-renowned for its sediment starved conditions. Nearly level topography characterizes the placement area from 3 km (1.9 mi) to 10 km (6.2 mi) south of the inlet and dunes are generally lacking (Figures 3-3 and 3-4). The area is frequently overwashed (as many as 20 times per year) and is largely devoid of vegetation. North of 3 km and south of 10 km the island possesses dunes and vegetation. The placement area is notable for its concentration of rare beach-nesting bird species, including Piping Plover (Federally listed as Threatened), Least Tern (State Listed as Threatened), and American Oystercatcher (State Listed as Rare/Watch List).

f. Description of Dredging and Placement Method

Two Island Class hopper dredges with pump-out capability will be used to dredge sand for the restoration. Work will be done over two fall work seasons during the period of late August through mid October. Each dredge is capable of producing 219,073 m^3 (286,520 yd^3) of sand per month. Sand will be dredged off the shoal and pumped into the vessel which has an effective hopper capacity of 1,444 m^3 (1,888 yd^3). Each hopper dredge will transect the borrow area until the hopper is full. The hopper dredge will then travel to a pump-out point located about 600 m (2000 feet) offshore of Assateague Island where a barge with a booster pump will be waiting. The barge mounted booster pump will pump the sand in a slurry from the hopper dredge to the beach through a steel pipeline. The pipeline will lie on the seafloor oriented perpendicularly to the shoreline and be marked with buoys. The hopper dredge will then return to the borrow area and resume dredging. Approximately 1,055 transits from the borrow area to the pump-out point will be made between the two hopper dredges. Bulldozers will then be used to create areas to trap and shape sand as it exits the pipeline to form the berm and dune. Bulldozers will access the project area from the state park. Pumping of sand will be done for a maximum distance of up to 1,220 m (4,000 feet) north or south of where the pipeline crosses up onto the beach. Beach nourishment will be completed in sections of 2,450 m (8000 feet). Once a 2,450 m section of the project is built, the barge and booster pump would be moved to a new pump out point to continue the project. A minimum of three pump out points will be established. Using the two dredges simultaneously it will take a minimum of 3 months to complete the dredging. Due to environmental time constraints, work will be done over two years. Work will begin in Year 1 within the State Park in July and proceed northward. Work will commence in Year 2 within the National Seashore after about September 1st. Work will cease by late-October in both years, weather permitting. Inclement weather or equipment problems may increase the amount of time required.

II. Factual Determinations

a. Physical and Substrate Determinations

(1) *Substrate elevation and slope* - Water depths on Great Gull Bank range from 5.8 (19 ft) to about 15 m (50 ft). Water depths on the seafloor adjacent to the offshore shoal range from 11 m (36 ft) to about 18 m (60 ft). Water depths in the southwestern quadrant of Great Gull Bank where dredging is proposed range from 6 to 9 m (20 ft to 30 ft). Slopes on the shoals are very gentle, and range from 0.5 % to 2 %. During dredging the borrow area on Great Gull Bank will be lowered to 9 m depth. The shoal crest and overall shape of the shoal will be maintained. Following dredging, over a period of several months to years, partial infilling of the borrow area is expected by sand transported from adjacent areas of the shoal. Elevations on Assateague Island in the placement area range from 2.5 m (8.2 ft) NGVD on the existing berm crest to -3 m (-9.8 ft) NGVD in the nearshore. Construction will alter substrate elevations and slopes to conform to the specifications of the restoration construction template (Plate 6-5). The constructed storm berm will crest at 3.3 m (10.8 ft) NGVD, and the berm crest will be extended seaward. After several months of wave and tidal action causing net seaward transport of material placed in the berm, the design configuration of the berm will be obtained. Over the same period

of time, the constructed storm berm is expected to generally lose elevation due to deflation from prevailing winds from the northwest/west. Over a several year period, additional material will be available for landward transport during overwash events in the placement area and downdrift of the placement area. Localized infilling of interior depressions and subsequent dune growth are expected, however interior slopes and elevations on Assateague Island landward of the constructed storm berm are not expected to change significantly on a landscape scale following construction.

(2) *Sediment Type* - The existing sediment on Great Gull Bank possesses a grain-size of approximately 1.62 ϕ (medium sand) with a standard deviation of 0.80 ϕ (one standard deviation includes sand ranging from coarse to fine). The project will remove 3% of the shoal. Sand at the placement area along northern Assateague ranges from an average grain-size of 1.76 ϕ (medium sand) at the "dune" base, to 1.15 ϕ (medium sand) at mean low water, to 2.23 ϕ (fine sand) on the nearshore sand bar crest.

(3) *Dredged/Fill Material Movement* - Sand placed on Assateague Island to form the berm according to the construction template will be immediately attacked and moved by waves and tides. After a period of several months the constructed berm is expected to conform to the design template (Plate 6-5). Shoreline erosion will continue in the placement area at the same rate as prior to construction, about 5 m/yr (16 ft/yr). By the end of the third year following construction only about half of the project area shoreline will still lie seaward of the shoreline position at the time of construction. On average, the shoreline will have returned to its pre-construction position. By the end of year 4 the shoreline throughout the majority of the project area will have eroded to about 5 m (16 feet) west of its position at the time of construction. Following construction, longshore transport will move the placed material southward at a rate of approximately 190,000 m^3/yr (248,000 yd^3/yr). A percentage of the placed material carried downdrift will be available for deposition on the island during overwash events, and may measurably increase island width over a distance of up to 15 to 18 km (9.3 to 11.2 miles) south of the inlet over a period of several years. After approximately 7 yrs it is expected that the fill material will have been effectively removed from the placement area beach and nearshore if no long-term solution is implemented. However, it is expected that a long-term solution will be implemented after year 2. It is expected that this solution will be designed to slow both the erosion rate and rate of loss of material to the longshore transport system to natural pre-jetty rates (3 m/yr (10 ft/yr) and 150,000 m^3/yr (196,000 yd^3/yr) respectively). Material placed to form the constructed storm berm on Assateague will be subject to deflation by prevailing winds from the west/northwest immediately following construction. Much of the sand will be transported in an offshore direction. However, it is expected that localized increase in storm berm height will occur and low discontinuous dunes may form during periods of wind reversal.

(4) *Other Effects* -

(5) *Actions Taken to Minimize Impacts* - Dredging impacts to the physical character of the Great Gull Bank will be minimized by delineation of the borrow area to avoid the shoal crest, and by dredging a maximum of 3 m (10 feet) off the offshore shoal. To minimize physical impacts during the placement of sand on Assateague bulldozers will be used to trap and shape sand as it exits the pipeline All work will conform to the requirements of the State water quality certificate. Construction specifications provided to the contractor state that compliance is mandatory for all applicable environmental protection regulations for pollution control and abatement.

<u>b. Water Circulation, Fluctuation, and Salinity Determinations</u>

(1) *Water*

(a) Salinity - No change expected.

(b) Chemistry - No change expected.

(c) Clarity - Minor and temporary reduction expected during construction due to turbidity. No long-term impact expected.

(d) Color - Minor and temporary change expected during construction due to minor increase in turbidity. No long-term impact expected.

(e) Odor - No change expected.

(f) Taste - Not applicable.

(g) Dissolved Gas Levels - No change expected.

(h) Nutrients - No change expected.

(i) Eutrophication - Not expected to occur.

(j) Temperature - No change expected.

(2) *Current Patterns and Circulation*

(a) Current Patterns and Flow - Following placement of material on Assateague, the shoreface will be steeper than in nature, causing wave energy to be concentrated on the seaward side of the berm. After several months, a profile will be achieved which is in equilibrium with natural conditions, causing wave action and water circulation to achieve pre-project conditions. The borrow area on the offshore shoal will have a slope comparable to the existing shoal bottom and no significant alteration in current patterns are expected.

(b) Velocity - Reduction in the height of the shoal will allow a minor and negligible increase in velocity of the predominantly southerly currents. These currents are very slow and no negative environmental impacts are expected from this change.

(c) Stratification - No change expected.

(d) Hydrologic Regime - Minor and non-significant change expected concomitant with minor changes in current patterns and velocity.

(3) *Normal Water Level Fluctuations* - No change expected.

(4) *Salinity Gradients* - No change expected.

(5) *Actions That Will Be Taken to Minimize Impacts* - Not applicable.

c. Suspended Particulate/Turbidity Determinations

(1) *Expected Changes in Suspended Particulates and Turbidity Levels in Vicinity of Placement Site* - Minor, localized, and short-term impacts are expected to occur during both dredging and placement. Coarse grain-size of material will cause rapid settling of dredged and placed material. Turbidity levels are expected to rapidly return to background levels once dredging is completed.

(2) *Effects (degree and duration) on Chemical and Physical Properties of the Water Column*

(a) Light Penetration - Minor, temporary, and localized reduction in light penetration due to turbidity may occur during dredging on Great Gull Bank and in nearshore of Assateague during placement. No change expected after construction.

(b) Dissolved Oxygen - Minor, temporary, and localized reduction in dissolved oxygen due to turbidity may occur during construction. No change expected after construction.

(c) Toxic Metals and Organics - No toxic metals or organics are expected to be released into the water column. No change expected after construction.

(d) Pathogens - No pathogens are expected to be released into the water column.

(e) Aesthetics - A temporary and minor reduction in aesthetic value within the area of construction is expected to occur during construction activities. No change expected after construction.

(f) Temperature - No change expected.

(3) *Actions Taken to Minimize Impacts* - Construction methods are based on previous beach nourishment projects at Ocean City in which measures taken to reduce environmental impacts that would occur from loss of sand also generally reduce costs. Best management practices will minimize turbidity created by construction activities.

d. Contaminant Determinations

Environmental coordination letters and historical research indicate that no contaminant sources are located in the area which will be affected by the construction. Clean sand will be used for the restoration; therefore, no significant levels of contaminants are anticipated to be released into the water column.

e. Aquatic Ecosystem and Organism Determinations

(1) *Effects on Plankton* - Impacts from entrainment into the dredge and because of potential turbidity during construction are anticipated to be minor and temporary. No detrimental long-term impacts are expected.

(2) *Effects on Benthos* - Dredging of Great Gull Bank will destroy relatively non-motile benthic organisms that inhabit the site. It is expected that benthos will recolonize the area and return to pre-project levels within several months to a year following dredging. Placement of fill material on the beach and in the nearshore will destroy relatively non-motile benthic organisms that inhabit the site. It is expected that benthos will recolonize the area and return to pre-project

levels within several months to a year following dredging. The increased width of Assateague Island will directly displace and cause the loss of a negligible amount of surf zone and nearshore shallow water habitat. As the island retreats this habitat will be restored within several years. Negligible and temporary impacts may occur during construction as a result of increased turbidity.

(a) Primary Production, Photosynthesis - Minor, temporary, and localized reduction in photosynthesis and primary production due to turbidity may occur during construction. No change expected after construction.

(b) Suspension/Filter Feeders - Dredging will destroy relatively non-motile suspension/filter feeders that inhabit the Great Gull Bank site. Placement of sand will smother and destroy relatively non-motile suspension/filter feeders that inhabit the nearshore. Minor, temporary, and localized impacts to suspension and filter feeders in the dredging area and placement zone may occur due to turbidity created by construction activities. Suspension and filter feeders are expected to recolonize the dredging and placement sites and recover to pre-project levels within several months to a year following project construction.

(c) Sight Feeders - Minor, temporary, and localized impacts due to turbidity may occur during construction. Non-significant change expected after construction.

(3) *Effects on Nekton* - The placement of fill material is anticipated to temporarily affect the distribution of nektonic organisms during construction activities. Nekton will return to borrow and placement areas immediately following construction.

(4) *Effects on Aquatic Food Web* - The aquatic food web is anticipated to be temporarily impacted to a minor degree by construction activities. Initial loss of benthic and open water habitat is expected to cause negligible detrimental impacts to the aquatic food web. Probable gain in tidal wetlands and SAV beds on lee of island is expected to produce a benefit to the Sinepuxent Bay aquatic food web.

(5) *Effects on Special Aquatic Sites*

(a) Sanctuaries and Refuges - Beach nourishment will take place on Assateague Island National Seashore and Assateague State Park. Impacts to these parks and discussed extensively in this document. Dredging will take adjacent to an area designated by the state as a fish haven. Impacts to the fish haven will be minimal since the fish haven was excluded from consideration as an area to be dredged.

(b) Wetlands - The project will induce formation of tidal wetlands on lee side of Assateague Island and serve to protect mainland tidal wetlands from loss to erosion that would occur if inlet occurred. However, the project will prevent formation of additional salt marsh that would form on flood-tidal shoals that would form in a breach.

(c) Tidal flats - The project will reduce overwash frequency which is forming tidal flats on the lee side of Assateague. This will cause a reduction in the rate of tidal flat formation. Existing tidal flats will be more rapidly colonized by salt marsh vegetation.

(d) Vegetated Shallows - Reduction in rate of overwash frequency may facilitate formation of SAV beds in lee of Assateague.

(6) *Threatened and Endangered Species* - Threatened and endangered species known to occur in the project area are listed in Table 2-1. To prevent entrainment of sea turtles in the dredge, each dredge will be equipped with a WES designed turtle excluder device and will utilize observers approved by the National Marine Fisheries Service for this purpose. To prevent whale-strikes an observer on the hopper dredge will scan for whales. Coordination with the NMFS has indicated that with the above safeguards, significant adverse impacts to sea turtles and mammals are unlikely. Impacts to the rare species occurring on the island will be avoided by time of year restrictions, construction sequencing, and project design. In addition, for Piping Plover a long term monitoring and mitigation plan has been established which will allow corrective action to be taken should any detrimental impacts to plovers occur because of the project.

(7) *Other Wildlife* - Detrimental impacts to other wildlife are expected to be non-significant as the placement area has limited habitat value. After completion, the project will provide and maintain overwash habitat on Assateague Island, but should also cause a minor increase in habitat diversity which should benefit other barrier island species.

(8) *Actions to Minimize Impact* - Construction activities will be sequenced to avoid work during the time of year when rare beach-nesting birds are in placement area.

f. Proposed Disposal Site Determinations

(1) *Mixing Zone Determination* - Coarse grained-sand will rapidly settle to the bottom both at the dredging site and at the placement site.

(2) *Determination of Compliance with Applicable Water Quality Standards* - Construction activities will be conducted in accordance with all applicable state water quality standards.

(3) *Potential Effects on Human Use Characteristic*

(a) Municipal and Private Water Supply - Not applicable.

(b) Recreational and Commercial Fisheries - Minor short-term negative impact to commercial fishery anticipated during dredging and following loss of benthos. Benthic fauna on Great Gull Bank is expected to recover within several months to a year following dredging. No long-term impact to fisheries are expected from placement of material on Assateague.

(c) Water Related Recreation - Positive impact expected, project will allow for maintenance of access to Assateague Island for pedestrians by reducing likelihood of breach. Reduced frequency of overwash will slow infilling of Sinepuxent Bay by sand, reducing the rate of loss of navigable waters.

(d) Aesthetics - A temporary and minor reduction in aesthetic value within the area of construction is expected to occur during placement and shaping activities on Assateague Island. The restored island will maintain the aesthetic conditions that make the area a tourist attraction.

(e) Parks, National and Historical Monuments, National Seashores, Wilderness Areas, Research Sites, and Similar Preserves - A fish haven is located on Great Gull Bank, but dredging will occur several miles to the south of the area and no impacts are expected. The project will serve to maintain the integrity of Assateague Island National Seashore and State Park and has been fully coordinated with the National Park Service and Md. DNR.

g. Determination of Cumulative Effects on the Aquatic Ecosystem - This project will contribute to the maintenance of Assateague as an undeveloped barrier island by the National Park Service by restoring a measure of the island's geological integrity. This is of particular importance given the relative scarcity of undeveloped barriers along the Atlantic coast. The project will contribute incrementally to the loss of offshore shoals as fish habitat and sand resources. Cumulative environmental impacts of this loss are not known.

h. Determinations of Secondary Effects on the Aquatic Ecosystem - Indirect effects resulting from the project have been discussed previously in this analysis under each category. No significant detrimental secondary effects are anticipated.

III. Finding of Compliance

a. Adaptation of the Section 404(b)(1) Guidelines to This Evaluation - No adaptations of the Guidelines were made relative to this Evaluation.

b. Evaluation of Availability of Practicable Alternatives to the Proposed Discharge Site Which Would Have Less Adverse Impact on the Aquatic Ecosystem. - The project is by its nature water-dependent and will require activity within the aquatic realm. The completed project will restore the geologic integrity of Assateague Island National Seashore for an interim period of time until a long-term solution can be implemented.

c. Compliance With Applicable State Water Quality Standards. - The proposed placement of fill material will be in compliance with Maryland state water quality standards.

d. Compliance With Applicable Toxic Effluent Standard or Prohibition Under Section 307 of the Clean Water Act. - The proposed fill material is not anticipated to violate the Toxic Effluent Standard of Section 307 of the Clean Water Act.

e. Compliance With Endangered Species Act of 1973 - The project will not significantly detrimentally impact any endangered species or its critical habitat, and is therefore in compliance with the Endangered Species Act of 1973. To avoid detrimental impacts the needs of endangered species were incorporated into the project design, construction sequencing, dredging methodology, and monitoring and mitigation plan.

f. Compliance With Specified Protection Measures for Marine Sanctuaries Designated by the Marine Protection, Research, and Sanctuaries Act of 1972 - No Marine Sanctuaries, as designated in the Marine Protection, Research, and Sanctuaries Act of 1972, are located within the study area.

g. Evaluation of Extent of Degradation of Waters of the United States - The proposed placement of fill material will not result in significant adverse impacts on human health and welfare, including municipal and private water supplies, recreation and commercial fishing, plankton, fish and shellfish, wildlife, and special aquatic sites. The life stages of aquatic life and wildlife will not be significantly adversely affected. Significant adverse impacts on aquatic ecosystem diversity, productivity and stability, and recreation, aesthetics and economic values will not occur as a result of the project.

h. Appropriate and Practicable Steps Taken to Minimize Potential Adverse Impacts of the Discharge on the Aquatic Ecosystem - Appropriate steps will be taken to minimize potential adverse impacts of placing the fill material in the aquatic system. The project construction sequence was designed to minimize adverse aquatic impacts, and best management practices will be utilized during construction to minimize adverse environmental impacts. Once completed, the project is expected to mimic the natural condition of the barrier island.

i. On the basis of the guidelines, the proposed discharge site for the material is specified as complying with the inclusion of appropriate and practical conditions to minimize pollution or adverse effects on the aquatic ecosystem.

ANNEX A, PART 2

State Water Quality Certificate

The Water Quality Certificate will be applied for.

ANNEX A, PART 3

Supplemental Biological Resources Information

Amphibians

A list of amphibians that are likely to occur within the terrestrial, wetland, and freshwater aquatic habitats of the coastal bays watershed was prepared by consulting maps in Conant and Collins (1991) and Harris (1975). This potential list of species includes:

Common Name	*Scientific Name*
northern crickert frog	*(Acris crepitans)*
marbled salamander	*(Ambystoma opacum)*
eastern tiger salamander	*(Ambystoma tigrinum)*
american toad	*(Bufo americanus)*
fowler's toad	*(Bufo woodhousii)*
dusky salamander	*(Desmognathus fuscus)*
northern two-lined salamander	*(Eurycea bislineata)*
eastern narrowmouth toad	*(Gastrophryne carolinensis)*
four toed salamander	*(Hemidactylium scutatum)*
green treefrog	*(Hyla cinerea)*
gray treefrog	*(Hyla versicolor/chrysoscelis)*
red-spotted newt	*(Notophthalmus viridescens)*
redback salamander	*(Plethodon cinereus)*
northern spring peeper	*(Pseudacris crucifer)*
New Jersey chorus frogs	*(Pseudacris triseriata)*
mud salamander	*(Pseudotriton montanus)*
bullfrog	*(Rana catesbeiana)*
green frog	*(Rana clamitans)*
pickerel frog	*(Rana palustris)*
wood frog	*(Rana sylvatica)*
southern leopard frog	*(Rana utricularia)*
carpenter frog	*(Rana virgatipes)*
spadefoot	*(Scaphiopus holbrookii)*

Sixteen species of amphibians are known to occur on Assateague Island (Mitchell et al., 1993). Some of the most common are:

Fowlers toad	*Bufo woodhousii*
bullfro*g*	*Rana catesbeiana*
green frog	*Rana clamitans*
southern leopard frog	*Rana sphenocehpla*
green tree frog	*Hyla cinera*
New Jersey chorus frog	*Pseudacris triseriatai*

Benthos

Detailed information on nearshore benthos of Assateague Island will be available following completion of a 3 year Benthic Invertebrate Divesity Study which began in 1994 (Counts and Clements, 1995). Sampling for benthos is being conducted during three sampling periods: July, October, and April. Initial results are available at three stations: OS-2; OS-7; and OS-12. Sampling station OS -2 is located approximately 3 km south of the inlet and corresponds with profile GPS-2. OS-7 is located along profile GPS-7 approximately 10 km south of station OS-2. Station OS 12 is located along profile GPS-12 approximately 20 km south of station OS-2. The table below presents the most numerous species collected in the summer and fall of 1994.

Table of benthos collected off Assateague Island in Summer and Fall 1994.

Station	Species
OS-2	*Neomysis americana, Psammonyx nobilis, Scolelpis squamata, Emerita talpoida, and Parahaustorius holmesi*
OS-7	*Emerita talpoida, Neomysis americana, Scolelepis squamata, Psammonyx nobilis, and Aschelminthes nematoda*
OS-12	*Neomysis americana, Scolelepsis squamata, Psammonyx nobilis, Emerita talpoida, and Eutima mira*

A species list of molluscs occurring in the waters surrounding the island is available in Counts and Bashore (1991).

Benthic invertebrates collected in Chincoteague Bay (Boynton *et al.* 1993).

Phylum	Genus/Species
Porifera	*Cliona celata*
Coelenterata	*Ceriantheopsis americanus*
	Haloclava producta
	Diadumene spp.
Annelida	*Glycera spp.*
	Cerebratulus spp.
	Stylochus spp.
	Malacobdella grossa
	Arenicola cxristata
	Diopatra cuprea
	Melinna cristata
	Pista spp.
	Hydroides dianthus
Echinodermata	*Asterias forbesi*
	Ophioderma brevispina
	Arbacia punctulata
Bryozoa	*Mebranipora spp.*
	Eucratea spp.
	Anguinella spp.
Mollusca	*Anadara transversa*
	Noetia ponderosa
	Mytilus edulis
	Modiolus demissus
	Mercenaria mercenaria
	Ensis directus
	Gemma gemma
	Donax spp.
	Tellina spp.
	Macoma spp.
	Tagelus spp.
	Mulinia lateralis
	Crassostrea spp.
	Crepidula spp.
	Polinices spp.
	Busycon canaliculatum
Crustacea	*Callinectes sapidus*
	Libinia spp.
	Palaemenetes spp.
	Crangon septemspinosa
	Limnoria lignorum
	Neopanope texana sayi
	Ovalipes ocellatus
	Cancer irroratus
	Gammarus spp.
	Pagurus spp.
	Balanus spp.
	Neomysis spp.
	Penaeus aztecus
Chordata	*Botryllus schlosseri*

Benthic invertebrates collected in Isle of Wight and Assawoman Bays (Boynton *et al.* 1993).

Taxonomic Classification	Genus/Species	Common Name
Cnidaria/Anthozoa/Haloclavidae	Haloclava producta	Burrowing sea anemone
Cnidaria/Anthozoa/Edwardsudae	Edwardsia elegans	Burrowing sea anemone
Cnidaria/Anthozoa/Ceranthidae	Cenantheopsis americanus	
Nemertea/Anopla/Lineidae	Cerebratulus lacteus	Ribbon worm
Annelida/Polychaeta/Arabellidae	Arabella iricolor	Opal worm
Annelida/Polychaeta/Arabellidae	Drilonereis longa	Polychaete worm
Annelida/Polychaeta/Arabellidae	Notocirrus spiniferous	Polychaete worm
Annelida/Polychaeta/Orbinidae	Scoloplos robustus	Polychaete worm
Annelida/Polychaeta/Spionidae	Parapnonospio pinnata	Polychaete worm
Annelida/Polychaeta/Cirratulidae	Cirratulus grandis	Fringed worm
Annelida/Polychaeta/Flabelligeridae	Semiodera roberti	Polychaete worm
Annelida/Polychaeta/Capitellidae	Notomastus latericeus	Polychaete worm
Annelida/Polychaeta/Capitellidae	Heteromastus filiformis	Polychaete worm
Annelida/Polychaeta/Arenicoliae	Arenicola cristata	Lug worm
Annelida/Polychaeta/Maldanidae	Clymenella torquata	Tube worm
Annelida/Polychaeta/Maldanidae	Clymenella zonalis	Tube worm
Annelida/Polychaeta/Maldanidae	Asychis elongata	
Annelida/Polychaeta/Pectinaridae	Pectinaria gouldi	Trumpet worm
Annelida/Polychaeta/Ampharetidae	Melinna cristata	
Annelida/Polychaeta/Terebellidae	Pista cristata	Tube worm
Annelida/Polychaeta/Terebellidae	Pista palmata	
Annelida/Polychaeta/Terebellidae	Loimia medusa	
Annelida/Polychaeta/Sabillidae	Sabella microphthalma	Tube worm
Annelida/Polychaeta/Serpulidae	Hydroides hexagona	
Annelida/Polychaeta/Polynoidae	Harmothoe extenuata	
Annelida/Polychaeta/Sigalionidae	Sthenelais boa	
Annelida/Polychaeta/Phyllodocidae	Phyllodoce arenae	
Annelida/Polychaeta/Nereidae	Neries succinea	Clam Worm
Annelida/Polychaeta/Nephtyidae	Nethtys bucera	
Annelida/Polychaeta/Glyceriae	Glycera spp.	Blood Worm
Annelida/Polychaeta/Eunicidae	Marphysa sanguinea	
Annelida/Polychaeta/Onuphidae	Diopatra cuprea	Plumed Worm
Arthropoda/Crustacea/Tanaidae	Leptochelia spp.	
Arthropoda/Crustacea/Anthuridae	Cyathura polita	
Arthropoda/Crustacea/Sphaeromidae	Paracerceis caudata	
Arthropoda/Crustacea/Idoteidae	Idotea balthica	
Arthropoda/Crustacea/Idoteidae	Edotea triloba	
Arthropoda/Crustacea/Idoteidae	Erichsonella attenuata	
Arthropoda/Crustacea/Crangonidae	Crangon septemspinosa	
Arthropoda/Crustacea/Palaemonidae	Palaemonetes spp.	Common Grass Shrimp
Arthropoda/Crustacea/Callianassidae	Callianassa atlantica	Mud Shrimp
Arthropoda/Crustacea/Callianassidae	Upogebia affinis	Mud Shrimp
Arthropoda/Crustacea/Paguridae	Pagurus spp.	Hermit Crab
Arthropoda/Crustacea/Pinotheridae	Pinnixa cylindrica	
Arthropoda/Crustacea/Majidae	Libinia dubia	Spider Crab
Mollusca/Pelecypoda/Arcidae	Noetia ponderosa	Ponderous Ark
Mollusca/Pelecypoda/Arcidae	Anadara ovalis	Blood Ark
Mollusca/Pelecypoda/Veneridae	Mercenaria mercenaria	Hard-Shelled Clam
Mollusca/Pelecypoda/Veneridae	Gemma gemma	Amethystine Gem Shell
Mollusca/Pelecypoda/Tellinidae	Macoma tenta	
Mollusca/Pelecypoda/Sanguinolaridae	Tagelus plebeius	Stout Razor Clam
Mollusca/Pelecypoda/Sanguinolaridae	Tagelus divisus	Purple Tagelus
Mollusca/Pelecypoda/Solenidae	Ensis directus	Razor Clam
Mollusca/Pelecypoda/Mactridae	Spisula solidissima	Atlantic Surf Clam
Mollusca/Pelecypoda/Mactridae	Mulinia lateralis	Dwarf Surf Clam
Mollusca/Gastropoda/Calyptraeidae	Crepidula convexa	Convex Slipper Shell
Mollusca/Gastropoda/Nassaridae	Nassarius vibex	Mud Snail
Echinodermata/Holothuroidea/Synaptidae	Leptosynapta tenuis	Common Synapta
Echinodermata/Holothuroidea/Cucumaridae	Cucumaria pulcherrima	Sea Cucumber
Echinodermata/Holothuroidea/Cucumaridae	Thyone briareus	Common Thyone
Echinodermata/Asteroidea/Asteridae	Asterias forbesi	Common Eastern Starfish
Echinodermata/Ophiuroidea/Ophiodermatidae	Ophioderma brevispina	Green Brittle Star
Echinodermata/Phoronidea	Phoronis architecta	
Hemichordata/Enteropneusta/Harrimaniidae	Saccoglossus kowalewskyi	Acorn Worm

Birds

Several references are available that provide information on birds in the study area. For Assateague Island these include Kirkpatrick and others (1992) for waterfowl and Kumer (1996) for shorebirds. Regional information on colonial waterbirds can be found in Brinker and others (1996). Regional information on neo-tropical migrants can be found in Mabley and others (1993). The geographic position of the Delmarva peninsula invites a wide variety of northern and southern species to utilize the area. Notable and common birds utilizing the coastal bays watershed are likely to include the following species (Scott, 1991):

Species	Species
American bittern	brown thrasher
American black duck	Canada goose
American coot	canvasback
American goldfinch	Cardinal
American kestrel	Carolina chickadee
American oystercatcher	Carolina wren
American redstart	Caspian tern
American robin	cattle egret
American widgeon	cedar waxwing
bald eagle	cerulean warbler
barn owl	chipping sparrow
barred owl	chuck-will's widow
black and white warbler	clapper rail
black-bellied plover	common crow
black-billed cuckoo	common gallinule
black-capped chickadee	common merganser
black-crowned night heron	common tern
black skimmer	cooper's hawk
black vulture	downy woodpecker
black rail	dunlin
black scoter	eastern kingbird
blue-gray gnatcatcher	eastern meadowlark
blue grosbeak	eastern wood peewee
blue jay	European starling
blue-winged teal	evening grosbeak
boat-tailed grackle	field sparrow
bobolink	fish crow
brant	Forster's tern
broad-winged hawk	gadwall
brown creeper	glossy ibis
brown pelican	golden crowned kinglet
brown-headed cowbird	golden eagle
brown-headed nuthatch	grasshopper sparrow

gray catbird
great blue heron
great-creasted flycatcher
great egret
great horned owl
greater black-backed gull
greater scaup
green-winged teal
green heron
hairy woodpecker
Henslow sparrow
herring gull
hooded merganser
hooded warbler
horned lark
house finch
house sparrow
house wren
indigo bunting
Kentucky warbler
king rail
laughing gull
least bittern
least sandpiper
least tern
lesser scaup
little blue heron
long-eared owl
Louisiana waterthrush
mallard
marsh wren
mourning dove
nighthawk
northern bobwhite
northern flicker
northern harrier
northern mockingbird
northern oriole
northern shoveler
oldsquaw
osprey
ovenbird
phoebe
pileated woodpecker
pine warbler
pine siskin
pintail
piping plover
prairie warbler
prothonotary warbler
purple finch
purple gallinule
red-bellied woodpecker
red-breasted merganser
red-breasted nuthatch
red-eyed vireo
red-headed woodpecker
red-shouldered hawk
red-tailed hawk
red-winged blackbird
redhead
red knot
ring-billed gull
rough-legged hawk
royal tern
ruddy duck
ruddy turnstone
rufous-sided towhee
sanderling
sandwich tern
Savannah sparrow
saw-whet owl
scarlet tanager
screech owl
seaside sparrow
sedge wren
semi-palmated plover
semi-palmated sandpiper
sharp-shinned hawk
sharp-tailed sparrow
short-eared owl
short-billed dowitcher
snow geese
snowy egret
snowy owl
song sparrow
sora
southern orchard oriole
summer tanager
surf scoter

swamp sparrow
Swainson’s warbler
tri-colored heron
tufted titmouse
tundra swan
turkey vulture
Virginia rail
whimbrel
whippoorwill
white-eyed vireo
white flicker
white-rumped sandpiper
white-winged scoter
willet
Wilson’s plover
wood duck
woodcock
wood thrush
worm-eating warbler
yellow-billed cuckoo
yellow-breasted chat
yellow-crowned night heron
yellow-rumped warbler
yellow-throated vireo
yellow-throated warbler
yellow warbler

Colonial waterbird sites within the Maryland portion of the study area.
(Source: David Brinker, Colonial Bird Coordinator, Maryland Dept. of Natural Resources).

MD ID Number	Colony Name	Nearest Town	UTM East	UTM North	Species	Status*
WOR004	Snug Harbor Islands	Ocean City	489850	4237940	Laughing Gull Herring Gull	Historical
WOR009	Pirate Islands	Public Landing	479780	4216410	Green-backed Heron Black-crowned Night-Heron Herring Gull	Historical
WOR012	Striking Marsh	Stockton	476790	4211650	Forster's Tern	Historical
WOR015	Gray's Cove	Ocean City	489160	4237360	Great Egret Snowy Egret Little Blue Heron Tricolored Heron Black-crowned Night-Heron Laughing Gull Herring Gull	Historical
WOR018	Ocean City Airport	Ocean City	490410	4238790	Least Tern Black Skimmer	Historical
WOR019	Coffins Point	Ocean City	490250	4237890	Least Tern Black Skimmer	Historical
WOR020	Assacorkin Island	Girdletree	472090	4212280	Black-crowned Night-Heron	Historical
WOR022	Tingles Island	Public Landing	483420	4224750	Herring Gull	Historical
WOR024	North Middlemoor	Public Landing	478860	4213580	Forster's Tern	Historical
WOR032	Tiny Bay Island	Public Landing	480020	4213640	Forster's Tern	Historical
WOR035	Catbird Creek	Ironshire	480770	4232810	Forster's Tern	Historical
WOR038	Little Pirates	Public Landing	479450	4216470	Green-backed Heron Black-crowned Night Heron	Historical
WOR041	Crown Tump	Public Landing	483010	4224430	Herring Gull	Recent
WOR002	Ocean City Spoils	Ocean City	492160	4243240	Snowy Egret Green-backed Heron Gull-billed Tern Common Tern Herring Gull Black Skimmer	Recent
WOR003	Spoil Buoy 11	Ocean City	489320	4238290	Green-backed Heron	Recent
WOR005	South Point Spoil	Public Landing	482450	4227200	Brown Pelican Great Blue Heron Great Egret Snowy Egret Little Blue Heron Tricolored Heron Cattle Egret Black-crowned Night-Heron Yellow-crowned Night-Heron Glossy Ibis Herring Gull Great Black-backed Gull Black Skimmer	Recent
WOR006	Lumber Marsh	Public Landing	485410	4227030	Herring Gull Green-backed Heron	Recent
WOR007	Outward Tump	Public Landing	482550	4225220	Herring Gull Great Black-backed Gull Common Tern	Recent

(continued).

MD ID Number	Colony Name	Nearest Town	UTM East	UTM North	Species	Status*
WOR008	Robins Marsh	Public Landing	478100	4222910	Snowy Egret Tricolored Heron Cattle Egret Glossy Ibis Herring Gull Great Black-backed Gull Laughing Gull Forster's Tern	Recent
WOR010	Ready Cove Tump	Girdletree	472670	4214670	Great Egret Snowy Egret Tricolored Heron Green-backed Heron Black-crowned Night-Heron Glossy Ibis Herring Gull Great Black-backed Gull	Recent
WOR011	Mink Tump	Girdletree	472620	4213250	Forster's Tern	Recent
WOR013	Horsehead Tump	Stockton	476780	4210780	Laughing Gull Forster's Tern Common Tern Black Skimmer Royal Tern	Recent
WOR014	Cedar Islands	Stockton	475690	4209420	Black Skimmer Royal Tern Great Black-backed Gull Herring Gull Laughing Gull Forster's Tern Common Tern	Recent
WOR016	Ocean City Inlet	Ocean City	491590	4241370	Least Tern Common Tern Black Skimmer	Recent
WOR021	Big Bay Marsh	Public Landing	473970	4214240	Great Egret Snowy Egret Gull-billed Tern Royal Tern Common Tern Forster's Tern Least Tern Laughing Gull Great Black-backed Gull Herring Gull Black Skimmer	Recent
WOR023	Bridge Island	Ironshire	486330	4231750	Laughing Gull Herring Gull Black Skimmer	Recent
WOR025	Heron Harbor	Ocean City	494230	4252940	Black Skimmer Common Tern Least Tern	Recent
WOR026	Whittington Point	Public Landing	479330	4217020	Forster's Tern Green-backed Heron	Recent
WOR027	Horse Island	Ocean City	493760	4252510	Common Tern Forster's Tern	Recent

(continued).

MD ID Number	Colony Name	Nearest Town	UTM East	UTM North	Species	Status*
WOR028	Reedy Island	Ocean City	493560	4247780	Black Skimmer Common Tern	Recent
WOR029	Heron Island	Ocean City	492580	4244860	Great Egret Snowy Egret Little Blue Heron Tricolored Heron Cattle Egret Green-backed Heron Black-crowned Night-Heron Glossy Ibis	Recent
WOR030	Dog & Bitch Island	Ocean City	491350	4245040	Common Tern Herring Gull	Recent
WOR031	Drum Island	Ocean City	491760	4244380	Common Tern	Recent
WOR033	Parker Bay Tumps	Stockton	469520	4210870	Forster's Tern	Recent
WOR034	Robbins Tump	Public Landing	472910	4214270	Great Egret Green-backed Heron Black-crowned Night-Heron Herring Gull Great Black-backed Gull	Recent
WOR036	Easter Opening Island	Public Landing	473290	4214520	Forster's Tern	Recent
WOR037	Bay Point Island	Public Landing	478730	4213920	Forster's Tern	Recent
WOR039	Rams Horn Tump	Girdletree	471320	4215530	Forster's Tern	Recent
WOR040	Shelldrake Island	Girdletree	472090	4215490	Black-crowned Night-Heron Forster's Tern	Recent
WOR042	Newport Neck	Ironshire	482450	4232490	Forster's Tern	Recent
WOR043	Hill's Island	Ocean City	490970	4252470	Laughing Gull	Recent
WOR044	Cape Windsor Island	Ocean City	493630	4255630	Black Skimmer Common Tern	Recent
WOR045	South Piney Island	Ocean City	491710	4253270	Forster's Tern	Recent
WOR046	Skimmer Island	Ocean City	491980	4243000	Herring Gull Royal Tern Gull-billed Tern Common Tern Black Skimmer	Recent
WOR047	Rum Harbor Tumps	Ocean City	477300	4212080	Forster's Tern	Recent
WOR048	Keyser Point	Ocean City	489790	4246590	Common Tern	Recent
WOR049	Brady Island	Ocean City	491160	4252250	Laughing Gull	Recent
WOR050	Nassawango Creek	Whitesburg	460060	4227280	Great Blue Heron	Recent
WOR001	26th Street	Ocean City	492570	4245140	Common Tern	Usurped
WOR017	Oyster Island	Ocean City	488000	4234980	Laughing Gull Royal Tern Gull-billed Tern Common Tern Sandwich Tern Black Skimmer	Usurped
WOR051	Ditch Point	Ocean City	493843	4255232	Least Tern	Usurped

* Historical - not used in any of the last five summers
Recent - used at least once in the last five summers
Usurped - island has eroded away or site now developed and no longer suitable habitat

Fishes collected in Chincoteague/Sinepuxent and Assawoman/Isle of Wight Bays (Schwartz 1964).

Species	Both Bays	Sinepuxent-Chincoteague Only	Isle of Wight-Assawoman Only
Carcharias taurus	X		
Alopias vulpinus			X
Carcharinus milberti	X		
Mustelus canis	X		
Negaprion brevirostris			X
Sphyrna zygaena			X
Squalus acanthias	X		
Raja eglanteria	X		
Raja ocellata		X	
Dasyatis americana	X		
Dasyatis sayi			X
Gymnura micrura	X		
Rhinoptera bonasus	X		
Acipensar (sturio) oxyrhynchus		X	
Megalops atlantica		X	
Alosa mediocris	X		
Alosa pseudoharengus	X		
Alosa sapidissima	X		
Brevoortia tyrannus	X		
Clupea harengus	X		
Opisthonema oglinum			X
Cyprinus carpio		X	
Anchoa h. hepsetus	X		
Anchoa m. mitchilli	X		
Osmerus mordax		X?	
Esox americanus			X
Esox niger	X		
Bagre marina	X		
Ictalurus catus	X		
Ictalurus nebulous			X
Synodus foetens	X		
Anquilla rostrata	X		
Strongylura marina	X		
Hemiramphus (unifasciatus)			X
Cypselurus heterurus			X
Cyprinodon variegatus	X		
Fundulus diaphanus			X
Fundulus heteroclitus macrolepidotus	X		
Fundulus luciae	X?		
Fundulus majalis	X		
Lucania parva	X		
Gambusia affinis	X		
Gadus morhua		X	
Merluccius bilinearis	X		
Microgadus tomcod			X
Urophycis chuss			X
Urophycis regius	X		
Apeltes quadracus	X		
Gasterosteus aculeatus	X?		
Fistularia tabacaria		X	
Hippocampus erectus	X		
Syngnathus floridae	X		
Syngnathus fuscus	X		
Centropristes striatus	X		
Epinephelus niveatus			X
Mycteroperca microlepis		X	
Roccus americanus	X		
Roccus saxatilis	X		
Lepomis gibbosus			X
Perca flavescens	X		
Pomatomus saltatrix	X		
Alectis crinitus		X	
Caranx crysos	X		
Caranx hippos			X
Naucrates ductor			X
Selene vomer			X
Seriola dumerili	X		
Vomer setipinnis	X		
Eucinostomus argenteus			X
Orthopristis chrysopterus	X		
Bairdiella chrysura	X		
Cynoscion nebulosus	X		
Cynoscion regalis	X		
Larimus fasciatus		X	
Leiostomus xanthurus	X		
Menticirrhus americanus		X	
Menticirrhus saxatilis	X		
Micropogon undulatus	X		
Pogonias cromis	X		
Sciaenops ocellata	X		
Archosargus probatocephalus	X		
Lagodon rhomboides	X		
Stenotomus chrysops	X		
Chaetodipterus faber		X	
Chaetodon ocellatus	X		
Abudefduf saxatilis	X		
Tautoga onitis	X		
Tautogolabrus adspersus	X		
Trichiurus lepturus	X?		
Sarda sarda		X	
Scomberomorus maculatus		X	
Microgobius thalassinus			X
Gobiosoma bosci	X		
Gobiosoma ginsburgi	X		
Prionotus carolinus	X		
Prionotus evolans	X		
Astroscopus guttatus	X		
Chasmodes bosquianus	X		
Hypsoblennius hentzi	X		
Rissola marginata			X
Peprilus alepidotus	X		
Peprilus paru			X
Poronotus triacanthus	X		
Sphyraena barracuda			X
Mugil cephalus	X		
Mugil curema	X		
Membras martinica			X
Menidia b. beryllina	X		
Menidia m. menidia	X		
Etropus crossotus			X
Etropus microstomus		X	
Paralichthys dentatus	X		
Scophthalmus aquosus	X		
Pseudopleuronectes americanus	X		
Trinectes m. maculatus	X		
Rachycentron canadum		X	
Echeneis naucrates	X		
Gobiesox strumosus	X		
Alutera schoepfi	X		
Balistes capriscus			X
Balistes vetula	X		
Sphaeroides maculatus	X		
Chilomycterus schoepfi	X		
Mola mola			X
Opsanus tau	X		
Lophius americanus			X

Mammals

A list of mammals that are likely to occur within the terrestrial, wetland, and freshwater aquatic habitats of the coastal bays watershed was prepared by consulting maps in Burt and Grossenheider (1976). This potential list of species includes:

Common Name	*Scientific Name*
short-tailed shrew	*(Blarina brevicauda)*
coyote	*(Canis latrans)*
beaver	*(Castor canadensis)*
boreal redback vole	*(Clethrionomys gapperi)*
star-nosed mole	*(Condylura cristata)*
least shrew	*(Cryptotis parva)*
opossum	*(Didelphia virginiana)*
big brown bat	*(Eptesicus fuscus)*
southern flying squirrel	*(Glaucomys volans)*
silver-haired bat	*(Lasionycteris noctivagans)*
red bat	*(Lasiurus borealis)*
hoary bay	*(Lasiurus cinereus)*
seminole bat	*(Lasiurus seminolus)*
river otter	*(Lutra canadensis)*
groundhog	*(Marmota monax)*
skunk	*(Mephitis mephitis)*
meadow vole	*(Microtus pennsylvanicus)*
house mouse	*(Mus musculus)*
long-tailed weasal	*(Mustela frenata)*
mink	*(Mustela vison)*
keen myotis bat	*(Myotis keenii)*
little brown bat	*(Myotis lucifugus)*
small-footed myotis bat	*(Myotis subulatus)*
evening bat	*(Nycticeius humeralis)*
white-tailed deer	*(Odocoileus virginianus)*
muskrat	*(Ondatra zibethica)*
rice rat	*(Oryzomys palustris)*
white-footed mouse	*(Peromyscus leucopus)*
eastern pipistrelle	*(Pipistrellus subflavus)*
pine vole	*(Pitymys pinetorum)*
raccoon	*(Procyon lotor)*
house rat	*(Rattus norvegicus)*
eastern mole	*(Scalopus aquaticus)*
gray squirrel	*(Sciurus carolinensis)*
fox squirrel	*(Sciurus niger)*
masked shrew	*(Sorex cinereus)*
eastern cottontail rabbit	*(Sylvilagus floridanus)*
bog lemming	*(Synaptomys cooperi)*
eastern chipmunk	*(Tamias striatus)*

red squirrel	*(Tamiasciurus hudsonicus)*
gray fox	*(Urocyon cinereoargenteus)*
red fox	*(Vulpes fulva)*
jumping mouse	*(Zapus hudsonius)*

Terrestrial Mammals occurring on Assateague Island include (Paradiso, 1965):

Cottontail rabbit	*Sylvilagus flordanus*
Rice rat	*Oryzonus palusris*
White-footed mouse	*Peromyscus leucopus*
Meadow vole	*Microtus pennsylvanicus*
Muskrat	*Ondatra zibethicus*
Norway rat	*Rattus norvegicus*
House mouse	*Mus musculus*
Meadow jumping mouse	*Zapus hudsonius*
Least shrew	*Cryptosis parva*
Red fox	*Vulpes vulpes*
River otter	*Lutra canadensis*
Sika deer	*Cervus nippon*
Raccoon	*Procyon lotor*
Domestic horse	*Equus caballus*
Humans	*Homo sapiens*

Marine Mammals potentially occurring in the study area include (Scott, 1991):

Harbor seal	*Phoca vitulina*
Bottlenose dolphin	*Tursiops truncatus*
Altlantic white-sided dolphin	*Lagenorhyncus acutus*
Grampus dolphin	*Grampus griseus*
Saddleback dolphin	*Delphinus delphis*
Pilot whale	*Globicephala melaena*
Short-finned pilot whale	*Globicephala macrorhyncha*
Finback whale	*Balaenoptera physalus*
Goosebeak whale	*Ziphius cavrostris*

Assateague Island Flora

Information on the flora of Assateague is available in Higgins, Rappleye, and Brown (1971); Hill (1984, and 1986); and Stalter and Lamont (1990). Hill (1984) provides a comprehensive survey, and includes a vegetation map that is considered the best source currently available to describe the part of the island south of the project area not subject to overwash. The National Park Service has contracted the Nature Conservancy to prepare an in-depth plant community survey for Assateague Island. And aerial photographs of the island were taken in 1993 in order to prepare a detailed vegetation map. However, the map is currently available only in draft form and has not yet been ground-truthed. An interim map is available for approximately the northernmost 7,000 ft of the island. Sneddon and Berdine (1995) provide information on the classification scheme used to delineate vegetation on this map. It is anticipated that new aerial photographs will be taken in 1998 to compile a second vegetation map. Recent qualitative mapping of the vegetation on Assateague Island is available in the annual Piping Plover management and monitoring reports (Brady et al., 1995). Higgins and others (1971) and Hill (1984) classified the vegetation into four vegetative zones: dune herbaceous, shrub, woodland, and marsh herbaceous. Each author further sub-divides these zones, but they utilize different subgroupings. The zone and community descriptions below are from Hill (1986). The species given for each community are a composite from Higgins and others (1971) and Hill (1984).

I. Dune Herbaceous Zone

The dune herbaceous zone is subdivided into two communities: beach; and dunegrass.

A. Beach Community: narrow region extending from intertidal sands to the Dunegrass Community. It consists mostly of shifting coastal sands and beaches and has limited diversity of mostly annual halophytes such as *Cakile*. Plant species include:

Sea Rocket	*Cakile edentula*
Russian thistle	*Salsola kali*
Cocklebur	*Xanthium strumarium*
Sea chickweed	*Arenia peploides*
Seabeach Amaranth	*Amaranthus pumilus*

B. Dunegrass Community: region of elevated dunes and shifting sands exposed to salt spray. There is limited diversity of both annual and perennial salt-tolerant species such as *Ammophila breviligulata* and *Solidago sempervirens*. Species include:

American beachgrass	*Ammophila breviligulata*
Saltmarsh hay	*Spartina patens*
Seaside goldenrod	*Solidago sempervirens*
Sand burr	*Cenchrus tribuloides*
Rough buttonweed	*Diodia teres*
Seaside spurge	*Euphorbia polygonifolia*
Carpet-weed	*Mollugo verticullata*
Seaside primrose	*Oenothera humifusa*
Purple sand-grass	*Triplasis purpurea*

Switch grass	*Panicum amarulum*

Dunegrass/Shrub Transition Zone: *Andropogon* spp. replace *Ammophila* as dominant grass.

<u>II. Shrub Zone</u>
This zone is further divided into three communities: shrub succession; *Hudsonia* dunes; and bog.

A. Shrub succession community: bounded on the east by Dunegrass Community (including both the Xeric Shrub Community and the Mesic Shrub Community of Higgins and others, 1971). It is a diverse community composed predominantly of deciduous trees, shrubs, and vines with limited exposure to salt spray. Plant species expected are:

Wax myrtle	*Myric cerifera*
Wild black cherry	*Prunus serotina*
Persimmon	*Diospyros virginia*
Shad bush	*Amelanchier canadensis*
Crabapple	*Pyrus angustifolia*
Bayberry	*Myrica pensylvanica*
Raspberry	*Rubus spp*
Poison Ivy	*Rhus radican*
Greenbrier	*Smilax spp*
Red Cedar	*Juniperus virginiana*
Chain-Fern	*Woodwardia spp*
American holly	*Ilex opaca*

B. *Hudsonia* Dunes Community: defined by dunes stabilized by *Hudsonia tomentosa* generally out of reach of salt spray. Annual and perennial species that are tolerant of xeric conditions and sterile soils occur in limited diversity. Plant species expected are:

Beardgrass	*Andropogon spp.*
Pinweed	*Lechea maitima*
Seabeach Needlegrass	*Aristida tuberculosa*
Smartweed	*Polygonella articulata*
Old Field Toadflax	*Linaria canadensis*
Field Sorrel	*Rumex acetosella*
Little Bluestem	*Schizachyrium scoparium*
Pricky Pear	*Opuntia humifusa*

Lechea maitima, A*ristida tuberculosa*, *Polygonella articulata*, and *Linaria canadensis* do not occur on the mainland and are considered rare for the state. (check on this).

C. Bog Community: a pioneering community that is found most frequently in low bulldozed areas along old roadcuts where freshwater reaches the surface but no open water occurs. This community is free from salt spray influence. Species include:

Bog Clubmoss	*Lycopodium appressum*
Zig-zag Bladderwort	*Utricularia subulata*
Spatulate-leaved Sundew	*Drosera intermedia*
Yellow-eyed grass	*Xris spp*
Rush	*Juncus spp*
Sedges	Cyperaceae
Large cranberry	*Vaccinium macrocarpon*

III. Woodland Zone

This zone consists of pine woodland and pine-deciduous woodlands which can be considered a single community. This region occurs along the west island ridge of dunes. It is composed predominantly of perennial herbs, vines, shrubs, and trees. This community is best developed on the widest parts of the island. Plant species expected are:

Loblolly Pine	*Pinus taeda*
American Holly	*Ilex opaca*
White Sassafras	*Sassafras albidum*
Sweetgum	*Liquidbar styraciflua*
Oak	*Quercus spp.*
Greenbriar	*Smilax spp.*
Grape	*Vitis spp.*
Blueberry	*Vaccinium spp.*
Poison Ivy	*Rhus radicans*
Common Waxmyrtle	*Myrica cerifera*
Choke Cherry	*Prunus virginiana*

The woodlands are extremely significant because they have been the most stable part of the island and harbor many of the rare plants on the island, such as :

Red Bay	*Persea palustris*
Indian Pipe	*Monotropa uniflora*
Orchid	*Habenaria cristata*
Spotted wintergreen	*Chimaphila maculata*
Patridge Berry	*Mitchella repens*
Bedstraw	*Galium hispidulum*

IV. Marsh Herbaceous Zone

This zone is further subdivided into four communities: fresh marsh; salt marsh; washes and salt pan; and pone.

A. Fresh Marsh Community: this community is a very diverse community and can be further subdivided into woodland fresh marsh, transitional fresh marsh, and flatland or level marsh.

1. Woodland Marsh Community: This community is characterized by a closed canopy and many woody species. Species include:

Red Maple	*Acer rubrum*
Black Willow	*Salix nigra*
Common Waxmyrtle	*Myrica cerifera*
Royal Fern species	*Osmunda spp.*
Blueberry	*Vaccinium spp.*
Swamp Magnolia	*Magnolia virginiana*
Lance-leaved Violet	*Viola lanceolata*
St. John's Wort species	*Hypericum virginicum*
Chain-Fern	*Woodwardia spp.*

2. Transition Fresh Marsh Community: this marsh borders the saltmarsh communities and is somewhat brackish. Species include:

Common Reed	*Phragmites australis*
Groundsel Tree	*Baccharis halimifolia*
Cattail	*Typha spp.*
Swamp Rose	*Rosa palustris*
Green Fog-fruit	*Phyla lanceolata*
Wax Myrtle	*Myrica cerifera*
Common Elder	*Sambucus canadensis*
Coinleaf	*Centella erecta*

3. Flatland or level marsh community: This marsh is more salt tolerant, and has few woody components. Species expected area:

Saltmarsh Loosestrife	*Lythrum lineare*
Marsh Hibiscus	*Hibiscus palustris*
Needlerush	*Juncus roemerianus*.
Umbrella Grass	*Fuirena spp*.
Sedge	*Fimbristylis spp*.
Umbellate Water Pennywort	*Hydrocotyle umbellata*
Brookweed	*Samolus floribunda*
Pursh Marsh-pink	*Sabatia stellaris*
Larger Buttonweed	*Diodia virginiana*
Ladies-tresses	*Spiranthes spp*.

These marshes are extremely rich in species and are an extremely valuable resource for wildlife at Assateague.

B. Salt Marsh Community: this area is governed by daily tides mostly along the bay side of the island. It is characterized by halophytic perennials. This marsh is dominated by *Spartina* associations. Species include:

Saltmarsh Cordgrass	*Spartina alterniflora*

Saltmarsh Hay	*Spartina patens*
Salt Grass	*Distichlis spicata*
Saltwort	*Salicornia europaea*
Sea Lavender	*Limonium nashii*
Spearscale Orach	*Atriplex patula*
Marsh Elder	*Iva frutescens*

C. Wash and Salt Pan Community: these communities occur on level ground on which salt water stood and has evaporated. It is dominated by predominantly halophytic annuals and perennials. Species include:

Saltwort	*Salicornia bigelovii*
Salt Grass	*Distichlis spicata*
Seabeach Orach	*Atriplex arenaria*
Sea Blite	*Suaeda linearis*
	Bassia tomentosa
Sea-purslane	*Sesuvium maritimum*
Sand-Spurrey	*Spergularia spp*.

D. Pond community: restricted to the few permanent ponds on the island. Most are poorly developed due to brackish waters. This area is best developed in impoundments on the Virginia portion. Species expected are: widgeon grass (*Ruppia maritima*) and duckweed (*Lemna minor*).

Coastal Bays Flora

Numerous schemes for the classification of vegetative communities exist. McCormick and Somes (1982) classified existing coastal wetlands by dominant flora in the study area watershed into the following types:

Coastal wetland types in the Coastal Bays (McCormick and Somes, 1982).

Common Name	*Scientific Name*
Red maple/ash	*Acer rubrum/Fraxinus species*
Baldcypress	*Taxodium distichum*
Loblolly pine	*Pinus taeda*
Rosemallow	*Hibiscus species*
Smartweed/rice cutgrass	*Polygonum species/ Leersia oryzoides*
Cattail	*Typha species*
Switchgrass	*Panicum virgatum*
Threesquare	*Scirpus species*
Common reed	*Phragmites communis*
Marshelder/groundsel	*Iva frutescen/Baccaris halimifolia*
Meadow cordgrass/spikegrass	*Spartina patens/Distichlis spicata*
Smooth cordgrass	*Spartina alterniflora*
Needlerush	*Juncus roemerianus*

Brush and others (1980) classified existing forest vegetation in the coastal bays watershed into the following associations:

Association Name	Other Typical Woody Species
Bald cypress	Green ash, Red maple, Sweet gum, Green briar, Sweet pepper bush, Poison ivy, Virginia creeper, Black gum, Southern arrowwood, American holly
River birch-sycamore	Slippery elm, Green ash, Spice bush, Poison ivy, Red maple, Virginia creeper, Green briar, Japanese honeysuckle, Southern arrowwood, Tulip tree, Black gum
Chestnut oak-post oak-blackjack oak	Eastern chinquapin, Sassafras, Scrub pine, Eastern red cedar, Pitch pine, Blueberries, Huckleberries, Mountain laurel
Loblolly pine	Wax myrtle
Swamp chestnut oak-Loblolly pine	Willow oak, Red maple, Sweet gum, American holly, Black gum, Green briar, White oak, Sweet pepper bush, Highbush blueberry
Willow oak-Loblolly pine	Red maple, Sweet gum, Black gum, American holly, Sassafras, Green briar, Virginia creeper, Sweet pepper bush
Tulip tree	Red maple, Flowering dogwood, Virginia creeper, Black gum, White oak, Sassafras, Black cherry, Grape, Mockernut hickory, Southern arrowwood, Japanese honeysuckle, Ironwood

United States Department of Agriculture

Soil Conservation Service

301 Bank Street
Snow Hill, Maryland 21863
(301) 632-0939

PRIME FARMLAND SOILS
FOR
WORCESTER COUNTY MARYLAND

MdA	3,645	Matapeake Fine Sandy Loam, 0 to 2 percent slopes
MdB	5,505	Matapeake Fine Sandy Loam, 2 to 5 percent slopes
MeA	3,275	Matapeake Silt Loam, 0 to 2 percent slopes
MeB	2,010	Matapeake Silt Loam, 2 to 5 percent slopes
MoA	1,630	Mattapex Fine Sandy Loam, 0 to 2 percent slopes
MoB	615	Mattapex Fine Sandy Loam, 2 to 5 percent slopes
MpA	3,855	Mattapex Loam, 0 to 2 percent slopes
MpB	865	Mattapex Loam, 2 to 5 percent slopes
MtA	4,560	Mattapex Silt Loam, 0 to 2 percent slopes
MtB	995	Mattapex Silt Loam, 2 to 5 percent slopes
SmA	505	Sassafras Loam, 0 to 2 percent slopes
SmB_2	385	Sassafras Loam 2 to 5 percent slopes, moderately eroded
SaA	7,435	Sassafras Sandy Loam, 0 to 2 percent slopes
SaB_2	13,560	Sassafras Sandy Loam, 2 to 5 percent slopes, moderately eroded
WoA	2,310	Woodstown Loam, 0 to 2 percent slopes
WoB	515	Woodstown Loam, 2 to 5 percent slopes
WdA	16,385	Woodstown Sandy Loam, 0 to 2 percent slopes
WdB	4,010	Woodstown Sandy Loam, 2 to 5 percent slopes

Unique

1/86

SOILS OF STATEWIDE IMPORTANCE

FOR

WORCESTER COUNTY, MARYLAND

Acres	Soil Mapping Unit
9,655	FALLSINGTON LOAM
31,135	FALLSINGTON SANDY LOAM
1,285	FORT MOTT LOAMY SAND, 0 TO 2 PERCENT SLOPES
7,085	FORT MOTT LOAMY SAND, 2 TO 5 PERCENT SLOPES
6,815	KLEJ LOAMY SAND, 0 TO 2 PERCENT SLOPES
1,920	KLEJ LOAMY SAND, 2 TO 5 PERCENT SLOPES
7,760	LAKELAND LOAMY SAND CLAYEY SUBSTRATUM, 0 TO 5 PERCENT SLOPES
4,790	LAKELAND SAND CLAYEY SUBSTRATUM, 0 TO 5 PERCENT SLOPES
867	LAKELAND-FORT MOTT LOAMY SANDS, 0 TO 5 PERCENT SLOPES
505	MATAPEAKE FINE SANDY LOAM, 5 TO 10 PERCENT SLOPES
275	MATAPEAKE SILT LOAM, 5 TO 10 PERCENT SLOPES
50,135	OTHELLO SILT LOAM
16,260	POCOMOKE LOAM, DRAINED
10,185	POCOMOKE SANDY LOAM, DRAINED
905	PORTSMOUTH SANDY LOAM
6,825	PORTSMOUTH SILT LOAM
950	SASSAFRAS SANDY LOAM, 5 TO 10 PERCENT SLOPES, MODERATELY ERODED
2,620	ST JOHNS LOAMY SAND
530	ST JOHNS MUCKY LOAMY SAND

6/2/86 - Copy to Bob [illegible] Dept. of Housing & Urban Dev.

CURRENT AND HISTORICAL RARE, THREATENED, AND ENDANGERED SPECIES OF MARYLAND'S COASTAL BAYS

July 22, 1993

Maryland Natural Heritage Program; Department of Natural Resources

Scientific Name	Common Name	State Status
Animals		
Acantharchus pomotis	Mud sunfish	Rare
Caretta caretta[2]	Atlantic loggerhead turtle	Threatened
Charadrius melodus[1]	Piping plover	Endangered
Charadrius wilsonia	Wilson's plover	Endangered
Cicindela dorsalis media[2]	White tiger beetle	Endangered
Cicindela lepida	Little white tiger beetle	Highly Rare
Circus cyaneus	Northern harrier	Rare
Egretta caerulea	Little blue heron	Rare
Fundulus luciae	Spotfin killifish	Rare
Haliaeetus leucocephalus[1]	Bald eagle	Endangered
Picoides borealis[1]	Red-cockaded woodpecker	Endangered Extirpated
Pituophis melanoleucus[4]	Northern pine snake	Historical
Podilymbus podiceps	Pied-billed grebe	Rare
Rynchops niger	Black skimmer	Threatened
Sterna antillarum	Least tern	In Need of Conservation
Sterna dougallii[1]	Roseate tern	Endangered Extirpated
Sterna maxima	Royal tern	Endangered
Sterna nilotica	Gull-billed tern	Threatened
Sterna sandvicensis	Sandwich tern	Highly Rare
Plants		
Agalinis fasciculata		Endangered
Alnus maritima	Seaside alder	Rare
Amaranthus pumilus[4]	Beach pigweed	Endangered Extirpated
Ammannia latifolia	Koehne's ammannia	Rare
Antennaria solitaria	Single-headed pussytoes	Threatened
Aristida lanosa	Woolly three-awn	Endangered
Aster concolor	Silvery aster	Endangered Extirpated
Bidens discoidea	Swamp beggar-ticks	Endangered
Borrichia frutescens	Sea ox-eye	Endangered Extirpated
Buchnera americana	Blue-hearts	Endangered Extirpated
Carex barrattii	Barratt's sedge	Endangered
Carex gigantea	Giant sedge	Endangered
Carex glaucescens		Endangered Extirpated
Carex joorii		Endangered
Carex silicea	Sea-beach sedge	Endangered
Carex tenera	Slender sedge	Endangered Extirpated
Centella erecta	Coinleaf	Endangered
Centrosema virginianum	Spurred butterfly-pea	Rare
Cleistes divaricata	Spreading pogonia	Endangered
Coelorachis rugosa	Wrinkled jointgrass	Endangered
Cyperus retrofractus	Rough cyperus	Rare
Desmodium rigidum	Rigid tick-trefoil	Endangered

Scientific Name	Common Name	State Status
Desmodium strictum	Stiff tick-trefoil	Endangered
Dryopteris celsa	Log fern	Endangered
Eleocharis albida		Endangered
Eleocharis rostellata	Beaked spikerush	Threatened
Eleocharis tortilis	Twisted spikerush	Rare
Eragrostis refracta		Threatened
Eupatorium leucolepis	White-bracted boneset	Endangered
Fimbristylis puberula	Hairy fimbristylis	Status Uncertain
Fuirena pumila	Smooth fuirena	Endangered
Galactia volubilis	Downy milk pea	Endangered
Galium hispidulum	Coast bedstraw	Endangered
Gymnopogon brevifolius	Broad-leaved beardgrass	Endangered
Honckenya peploides	Sea-beach sandwort	Endangered Extirpated
Juncus megacephalus		Endangered Extirpated
Juncus polycephalus		Status Uncertain
Juncus torreyi	Torrey's rush	Endangered Extirpated
Leptochloa fascicularis	Long-awned diplachne	Endangered Extirpated
Limonium nashii	Nash's sea lavender	Status Uncertain
Ludwigia hirtella	Hairy ludwigia	Endangered
Lupinus perennis	Wild lupine	Threatened
Myriophyllum humile	Low water-milfoil	Endangered
Oldenlandia uniflora	Clustered bluets	Rare
Panicum commonsianum	Commons' panicgrass	Rare
Panicum flexile	Wiry witch-grass	Endangered
Panicum oligosanthes	Few-flowered panicgrass	Endangered
Paspalum dissectum	Walter's paspalum	Endangered
Persea borbonia	Red bay	Threatened
Platanthera cristata	Crested yellow orchid	Threatened
Pluchea camphorata	Marsh fleabane	Endangered
Polygonum glaucum	Seaside knotweed	Highly Rare
Potamogeton pusillus	Slender pondweed	Highly Rare
Prunus maritima	Beach plum	Endangered
Pycnanthemum setosum	Awned mountain-mint	Endangered Extirpated
Rhynchosia tomentosa		Endangered
Rhynchospora corniculata	Short-bristled hornedrush	Endangered
Rhynchospora globularis	Grass-like beakrush	Endangered
Rhynchospora glomerata	Clustered beakrush	Endangered
Rhynchospora torreyana	Torrey's beakrush	Endangered
Sacciolepis striata	Sacciolepis	Endangered
Sagittaria longirostra	Long-beaked arrowhead	Status Uncertain
Sagittaria rigida	Sessile-fruited arrowhead	Endangered
Schwalbea americana[3]	Chaffseed	Endangered Extirpated
Scleria reticularis	Reticulated nutrush	Rare
Scleria verticillata	Whorled nutrush	Endangered
Sesuvium maritimum	Sea-purslane	Highly Rare
Spiranthes odorata	Sweet-scented ladys' tresses	Endangered Extirpated
Spiranthes praecox	Grass-leaved ladys' tresses	Highly Rare
Trachelospermum difforme	Climbing dogbane	Endangered

Scientific Name	Common Name	State Status
Triglochin striatum	Three-ribbed arrow-grass	Endangered Extirpated
Trillium pusillum var virginianum[4]	Dwarf trillium	Threatened
Xyris smalliana	Small's yelloweyed-grass	Endangered
Zephyranthes atamasca	Atamasco lily	Highly Rare

[1]This species is listed as Endangered by the U.S. Fish and Wildlife Service.
[2]This species is listed as Threatened by the U.S. Fish and Wildlife Service.
[3]This species is a category 1 candidate for listing by the U.S. Fish and Wildlife Service.
[4]This species is a category 2 candidate for listing by the U.S. Fish and Wildlife Service.

Reptiles

A list of reptiles that are likely to occur within terrestrial, wetland, and freshwater aquatic habitats of the coastal bays watershed was prepared by consulting maps in Conant and Collins (1991) and Harris (1975). This potential list of species includes:

Common Name	*Scientific Name*
copperhead	*(Agkistrodon contortrix)*
eastern worm snake	*(Carphophis amoenus)*
northern scarlet snake	*(Cemophora coccinea)*
snapping turtle	*(Chelydra serpentina)*
eastern painted turtle	*(Chrysemys picta)*
spotted turtle	*(Clemmys guttata)*
northern black racer	*(Coluber constrictor)*
ringneck snake	*(Diadophis punctatus)*
corn snake	*(Elaphe guttata)*
black rat snake	*(Elaphe obsoleta)*
five-lined skink	*(Eumeces fasciatus)*
broadhead skink	*(Eumeces laticeps)*
eastern hognose snake	*(Heterodon platirhinos)*
mud turtle	*(Kinosternon subrubrum)*
eastern kingsnake	*(Lampropeltis getula)*
eastern milk snake	*(Lampropeltis triangulum)*
diamondback terrapin	*(Malaclemys terrapin)*
plainbelly water snake	*(Nerodia erythrogaster)*
northern water snakes	*(Nerodia sipedon)*
rough green snake	*(Opheodrys aestivus)*
redbelly turtle	*(Pseudemys rubriventis)*
northern fence lizard	*(Sceloporus undulatus)*
ground skink	*(Scincella lateralis)*
common musk turtle	*(Sternotherus odoratus)*
northern brown snake	*(Storeria dekayi)*
northern redbellied snake	*(Storeria occipiomaculata)*
box turtle	*(Terrapene carolina)*
eastern ribbon snake	*(Thamnophis sauritus)*
eastern garter snake	*(Thamnophis sirtalis)*
eastern smooth earth snake	*(Virginia valeriae)*

Reptiles known to occur on Assateague Island, including marine sea turtles, include (Mitchell et al., 1993):

Loggerhead sea turtle	*Caretta caretta*
Atlantic green turtle	*Chelonia mydas*
Leatherback sea turtle	*Dermochelys coriacea*
Common snapping turtle	*Chelydra serpentina*
Eastern painted turtle	*Chrysemys picta*

Spotted turtle	*Clemmys guttata*
Northern diamondback turtle	*Malaclemys terrapin*
Red-bellied turtle	*Pseudemys rubriventris*
Eastern box turtle	*Terrapene carolina*
Eastern mud turtle	*Kinisternon subrubrum*
Northern fence lizard	*Sceloporus unulatus*
Northern black racer	*Coluber constrictor*
Black rat Snake	*Elaphe obsoleta*
Eastern hognose snake	*Heterodon platirhinos*
Northern water snake	*Nerodia sipedon*
Rough green snake	*Opeodrys aestivus*
Northern brown snake	*Storeria dekayi*

ANNEX A, PART 4

Planning Aid Report

Ocean City, Maryland and Vicinity Water Resources Feasibility Study

Planning Aid Report: Baseline Biological Resources and Potential Impacts of Dredging At Four Candidate Offshore Sand Borrow Sites

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April 1996

ABSTRACT

Ocean City, Maryland and Vicinity Water Resources Feasibility Study

Baseline Biological Resources and Potential Impacts of Dredging At Four Candidate Offshore Sand Borrow Sites

April 1996

This report provides planning aid information to assist the Baltimore District, U.S. Army Corps of Engineers in their Ocean City, Maryland and Vicinity Water Resources Feasibility Study. The report provides information on the baseline biological conditions at four offshore candidate sand borrow areas which are being considered in connection with the proposed beach replenishment of the north end of Assateague Island. The report also contains information on the potential impacts of sand dredging and mitigation measures. The information is derived from existing data sources including consultations with Federal and State agencies and representatives of the local fishing industry. The report notes that all four sites are prominent shoals where commercial and recreational fishing activity occurs. The bottom relief associated with these shoals is likely to be a factor contributing to their fishery value. Artificial reefs exist close to each area. The two offshore sites are in an area where surf clams are commercially harvested. With the exception of commercial surf clam populations, the benthic invertebrate assemblages are not expected to suffer any direct long-term impacts as a result of dredging. However, if dredging over the life of the project were to result in a substantial decrease in the shoal's elevated profile, there could be an adverse effect on the fishery value. Alternative sand sources may need to be considered to preclude this from happening. The report recommends coordination with the National Marine Fisheries Service regarding the presence of Federally listed threatened and endangered sea turtles and whales. The Minerals Management Service should be contacted about requirements relating to mineral (sand) extraction under the Outer Continental Lands Act.

Key Words: sand borrow, benthic fauna, beach replenishment, Assateague Island

INTRODUCTION

The Baltimore District, U.S. Army Corps of Engineers is conducting the Ocean City, Maryland Water Resources Feasibility Study. One aspect of the study is investigating beach replenishment at the northern end of Assateague Island. Four offshore areas have been identified as potential sand borrow sites. This report provides information on the baseline biological conditions at the borrow sites, potential dredging impacts, and mitigation measures. The report is submitted in accordance with provisions of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 et seq.) and Section 7 of the Endangered Species Act (87 Stat. 884, as amended; 16 U.S.C. 1531 et seq.)

BASELINE CONDITIONS

The four candidate borrow sites are shoals that lie offshore from the north end of Assateague Island (Figure 1). Little Gull Bank is located approximately 2.5 nautical miles offshore. Water depths at this site are generally in the range of 5.2 to 9.2 meters. Great Gull Bank is located approximately 4.0 nautical miles offshore. The depths at this shoal range from 5.8 to 9.2 meters. Shoal B is located approximately 10 nautical miles offshore. The depths here are from 8.2 to 11.0 meters. Shoal C is located approximately 10.5 nautical miles offshore. The approximate depth range is 10.1 to 15.9 meters. The borrow sites are situated within the inner portion of the continental shelf, which in this region extends approximately 60 nautical miles offshore.

The Atlantic coast of Maryland has a humid continental climate that is moderated by the large ocean water mass. During July, the hottest month, air temperatures along the coast often exceed 90°F. However, air temperatures over the coastal ocean typically run 5-10°F lower due to the cooler surface water temperatures which rarely exceed 80°F. January and February are the coldest months. The air temperatures drop below freezing only about 40 days per year. The prevailing winds are southerly with moderately low velocity (8-14 miles per hour) during the spring and summer (U.S. Army Corps of Engineers 1980). Storm winds from the northeast are frequent during the fall and winter months.

The mean tide range based on measurements at the Ocean City Coast Guard Station is 1.04 meters (U.S. Department of Commerce 1989). The salinity in the region of the borrow sites is likely to fall within the range of 30 to 33 parts per thousand (Cook 1988). There may often be a slightly higher salinity on the bottom compared to the surface. Continental shelf waters undergo progressive thermal stratification from spring through summer when the thermocline reaches a depth of 9 to 12 meters (Freeman and Walford 1974). At coastal locations within the 20 meter contour the stratification is somewhat less intense as the shallower depths permit some turbulent mixing through the water column. Table 1 shows measurements of temperature, salinity, and dissolved oxygen taken at three stations located one, five, and nine miles off the north end of Assateague Island during a 1994 mid-summer survey by the Environmental Protection Agency.

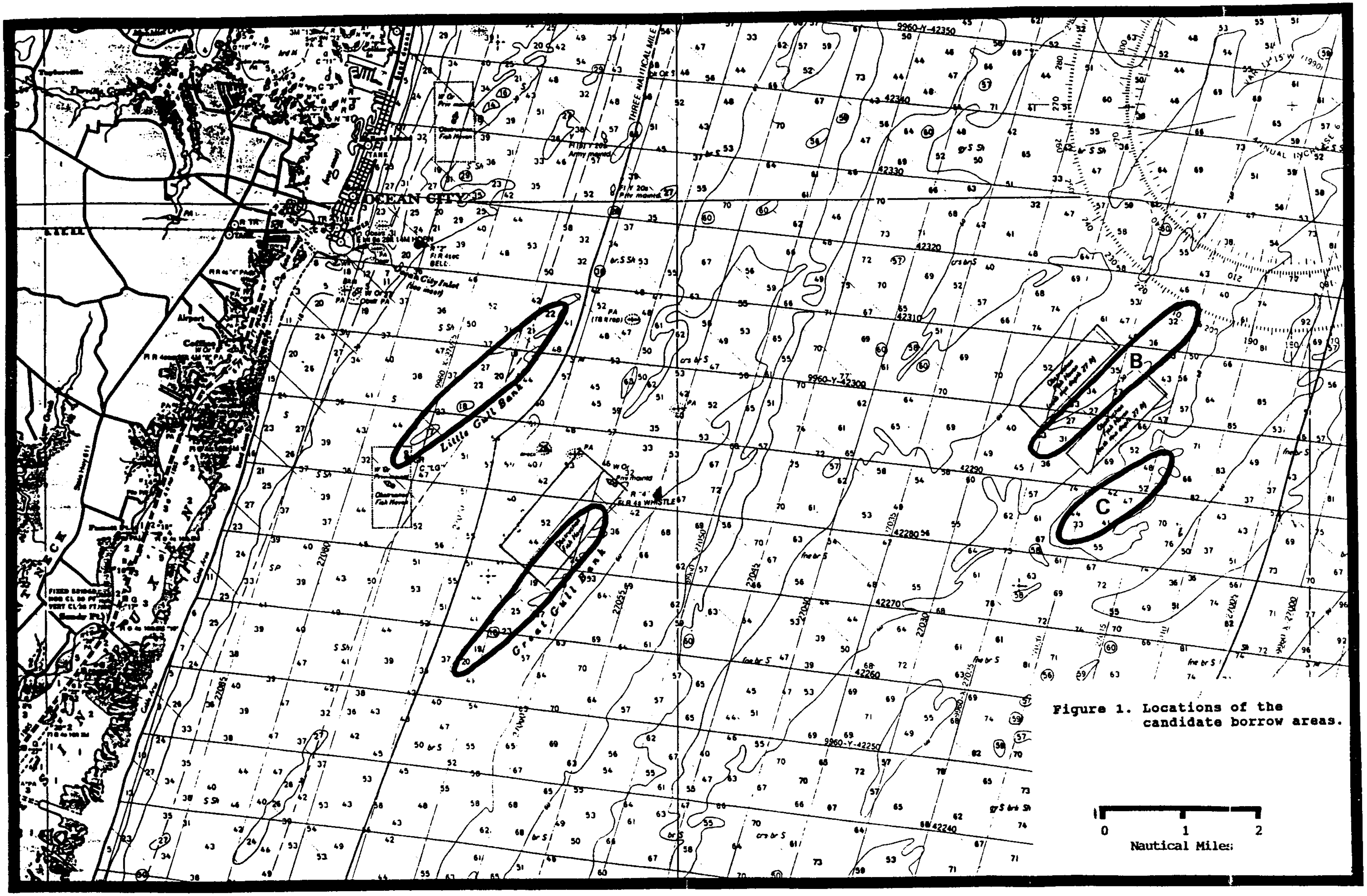


Figure 1. Locations of the candidate borrow areas.

Table 1. Water quality measurements taken at three stations off the north end of Assateague Island during a 1994 mid-summer survey by the Environmental Protection Agency.

Station	Depth (meters)	Salinity (ppt.)	Temperature (deg. C.)	Dissolved Oxygen Actual (mg/l)	Dissolved Oxygen % Saturation
CD 14(b)	0.1	32.0	19.8	8.05	107
(1 mile)	5.0	31.9	17.0	8.82	110
	10.0	32.4	14.0	8.36	99
	12.3	32.5	13.6	7.55	89
CD 14	1.1	32.0	20.0	7.67	102
(5 miles)	4.9	32.0	15.6	8.02	98
	9.8	32.6	13.3	8.63	101
CD 14(a)	1.2	31.8	21.1	7.06	96
(9 miles)	4.9	31.9	20.2	7.33	98
	9.9	32.2	14.5	8.59	103
	15.1	32.8	11.0	9.26	103

The water circulation in this region of the inner continental shelf is characterized by a general southward movement of the surface and bottom water throughout the year (Bumpus 1965, Bumpus and Lauzier 1965, and Bumpus 1973). However, from April to September the surface water movement may periodically reverse and more northward (Bumpus 1969). These reversals in the normal surface water pattern are associated with low spring runoff and the prevalence of south winds.

No significant water quality problems have been reported from the study area. The State of Maryland has designated all of its coastal waters (i.e. to the three mile limit) as Use II, shellfish harvesting waters. No water quality impacts that would threaten this designation have been reported (Maryland Department of the Environment 1994). However, there is an area off 64th Street in Ocean City where shellfish harvesting is prohibited as a precautionary measure due to the discharge of the City's wastewater treatment plant. The restricted area encompasses the ocean side waters between 55th Street and 73rd Street extending offshore for 1.5 miles.

Phytoplankton abundance, as indicated by chlorophyll *a* measurements, is relatively high in coastal waters out to the 20 meter depth contour compared to other regions further offshore (Evans-Zetlin and O'Reilly 1988). This is likely due to the nutrients supplied via coastal runoff and greater water column mixing. Chlorophyll *a* concentrations typically exceed 3.0 mg/m^3 except during the late spring and summer (1.7-2.7 mg/m^3) when the water column is stratified. The chlorophyll *a* concentration varies over an annual cycle with primary peaks typically occurring in the early spring and late fall, and a secondary peak in September.

Zooplankton comprise those animals which are found suspended in the water column, but which cannot swim well enough horizontally to overcome normal currents. Zooplankton studies in the coastal region between New Jersey and Virginia are reported in: Deevey (1960), Van Engel and Tan (1965), Grant (1979), and Sherman et al. (1988). Zooplankton may be divided into two groups, holoplankton and meroplankton. Holoplankton are those species which spend their entire life as plankton. They are a critical component of the marine food web, linking the primary producers with higher trophic levels. Copepods dominate the holoplankton in the mid-Atlantic coastal region throughout the year. Abundance tends to be relatively low in winter and high in late spring, summer and fall. There is a marked change in species composition with the seasons.

Meroplankton only spend a part of their life as plankton. They include the eggs and larval stages of many fish and invertebrates. Meroplankton are particularly numerous in the late spring and summer, but they occur throughout the year.

Benthic macrofauna in marine environments are important as a food source for many fish species. In general benthic macrofauna are operationally defined as those organisms collected with grab samplers and fine sieves (e.g. 0.5 or 1.0 mm). Larger mollusks, decapods, echinoderms and others (sometimes referred to as megabenthos) are not effectively sampled by this method. Collection of these organisms requires more specialized sampling gear such as anchor dredges or small trawls.

While the benthic fauna at the borrow sites has not been specifically sampled, surveys conducted at other Maryland and Delaware coastal locations provide pertinent information. Mihursky et al. (1986 and 1987) surveyed benthic macrofauna at 29 stations within four candidate sand borrow areas off Ocean City. For comparison this study also sampled 25 stations distributed up to 3.5 nautical miles offshore between the Ocean City Inlet and the Maryland/Delaware line. The sampling was conducted in April 1986 and April 1987. Most of the stations had sediments with 98 percent or greater sand content. With the exception of those stations located in shallower water (< 8 meters), these sand dominated stations shared similar characteristics in terms of numerical abundance, number of species, biomass, and community structure. Species which were common at many of the stations included: the mollusks *Ensis directus* and *Tellina agilis*, haustorid amphipods such as *Acanthohaustorius similis*, *Protohaustorius wigleyi*, and *Parahaustorius longimerus*, and polychaete worms such as *Spiophanes bombyx*, *Spio setosa*, and *Nephtys bucera*. Stations located in shallower water were distinguished by having lower species richness. One station was unusual in containing a high percentage of silt and clay material (29%), apparently a consequence of being a 14 m deep depression between shallower (8 m) areas. This station had the highest total number of organisms and biomass.

A study of a proposed sand borrow site at Hen and Chickens Shoal, Delaware (Dames and Moore, Inc. 1993) found that benthic organism density, number of taxa, and biomass per unit area were lower than other offshore areas in the mid-Atlantic region. The most common species in terms of frequency of occurrence were several haustorid amphipods, an isopod (*Chiridotea tuftsi*), a bivalve (*Tellina agilis*), and a polychaete (*Nephtys bucera*). These species were also common in the Maryland study. Numbers of organisms, species, and biomass tended to be lower in a relatively shallow area (5.8-7.6 m) than at an adjacent area where the depths were somewhat deeper (7.0-9.4 m).

Maurer et al. (1979) also found that stations on Hen and Chickens Shoal (depths 6.1-9.8 m) had lower invertebrate abundance and number of species than stations in a trough east of the shoal (depths 8.3-24.4 m). Another area in this study off South Bethany Beach with depths of 6.4 to 14.6 m had similar numbers of organism as Hen and Chickens Shoal but higher numbers of species. This study also demonstrated that the benthic assemblages can undergo significant seasonal changes.

Kelley and Chaillou (1996) surveyed macroinvertebrates at a proposed sand borrow area near Bethany Beach, Delaware. The 36 stations in this survey were selected to represent three habitats: shoal (6.1-9.1 m deep), shoal edge (9.1-12.2 m), and trough (>12.2 m). The number of organisms, number of species, and biomass per unit area increased along the gradient from the shoal to the trough. This distribution paralleled an increase in finer sediments and higher organic carbon content.

Boesch (1979) studied macrobenthos in ridge and swale habitats throughout a wide area of the middle Atlantic continental shelf. This study found that swales contained higher macroinvertebrate abundance, species richness, and biomass than ridges or flanks. The richer benthic fauna in the swales was again correlated with the presence of finer sediments and higher organic carbon content.

The four candidate borrow sites for the current study are all shoal areas. The results of the previous studies indicate that the macroinvertebrate benthic fauna will be somewhat reduced in terms of organism numbers, species richness, and biomass relative to the deeper waters around them. Table 2 shows a list of species that were common at another sand borrow site off Ocean City. Because the habitat at this site is similar to the current candidate sites, particularly Little Gull Bank and Great Gull Bank, this list should be representative of these sites. Additional megafauna species which would also be expected at the candidate sites include: moon snails (*Polinices duplicatus* and *Lunatia heros*), whelks (*Busycon canaliculatum* and *B. carica*), starfish (*Asterias forbesi*), and various crabs (*Pagurus longicarpus, P. pollicaris, Cancer irroratus, Callinectes sapidus, Ovalipes ocellatus, Libinia emerginata, L. dubia,* and *Limulus polyphemus*), (Casey et al. 1993, 1994).

It should be noted that biomass or other indicators of benthic structure may not necessarily be a reflection of the value and contribution to higher trophic levels. Individual benthic invertebrate species vary widely in their value as prey for fish and other predators. Predation can result in a substantial reduction in the benthos biomass especially where the benthic assemblage includes highly sought after and available species.

The surf clam (*Spisula solidissima*) is a species of particular interest because of its high commercial fishery value. Surf clams often show a preference for the same sandy shoal habitat that is desirable for beach replenishment sand. They are, however, not restricted to these areas and are also common in silty-sand sediments. Surveys of potential borrow areas off Ocean City (Mihursky et al. 1986, 1987), Bethany Beach (Kelley and Chaillou 1996), and Rehoboth Beach (Dames and Moore, Inc. 1993) have consistently shown the presence of juvenile surf clams. However, surveys for commercial size clams have not revealed any harvestable populations. Apparently there is extensive mortality of the juvenile clams on the inshore shoals. Nearly 100 percent mortality of juveniles has been reported at some locations off New Jersey and Long Island (Mackenzie 1988). Predation by the lady crab (*Ovalipes ocellatus*) and the rock crab (*Cancer irroratus*) was implicated as the primary factor in the mortality.

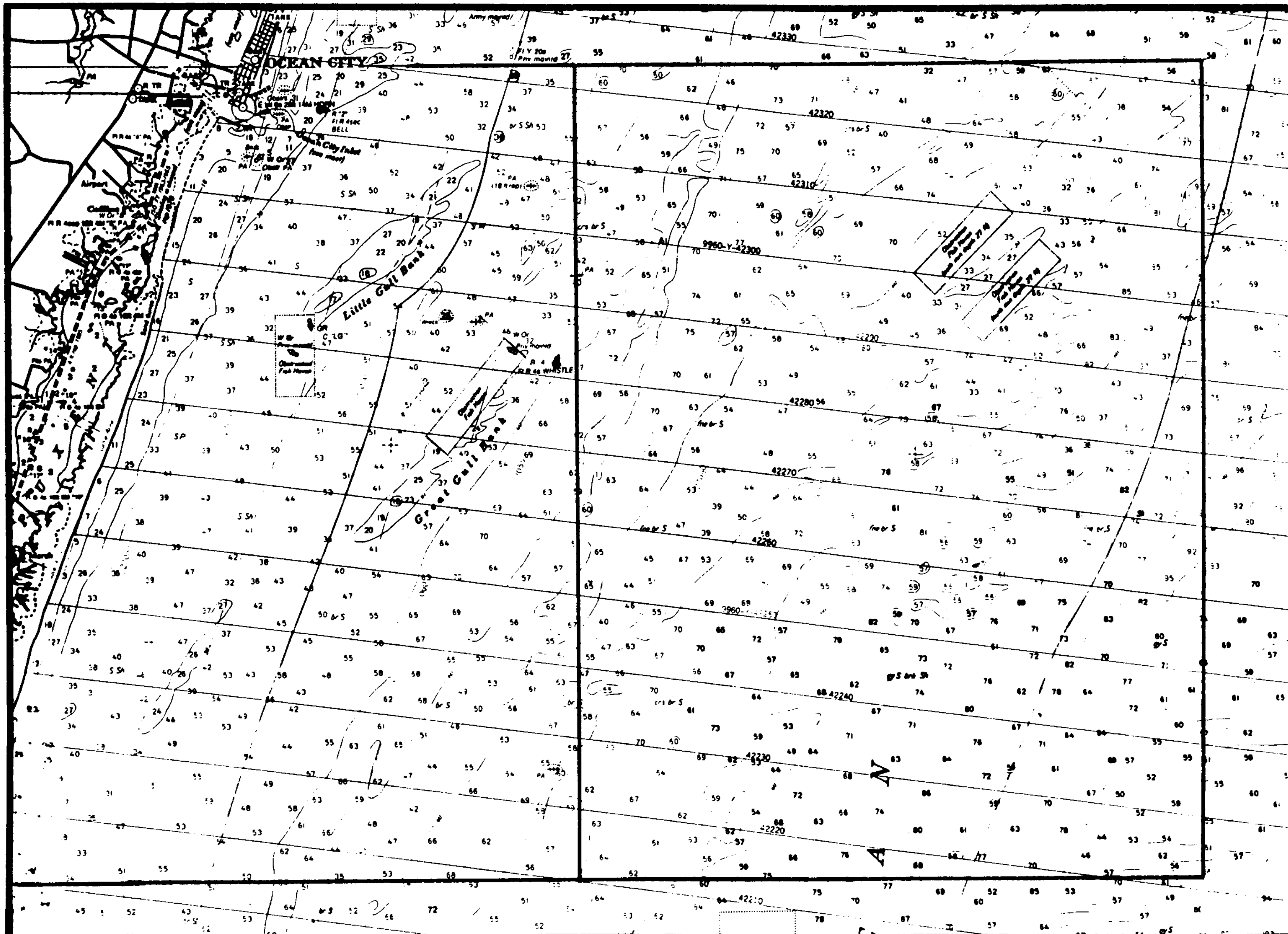
The commercially harvestable surf clam populations in the Delmarva region have historically been located at depths between 18 and 37 meters (Ropes 1982). The National Marine Fisheries Service monitors harvest records by 10 minute block. No clam harvest was reported for the inshore block containing Little Gull and Great Gull Banks (Figure 2) during the recent years 1992-1995. Recent harvest records for the block containing Shoals B and C are: 72,882 bushels in 1992, 30,104 bu. in 1993, 57,920 bu. in 1994, and 68,448 bu. for Jan.-July 1995. The dockside value of the catch based on 1993 prices would be approximately $8.50 per bushel.

We contacted the captains of two surf clam vessels that operate out of Ocean City to obtain further information of the value of the candidate borrow areas for surf clam harvesting. Both captains said that the area around Shoals B and C, which they called "first lumps", was good for harvesting. Neither had ever had any success at Great Gull Bank. They did consider Great Gull to be potential habitat, and they periodically test the bottom here for the presence of clams. Little Gull Bank lies within the three nautical mile limit where clam harvesting is prohibited. Although they don't bother testing for clams

Table 2. Macroinvertebrate species that were prevalent at a candidate sand borrow site located approximately 1-2 nautical miles off Ocean City during an April survey (Mihursky et al. 1986). The species occurred at a minimum of 4 of 8 sand dominated stations. Three replicate samples were taken at each station with a 0.1 square meter Van Veen grab and processed through a 1.0 mm sieve. Station depths varied from 10 to 13 meters.

TAXA		MEAN NO./0.1 M^2
POLYCHAETA		
Magelona sp.		16.5
Nephtys bucera		5.7
Travisia parva		2.4
Owenia fusiformis		0.8
Glycera dibranchiata		0.7
Onuphis eremita		0.4
Dispio uncinata		0.4
AMPHIPODA		
Acanthohaustorius similis		20.8
Protohaustorius cf. *deichmannae*		12.6
Pseudunciola obliquua		4.0
Protohaustorius wigleyi		2.3
Rhepoxynius epistomus		1.1
Monoculodes sp.		0.3
CUMACEA		
Pseudoleptocuma minor		0.3
Mancocuma stellifera		0.2
ISOPODA		
Chiridotea tuftsi		1.5
BIVALVIA		
Tellina agilis	Northern dwarf Tellin	7.4
Siliqua costata	Atlantic razor clam	4.4
Ensis directus	Atlantic jackknife clam	2.3
Spisula solidissima	Atlantic surf clam	1.7
Pandora bushiana	Pandora clam	0.3
ECHINODERMATA		
Echinarachnius parma		1.4
NEMERTINEA		1.2

Figure 2. Boundaries of the 10-minute blocks used to tabulate the surf clam catch in the study area.



there, one captain said that the lack of clam sign in the hauls of finfish trawlers which work the area was a good indication that harvestable populations do not occur.

In summary, while it is likely that juvenile surf clams occur at all four candidate borrow areas, only the area around Shoals B and C supports a commercial harvest.

A wide variety of fish species will occur in the vicinity of the borrow areas. Table 3 shows a list of species and the number collected in the coastal area off Maryland during the annual spring and fall groundfish surveys conducted by the National Marine Fisheries Service between 1991 and 1995. Most of the fishes in the coastal area are seasonal migrants (Grosslein and Azarovitz 1982). Winter is a time of low abundance as most species leave the area for warmer waters offshore and southward. Spring brings a progressive influx of species which reach a peak in the fall.

Spawning often takes place over relatively wide geographical areas. The production of pelagic eggs and larvae by most species further enhances the dispersal of the reproductive effort. As a consequence, the larvae of many species may occur in the vicinity of the borrow sites at different times of the year, but no species appears to concentrate a significant part of its spawning effort here.

There is substantial commercial fishing activity in the region. Table 4 shows the commercial landings reported for 1993 for a selected area off the Maryland coast. These data indicate that, in terms of dollar value, the surf clam is the most important species, followed by summer flounder, dogfish, whelks/conchs, horseshoe crabs, weakfish, black sea bass, etc. A variety of gear is utilized including hydraulic dredges, trawls, gill nets, and pots. We contacted the captain of a trawler that works out of Ocean City to obtain information on the extent of harvesting at the candidate borrow sites. He said that trawlers work at each of the sites. They work both on top of the shoals and, more frequently, at the shoal edges.

Substantial recreational fishing also takes place in the vicinity of the borrow sties. It appears that some recreational fish species are attracted to the elevated bottom profile as well as to the shoal edges. In addition, fish havens have been established near each of the candidate borrow areas. These fish havens are places where structures have been placed to enhance fish habitat. The fish havens particularly benefit structure oriented species such as sea bass, tautog, and triggerfish. Figure 1 shows the locations of the fish havens.

The paired fish havens adjacent to Shoals B and C are quite popular for recreational fishermen including the commercial party boats. Structures which have been placed here to serve as artificial reefs include tire units, a menhaden boat, and a clam dredge. The Maryland Department of Natural Resources has plans to place additional structures at these sites which are known as the "bass grounds".

Table 3. Fishes collected off the Atlantic coast of Maryland during the annual spring (February/March) and fall (September) groundfish surveys conducted by the National Marine Fisheries Service from 1991-1995. The data are from their inshore sampling strata at depths between 7 and 24 meters.

Scientific Name	Common Name	Spring	Fall	Total
Anchoa mitchilli	bay anchovy	639	259,196	259,835
Anchoa hepsetus	striped anchovy	0	8,414	8,414
Peprilus triacanthus	butterfish	0	8,288	8,288
Cynoscion regalis	weakfish	0	5,798	5,798
Micropogonias undulatus	Atlantic croaker	0	5,103	5,103
Leiostomus xanthurus	spot	2	5,005	5,007
Engraulis eurystole	silver anchovy	0	4,263	4,623
Stenotomus chrysops	scup	0	3,607	3,607
Raja erinacea	little skate	1,283	4	1,287
Prionotus carolinus	northern searobin	5	1,227	1,232
Urophycis regius	spotted hake	326	874	1,200
Alosa aestivalis	blueback herring	744	1	745
Scomber scombrus	Atlantic mackerel	677	1	678
Clupea harengus harengus	Atlantic herring	612	0	612
Pomatomus saltatrix	bluefish	0	566	566
Scopthalmus aquosus	windowpane	283	30	313
Merluccius bilinearis	silver hake	260	3	263
Paralichthys dentatus	summer flounder	64	120	184
Raja ocellata	winter skate	166	0	166
Squalus acanthias	spiny dogfish	159	0	159
Alosa pseudoharengus	alewife	124	3	127
Menidia menidia	Atlantic silverside	121	0	121
Myliobatis freminvillei	bullnose ray	0	83	83
Urophycis chuss	red hake	81	0	81
Alosa sapidissima	American shad	69	1	70
Etropus microstomus	smallmouth flounder	64	2	66
Raja eglanteria	clearnose skate	6	40	46
Etrumeus teres	round herring	0	44	44
Menticirrhus americanus	southern kingfish	0	42	42
Prionotus evolans	striped searobin	0	39	39
Scomberomorus maculatus	Spanish mackerel	0	38	38
Morone saxatilis	striped bass	38	0	38
Brevoortia tyrannus	Atlantic menhaden	25	10	35
Symphurus plagiusa	blackcheek tonguefish	32	3	35
Opisthonema oglinum	Atlantic thread herring	0	31	31
Ophidion marginatum	striped cusk-eel	15	11	26
Sphoeroides maculatus	northern puffer	0	25	25
Centropristis striatus	black sea bass	0	24	24
Synodus foetens	inshore lizardfish	0	20	20
Trinectes maculatus	hogchoker	1	17	18
Peprilus alepidotus	harvestfish	0	17	17
Citharichthys arctifrons	Gulf Stream flounder	16	0	16
Ammodytes dubius	northern sand lance	15	1	16
Dasyatis sayi	bluntnose stingray	0	14	14
Seriola zonata	banded rudderfish	0	11	11
Synathus fuscus	northern pipefish	10	1	11
Sphyraena borealis	northern sennet	0	10	10

Table 3 con't.

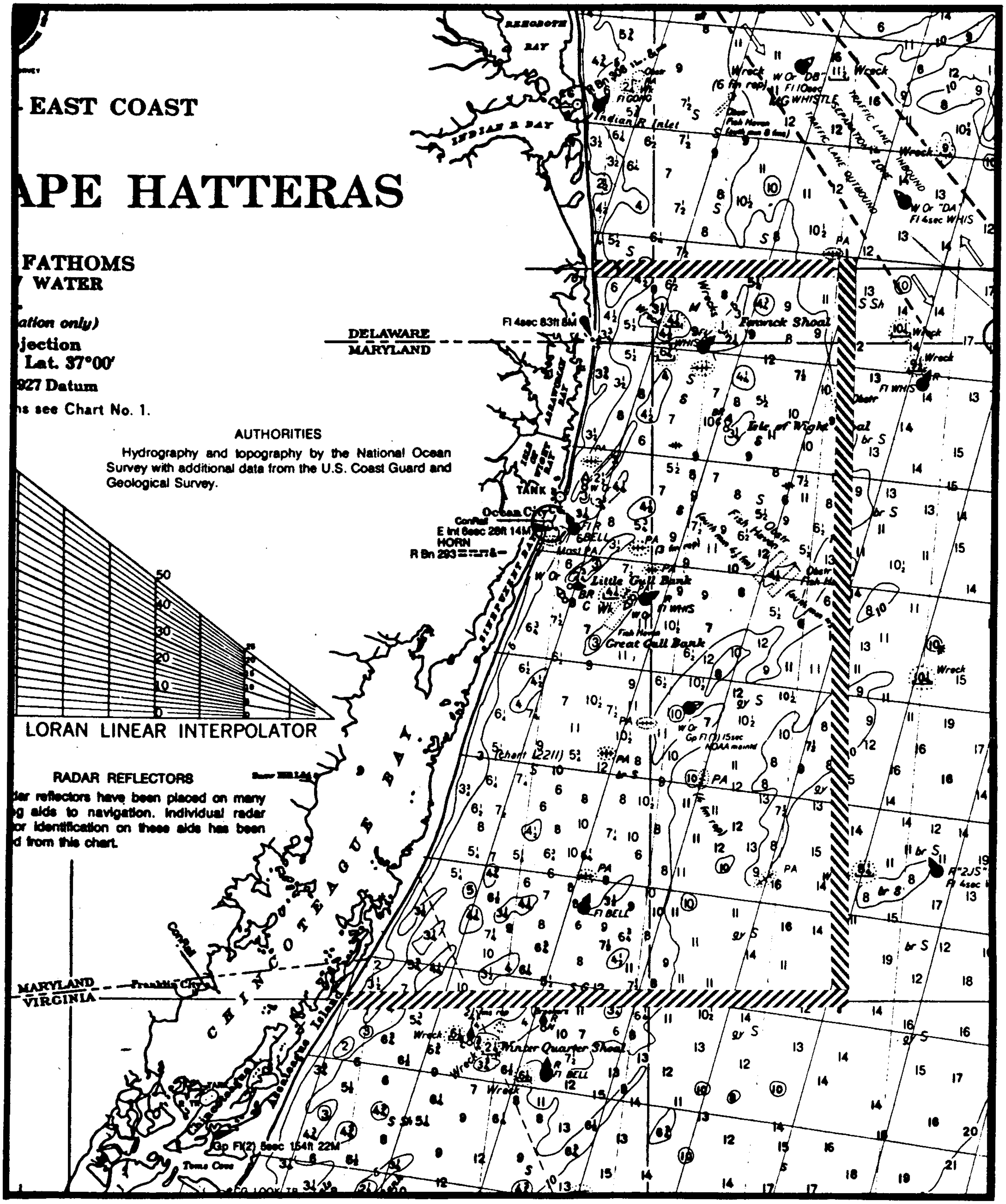
Menticirrhus saxatilis	northern kingfish	0	10	10
Mustelus canis	smooth dogfish	0	9	9
Orthopristis chrysoptera	pigfish	0	7	7
Squatina dumerili	Atlantic angel shark	0	6	6
Petromyzon marinus	sea lamprey	4	0	4
Lepophidium cervinum	fawn cusk-eel	3	0	3
Gasterosteus aculeatus	threespine stickleback	3	0	3
Acipenser oxyrhynchus	Atlantic sturgeon	3	0	3
Pleuronectes americanus	winter flounder	2	0	2
Rhizoprionodon terraenovae	Atlantic sharpnose shark	0	2	2
Rhinoptera bonasus	cownose ray	0	2	2
Caranx hippos	crevalle jack	0	2	2
Conger oceanicus	conger eel	1	1	2
Gymnura altavela	spiny butterfly ray	0	2	2
Scomber japonicus	chub mackerel	0	2	2
Bairdiella chrysoura	silver perch	0	1	1
Remora naucrates	sharksucker	0	1	1
Lagodon rhomboides	pinfish	0	1	1
Sardinella aurita	Spanish sardine	0	1	1
Mullus auratus	red goatfish	0	1	1
Monacanthus hispidus	planehead filefish	0	1	1
Lophius americanus	goosefish	1	0	1
Tautoga onitus	tautog	0	1	1
Dasyatis centroura	roughtail stingray	0	1	1
Trachurus lathami	rough scad	0	1	1

Table 4. 1993 commercial landings reported by the National Marine Fisheries Service for a selected area off the Maryland coast. (See Figure 3 for area boundary)

SPECIES NAME	POUNDS*	VALUE
ANGLER	1,157	920
BASS, STRIPED	690	889
BLUEFISH	9,949	1,351
BONITO	101	41
BUTTERFISH	5,060	1,834
CLAM, SURF	616,216	324,452
COBIA	110	101
CONCHS	5,327	4,546
CRAB, HORSESHOE	218,640	24,811
CROAKER, ATLANTIC	1,572	730
DOGFISH, SMOOTH	24,683	13,276
DOGFISH, SPINY	276,319	31,737
DOGFISH (NK)	411	172
DRUM, RED	31	9
DRUM, BLACK	25	6
EEL, CONGER	104	12
FLOUNDED, SUMMER	144,895	163,478
FLOUNDER, WITCH	7	6
HAKE, RED	1,013	156
HAKE, SILVER	2	1
HERRING, ATLANTIC	5,820	678
LOBSTER	323	1,454
MACKEREL, SPANISH	65	15
MACKEREL, KING	2,478	6,125
MENDADEN	2,436	190
OTHER FISH	21	4
PUFFER, NORTHERN	395	121
SCALLOP, SEA	45	236
SCUP	497	114
SEA BASS, BLACK	16,236	13,555
SHAD, AMERICAN	173	180
SHARK, BLACK TIP	174	56
SHARK, DUSKY	139	40
SHARK, MAKO	14	9
SHARK, SAND TIGER	168	24
SHARK, SANDBAR	4,180	1,203
SHARK, THRESHER	64	21
SHARK, NK	997	3387
SHEEPSHEAD	24	10
SKATES	39,541	3,279
SPOT	133	63
SQUID (LOLIGO)	2,304	932
SQUIDS (NS)	325	156
STURGEONS	439	471
TAUTOG	113	37
TUNA, ALBACORE	242	20
WEAKFISH, SQUETEAGUE	29,590	15,901
WHELK, CHANNELED	13,505	20,163
WHELK, KNOBBED	2,310	1,281
WHITING, KING	298	103

* The weight for mollusks includes the meat only.

Figure 3. Boundary for reporting of the catch data in Table 4.



The fish haven at Great Gull Bank contains structures such as tire units and a barge. The Maryland Department of Natural Resources also plans to place additional structures at this site for fishery enhancement. This is a popular site for private recreational fishing vessels and commercial party boats.

The fish haven at Little Gull Bank is located at the southern end of the shoal. The structure at this site, which is sometimes referred to as Kelly's reef, appears to be limited to tire units which were placed there in the 1960s. It is likely that many have been washed out of the area during storm events. The Maryland DNR has no plans to place additional material at this site. They believe that the wave energy here is too high for most types of material. Little Gull Bank is not often fished by commercial party boats who prefer sites further offshore. This area is popular with private recreational boats particularly in the late summer and fall when weakfish and striped bass are available. It has the advantage of being easily accessible to the boats coming out of Ocean City Inlet.

A number of bird species may be found feeding and/or resting in the coastal waters of the project area. These include: gulls (*Larus* spp.), terns (*Sterna* spp.), scoters (*Melanitta* spp.), oldsquaw (*Clangula hyemalis*), red-throated loon (*Gavia stellata*), and red-breasted merganser (*Mergus serrator*), as well as some more open ocean species such as northern gannet (*Morus bassanus*), black legged-kittiwake (*Rissa tridactyla*), Wilson's storm petrel (*Oceanites oceanicus*), and shearwaters (*Puffinus* spp.). Sea turtles ,especially the loggerhead (*Caretta caretta*), but also the Kemp's ridley (*Lepidochelys kempii*), green (*Chelonia mydes*), and leatherback (*Demochelys kempii*) may occur in the area from June to November. Several species of marine mammals may occur in the area although the bottlenose dolphin (*Tursiops truncatus*) is the only common one (McKenzie and Nicolas 1988). Other rare or occasional visitors include Atlantic spotted dolphin (*Stenella plagiodon*), spinner dolphin (*S. longirostris*), harbor porpoise (*Phocoena phocoena*), harbor seal (*Phoca vitulina*), humpback whale (*Megaptera novaeangliae*), fin whale (*Balaenoptera physalus*), and right whale (*Eubalaena glacialis*). The opportunity to view unusual wildlife species has lead some companies to offer nature cruises specifically for this purpose.

Endangered Species

As previously mentioned, several species of sea turtles and whales may occur in the project area. These are Federally listed as endangered or threatened species and are under the jurisdiction of the National Marine Fisheries Service. We recommend that you contact Ms. Laurie Silva at (508) 281-9251 to determine the need for a Biological Assessment or further Section 7 consultation pursuant to the Endangered Species Act.

Future Conditions Without the Project

The future without the project is expected to be similar to the existing conditions. The shoals at the candidate borrow sites are relatively stable and persistent over time (Swift and Field 1981). We expect that additional fisheries enhancement structures will be placed at the designated fish havens at Great Gull Bank and near Shoals B and C. Coastal shoals may become depleted over time in order to satisfy the ongoing need for sand to replenish the beach at Ocean City.

POTENTIAL ENVIRONMENTAL IMPACTS

The dredging will remove the existing benthic macrofauna. Several studies have examined the recovery of the benthic fauna following sand dredging in the marine environment (Saloman et al. 1982, Culter and Mahadevan 1982, Turbeville and Marsh 1982, Naqvi and Pullen 1982, Oliver et al. 1977, Thompson 1973). Generally, repopulation occurs over a period ranging from a few months to a year. The recolonized benthic assemblage will be affected by the substrate composition which results after dredging. Since the existing benthic assemblages are thought to be relatively low in terms of species richness, faunal density, and biomass, the assemblage which recolonizes would be expected to achieve levels at least as great as pre-project conditions. The species composition could be significantly different if the sediment composition changes.

The surf clam is one species that could be adversely affected by dredging. Surf clams often favor the medium sand substrate which would be dredged for beach replenishment. Commercially harvested populations of surf clams are found in the vicinity of the candidate borrow sites at Shoals B and C. It is not known whether surf clams would recolonize after dredging.

The dredging will reduce the elevated bottom profile associated with the borrow sites. This is of particular concern because the shoals at these sites are so prominent. There is little information available to assess the effect of this because most of the impact studies have looked at sites with a relatively flat profile. A reduction in the shoal profile could result in fewer fish being attracted to the area, and a consequent reduction in the value for the recreational and/or commercial fisheries. It can be surmised that a reduction in the shoal profile could affect wave, current, and sedimentation patterns. This could alter the habitat alongside the shoal. Anecdotal information suggests that "sloughs" and other depressions adjacent to the shoals often provide good fishery habitat. The captain of one commercial trawling vessel reported that the sand dredging conducted for the Ocean City beach replenishment project reduced the catch in that area to such an extent that he no longer finds it profitable to fish there. He believed that dredging had affected the adjacent sloughs that had been responsible for attracting fish to the area. He also said that debris left on the bottom by the dredging contractor (eg. cables, anchors, tires, and a cutterhead) was a hindrance to his fishing.

The artificial reefs in the fish haven areas could be adversely affected if the dredging was conducted close to them. The epifaunal communities would be susceptible to burial and smothering by sediment suspended during dredging. Dredging close to the structures could also destabilize them by undermining the bottom.

Based on existing information it appears that sand dredging st Shoals B and C would have the greatest potential for adverse biological impacts, followed in order by Great Gull Bank and Little Gull Bank. The fact that the vicinity of Shoals B and C supports a significant harvest of surf clams is an important consideration. Surf clams would be susceptible to impacts from dredging. Each of the candidate sites is popular for commercial and recreational fishing. The fish havens in the vicinity of Shoals B and C and at Great Gull Bank are popular with fishermen and will likely be expanded in the future.

The fish haven at Little Gull Bank has relatively little structure and currently has a low priority for future development. Party boats generally prefer fishing the areas further offshore. Nevertheless, the prominence of Little Gull Bank and its location close to the Ocean City Inlet causes it to be a popular area for many small boat recreational fishermen.

ADDITIONAL INFORMATION NEEDS AND MITIGATION MEASURES

Dredging sand from further than three nautical miles offshore will require coordination with the Minerals Management Service, which is the Federal agency that regulates mineral extraction under provisions of the Outer Continental Shelf Lands Act. The appropriate MMS contact is:

Mr. Roger Amato
Minerals Management Service
Interman M.S. 4030
381 Elder St.
Herndon, VA 22070
(703) 737-1282

If dredging at Shoals B or C is seriously contemplated, it will be necessary to collect more detailed information on the distribution and abundance of surf clams. This could be accomplished by conducting detailed interviews with commercial fishermen and/or conducting a clam survey of the area.

To better assess the impacts of dredging, the dredging quantities need to be computed both for the initial work and for any subsequent maintenance. Information also needs to be developed to describe the physical changes in the shoal profile after dredging. Evidence presented by Swift and Field (1981) indicates that these shoals are dynamic, being subject to hydraulic conditions that transport sand across them. The Corps should address the possibility that sand could accrete to the shoals after dredging.

If the amount of dredging is such that a major reduction in the size of a shoal is expected, we believe that the impacts would be significant enough to warrant evaluation of additional borrow source alternatives. We suggest that these additional sand sources include areas where sand has accreted in recent years such as the back bay from the inlet to the vicinity of the Route 50 bridge, the ebb shoal at the entrance to the inlet, and behind the north jetty. Other less prominent offshore borrow areas should also be considered. These need not be considered as complete alternatives, but rather may be supplemental sources which would reduce the amount of material needed from the identified shoals.

Several commercial fishermen who have spent considerable time in this area believe that both Little Gull Bank and Great Gull Bank reduce the wave energy transported toward the shoreline. It therefore seems possible that dredging of these areas could result in increased wave energy reaching Assateague Island with a consequent increase in the rate of erosion. This aspect needs to be evaluated.

It is possible that impacts can be reduced by directing the dredging to certain areas of a shoal. For example, it may be preferable to dredge the side of a shoal instead of the top in order to preserve the height of the shoal profile. Dredging a moderate amount below the existing bottom could create a trough or slough that might be attractive for fish and invertebrates enhancing the fishery value of the remaining shoal. Information that the Corps could provide on the level of persistence of this altered topography would be useful.

One additional option to offset some of the potential fishery losses resulting from extensive dredging of the shoals would be to augment the artificial reef program of the Maryland DNR in this area. This would provide some additional fishing opportunities for recreational fishermen.

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United States Department of the Interior

FISH AND WILDLIFE SERVICE
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May 23 1997

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Baltimore District
U.S. Army Corps of Engineers
P.O. Box 1715
Baltimore, MD 21203-1715

Attn: Christopher Spaur

Re: Assateague Island Short-term Restoration Project, Worcester County, Maryland

Dear Dr. Johnson:

The U.S. Fish and Wildlife Service has reviewed the Corps of Engineers' proposed Short-term Assateague Island Restoration Project, which is a part of the larger Ocean City, Maryland, and Vicinity Water Resources Study. Your October 28, 1996, request for formal consultation was received on October 30, 1996. However, this biological opinion is based on the project description contained in the Corps' November 1996, Draft Integrated Feasibility Report I and Programmatic Environmental impact statement for the Restoration of Assateague Island as well as less formal documents and information on project modifications received subsequently. The latter include a 2/21/97 memorandum from Ms. Stacey Underwood of the Corps, describing a significant project modification, and a 4/21/97 memorandum from Mr. Christopher Spaur of the Corps, concerning finalization of the project Monitoring and Action Plan. The Corps' July 14, 1996, Biological Assessment for the project, prepared prior to final project design, provided especially valuable information concerning the probable impacts of the project.

This document represents the Service's biological opinion on the effects of the proposed project on the piping plover (*Charadrius melodus*) and the seabeach amaranth (*Amaranthus pumilis*) in accordance with Section 7 of the Endangered Species Act of 1973, as amended, (16 U.S.C. 1531 et seq.). A complete administrative record for this consultation is on file in this office.

I. DESCRIPTION OF PROPOSED ACTION

The principal justification for the proposed project is to mitigate the disruption of the long-shore sand transport system caused by jetties constructed by the Corps to stabilize Ocean City Inlet. The short-term project, about which we are consulting now, would begin the process of restoring sand to the north end of Assateague Island; the long-term project, still being designed, would continue it. This project is authorized by the Water Resources Development Act of 1996 and Section 111 of the River and Harbor Act of 1968, as amended, which authorizes the Corps of Engineers to mitigate for shore damage attributable to a navigation project.

The short-term restoration plan includes placing approximately 1.4 million cubic meters (1.8 million cubic yards) of sand on Assateague Island over a two-year period. An additional 0.11 to 0.15 million cubic meters of sand may be placed on the island during the third year of the project (S. Underwood, in litt. 2/21/97). The borrow area to be used for the project is Great Gull Bank, an offshore shoal, and possibly a small portion of the ebb shoal. The area of Assateague to be renourished is between 2.5 km (1.6 Miles) and 11.3 Km (7 miles) south of the inlet. The distance across the beach in that area will be increased by varying widths (up to 100 feet) based on the erosion rates affecting each part of the beach. A low storm berm, up to 160 feet in width, will be constructed to an elevation of 3.3m (10.8 feet) NGVD (averaging 0.8m in height) in the portion of the beach between 2.5 km and 10 km (1.6 miles and 6.2 miles) south of the inlet. The project will include no dune grass planting, snow fencing, or other dune stabilization features.

A monitoring and action plan has also been developed (and included in the project) to: 1) monitor the piping plover and its habitat and mitigate observed negative impacts of this project, as necessary; and 2) monitor elevations, overwash frequencies and other factors affecting breach potential and correct short-comings as necessary. In both cases, if it is determined that the observed conditions are not acceptable, corrective actions must be taken by the Corps or its cooperators (U.S. Army Corps of Engineers 1996). The monitoring and action plan would continue for a period of at least 5 years or until the long-term plan is in place.

Construction methods have been described by the Corps as follows (C. Spaur, 23 October 1996, in litt.):

> Two Island Class hopper dredges with pump-out capability will be used to excavate a total of 1.4 million cubic meters (m^3) (1.8 million yd^3) of sand from the southwest quadrant of Great Gull Bank. Each dredge is capable of producing 219,073 m^3 (286,520 yd^3) of sand per month. Sand will be dredged off the shoal and pumped in to the vessel which has an effective hopper capacity of 1,444 m^3 (1,888 yd^3). Each hopper dredge will transect the borrow area over Great Gull Bank until the hopper is full. The hopper dredge will then travel to a pump out point located about 600 m (2000 ft) offshore of Assateague Island where a barge with a booster pump will be waiting. The barge mounted booster pump will pump the sand in a slurry from the hopper dredge to the beach through a steel pipeline. The pipeline will lie on the seafloor perpendicular to the shoreline and be

marked with buoys. The hopper dredge will then return to the borrow area and resume dredging. Approximately 1,055 transits from Great Gull Bank to the pump out point will be made between the two hopper dredges. Bulldozers will be used to create areas to trap and shape sand as it exits from the pipeline to form the berm and dune. Pumping of sand will be done for a maximum distance of up to 1, 220 m (4,000 ft) north or south of where the pipeline crosses up onto the beach. Beach nourishment will be completed in 2,450 m (8,000 ft) sections. Once a 2,450 m section of the project is built, the barge and booster pump would be moved northward to a new pump out point to continue the project. A minimum of three pump out points will be established. Work will be done over two years. Beach nourishment will begin in Year 1 within the State Park in July and will proceed northward. Work within the National Seashore will commence after about September 1st. Work will cease by mid-October. Work will begin in Year 2 within the National Seashore after about September 1st. Using the two dredges simultaneously it will take a minimum of 3 months to complete the dredging. Inclement weather or equipment problems may increase the amount of time required.

II. BIOLOGICAL OPINION: PIPING PLOVER

RANGEWIDE STATUS OF THE SPECIES

The Atlantic Coast piping plover (*Charadrius melodus*) population breeds on coastal beaches from Newfoundland to North Carolina (and occasionally in South Carolina) and winters along the Atlantic Coast from North Carolina south, along the Gulf Coast and in the Caribbean (USFWS 1996). The recovery plan (USFWS 1996) divides the Atlantic Coast piping plover population into four recovery units or geographic subpopulations. These are: Atlantic Canada, New England, New York-New Jersey, and Southern (Delaware, Maryland, Virginia, and North Carolina).

Since being listed as threatened in 1986, the population has increased from approximately 800 pairs to almost 1350 pairs in 1995; however, most of the apparent increase between 1986 and 1989 is attributable to increased survey effort in two States, and the population increase between 1989 and 1995 has been very unevenly distributed. Since 1989, the New England subpopulation has increased 346 pairs, while the New York-New Jersey and the Southern subpopulations gained 62 and 18 pairs respectively, and the Atlantic Canada subpopulation declined by 34 pairs. Substantially higher productivity rates have also been observed in New England than elsewhere in the population's range. Recovery of the Atlantic Coast piping plover population is occurring in the context of an extremely intensive protection effort now being implemented on an annual basis. Pressure on Atlantic Coast beach habitat from development and human disturbance is pervasive and unrelenting, and the species is sparsely distributed (USFWS 1996).

Since the above paragraph was written, an additional year of population and productivity data has been gathered. Between 1995 and 1996 all recovery units either declined or increased less than expected based on 1995 productivity data. The Southern recovery unit, which includes

Assateague Island, declined 13% between 1995 and 1996. This decline is of particular concern due to the small number of breeding pairs (less than 200 pairs) and their distribution over a relatively large geographic area within this recovery unit. The precarious status of the Southern subpopulation has heightened concern over any proposed activities which would further impede recovery in this area. Furthermore, the piping plover recovery strategy (USFWS 1996) is premised on attainment of population increases in each of the four recovery units in order to: (1) contribute to the population total; (2) reduce vulnerability to environmental variation, including catastrophes; and (3) increase the likelihood of interchange among recovery units.

Piping plovers nest above the high tide line on coastal beaches, sandflats at the ends of sandspits and barrier islands, gently sloping foredunes, blowout areas behind primary dunes, sparsely vegetated dunes, and washover areas cut into or between dunes. Feeding areas include intertidal portions of ocean beaches, washover areas, mudflats, sandflats, wrack lines, and shorelines of coastal ponds, lagoons, or salt marshes. Wintering plovers on the Atlantic Coast are generally found at accreting ends of barrier islands, along sandy peninsulas, and near coastal inlets (USFWS 1996).

Loss and degradation of habitat due to development and shoreline stabilization have been major contributors to the species' decline. Disturbance by humans and pets often reduces the functional suitability of habitat and causes direct and indirect mortality of eggs and chicks. Predation has also been identified as a major factor limiting piping plover reproductive success at many Atlantic Coast sites, and substantial evidence shows that human activities are affecting types, numbers, and activity patterns of predators, thereby exacerbating natural predation (USFWS 1996).

The importance to piping plovers of early successional habitats maintained by natural overwash processes, and the severe threat posed by dune construction and other coastal stabilization projects, has been observed at many Atlantic coastal locations ranging from Virginia to Massachusetts (Wilcox 1959, Elias-Gerken 1994, Strauss 1990, Loegering and Fraser 1995). A detailed discussion of these studies is provided on pages 36 and 37 of the species recovery plan (USFWS 1996).

An excellent comprehensive description of the life history, status, and threats to the Atlantic coast population of the piping plover throughout its range is provided in the Revised Recovery Plan for the Piping Plover, Atlantic Coast Population (USFWS 1996) and is incorporated by reference.

ENVIRONMENTAL BASELINE

As defined in 50 CFR 402.02 "action" means all activities or programs of any kind authorized, funded, or carried out, in whole or in part, by Federal agencies in the United States or upon the high seas. The "action area" is defined as all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action. The direct and indirect effects of the actions and activities resulting from the Federal actions must be considered in conjunction with the effects of other past and present Federal, State, or private activities within the action area.

Direct effects on plover habitat resulting from the Assateague restoration project will occur in the immediate project area--Assateague Island between 2.5 km and 11.3 km south of the Ocean City inlet. Because the most significant project effects on piping plovers and their habitat are expected to occur in this area, most discussions in this opinion are focused there. However, the action area for this consultation is considered to extend from Ocean City Inlet south to the Maryland/Virginia line, because indirect or long-term effects from increased sand supply may occur throughout this area. With the exception of Assateague State Park, the entire action area is within Assateague Island National Seashore (ASIS) and is administered by the National Park Service.

Status of the Species. A description of piping plover biology and threats for the Mid-Atlantic region and Assateague Island, specifically, was provided on pp. 9 through 16 of the Corps' biological assessment for this project (MacIvor 1996). Some particularly relevant sections of this document are summarized or excerpted below because they relate directly to this opinion's recommendations for time-of-year restrictions, evaluation of effects of beach elevation/washover events, and the significance of predation on plovers.

As pointed out by the biological assessment (MacIvor 1996), piping plovers typically return to the mid-Atlantic region in mid-March, but have been observed as early as February 24 in Virginia. Males begin to establish territories by early April. First nests on northern Assateague Island have been found as early as the third week of April (NPS reports), but eggs may be present on the beach from mid-April to late July and unfledged chicks until late August (USFWS 1996). Southward migration to the wintering grounds extends from late July, August, and September, but plovers are occasionally sighted during October (USFWS 1996).

Maryland's remaining population of piping plovers is restricted to the Assateague Island National Seashore portion of the Island. This population has been monitored since 1986 (MacIvor 1996). During 1986-96, Maryland's portion of Assateague Island has supported between 14 and 61 breeding pairs of piping plovers (Kumer *et al.* 1997). Reproductive success, measured as the number of chicks fledged per nesting pair, has greatly varied due to effects of predation and low chick survival caused by restricted access to the bay side for foraging (Table 1). During this time, the vast majority of nesting activity occurred along the northern 8 km of the island (MacIvor 1996). The following information is taken directly from the biological assessment (MacIvor 1996):

> On Assateague Island in Maryland, piping plovers typically nest in open sandy areas that are frequently mixed with shell and cobble and have little or no vegetation. During a three-year study on Assateague Island by Loegering (1992), 81 percent of 46 plover nests

Table 1. Summary of Piping Plover reproductive success on Assateague Island National Seashore, 1986-1996.

	86	87	88	89	90	91	92	93	94	95	96
Breeding pairs	17	23	25[d]	20[d]	14[d]	18	24	20	32	44	61
Nest attempts	23	33	34	27	20	20	30	30	42	45	72
No. eggs laid	87[a]	124[a]	116	92	76	77	104	104	155	168	263
Chicks hatched	38	46	37	36	25	47	43	39	104	148	173
Hatching Success (%)[b]	44	37	32	39	33	61	41	38	67	88	66
Chicks Fledged	18	27	13	18	11	7	24	34	77	76	91
Fledging Success (%)[c]	47	59	35	50	45	15	56	87	74	51	53
No. Fledged per Nest Attempt	0.78	0.82	0.38	0.67	0.55	0.35	0.80	1.13	1.83	1.69	1.26
No. Fledged per Breeding Pair	1.06	1.17	0.52	0.90	0.78	0.41	1.00	1.70	2.41	1.73	1.49

[a] Estimated from available data (Patterson 1988).
[b] Number of chicks hatched per eggs laid.
[c] Number of chicks fledged per chicks hatched.
[d] Reproductive success was calculated from nesting pair (Loegering 1992).

Table taken from Kumer et al. 1997.

had no vegetation near the nest. Between 1992-95, 68 percent (98 of 145) of total nests occurred in open habitats without vegetation (NPS Annual Reports 1992-95).

Piping plovers on Assateague rear their broods on the bay beach, in the island interior, and on the ocean beach (Loegering and Fraser 1995). In certain years, vegetation blocked access between nest sites and the bay side, causing chicks to be restricted to ocean side foraging. Survival rates of chicks raised on the ocean beach were found to be lower than those of chicks reared on the bay beach (Patterson *et al.* 1991). During 1988-90, chicks with access to the bay side had higher daily survival rates than those without access (Loegering and Fraser 1995). Further, they found that piping plover chicks that occupied bay beach and island interior habitats have higher daily survival rates than chicks in ocean beach habitat. For chicks less than 20 days old, foraging rates on ocean beach were lower than on bay beach and island interior habitats. Findings from this study on northern Assateague indicated that ocean beaches had fewer insects, chicks foraged at a lower rate along the ocean beach, chicks weighed less, and exhibited higher mortality than chicks elsewhere.

Overwash has played an important role in maintaining suitable piping plover habitat on Assateague Island. Overwash was defined by Leatherman (1988) as any swash uprush that crosses the dune line or, if no dunes are present, the storm berm. Storm overwash can occur in a variety of situations, including through narrow dune gaps, over wide sections of the barrier with low dune topography, or over an entire stretch of the barrier island. Depending on storm magnitude and island width, the flow of water may or may not carry sand to the barrier flats and/or marsh on the bayside. An overwash fan was defined by Elias-Gerken (1994) as a break in a continuous dune or vegetation line where storm tides carry sand from oceanside to bayside, often clearing a vegetation-free path from ocean to bay. Usually overwashes occur during coastal storms, but a marginal event can occur during extremely high spring tide conditions at lower areas along the barrier dune line. On northern Assateague Island storm overwashes typically occur over wide sections of the barrier with low dune topography. During some storm events, overwashes have occurred over entire stretches of the island. During overwash, if scour of the barrier gets to an elevation below mean sea level, an inlet is created (Leatherman 1988). On the north end of Assateague Island, overwash processes appear to be essential in maintaining high quality piping plover nesting and brood rearing habitat (Loegering and Fraser 1995).

It is likely that piping plovers historically relied on winter storm events to create and maintain suitable nesting and foraging habitats by scouring and covering up vegetation (Loegering 1992). Maps showing overall vegetation cover along the northern 8 km of Assateague Island between 1985 and 1995 indicate great changes in the distribution of the island's plant communities. During Loegering's study, from 1988-90, there were no cross-island overwashing storm events and dramatic vegetative succession occurred within two years (Loegering, pers. comm.). He believes that the lack of overwash activity that resulted in vegetation encroachment, which reduces foraging opportunities for plovers, was a major factor in the population decline on northern Assateague Island during those three years (from 25 to 14 pairs). During this time, plover broods restricted to the ocean beach by either dunes or vegetation had adequate nest success but nearly all chicks died. A relationship between the presence of overwash corridors and piping plover productivity was documented during this study (Loegering and Fraser 1995). Loegering also predicted that a piping plover population increase would follow major storm events.

Following the January 1992 storm, much of the northern portion of Assateague Island experienced cross-island overwash that scoured or covered vegetation. Large expanses of vegetation-free areas were created, increasing the areas available for nesting and improving access to the bay side for foraging chicks. Data collected between 1992-95 also showed a preference for interior and bay habitats by chicks. During these four years, 91 percent (1,621 of 1,775) of all chick observations along the northern 8 km of the island were of chicks using interior and bayside habitats and 9 percent (154 of 1,775) were of chicks using ocean beach habitats (NPS Annual Reports 1992-95).

Based on aerial photographs between 1992 and 1996, it appears that there has been very little change in overall vegetation and sand cover. Large areas of sand with low-lying dunes remain and areas that allow cross-island overwash are common. The more recent photographs (Sept. 1995) indicate that there are more channel corridors from the bay side and that they cross farther over towards the ocean side than in 1992. The role that bay side flooding plays in maintaining overwash areas is not well understood.

In 1996, the piping plover population increased to 61 breeding pairs, the highest number of pairs since monitoring began (Kumer *et al.* 1997). Nearly 100 percent of the open areas were used by piping plovers for nesting and/or foraging. One of the two areas considered in this project as vulnerable to breaching consists of a large, mostly flat and unvegetated overwash area. This low-lying area supported the highest concentrations of nesting plovers during 1995 and 1996. However, reproductive success was lower in this area compared to other areas during 1995 and 1996, potentially due to exposure to predators and weather because vegetation was completely lacking (Brady *et al.* 1995, Kumer *et al.* 1997).

Piping plover populations in the Southern recovery unit (Delaware, Maryland, Virginia, and North Carolina) have been increasing more slowly (or even decreasing in some years) than most of the other recovery units. Over the past several years ASIS has taken on a particularly critical role in recovery of the Southern recovery unit, because it is one of the few areas within this unit showing a significant population increase. ASIS plovers have increased from 9% of the recovery unit population in 1991 to 32% in 1996. Furthermore, in 1996, ASIS supported 36% of the pairs (for which we have productivity data) in the southern unit, but produced 45% of the chicks (Anne Hecht, Pers. comm., 1997).

Effects of the Action. In evaluating the effects of the Federal actions under consideration in this consultation, 50 CFR 402.2 and 402.14(g)(3) require the Service to evaluate the direct and indirect effects of the actions on the species. Direct impacts on piping plover are not expected to occur, because of the time-of-year restrictions on construction agreed to by the Corps. Significant indirect effects of the project on piping plover will result from project-induced habitat changes.

The proposed project would involve storm berm construction either in, or adjacent to, areas that were occupied by 44 pairs (100 percent of Maryland's plover population) of nesting piping plovers in 1995 (Brady et al. 1995). In 1995 three nests were directly within the proposed work area, 30 (67 percent) were within 150 m of the proposed work area, and 42 (93 percent) were within 225 m of the proposed work area (MacIvor 1996). A similar distribution of nesting pairs occurred in 1996, except that two pairs successfully nested in the oversand vehicle zone. In 1996, 59 of 61 pairs (96.7% of Maryland's population) nested in, or adjacent to, the project area.

It is likely that the newly placed dune/berm material will be used by nesting piping plovers assuming that substrate types are similar to current conditions (MacIvor 1996). However, the increased distance between nests and foraging areas following project construction may result in increased chick mortality rates. Mortality rates would be increased by increased energy expenditure, higher risk of predation, and increased exposure to inclement weather (Loegering 1992). Furthermore, although Corps models project an average of one overwash per year, the proposed project is expected to result in decreased frequency and intensity of overwash events. If the proper number and intensity of overwashes does not happen, plant succession will likely begin in as little as 1-2 years, and areas that are now devoid of vegetation or sparsely vegetated may become dominated by plants (MacIvor 1996). Increased vegetation is likely to result in the blockage of corridors essential for the movement of chicks between nesting and preferred foraging areas. If chicks are restricted to the ocean side of Assateague Island following hatching they are likely to die (Loegering and Fraser 1995). In addition, decreased overwash may result in a loss of moist soil areas and ephemeral pools which provide excellent foraging habitats for adults and chicks (MacIvor 1996). The project may also increase predation (a critical factor in determining chick fledgling rates) in several ways. First, the project may force increased foraging along the ocean beach which will enhance the probability of predation (Kumer *et al.* 1997). Second, by increasing the area and distribution of higher elevation berms, the project may enhance denning areas for red foxes, which are very efficient plover predators.

All of the above factors will contribute to a decrease in plover productivity rates and could easily lower them below the rates necessary for species recovery. The precise extent of this effect is difficult to predict since it depends on storm frequency/stability of Corps storm berms, predator population dynamics, etc. The Corps' Monitoring and Action Plan is intended to reverse this effect if it is significant enough to meet the criteria set forth in the plan's "performance indicators". Incorporation of the Monitoring and Action plan in the Corps' proposed project was a critical factor in the project's acceptance by the Service and State resource agencies.

Additional longer-term effects on plover habitat may occur in the oversand vehicle (OSV) zone , down-drift (south) of the immediate project area. Two productive piping plover nests occurred in the OSV zone in 1996--something that had not previously been observed, but, in all likelihood, resulted from storm/overwash events occurring from 1991-1995. Long-shore drift of the unnaturally large volume of sand to be placed on the north end of Assateague by the short-term project may reverse this process, impeding the restoration of plover habitat in the OSV zone.

Cumulative Effects. Cumulative effects include the effects of future State, local, or private actions that are reasonably certain to occur in the action area considered in this biological opinion. Although most of the action area is Federal land, there is limited potential for piping plovers in the action area to be affected by State and private actions. For instance, dune construction above the mean high water line on State park land would require no Corps permit and would likely have cumulative effects with the proposed restoration project. However, we are aware of no plans to do such a project independent of this Federal project. Private or State marina or boat ramp construction (which would require a Corps permit) could affect piping plovers by increasing boating activity and landings in the action area. The significance of these effects (which should be evaluated during future Section 7 consultations) has been greatly reduced by National Park Service and Maryland DNR boating regulations for the waters surrounding the north end of Assateague Island. Future Federal actions that are unrelated to the proposed action are not considered in this section because they require separate consultation pursuant to Section 7 of the ESA.

CONCLUSION

After reviewing the current status of the Atlantic Coast population of the piping plover throughout its range and in the action area, the environmental baseline for the action area, the effects of the proposed project and the cumulative effects, it is the Service's biological opinion that implementation of the project, as currently proposed by the Corps, is not likely to jeopardize the continued existence of the Atlantic coast population of the piping plover. No critical habitat has been designated for this species; therefore, none will be affected.

INCIDENTAL TAKE STATEMENT

Sections 4(d) and 9 of the ESA, as amended, prohibit taking (harass, harm, pursue, hunt, shoot, wound, kill, trap, capture or collect, or attempt to engage in any such conduct) of listed species of fish or wildlife without a special exemption. Harm is further defined to include significant habitat modification or degradation that results in death or injury to listed species by significantly impairing essential behavioral patterns such as breeding, feeding, or sheltering. Harass is defined as 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. Incidental take is any take of listed animal species that results from, but is not the purpose of, carrying out an otherwise lawful activity conducted by the Federal agency or applicant. Under the terms of Section 7(b)(4) and Section 7(o)(2), taking that is incidental to and not intended as part of the agency action is not considered a prohibited taking provided that such taking is in compliance with the terms and conditions of this incidental take statement.

AMOUNT OR EXTENT OF TAKE

Because of the time-of-year restrictions that the Corps has incorporated into project design, no direct take is expected to occur during periods of active construction (September 1 through mid-October of three consecutive years). Take is expected to occur in the form of harm resulting from habitat modification that reduces the survival of piping plover chicks by significantly impairing feeding behavior. These effects are expected to result primarily from project-induced habitat changes, including increased vegetation growth impeding access to prime foraging areas and decreased food supply during critical periods during chick development. Cairns (1977) found that piping plover chicks typically tripled their weight during the first two weeks after hatching; chicks that failed to achieve at least 60% of this weight gain by day 12 were unlikely to survive. Loegering (1992) found that chick weight and length of exposed bill measured at four or five days of age were significantly higher for chicks that ultimately fledged than for those not surviving. Another potential cause of project-induced chick mortality is elevated predation pressure due to enhancement of red fox denning habitat.

Quantification of anticipated take is extremely complicated. In part, this is due to the confounding factors that affect plover productivity (for example, breeding season weather and factors other than denning habitat that affect predation pressure). The effect of the project on availability and accessibility of plover foraging habitat will also be highly dependent on the frequency and magnitude of major storms needed to prevent encroachment of vegetation on Assateague Island. Corps modelling indicates that the project design will allow an *average* of one major overwash event annually, thereby perpetuating favorable piping plover habitat conditions. However, since storm patterns are irregular, there is a risk that the added sand will impede overwash in the years following project implementation and that vegetation growth will be accelerated. The monitoring and action plan has been incorporated into project design to detect and correct this potential eventuality, but some reduced chick survival would occur.

In light of the above discussion, incidental take associated with this project could range from none to 29 chicks[1] annually. However, the Service anticipates that the actual level of take will be

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[1] This number was derived by assuming that, under the monitoring and action plan, the piping plover population could decrease up to 25% or productivity could drop to 1.25 chicks/pair before corrective action would be taken. If 25% of the 60 pairs that nested on Assateague in 1996, or 15 pairs, were forced to nest elsewhere in the Southern recovery unit and their average productivity dropped from the 1993-1996 Assateague average of 1.67 chicks per pair to the 1988-1996 regional average of 1.02 chicks per pair, then chick survival would be reduced by 10 chicks. If 45 pairs continued to nest on Assateague at a reduced productivity of 1.25 chicks/pair, then chick survival would be further reduced by 19 chicks. It should be noted that this is a "worst case scenario," due to (1) the low probability that

towards the lower end of this range, approximately six chicks[2] per year. Due to the difficulties associated with separating the effects of this project from confounding factors, the performance indicators in the monitoring and action plan will be used to determine if incidental take has been exceeded. Incidental take will be deemed exceeded if:

1) Plover reproductive success falls below 1.25 chicks fledged per breeding pair for two consecutive years, or the plover breeding population size declines more than 25% from the population size at the start of the Corps project, and

2) There is a cumulative change, over time, of greater than 25% in the frequency distribution of any of the specified LIDAR elevation bands[3] on the north end of Assateague, compared with the frequency distribution immediately after project construction or a cumulative decrease of greater than 25% of the area on the north end classified as unvegetated open sand habitat.

The second criterion is intended to show whether significant habitat changes have really occurred following the project so that we can determine if its reasonable to attribute changes in plover numbers to project-induced habitat changes, rather than natural events or other factors that may affect chick survival.

REASONABLE AND PRUDENT MEASURES

The measures described below are nondiscretionary and must be implemented by the Corps in order for the exemption in Section 7(o)(2) to apply. The Corps has a continuing duty to regulate the activity covered by this incidental take statement. If the Corps fails to ensure compliance with these terms and conditions, the protective coverage of Section 7(o)(2) may lapse. The Service considers the following reasonable and prudent measures to be necessary and appropriate to minimize take of the piping plover.

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plover foraging will be degraded to this degree, (2) the assumption that productivity in the absence of the project would remain at the high level seen in 1993-96, and (3) because the performance measures in the monitoring and action plan trigger corrective action if either plover numbers *or* productivity exceed the specified thresholds, not both. Furthermore, it is expected that the earliest that vegetation growth sufficient to impede chick mobility would develop would be at least two years following sand deposition in that vicinity.

[2] This figure assumes that approximately 60 pairs will continue to nest in the project area and that average productivity will be reduced by 0.1 chicks/pair.

[3] The specific elevation bands to be utilized in this calculation are the 0.5 m bands identifiable with LIDAR imagery, with no single marginal category representing less than 10% of the total area of the north end.

- o Construction activities must be conducted when piping plovers are not present.
- o A monitoring program must be implemented to determine project effects on piping plover and piping plover habitat conditions.
- o If the monitoring program indicates that the project has caused significant adverse effects on piping plover habitat, these effects must be mitigated or corrected.

TERMS AND CONDITIONS

In order to be exempt from the prohibitions of Section 9 of the ESA, the Corps must comply (or ensure compliance) with the following terms and conditions, which implement the reasonable and prudent measures described above and outline the required reporting/monitoring requirements. These terms and conditions are non discretionary. Because of the long period of interagency coordination and informal consultation prior to the initiation of this formal consultation most of these terms and conditions have already been incorporated into the project design.

1. No construction, earth-moving, placement of materials or equipment, or maintenance will occur on Assateague Island north of Assateague State Park between March 15 and September 1 of any year.

2. No refueling of equipment will take place on intertidal areas of the beach.

3. A monitoring plan, as described in Annex E of the Corps' Draft Integrated Feasibility Report, will be implemented by the Corps or its cooperators. The monitoring program will be initiated prior to project construction and continued for a period of five years after project construction is completed.

4. An annual report on the monitoring program results will be produced each year by the Corps or its cooperators and provided to the Fish and Wildlife Service and other appropriate members of the Ocean City, MD, and Vicinity Water Resources Study group.

5. Should the monitoring program indicate a significant detrimental effect on piping plovers based on the performance indicators on page E-5 of the Monitoring and Action Plan, the Corps will take action directly or through their cooperators to ensure that these detrimental effects are corrected. Corrective measures will be tailored to correct the observed problems but are expected to include lowering the elevation of the storm berm and may also include physical removal of vegetation.

6. Should the monitoring program indicate an increase in predator populations (especially foxes) following project completion, corrective actions to reduce these populations will be taken by the Corps or its cooperators. If data shows a disproportionate use of

artificially elevated areas for fox denning, these areas (including the old Corps dredge spoil deposition area at the north end of Assateague) will be lowered to a more natural elevation by the Corps or its cooperators. Initiation of a predator control program must also be given consideration.

III. BIOLOGICAL OPINION: SEABEACH AMARANTH

RANGEWIDE STATUS OF SEABEACH AMARANTH

Seabeach amaranth (*Amaranthus pumilis*) is an annual plant native to the barrier island beaches of the Atlantic coast. Because of its vulnerability to threats and the fact that it has already been eliminated from two-thirds of its range, the species was Federally listed as threatened by the Service in 1993. Historically, seabeach amaranth occurred in nine states from Massachusetts to South Carolina; the species has now been completely eliminated from six of the states in its original range. Of the 55 remaining populations, 34 are in North Carolina, 8 are in South Carolina, and 13 are in New York (USFWS 1995).

This species is an annual plant which appears to need extensive areas of barrier island beaches and inlets, functioning in a relatively natural and dynamic manner, allowing it to move around the landscape, occupying suitable habitat as it becomes available (USFWS 1995). Its primary habitat consists of overwash flats (especially at accreting ends of islands), lower foredunes, and upper strands of noneroding beaches; it does not occur on well vegetated beaches (USFWS 1995). Like the piping plover, its habitat is maintained by overwash actions, which prevent establishment of competing vegetation. Inlets, including recent island breaches, are particularly favorable habitats for this species which is most frequently encountered on island-end flats and inlet edges (MacIvor 1996).

The recovery criteria for the species (USFWS 1995) require that at least 75% of the sites with suitable habitat within at least eight of the nine historically occupied states are occupied by amaranth populations for 10 consecutive years. Meeting this goal will undoubtedly require the establishment of at least one population site in Maryland; the only possible location for this site is Assateague Island.

A comprehensive description of the life history, status, and threats to the seabeach amaranth is found in the species recovery plan (USFWS 1995) and is incorporated by reference.

ENVIRONMENTAL BASELINE

The action area for this consultation on the seabeach amaranth is the same as the action area for the piping plover--from Ocean City Inlet south to the Maryland/Virginia line.

Status of the Species in the Action Area. Within the action area, seabeach amaranth was last reported during botanical surveys conducted in 1967 (Higgins et al. 1971). Because subsequent extensive searches have failed to locate any specimens on the Maryland portion of Assateague Island, the species is considered extirpated in Maryland. However, to assist in recovery of the species the Maryland Heritage and Biodiversity Conservation Program is currently conducting germination/propagation studies, and plans to use the results of these studies to assist in reintroduction of the species on the Maryland portion of Assateague. The most likely location for reintroduction of the species would be at the north end of the island in locations at the interface between overwash flats and low dunes (W. Tyndall, pers. comm. 1997). Because reestablishment of the species in Maryland is probably essential if we are to achieve full recovery of the species, we consider any project affecting or reducing potential reestablishment habitat significant.

Effects of the Action.

The project will have no direct effect on seabeach amaranth (except in the unlikely event that the species reestablishes a population on Assateague prior to project construction). The project may have a significant effect on the suitability of habitats on Assateague to support reestablishment of the species. Because seabeach amaranth is not currently present on Assateague Island and because it is uncertain whether existing conditions on the Maryland portion of the island are suitable for the species, prediction of project impacts is speculative.

Impacts on potential reestablishment habitat are likely to be negative at some locations on the island and positive at others. Such impacts include:

1) Adverse effects from breach prevention, which will prevent the formation of the island end flats and inlet edges preferred by seabeach amaranth.

2) Adverse effects from increased vegetative competition as overwash frequencies are decreased.

3) Positive effects from increased elevation in areas that are now flooding too frequently or eroding too rapidly to allow establishment of the species.

Overall it is expected that the project will probably decrease the suitability of most habitats for seabeach amaranth, especially in the area to the south of the State park. However, the extent of these impacts is difficult to predict and may, in any case, be of limited significance. Their most likely effect is to delay intentional reestablishment of the species on the Maryland portion of Assateague for several years until a new "equilibrium" has established itself.

CONCLUSION

After reviewing the current status of the seabeach amaranth throughout its range and in the action area and the effects of the proposed project, it is the Service's biological opinion that implementation of the project, as currently proposed by the Corps, is not likely to jeopardize the continued existence of the seabeach amaranth. No critical habitat has been designated for the species; therefore, none will be affected.

INCIDENTAL TAKE STATEMENT

Sections 7(b)(4) and 7(o)(2) of ESA do not apply to the incidental take of listed plant species. However, protection of listed plants is provided to the extent that ESA requires a Federal permit for removal or reduction to possession of endangered plants from areas under Federal jurisdiction, or for any act that would remove, cut, dig up, or damage or destroy any such species on any other area in knowing violation of any regulation of any State or in the course of any violation of a State criminal trespass law.

However, because the seabeach amaranth is considered extirpated from Assateague Island, no take, incidental or otherwise, is expected to occur as a result of the proposed project.

IV. CONSERVATION RECOMMENDATIONS

The Service strongly supports a *long-term* project to restore sand transport to the north end of Assateague Island. We believe such a project, if properly designed, will be beneficial to the overall ecological integrity of Assateague Island and to both the seabeach amaranth and the piping plover. On the other hand, the Service has had grave concerns about the impacts to piping plover and other avian species from the short-term project ever since the Corps made clear that it would include building up the elevation of the island. Any appreciable increase in elevation will decrease the frequency of overwash, increase vegetative succession, and adversely affect the piping plover.

In this regard, it must be pointed out that existing conditions over the last decade on the north end of Assateague show that there is already an extremely tenuous balance between natural forces which promote favorable conditions for plover nesting and those which degrade those habitat conditions. This is clearly shown by comparison of pre-1991 and post 1991 piping plover reproductive success. Between 1986 and 1991, during a period of lower than average storm frequency, reproductive success at Assateague had declined to abysmal levels, raising the spector that plovers would never recover in the southern part of their range. Following the Halloween storm of 1991, which leveled dunes and eliminated much of the vegetation on the North end of Assateague, Plover numbers and reproductive success began to rebound, with a rapid rate of increase in numbers occurring every year since (see Table 1).

The higher frequency of storms and overwash events since 1991 has maintained favorable plover habitat and at long last it appears that recovery of the piping plover throughout its range is at least a possibility. This turn of events is heartening, but raises concerns about a project which, in the name of restoration, could suddenly reverse this progress. In spite of the Corps' concerted efforts to design an environmentally sensitive project, this concern remains.

Although the restoration of natural conditions and processes is one of the stated goals of this project, the short-term project has substantial weaknesses in this area. Sudden delivery of a volume of sand ten to fifteen times the natural annual pre-inlet sand supply is hardly a restoration of natural conditions and there seem to be no models to predict its effects. More importantly, the construction of an artificial storm berm of uniform elevation along the entire 8 kilometer length of the project is a highly unnatural condition. Variation in elevation is the norm and there is no evidence the island's natural berm elevation ever averaged as high as the proposed artificial storm berm.

The Service has nonetheless delivered a non-jeopardy biological opinion based largely on the following two considerations:

1) The Corps' indication that the storm berm will be quickly altered by natural forces (at the same time, the Corps apparently believes that the berm will stay around long enough to justify the short-term project, again raising the possibility of significant accelerated vegetative succession).

2) The Corps and National Park Service have agreed to incorporate in project design an intensive monitoring program and to mitigate any observed adverse project effects on plover habitat by reducing berm elevation and/or removing vegetation. Nevertheless, some lingering doubts remain as to whether vegetative succession can be rapidly reversed.

The Corps is to be commended for its diligent efforts to accomplish a near-impossible task--building a project substantial enough to reduce breach potential, yet maintaining sufficient overwash for plovers and other species dependent on this habitat type. They have probably developed the best compromise possible among the disparate interests involved.

However, we cannot give unmitigated support for the project, because it will not contribute to the recovery of the piping plover (or benefit the many other avian species and plants adapted to natural overwash conditions). We have, from the start, advocated a less extensive short-term project. Short-term options which appeared biologically preferable to us involved:

1) Simply widening the island with no appreciable elevation increase, or

2) Widening the island and building up a minimal storm berm only in those limited areas most susceptible to breaching.

The Corps rejected these options because their model did not show any benefits from these approaches. Because it is counterintuitive, we believe this may result from a short-coming of their model, rather than reflecting reality.

Another short-term option considered by the Corps early in their planning and explored in their Biological Assessment was a breach contingency plan. Unfortunately, this option has been dropped from consideration, apparently because it did not fit the Corps' paradigm for restoration. It is our conservation recommendation that a breach contingency plan in combination with an accelerated long-term project be reconsidered as an alternative to the Corps' preferred plan. This alternative would consist of the breach contingency plan plus a short-term (and long-term) project involving placement of sand in the surf zone at an annual volume equal to (or somewhat exceeding) the existing annual deficit in long-shore sand transport. Because this alternative would limit placement of sand to the surf zone, time-of-year constraints to protect nesting piping plovers could be far less restrictive. Although implementation of a breach contingency plan would have some adverse effects on piping plovers, if conducted during the nesting season, these would probably be more controllable and more transient than those of the Corps' preferred alternative. With the possible exception of the breach contingency element, this alternative would appear to better meet the definition of "restoration", placing a volume of sand, similar to pre-inlet annual volumes, in the surf zone and allowing natural processes to redistribute it.

Should the Corps proceed with the project as proposed, in spite of the above recommendation, it is recommended that they fund and implement an in-depth plover foraging ecology study as outlined in the 11/5/96 memorandum from Anne Hecht, of the Service's Northeast Regional Office, to Christopher Spaur of your staff. Such a study is needed to understand and evaluate the effects of the short-term and long-term plans on plover productivity.

We appreciate the cooperation the Corps has shown during this interagency consultation. Please contact Andy Moser at (410) 573-4537 if you have any questions regarding this letter.

Sincerely,

for John P. Wolflin
Supervisor
Chesapeake Bay Field Office

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ANNEX A, PART 5

Biological Assessment for Piping Plover and Seabeach Amaranth

ASSATEAGUE ISLAND BEACH RESTORATION

Section 7 Biological Assessment
Piping Plovers and Seabeach Amaranth

June 1996

FINAL

Prepared for

U.S. Army Corps of Engineers
Baltimore District Office

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Fairfax, Virginia 22033

NOTE TO READER:

It is important for the reader to realize that this Biological Assessment was used to assist in the plan formulation process. The assessment was completed prior to the selection of a recommended plan and prior to the decision to include a monitoring and corrective action plan.

EXECUTIVE SUMMARY

Stabilization of the Ocean City Inlet through construction of jetties during 1934 greatly altered the sand supply and transport mechanisms on Assateague Island in Maryland. The jetties reduced the sand volume delivered to the island from the north via longshore transport, resulting in increased erosion rates and an accelerated retreat of the northern 13 km of shoreline. Although island retreat has been most pronounced in the northernmost 6.5 km of the island, it is believed that the northern 10km stretch may be vulnerable to breaching. Until a long-term restoration plan is implemented, several alternatives have been proposed for the immediate restoration of northern Assateague Island to return the sediment supply and prevent a breach.

The Coastal Engineering Research Center (CERC), through use of the SBEACH model, predicted nearshore wave transformation, beach profile changes, and water level responses. Based on these calculations, proposed alternatives for restoring the natural sand budget to northern Assateague Island were developed by the Baltimore District Office of the United States Army Corps of Engineers. "Dune Construction" alternatives include two dune heights with two volumes of sediment along two restoration lengths of the island. With the exception of the dune feature, the majority of the material will be placed intertidally. For the purpose of this document, a "No Action" and a "No Action, Repair Breach" will also be addressed as alternatives.

These alternatives may have impacts on piping plovers (*Charadrius melodus*) and seabeach amaranth (*Amaranthus pumilis*), which are both protected by the 1973 Endangered Species Act. Piping plovers have been monitored at Assateague Island National Seashore since 1986, and have ranged between 14 and 44 breeding pairs. During this time, the vast majority of nesting activity occurred along the northern 8 km of the island in sparsely vegetated habitats. In recent years, numbers of breeding pairs and productivity have increased, primarily in response to greater availability of nesting and foraging habitats, due to storm overwash, and lower predation rates. Seabeach amaranth is an annual plant endemic to barrier island systems along the Atlantic Coast, and has now been completely eliminated from six of the nine states where it historically occurred. Efforts to reestablish populations of seabeach amaranth are being considered by the Maryland Department of Natural Resources as part of overall federal recovery goals for this species.

Assuming a long-term restoration plan will be implemented within the next five years, the "No Action" alternative may benefit piping plovers by allowing current overwash frequencies to continue to maintain sparsely vegetated nesting areas and travel corridors for broods. Accreting sides of inlets, if a breach occurs, also provide suitable habitats for seabeach amaranth. However, the "No Action" alternative would result in the continuation of high erosion rates along the beach berm, which would not support seabeach amaranth.

Impacts from all dune construct alternatives, alternatives which involve placement of sediment on the island and along the intertidal zone, will depend on two factors: the magnitude and duration of storm events and the timing and type of construction activities. If predicted overwash effects are not realized, resulting in the invasion of vegetation into nesting and foraging habitats and/or creation of upland areas for den sites, adverse impacts to piping plovers are likely. However, if overwash frequencies and magnitude are enough to maintain open travel corridors between bayside and the ocean beach, adverse impacts are most likely to be minor. In addition, if construction activities are restricted to October through mid-March (time when the plovers are not present on the island) so that construction activities do not interfere with courtship, nesting, or brood-rearing, adverse impacts may be avoided. Placement of new material during the proper time may result in an increase in plover use and non-eroding habitats for seabeach amaranth. Differences in intensity or magnitude of impacts resulting from dune construct alternatives vary depending on dune height and volume of sand. Lowering the dune height increases the potential for effective overwash and decreasing the volume of sand decreases the length of time for construction activities. Mitigation measures incorporated into the proposed alternatives would lessen the severity of potential impacts and ensure protection of piping plovers and seabeach amaranth.

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1.0 INTRODUCTION

Sand supply and transport mechanisms on Assateague Island were greatly altered by the construction of jetties at the Ocean City Inlet, in Maryland, by the U.S. Army Corps of Engineers (USACE) in 1933-1935. Numerous physical, biological, and economic impacts to the northern portion of Assateague Island are now thought to have resulted from altering the Island's sand budget. Proposed alternatives for restoring the natural sand budget to northern Assateague Island are being developed by the Baltimore District Office of the USACE. These alternatives may have an impact on piping plovers *(Charadrius melodus)* and seabeach amaranth *(Amaranthus pumilis)*, which are both protected by the 1973 Endangered Species Act (ESA), as amended. The ESA is administered by the U.S. Fish & Wildlife Service (USFWS).

Pursuant to Section 7 of the ESA, the USACE has prepared this Biological Assessment to evaluate the potential effects of the Assateague Island Beach Restoration Project on piping plovers and seabeach amaranth. The results of this assessment will be used by USACE and the USFWS to determine if formal consultation is necessary (Federal Register/Vol. 51, No. 106, Rules and Regulations 1986). If the USACE initiates formal consultation, the USFWS may use the assessment in formulating its biological opinion (50 CFR, Part 402.12(k)(2). Findings of this assessment will also aid the USACE in determining a preferred project alternative.

2.0 REGIONAL AND PROJECT AREA DESCRIPTION

Assateague Island is located on the Delaware-Maryland-Virginia (Delmarva) peninsula long the Atlantic coastline (Figure 1). The island extends from Ocean City, Maryland, southward to Chincoteague Inlet, Virginia (Figure 2). The majority of Maryland's 35-km portion of the island is federal property managed by the National Park Service (NPS) as Assateague Island National Seashore (ASIS). The national park's boundary also includes the waters surrounding the island to one-half mile offshore, except where adjoining land masses restrict that distance and jurisdiction is reduced to half the distance to the adjacent shore (NPS 1993). The State of Maryland owns a 3.2-km section of the island that is managed as Assateague Island State Park. The Virginia portion of the island is under jurisdiction of the USFWS and managed as Chincoteague National Wildlife Refuge. The Maryland and Virginia island is approximately 58 km long and is separated from the Eastern Shore mainland by Sinepuxent and Chincoteague Bays. The island's width south of State Park is much wider than the northern end. The average width of the northern 8.5 km of the shoreline is only between 120 to 215 m. Assateague Island is the longest unbroken coastal barrier along the Delmarva Peninsula (Geottle 1978).

The project area that may be directly affected by the proposed beach restoration project includes approximately the northern 13 km of the island between Ocean City Inlet and a point just south of Assateague Island State Park (Figures 3 and 4). This northern end of the island has experienced the highest rates of erosion, and relatively frequent overwash events make it more vulnerable to breaching than portions of the island to the south (Dean and Division of Beaches 1986).

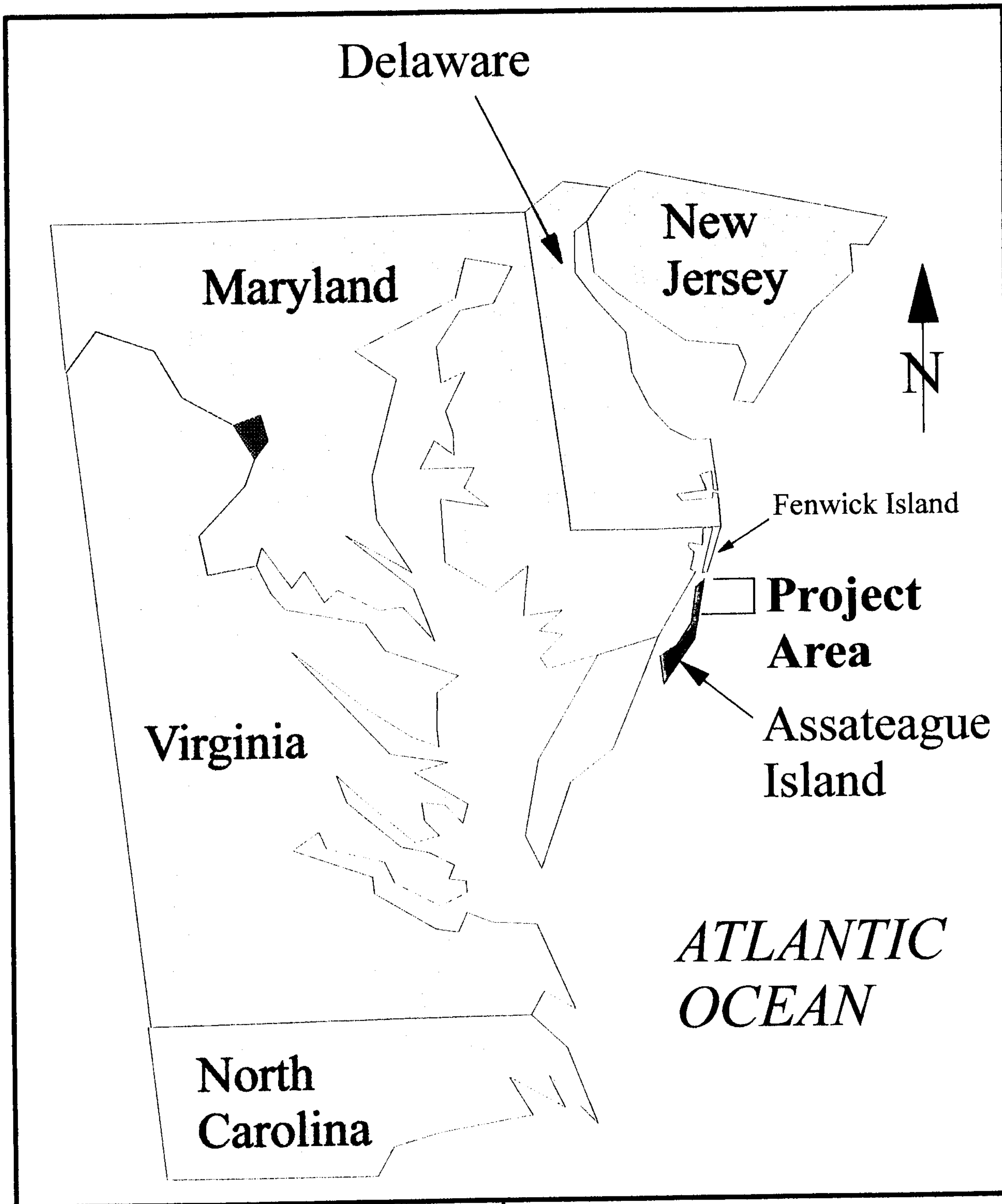

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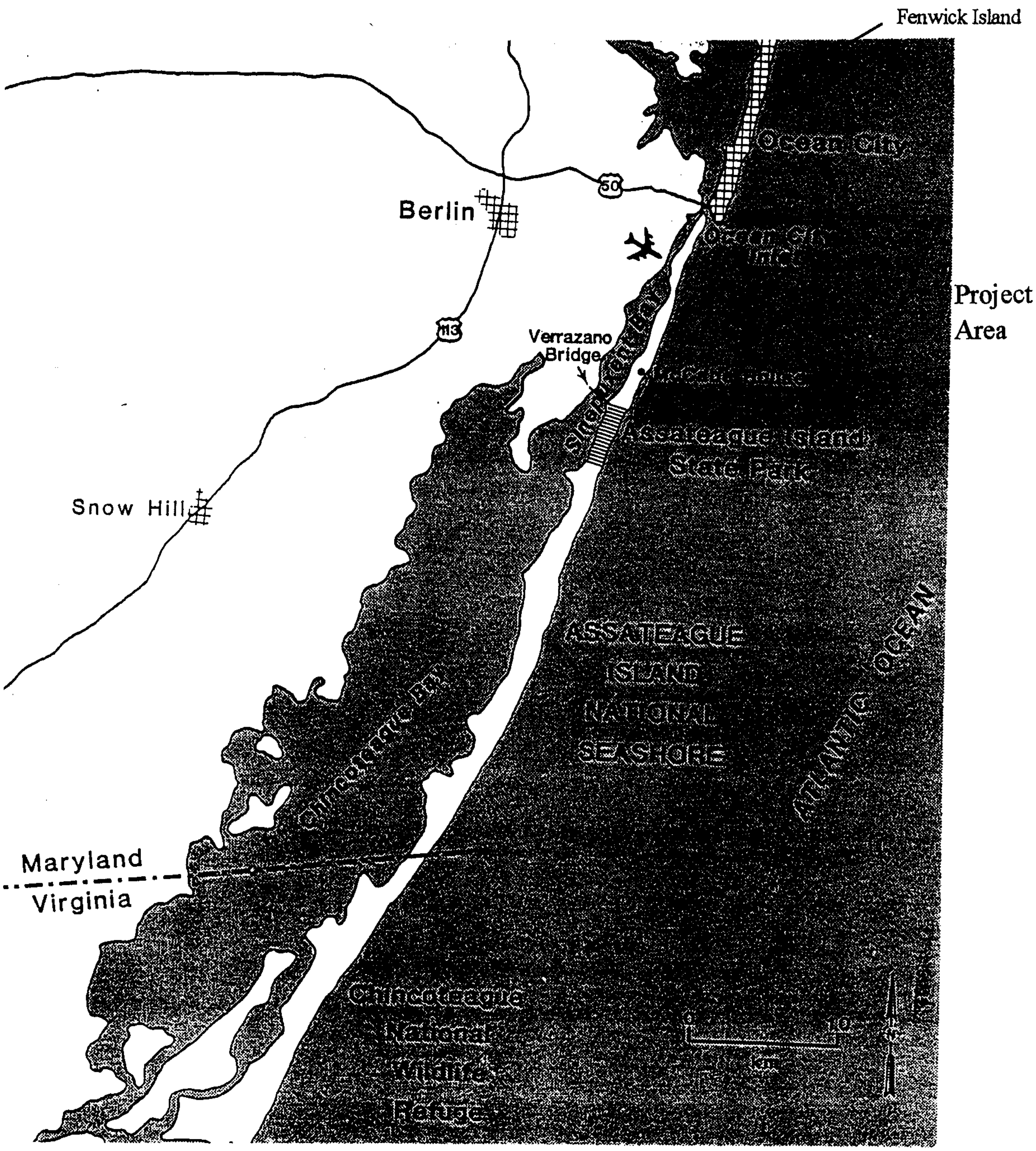
FIGURE 1

Regional Project Area Location



(Dean *et al.* 1986)

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FIGURE 2

Project Area Location

Northern End of Project Area Looking South from Ocean City Inlet along Assateague Island, April 1992 (MacIvor 1992).

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FIGURE 3

Northern End of Project Area

Southern End of Project Area Looking North from Assateague State Park Boundary along Assateague Island, April 1996. (MacIvor 1996).

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FIGURE 4

Southern End of Project Area

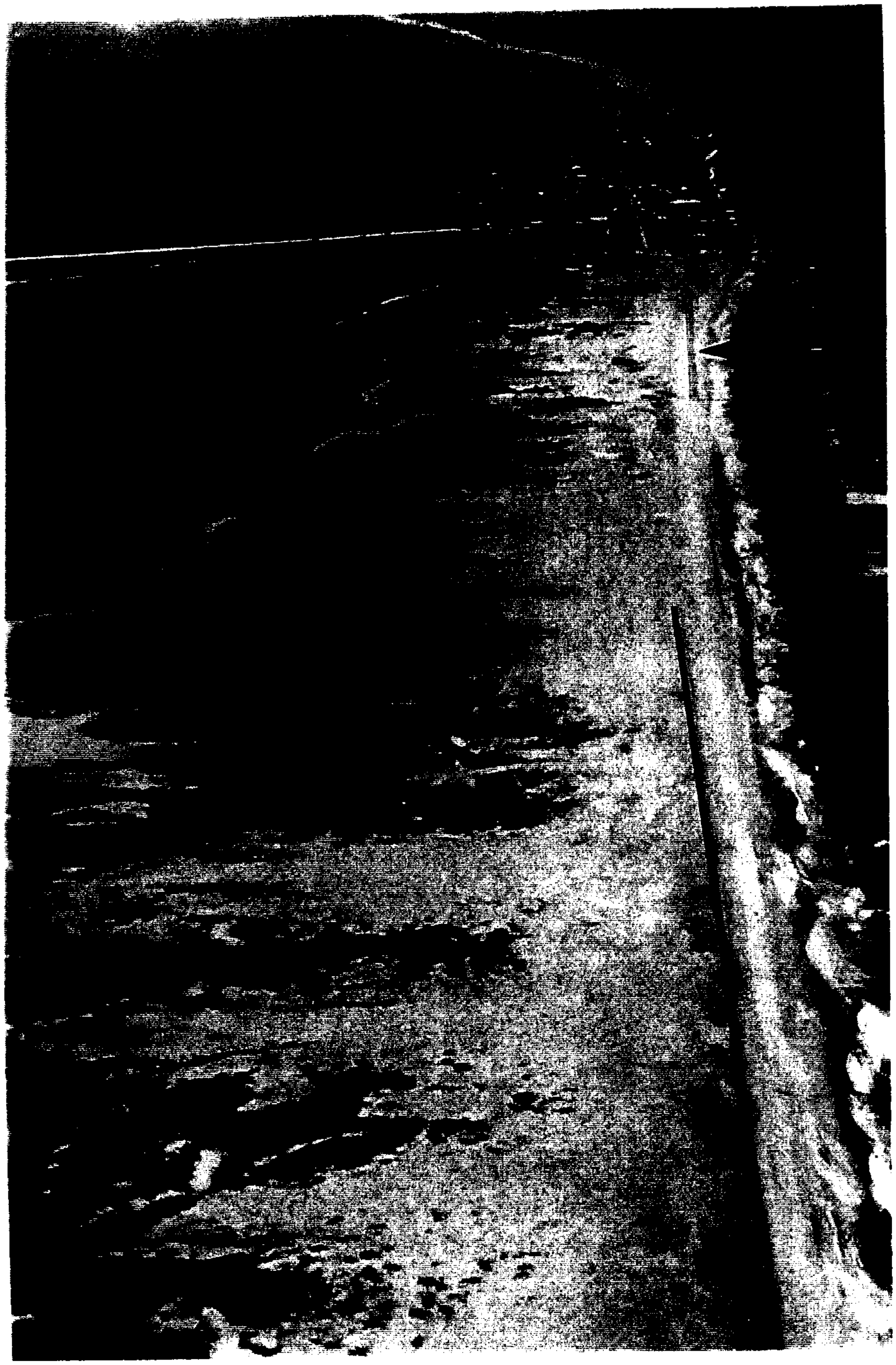
2.1 Review of Island Characteristics and Changes

The northern end of Assateague Island has historically been characterized by narrow widths, low-lying dunes, and washover fans. Early accounts of grazing by horses, sheep, goats, hogs, and cattle on Assateague Island's salt marshes were reported by Perkins and Bacon (1928). However, the extent and cumulative impacts of grazing, especially by horses, on northern Assateague Island's vegetation has not been documented. Prior to the existence of Ocean City Inlet (Figure 5), Shreve *et al.* (1910) described the island's morphology as a series of low and comparatively stable dunes that were discontinuous along the ocean side. The predominant plant along the dunes was American beach grass *(Ammophila breviligulata)*. Shreve described a small grove of loblolly pines *(Pinus taeda)* near Fenwick Light, at the extreme northern end of the sand bar, as being the only trees on the island's northern end, suggesting that maritime forest was absent. There was also indication of low shrub thickets and other low vegetation along the lee side of a continuous dunefield (Shreve *et al.* 1910).

Prior to 1933, what is currently known as northern Assateague Island was called Assateague Spit. Although Ocean City and Assateague Island were a part of Fenwick Island spit, Assateague Island was considered distinct from Fenwick Island. However, neither were actually islands and were instead extensions of the Bethany Beach, Delaware, headland (Underwood and Hiland 1995). On August 23, 1933, hurricane forces caused a major breach in the area now known as Ocean City Inlet, separating Fenwick Island to the north from Assateague Island to the south (Truitt 1967). Prior to stabilization, this inlet was approximately 3 m deep and 76 m wide (Underwood and Hiland 1995). One month later, the USACE began to stabilize the inlet through construction of stone jetties. Construction of the north jetty was initiated in September 1933 and completed by October 1934. South jetty construction began in October 1934 and was completed eight months later, in May 1935. Since that time, Ocean City Inlet has been maintained by dredging.

During 1849-50, island widths ranged from about 235 m to 527 m (770-1730 ft) (USACE 1994) and northern Assateague Island was thought to be migrating landward at the rate of approximately 2 m/yr (Underwood and Hiland 1995) (see Figure 6). At this time, a dynamic equilibrium existed between sand erosion and deposition, resulting in a relatively balanced sand budget. For example, sand lost during oceanside erosion processes was compensated for by sand deposition to the bayside through overwash processes. The Ocean City Inlet and jetties, resulting from the 1933 breach, interrupted the longshore transport of sand and caused sand accumulation on Ocean City beaches on the north side of Ocean City Inlet. In addition, offshore ebb-tidal and bay flood tidal shoals developed, trapping littoral materials before they reached Assateague Island. Sediment starvation on the south side of the inlet resulted in erosion on the ocean side of Assateague Island at a rate that outpaced formation of new land on the bayside. The impact on the northern-most 8.5 km was severe, with shoreline erosion and recession rates increasing to 9-12 m/yr (30 to 40 ft/yr) (Leatherman 1979).

Although accelerated retreat of the shoreline decreased the width and acreage of Assateague Island (see Figure 6) after 1934, it has been determined that net erosion (loss of volume) was occurring on northern Assateague Island even prior to inlet stabilization (USACE 1996). This indicates that the natural condition of the north end of the island was



Approximate Location of Ocean City Inlet

(Photograph taken in 1928)

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FIGURE 5

Ocean City Inlet Prior to 1933

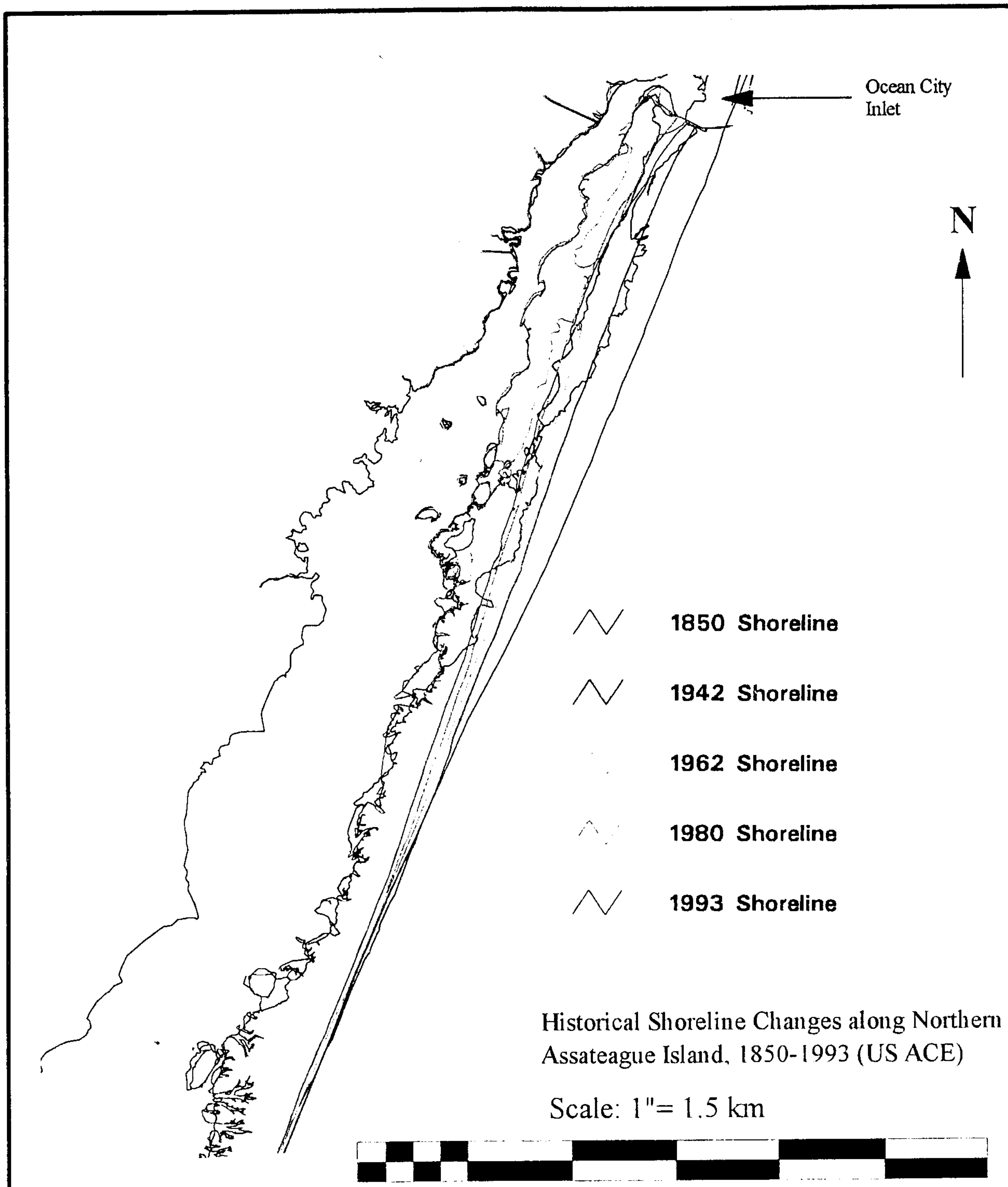

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FIGURE 6

Historical Shoreline Changes

typically narrow, low topography with frequent overwash. However, the rate of loss was much greater after the placement of the jetties. For example, between 1850-1933, the average net volume loss prior to inlet construction was 150,000 cubic meters per year, and between 1933-1995 was 255,000 cubic meters per year (USACE 1996). By the early 1950s, overwash deposition on the bayside appeared to reach a dynamic equilibrium with ocean-side erosion (USACE 1994), and by 1962 island widths ranged from about 161 to 311 m (530-1020 ft). Island width has actually increased since that year, partially due to routine and emergency placement of dredge material by USACE on northern Assateague.

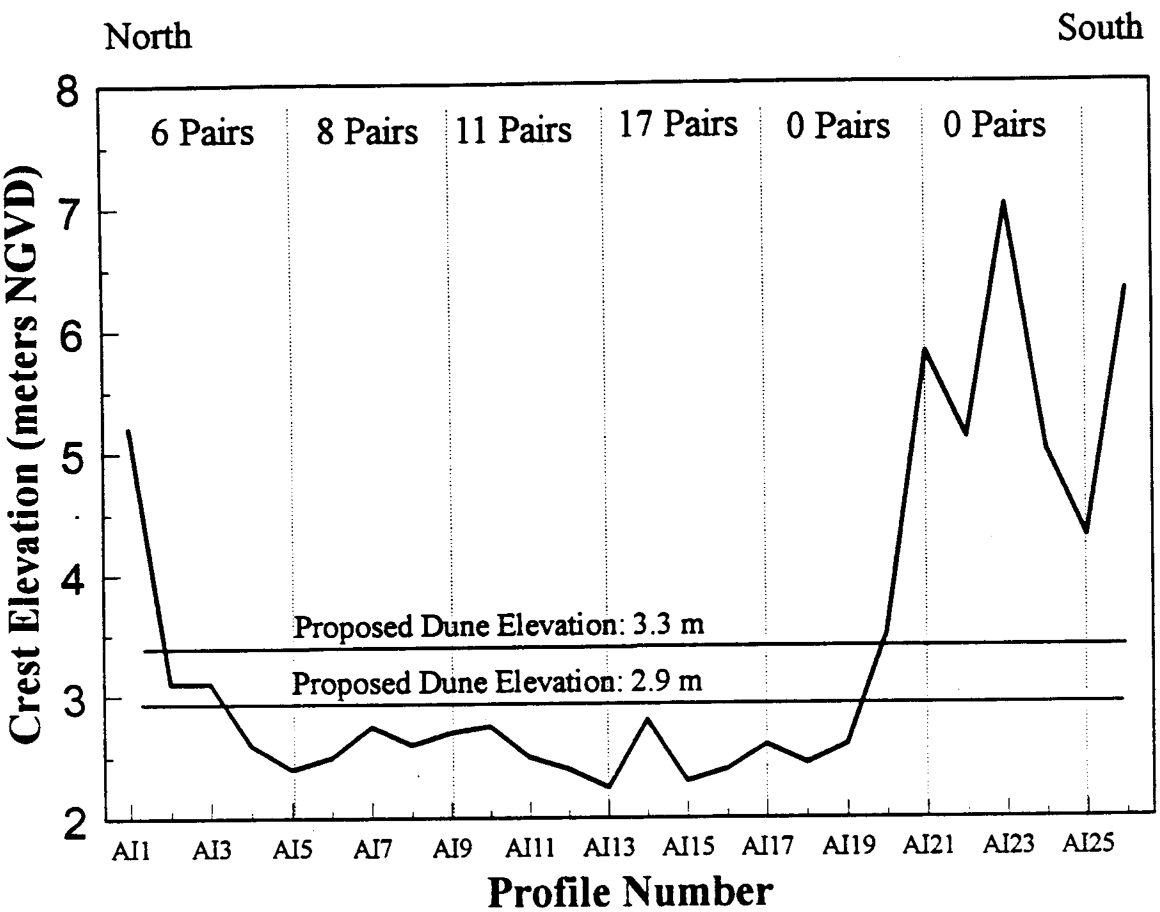
Strong northeasterly storms in November 1961 and March 1962 caused an additional two breaches on Assateague, one located at the inshore end of the south jetty (northern breach), and the other approximately 1.5 km south of Ocean City Inlet (Dean and Division of Beaches 1986). On March 9, 1962 the northern breach was calculated at mean low water (MLW) to be 122 m (400 ft) wide and 1.2 m (4 ft) deep. Since the southern breach was not affecting the navigation channel, it was not eligible for repair by the USACE. However, while construction activities were underway to fill the northern breach, some of the newly-deposited sand drifted to the southern breach and closed it off (Dean and Division of Beaches 1986). It is important to note that greater than one million cubic meters of sand were used to fill the northern breach in 1962. By 1965, this areas had breached again. A profile of the northern portion of the island and corresponding number of piping plover breeding pairs during 1995 are given in Figure 7.

During the 1962 northeastern storm, 32 of the 50 dwellings located on Assateague were lost and several others were damaged. Federal assistance to implement shoreline protection measures was requested by private citizens, but was rejected by the federal government. As federally-protected coastal recreation areas became more and more desirable, however, interests grew for creating a National Seashore. Finally in 1965, the Assateague Island National Seashore was officially authorized.

2.2 Piping Plovers

In 1986, piping plover populations were listed as endangered or threatened under provisions of the ESA (USFWS 1985). The Atlantic Coast population, which is considered threatened under the ESA, breeds and nests on sandy beaches along the east coast of North America from Newfoundland to South Carolina. Piping plovers typically nest above the high tide line along ocean shorelines, along gently-sloping foredunes, in blowout areas behind primary dunes, overwash fans and sandflats at inlets or ends of barrier islands, and in washover areas caused by the flow of water moving across the storm berm (USFWS 1995a). Preferred foraging areas include intertidal zones along ocean beaches, washover areas that remain moist throughout the summer, mud and sandflats, wrack lines, and shorelines of ponds and salt marshes (USFWS 1995a). One of the primary objectives of the Atlantic Coast piping plover recovery effort includes achieving well-distributed increases in numbers and productivity of breeding pairs. In recent years, Maryland has contributed dramatically to this goal with breeding pairs and productivity numbers reaching record highs.

Piping plovers typically return to the mid-Atlantic region in mid-March, but have been



Longitudinal profile of the northern end of the island. Data is from 1995. Maximum elevations run along berm or dune crest. Profile numbers increase southward. Profiles are placed at 0.5 km intervals; profile AI20 is located 10 km south of Ocean City Inlet.

Number of breeding pairs of piping plovers are calculated per 2 kilometers (dashed lines) and are based on 1995 nesting data.

(US ACE 1995)

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FIGURE 7

Assateague Island Dune Crest Elevations and Number of Breeding Pairs in 1995

observed as early as February 24 in Virginia (Cross 1991). Males begin to establish territories by early April. First nests on northern Assateague Island have been found as early as the third week of April (NPS reports), but eggs may be present on the beach from mid-April to late July (USFWS 1995a). Southward migration to the wintering grounds extends from late July, August, and September, but plovers are occasionally sighted during October (USFWS 1995a).

Although piping plovers depend on habitats that may change between years, they typically exhibit great site tenacity within and between years (Haig and Oring 1988,Wiens and Cuthbert 1988, Maclvor 1990). Over a six-year period, approximately 70 percent of surviving adult plovers were site faithful in Manitoba, Canada. At four breeding localities in Minnesota, 84 percent of all breeding birds nested within 200 m of their nest site of the previous year. At ten breeding localities over a five year period along Cape Cod, Massachusetts, up to 80 percent of banded surviving adults returned to the same breeding area to nest, and site fidelity was greater in males than females (same authors as above).

In some years, frequent clutch failures due to predators and storms provide opportunities for birds to change mates within the breeding season. Piping plovers are known to exhibit high mate-retention within the nesting season, but no not typically retain the same mate between years even if both birds return the following year (Haig and Oring 1988, Maclvor 1990). During studies in Manitoba, Canada, adults typically kept mates after nest destruction, but changed territories (Haig and Oring 1988). Birds changed territories more often following nest destruction by storms than following destruction by predation.

Shoreline stabilization and development along the Atlantic seaboard have been major contributors to the piping plover's decline through degradation and direct loss of habitat (Wilcox 1959). Predation and disturbance by humans and pets are also major factors that have limited reproductive success at many Atlantic Coast sites (Cairns and McLaren 1980, Flemming *et al.* 1988, Maclvor 1990, Patterson *et al.* 1991).

Maryland's remaining population of piping plovers is restricted to the Assateague Island National Seashore portion of the Island. This population has been monitored since 1986. During 1986-95, Maryland's portion of Assateague Island has supported between 14 and 44 breeding pairs of piping plovers. Reproductive success, measured as the number of chicks fledged per nesting pair, has greatly varied due to effects of predation and low chick survival caused by restricted access to the bay side for foraging (Table 1). During this time, the vast majority of nesting activity occurred along the northern 8 km of the island.

On Assateague Island in Maryland, piping plovers typically nest in open sandy areas that are frequently mixed with shell and cobble and have little or no vegetation. During a three-year study on Assateague Island by Loegering (1992), 81 percent of 46 plover nests had no vegetation near the nest. Between 1992-95, 68 percent (98 of 145) of total nests occurred in open habitats without vegetation (NPS Annual Reports 1992-95).

Table 1. Summary of Piping Plover Reproductive Success on Assateague Island National Seashore, 1986-1995

	86	87	88	89	90	91	92	93	94	95
Breeding Pairs	17	23	25[d]	20[d]	14[d]	18	24	20	32	44
Nest Attempts	23	33	34	27	20	20	30	30	42	45
No. Eggs Laid	87[a]	124[a]	116	92	76	77	104	104	155	168
Chicks Hatched	38	46	37	36	25	47	43	39	104	148
Hatching Success (%)[b]	44	37	32	39	33	61	41	38	67	88
Chicks Fledged	18	27	13	18	11	07	24	34	77	76
Fledging Success (%)[c]	47	59	35	50	45	15	56	87	74	51
No. Fledged per Breeding Pair	1.06	1.17	0.52	0.90	0.78	0.41	1.00	1.70	2.41	1.73
No. Fledged per Nest Attempt	0.78	0.82	0.38	0.67	0.55	0.35	0.80	1.13	1.83	1.69

[a] Estimated from available data (Patterson 1988)
[b] Number of chicks hatched per eggs laid
[c] Number of chicks fledged per chicks hatched
[d] Reproductive success was calculated from nesting pair (Loegering 1992)

Piping plovers on Assateague rear their broods on the bay beach, in the island interior, and on the ocean beach (Loegering and Fraser 1995). In certain years, vegetation blocked access between nest sites and the bay side, causing chicks to be restricted to ocean side foraging. Survival rates of chicks raised on the ocean beach were found to be lower than those of chicks reared on the bay beach (Patterson *et al.* 1991). During 1988-90, chicks with access to the bay side had higher daily survival rates than those without access (Loegering and Fraser 1995). Further, they found that piping plover chicks that occupied bay beach and island interior habitats had higher daily survival rates than chicks in ocean beach habitat. For chicks less than 20 days old, foraging rates on ocean beach were lower than on bay beach and island interior habitats. Findings from this study on northern Assateague indicated that ocean beaches had fewer insects, chicks foraged at a lower rate along the ocean beach, chicks weighed less, and exhibited higher mortality than chicks elsewhere.

Overwash has played an important role in maintaining suitable piping plover habitat on Assateague Island. Overwash was defined by Leatherman (1988) as any swash uprush that crosses the dune line or, if no dunes are present, the storm berm. Storm overwash can occur in a variety of situations, including through narrow dune gaps, over wide sections of the barrier with low dune topography, or over an entire stretch of the barrier island. Depending on storm magnitude and island width, the flow of water may or may not carry sand to the barrier flats and/or marsh on the bayside. An overwash fan was defined by Elias-Gerken (1994) as a break in a continuous dune or vegetation line where storm tides carry sand from oceanside to bayside, often clearing a vegetation-free path from ocean to bay. Usually overwashes occur during coastal storms, but a marginal event can occur during extremely high spring tide conditions at lower areas along the barrier dune line. On northern Assateague Island storm overwashes typically occur over wide sections of the barrier with low dune topography. During some storm events, overwashes have occurred over entire stretches of the island. During overwash, if scour of the barrier gets to an elevation below mean sea level, an inlet is created (Leatherman 1988). On the north end of Assateague Island, overwash processes appear to be essential in maintaining high quality piping plover nesting and brood rearing habitat (Loegering and Fraser 1995).

It is likely that piping plovers historically relied on winter storm events to create and maintain suitable nesting and foraging habitats by scouring and covering up vegetation (Loegering 1992). Maps showing overall vegetation cover along the northern 8 km of Assateague Island between 1985 and 1995 indicate great changes in the distribution of the island's plant communities (Figure 8). During Loegering's study, from 1988-90, there were no cross-island overwashing storm events and dramatic vegetative succession occurred within two years (Loegering, pers. comm.). He believes that the lack of overwash activity that resulted in vegetation encroachment, which reduces foraging opportunities for plovers, was a major factor in the population decline on northern Assateague Island during those three years (from 25 to 14 pairs). During this time, plover broods restricted to the ocean beach by either dunes
or vegetation had adequate nest success but nearly all chicks died. A relationship between the presence of overwash corridors and piping plover productivity was documented during this study (Loegering and Fraser 1995). Loegering also predicted that a piping plover population increase would follow major storm events.

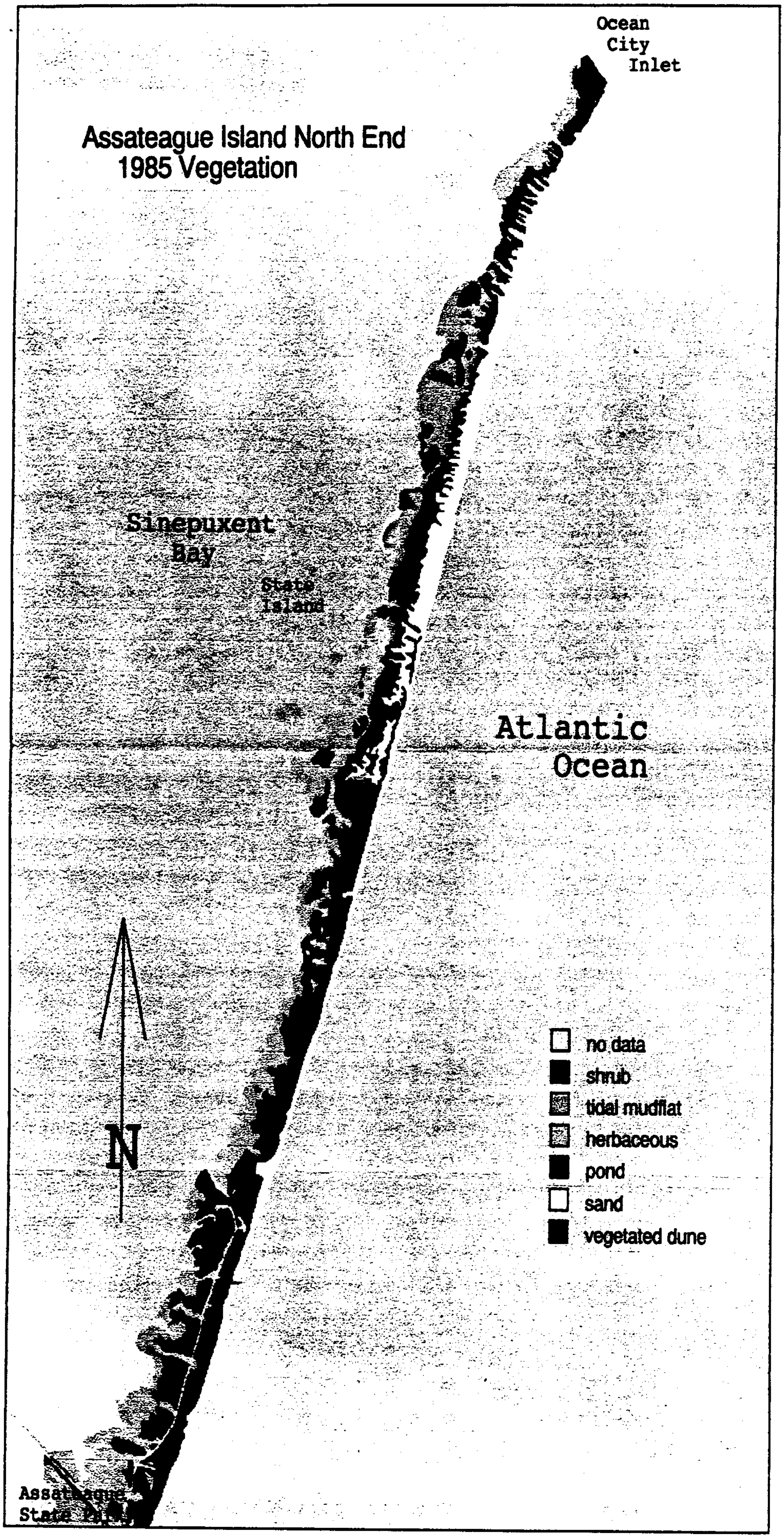

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FIGURE 8A

Northern Assateague Island Vegetation, 1985

(National Park Service)

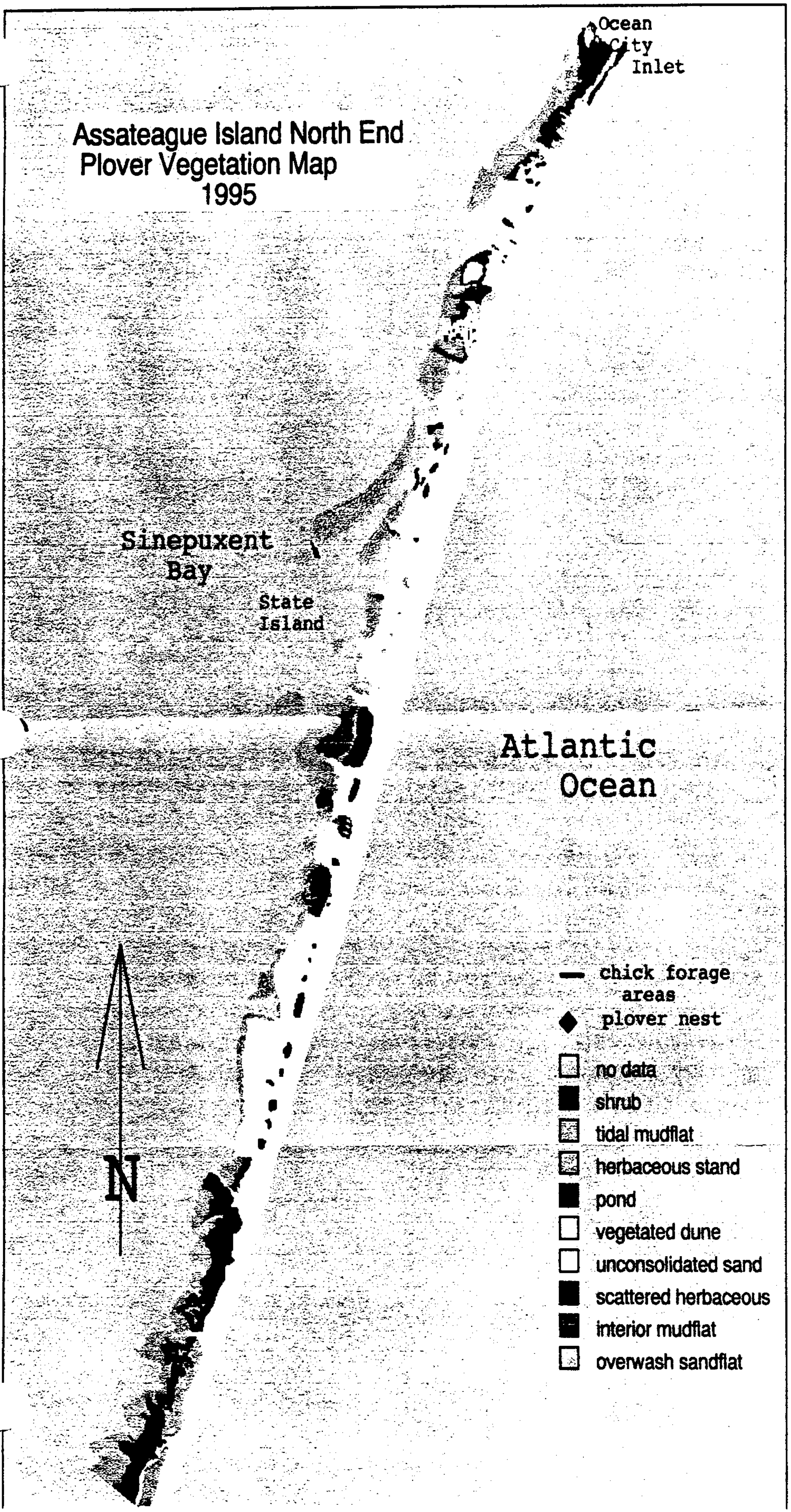

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FIGURE 8B

Northern Assateague Island Vegetation, 1995

(National Park Service)

Following the January 1992 storm, much of the northern portion of Assateague Island experienced cross-island overwash that scoured or covered vegetation. Large expanses of vegetation-free areas were created, increasing the areas available for nesting and improving access to the bay side for foraging chicks. Data collected between 1992-95 also showed a preference for interior and bay habitats by chicks. During these four years, 91 percent (1,621 of 1,775) of all chick observations along the northern 8 km of the island were of chicks using interior and bayside habitats and 9 percent (154 of 1,775) were of chicks using ocean beach habitats (NPS Annual Reports 1992-95).

Based on aerial photographs between 1992 and 1996, it appears that there has been very little change in overall vegetation and sand cover. Large areas of sand with low-lying dunes remain and areas that allow cross-island overwash are common. The more recent photographs (Sept. 1995) indicate that there are more channel corridors from the bay side and that they cross farther over towards the ocean side than in 1992. The role that bay side flooding plays in maintaining overwash areas is not well understood.

In 1995, the piping plover population increased to 44 breeding pairs, the highest number of pairs since monitoring began. Nearly 100 percent of the open areas were used by piping plovers for nesting and/or foraging (Figures 9 and 10). One of the two areas considered in this project as vulnerable to breaching consists of a large, mostly flat and unvegetated overwash area. (Figure 11). This low-lying area supported the highest concentrations of nesting plovers during 1995. However, reproductive success was lower in this area compared to other areas during 1995, potentially due to exposure to predators and weather because vegetation was completely lacking (Brady *et al.* 1995).

2.3 Seabeach Amaranth

Seabeach amaranth is an annual plant endemic to the barrier island beaches of the Atlantic Coast. Its primary habitat consists of overwash flats at accreting ends of islands, lower foredunes, and upper strands of noneroding beaches (USFWS 1995b). No vascular plant occurs at a lower topographic position on beaches than seabeach amaranth, though several others, notably saltwort (*Salsola australis*) and sea rocket (*Cakile edentula*), occur with amaranth. Seabeach amaranth occupies elevations from 0.2 to 1.5 meters (8 inches to 5 feet) above mean high tide and is usually found growing on nearly pure silica sand substrates, occasionally with a few shell fragments mixed in.

It historically occurred in nine states from Massachusetts to South Carolina. This species has now been completely eliminated from six of the States, including Maryland. Of the 55 remaining populations, 34 occur in North Carolina, 8 are in South Carolina, and 13 are in New York. Seabeach amaranth was federally-listed as threatened by the USFWS in 1993 due to its vulnerability to threats and its extirpation from two-thirds of its historic range (USFWS 1993). Proposed recovery objectives outlined in the Technical/Agency Draft Recovery Plan for Seabeach Amaranth calls for reestablishment of the species in eight of the nine states in its historic range (USFWS 1995b).

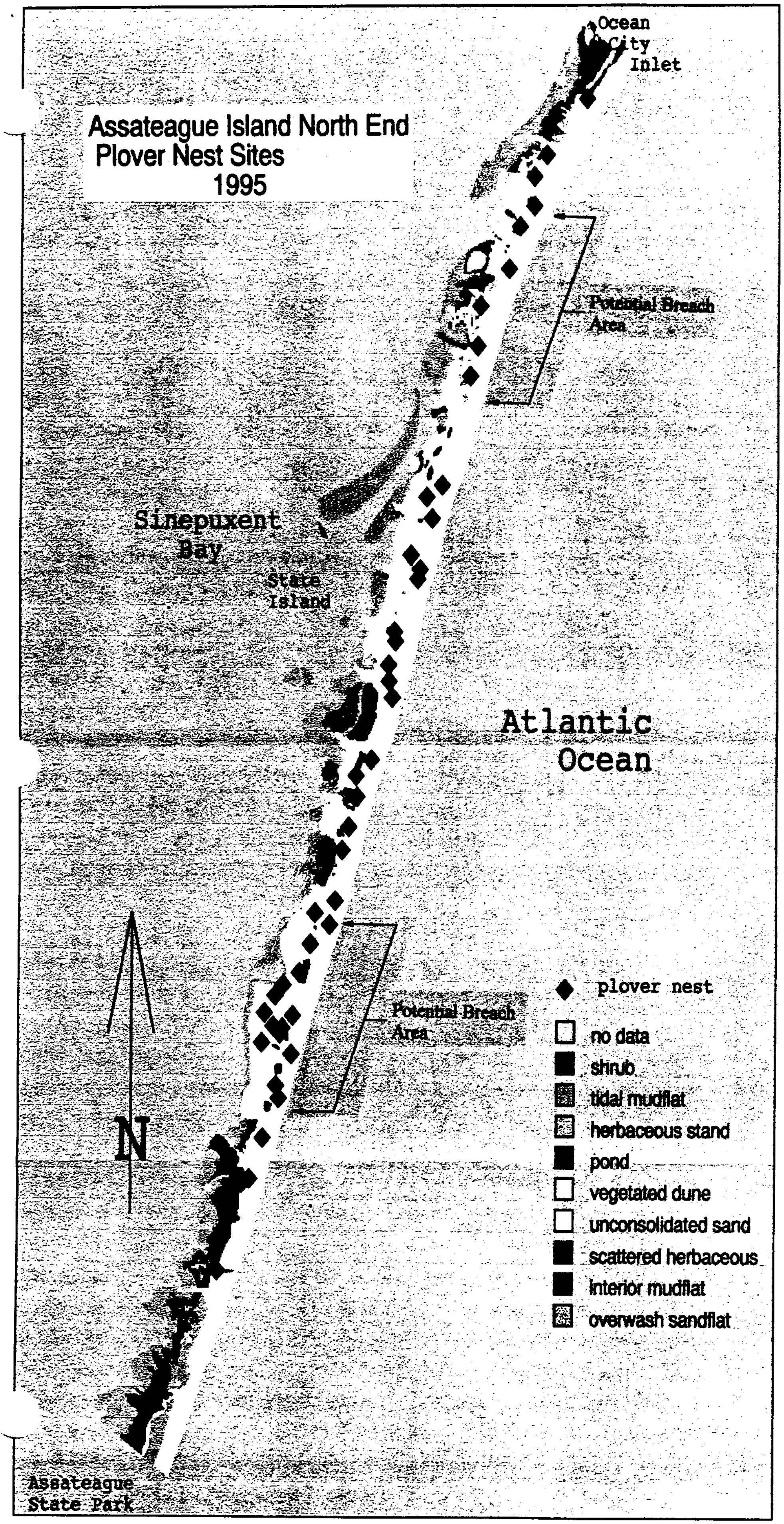

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FIGURE 9
1995 Piping Plover Nest Sites and Potential Breach Areas
(National Park Service)

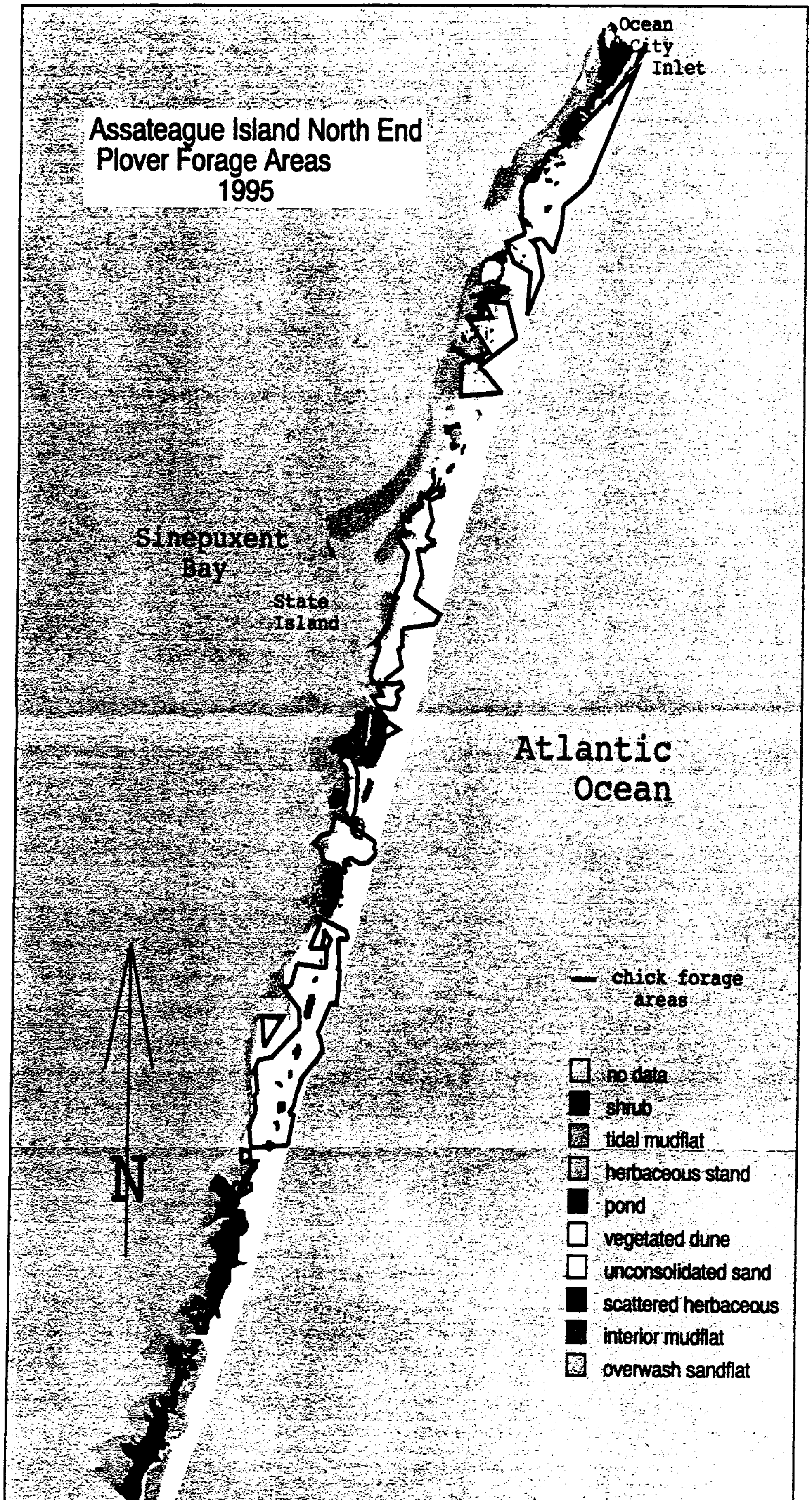

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FIGURE 10
Piping Plover Brood Foraging Territories
1995

(National Park Service)

Area Vulnerable to Breaching, 6-7 km South of Ocean City Inlet, Assateague Island, April 1996 (MacIvor 1996).

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FIGURE 11

Area Vulnerable to Breaching

Germination takes place over a relatively long period of time, generally from April to July (USFWS 1995b). Flowering can occur as early as June, but typically begins in July, and continues until the death of the plant in late fall. Seed production begins in late summer and continues until the death of the plant. Seeds are regularly produced by nearly all adult plants and seed fertility is assumed to be high. Under favorable conditions (without extreme weather events or webworm predation), the reproductive season may extend until January, or sometimes later in the south (Weakley and Bucher 1992). Presence of plants in any given year is evidence of reproduction in the former year, or even earlier reproduction and seed-banking. However, Ehrenfeld (1990) states that seed-banking in dune soils is small to nonexistent, likely due to the instability of the soil. Continual disturbance through deposition and erosion could either bury seeds too deeply for emergence or remove them entirely. However, it has been reported that dredged material placed on the beach harbored seabeach amaranth seeds that subsequently germinated and became established (pers. comm., N. Murdock, USFWS, to L. MacIvor on 30 May 1996). Based on morphology of the flower and inflorescence, seabeach amaranth is likely wind pollinated.

Seed dispersal is one of the most important characteristics of the biology of an annual plant such as seabeach amaranth. Lincoln *et al.* (1982) describe this species as a classic example of a fugitive species -- "...an inferior competitor which is always excluded locally under interspecific competition, but which persists in newly disturbed habitats by virtue of its high dispersal ability: a species of temporary habitats." Habitats for this species are sparsely vegetated barrier beach systems with annual herbs and, less commonly, perennial herbs and scattered shrubs. Many of these species are salt-tolerant and have life-histories that allow them to invade suitable habitat when it becomes available. Schafale and Weakley (1990) classified this vegetation type as Upper Beach.

Substantial or total mortality may be caused by early summer or fall hurricanes. This mortality does not necessarily result in population extirpation, but does reduce seed production, especially if the disturbance occurs during the growing season. For example, in 1989 Hurricane Hugo ended the amaranth season from Cape Fear south. However, amaranth populations that had been absent for several decades, reappeared in New York following Hurricane Hugo. Although this species may prefer disturbed overwash areas, such as washover flats and accreting ends of islands, storm tides during the early growing season can cause early mortality of young plants. Although hurricane flooding will generally kill seabeach amaranth plants, effects of a major hurricane such as Hugo on populations of this species need to be investigated (USFWS 1995b). Seabeach amaranth appears to be intolerant of competition and does not occur on well-vegetated beaches.

The absence of seabeach amaranth in certain portions of North Carolina corresponds closely with the artificial construction of a continuous barrier dune by the NPS. When looking at areas that represent altered and natural states of barrier islands in North Carolina, the most striking contrast is a large difference in beach width. The unaltered islands, which are more likely to have seabeach amaranth, have much wider beaches than the stabilized ones.

In Maryland, seabeach amaranth was last reported during botanical surveys on

Assateague Island in 1967 (Higgins *et al.* 1971). Hill (1986) returned to the reported location, but after extensive searches did not find it. The Maryland Natural Heritage Program is considering a reintroduction project on Assateague Island. Without the reestablishment of seabeach amaranth in Maryland, it is unlikely that the recovery objective will be met to reestablish populations in eight of the nine states where it historically occurred.

3.0 PURPOSE AND NEED FOR PROJECT

Although major shoreline retreat rates have been evident along northern Assateague Island between 1850 to 1993 (Figure 6), the recession and erosion rates have noticeably increased along the northern 8.5 km since 1933. The natural opening of the Ocean City Inlet by the 1933 hurricane, and subsequent stabilization and maintenance of the Inlet, has resulted in sediment starvation at the north end of Assateague Island. This has resulted in a very low-profile barrier island with increased vulnerability to breaching, a reduction of the island's buffering effect of the mainland during storm events, and altering of ecological character. Due to the accelerated erosion and landward migration of the island, as well as the potential impacts on natural resources and visitor use, the NPS identified the erosion problem as a priority management concern. It has been reported that if erosion continues at its present rate, the island is likely to breach by the formation of a new inlet at any time and is expected before the year 2020 (Dean and Division of Beaches 1986).

3.1 Project History

In February 1986, the NPS sponsored a workshop with the purpose of identifying appropriate management alternatives for addressing the erosion problem and its impact on island geomorphology, estuarine biology, and socioeconomic factors (Dean and Division of Beaches 1986). In July 1990, staff from NPS met with the U.S. Army Corps of Engineers Waterways Experiment Station's Coastal Engineering Research Center (CERC) to discuss physical and ecological changes occurring along northern Assateague Island. By 1992 a contract was in place to continue work on analyzing historical shoreline erosion trends along northern Assateague Island and evaluate how they may correlate with the Ocean City Inlet ebb-shoal growth (Underwood and Hiland 1995).

In 1994, the USACE completed a comprehensive study of navigation, storm damage, environmental quality, and water resources and evaluated how they are impacted by the dynamic processes associated with Assateague's barrier island and bays (USACE 1994). The reconnaissance surveys defined the general scope of the problems within study area and determined federal interests (USACE 1994). This study included a discussion of endangered, threatened, and rare species, but did not address specific impacts to these resources.

3.2 Current Problems

Sections within the northern 10 km portion of the island now appear to be highly vulnerable to breaching and this threat may even extend to 13 km south of the Ocean City Inlet jetties. However, available data suggest that the greatest amount of island retreat is along the northernmost 8 km. Current erosional conditions do not favor the reestablishment of natural dunes. Also, destruction of the primary dune system on the northern end of the island has diminished the ability of northern Assateague to buffer the mainland from coastal storms.

The Ocean City Water Resources (OCWR) study team has recently proposed a problem statement, objectives, and alternative solutions for immediate measures to restore the sediment supply and prevent a breach on northern Assateague Island until a long-term solution is implemented.

3.3 Proposed Project Description

Although long term goals by ASIS include environmental restoration of Assateague Island to counter effects of sand starvation caused by artificial stabilization of Ocean City Inlet, long-term management solutions are only in the initial planning stages at this time. This assessment will address the impacts of the short-term actions only for the immediate restoration of northern Assateague Island. Realizing that the proposed alternatives for the immediate actions will likely provide the island with only temporary protection and short-term restoration of sand, future implementation of a long-term restoration program is critical.

The current project area encompasses approximately the northern 13 km of the island (Figure 2). The area considered for the short-term assessment occurs between Ocean City Inlet and the State Park (Figures 3 and 4). However, the area of most concern is the northern-most 8 km due to its low lying topography and susceptibility to overwash. Two areas have been identified as being vulnerable to breaching (Figure 9). One location, approximately 1.5 km to 3 km south of the Inlet, was identified as having the highest shoreline erosion rate within the northern 10 km (Dean and Division of Beaches 1986). This study predicted that within a few years the barrier morphology would be so low and narrow that breaching would likely occur. The other area was recently identified as vulnerable based on its low topography and its frequent overwash activity. This area is located between 6.0 km to 7.5 km south of the Inlet (USACE 1996).

Sediment restoration and breach prevention were identified as co-principal objectives by the OCWR study team. To address restoring the sediment supply, a restoration volume was calculated based on the year the National Seashore was established. CERC determined that since 1965, over 3,000,000 m^3 of sand has failed to reach Assateague Island due to the interruption of the normal longshore transport system caused by the placement and maintenance of the jetties. The proposed lengths of the island considered for restoration are based on historical and current data, reports, maps, and aerial photographs indicating where accelerated retreat has occurred.

Based on longitudinal profiles of the northern 13 km of the island (Figure 7), a 9.2-km reach of the island is especially vulnerable to breaching. To reduce the probability of a breach, the OCWR study team proposed that island height and width be increased. However, CERC predicted that only a small decrease in water level response will result from a width increase alone and that island height is a much more important variable. Based on these findings, alternatives that rely on increasing width alone were excluded. The locations for placing sediment are along the shoreline of the restoration reach.

Two dune heights along two restoration shoreline lengths using two volumes of sand have been proposed under alternatives involving dune construction (Table 2). To maintain quality habitat for nesting plovers by keeping out woody vegetation and preventing a

Table 2. **List of Alternatives Involving Dune Construction**

Preliminary Restoration Length (km) (measured from inlet)	Preliminary Volume of Material (m^3)	Berm Height (m) NGVD	Berm Extension (m)
~10	~1,500,000	2.9	To be determined
		3.3	To be determined
	~3,000,000	2.9	To be determined
		3.3	To be determined
~13	~1,500,000	2.9	To be determined
		3.3	To be determined
	~3,000,000	2.9	To be determined
		3.3	To be determined

dominance of perennials, it was determined that an overwash frequency of at least one event per one to two years or less (i.e., cross-island overwash) was required (pers. comm., A. Weakley, The Nature Conservancy, N.C., to USACE, 4 December 1995). Although the importance of overwash seasonality is unknown, overwash activity would be most expected during hurricane and northeaster seasons (Dolan *et al.* 1988). Based on water level responses for frequent storm events over the past six years near Assateague, CERC calculated that the maximum berm height that would allow for the needed overwash frequency of once per year or less would be 3.3 m NGVD (National Geodetic Vertical Datum). The other height that was proposed is 2.9 m NGVD.

The proposed dune heights of 3.3 m and 2.9 m are not above current elevations, but are above sea level. Berm elevations in the low relief areas along northern Assateague Island ranged between 2.3 - 2.8 m during 1995. The proposed heights would, therefore, increase the existing berm elevation between 1.0 to 0.2 m (to reach 3.3 m dune height) and 0.6 to 0.1 m (to reach 2.9 m dune height) , resulting in low overall topographical relief (Figure 7).

Variables governing the berm configuration include restoration length, berm height, and sediment volume to be placed on the island. Berm extension widths will be largely determined by the total volume of material to be placed. Local beach conditions may induce need for local variation in berm width. For example, 3,000,000 m^3 along a 6.5 km length is the maximum berm width that would be created/restored if this volume was placed uniformly along this reach.

With the exception of the dune feature, all of the "Construct Dune" alternatives involve placement of material seaward of the existing high water berm at an elevation at or below existing conditions (Figure 12). The dune feature, itself, may be overlaid on either the existing beach or the new berm extension. The majority of the depositional material will be placed at or below the existing berm elevation in what is currently the intertidal zone. The volume of material to be incorporated in the dune will be less than three percent of the entire proposed volume of sand to be restored.

The source for sand has not yet been determined, but an offshore shoal is likely to be used for restoration material. USACE (1995) sampled 13 northern Assateague profiles for sand grain-size. Grain-size ranged from an average of 1.76 ϕ at the dune base, to 1.15 ϕ at mean low water, to 2.23 ϕ on the nearshore sand bar crest. For the proposed action alternatives, sand grain-size will be approximately 1.62 ϕ with a standard deviation of 0.80 ϕ.

If an action alternative is selected, sand will be transported by barge or piped to the island after being hydraulically mined from an offshore shoal. Material will then be hydraulically deposited on the beach berm and/or in the surf zone, or dumped from a hopper into the surf zone. It has not been determined whether any earth-moving equipment will be used for placement and shaping. For any action alternative, there will be no effort to maintain or re-nourish the newly-added material following deposition and configuration of sediment. ASIS is not interested in a solution that depends upon routine beach nourishment and maintenance, but wants to allow the natural coastal processes to drive the system. All alternatives relating to berm construction are designed for meeting project objectives for a

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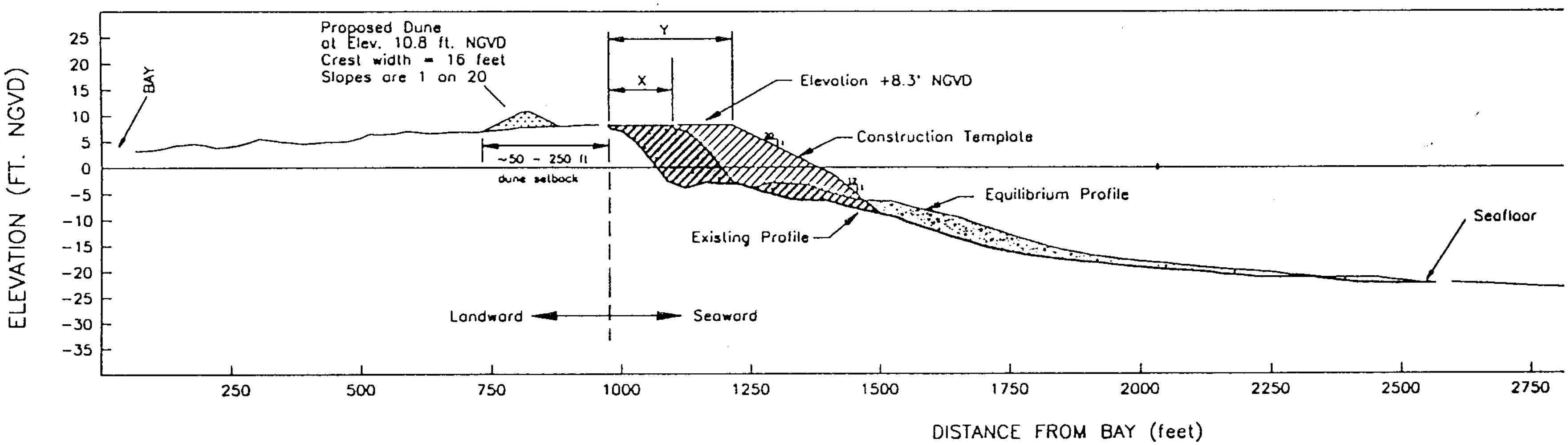
FIGURE 12

Assateague Island Proposed Restoration Project



Notes:

1. Section Based on Assateague Island Profile NPS 175m, taken September 28, 1995.
2. Profile shows sand as initially placed (construction template) and after adjustment due to the action of waves fore several months (equilibrium profile). Profile also shows range of design width and setbacks under consideration.
3. Vertical exageration is 10x.
4. Dune elevation is based on the 3.3m alternative.
5. X = Design width, Y = Construction width.

short-term period (approximately 5 years) until a long-term restoration project can be implemented. Currently, ideas for the long-term restoration project include a sand by-pass plant at Ocean City, or a program of periodic beach nourishment to Assateague Island using sand from one of the offshore shoals.

Any construction activities or related action from this project must minimize impacts to threatened and endangered species. Piping plovers are currently the only remaining federally-listed species on Assateague Island. However, another federally-listed species, seabeach amaranth, historically occurred along Assateague Island but has not been seen in Maryland since 1967 (Higgins *et al.* 1971). A reintroduction program for this species is being considered by the Maryland Department of Natural Resources and may be essential to meet the recovery goals for seabeach amaranth.

As a follow-up to the reconnaissance report, the OCWR study team was formed during 1995, including staff from USACE, NPS, USFWS, Maryland DNR, Worcester County, and the Town of Ocean City to determine specific problems and initiate a feasibility study for the immediate restoration of Assateague Island. To formulate potential alternatives for the immediate restoration project for northern Assateague, the OCWR study team developed a list of preliminary objectives:

1. Restore volume of sediment
2. Reduce probability of breach
3. Develop mitigation protocol for response to future breaching events
4. Minimize impacts to piping plovers
5. Promote natural diversity

These objectives provided guidance in the formulation of alternative solutions for Assateague Island's restoration. Several alternatives were excluded due to political, economic, or environmental concerns, including removal of the existing jetties and construction of offshore breakwaters. A preferred alternative has not been selected.

4.0 PIPING PLOVER IMPACT ASSESSMENT

This section includes an assessment of potential impacts on piping plovers from the proposed alternatives by the USACE for the immediate restoration of northern Assateague Island. There are ten scenarios being proposed under six main alternatives, including the "no action" alternative and five alternatives that involve some level of construction. A discussion of the potential impacts on piping plovers for each of the scenarios is provided in the following subsections. The discussion focuses on actions likely to occur within the short-term, defined as the next five years.

4.1 Alternative 1 - No Action

In the event that a breach does not occur, the overwash zone area is expected to continue to expand southward and increase in size (Dean and Division of Beaches 1986). Island height is expected to remain constant or to decrease slightly. Island width is also expected to change little, although island retreat and erosion rates will increase southward. If a breach occurs, and no repairs take place, erosion patterns similar to those observed in 1962 will likely occur. Overwash zone areas will continue to expand southward (Dean and Division of Beaches 1986, USACE 1996). There are two locations where breaches are likely to occur within the next few years (see Figure 9, Section 3.3).

In the short term, implementing the no action alternative may increase the amount of suitable plover habitat because open, sparsely vegetated areas will be maintained and will continue to form in overwash zones. Preferred nesting, brood rearing, and foraging habitats will be available as the overall breeding population of plovers increases. While plovers nesting in overwash areas are expected to experience a temporary decrease in productivity from increased loss of eggs due to flooding, this mortality should be localized. Further, minor losses in productivity will be more than offset by subsequent increases in available habitat, which should lead to increased nesting opportunities. If no action is taken and there is a very large storm event (i.e., a hurricane), however, there may be a drastic decrease in plover habitat. Nesting plovers would then be subjected to a higher frequency of flood tides, likely resulting in poor nesting success. If a hurricane results in the island breaching, it is possible that piping plovers might be isolated from predators on the north side of the breach. Further, suitable habitat for seabeach amaranth might be created on the accreting edges of the new inlet

4.2 Alternative 2 - No Action but Repair Future Breaches

Under this alternative, there would be no beach restoration until a breach occurs. When this happens, the overwash area will be filled with dredged material to a level consistent with that of its pre-breach character. This alternative assumes that a decision-making protocol for breach repair will be in place when a breach occurs. A breach contingency plan will be developed by the USACE so that detrimental environmental impacts from plan implementation will be minimized.

In the event of a breach, there will likely be both positive and negative impacts to plovers. The positive impacts are similar to those discussed above and would include a potential increase in the amount of plover habitat, and overall plover productivity if other factors like predation levels continue to be low. Impacts to plover populations from a breach would depend on the time of year when the breach occurs. For example, if a breach occurs and is repaired during the winter, when plovers are not on-territory (occupying a nest site), there would be no direct impacts. However, if the breach occurs during the summer nesting season, there would be direct impacts from the breach itself, and indirect impacts from the repair activities. Although a breach is most likely to occur during the hurricane/northeaster season (August to April), breach repair may occur at any time of year, depending on lag time between breach and repair action implementation. The extent of disturbance to plovers from repair activities will also vary with the size and location of the breach, numbers of plovers attempting to nest or renest near the breach, and the specific construction techniques used for repair. Adult plovers may be discouraged from nesting along the edges of the breach site and move to less optimal sites, possibly resulting in lower productivity. In the event of a major breach, it is possible that there would be an overall decrease in plover productivity if the overwash lowers island topography to a level where summer high tides flood nests.

Potential adverse impacts to piping plovers may occur as breach repair results in forestalling the natural inlet migration. Areas that form behind migrating inlets often support excellent nesting and foraging habitats for piping plovers. The southern most potential breach area currently supports sparsely vegetated suitable nesting habitat. If this area breaches and is repaired with pre-breach character, net loss of habitat will likely be minimal. However, it is possible that due to the vegetated area of the northern potential breach area, loss of opportunities for formation of suitable habitat may be substantial.

4.3 Alternative 3 - Construct 3.3-m Dune Along 9.2 km of Shore

Under this alternative, a 3.3-m high dune will be constructed along the northernmost 9.2 km of the island. The dune will have 1:20 side slopes and a 4.9-m crest width. The western toe-of-slope of the dune will be, at most, 76 m from the existing berm crest. Dune location will depend on the volume of sand added and the resultant berm width. This proposed dune alternative is either in, or adjacent to, areas that were occupied by 44 pairs (100 percent of the Island's population) of nesting piping plovers in 1995 (Brady *et. al.* 1995). In 1995 three nests were directly within the proposed work area, 30 (67 percent) were within 150 m of the proposed work area, and 42 (93 percent) were within 225 m of the proposed work area. The proposed year of construction and seasonal schedule for completing the work are unknown at this time. In addition, it is unknown whether a berm will be constructed in the intertidal area as a sacrificial beach. The timing and physical placement of this dune alternative may affect the degree of impacts to piping plovers.

If placement of sand and dune construction occurred outside of the nesting window, direct impacts could be eliminated. Assuming the newly placed material has similar substrate qualities and the newly constructed dune maintains a gradual slope (seaward and landward), it is likely that plovers will occupy this new area for nesting the following spring. Based on the recent increase in numbers of breeding pairs and high reproductive success, recruitment rates into the population are likely to be high, resulting in a concomitant increase in numbers of plovers using Assateague Island. Although additional suitable habitat is likely to be used by plovers on Assateague Island for nesting, it is critical that any new nesting habitat also has access to brood-rearing and foraging areas, and promotes good reproductive success.

4.3.1 Width Based on 1,500,000 m^3 of Sand

If this alternative is implemented there will likely be a decrease in the frequency and intensity of overwashes from that which presently occurs. This factor may be the single most important consideration for the maintenance of piping plover habitat on Assateague Island. If the proper number and intensity of overwashes do not happen, plant succession will likely begin in as little as 1-2 years, and areas that are now devoid of vegetation or sparsely vegetated may become dominated by plants, rendering them less suitable for plovers. The key to plover success on Assateague Island is maintaining vegetation-free corridors between the bay and ocean (Loegering and Fraser 1995). These corridors are primarily maintained by cross-island overwashes from both the bay and the ocean (Dean and Division of Beaches 1986, Loegering and Fraser 1995). Overwashes control vegetation by killing species intolerant of high salinity, and by transporting sand and burying plants.

Assuming that the constructed dune will not be maintained after initial placement of material, it is possible that there will be a lowering of the constructed dune/berm following the first overwash event. If this occurs, large portions of the restored area may be prone to overwash, although less so than what currently occurs today.

Dune and berm construction activities may also cause impacts to plovers on Assateague Island. If dune or berm construction occurs during March-August using heavy equipment, there will be direct and indirect impacts to plovers. In 1995, three nests were located in the area where the dune is proposed for construction. Further, the proposed location of the dune is adjacent to areas that contained 39 nesting pairs of plovers. All breeding pairs had nests that were located within 225 m of the proposed dune and could potentially be affected by disturbance from construction activities. Trucks or bulldozers, for example, could trample plover chicks, or noise from their operation could impact mate selection, courtship displays, and territorial defense. Exact timing and methods of construction are needed to determine these types of potential impacts.

Based on the upward trend that Maryland's population of piping plovers is currently experiencing, it is likely that the newly placed dune/berm material will be used by nesting piping plovers assuming that substrate types are similar to current conditions. Although monitoring data from Assateague Island indicate that some plover broods travelled long distances from their nest sites to foraging areas, farther distances are more costly energetically and broods suffer higher risks to predation and exposure from inclement weather (Loegering 1992). However, these risks may be offset by the potential benefits (increased number of breeding pairs) associated with the creation of suitable habitat resulting from sand placement. If needed overwash frequencies are not met, however, due to the proposed increased height and width, and result in travel corridors being blocked by vegetation, broods will be restricted to the beach side for foraging and resting. Plover broods restricted to the ocean beach on Assateague Island by either dunes or vegetation had adequate nest success but nearly all the chicks died (Loegering and Fraser 1995). Increasing number of breeding pairs without good productivity will not meet overall recovery goals for the Atlantic Coast piping plover population.

By placing sediment inter- and supra-tidally, lower densities of macroinvertebrates may result. Although northern Assateague Island broods typically forage on the bayside, adults often feed along the intertidal zone during migration and during territory establishment. It is unknown how rapidly intertidal populations of macroinvertebrates may recolonize. Moist areas (including ephemeral pools) provide excellent foraging habitats for adult and chick plovers. Maintaining these sites by promoting the occurrence of cross-island overwash can benefit plovers by providing a diversity of habitat types.

4.3.2 Width Based on 3,000,000 m^3 of Sand

This alternative may result in similar, but worse, impacts as those outlined above in Section 4.3.1. Impacts may be potentially more adverse due to the increased amount of construction effort and time needed to place and configure more material. For example, if a conservative two-month operating window is used outside of the nesting season, the 3,000,000 m^3 alternatives would take approximately 6.8 months and the 1,500,000 m^3 would take 3.4 months. There is also more potential for sand to be carried inland creating more upland habitats and/or carried inland into the interior wetlands of the island. The greater amount of depositional material, the more potential for longer duration of impacts, including the creation of more upland areas, establishment of more vegetation, and the larger storm that may be required to remove it once established

4.4 Alternative 4 - Construct 3.3-m Dune Along 12.9 km of Shore

The actions proposed under this alternative are similar to those discussed above under Section 4.3, except that the project area is 3.7 km longer. The barrier island is well-vegetated in the 3.7 km area and it is also wider. There were no known nesting plovers within this additional area in 1995.

4.4.1 Width Based on 1,500,000 m^3 of Sand

Under this scenario 1,500,000 m^3 of sand will be deposited along 12.9 km of beach. Impacts to plovers under this alternative will likely be similar to those discussed above. Berm width will likely be more narrow as the restoration length increases and volume decreases. Impacts from construction activities could affect most of the birds using the island from March-August. Impacts to the plovers will depend on the specific construction techniques used and the time-frame in which they occur. Construction during September-February will likely have little direct impact on plovers, while construction during March-August could have adverse impacts.

In the short-term, if this alternative is implemented with extending the berm seaward, some additional plover habitat may be created. Suitable nesting habitat will be created on the seaward side of the dune. However, this is not the preferred side for nesting on northern Assateague Island. Chicks from these nests may still move to the interior or bayside habitats for foraging and resting, which will increase their vulnerability to predation, disturbance, and exposure to inclement weather. However, by increasing the width of the island, there will be more available habitat for the breeding population. In recent years, Assateague's plover population has undergone an increase due to greater availability of preferred nesting and foraging habitats, lower predation pressure, and increased management.

4.4.2 Width Based on 3,000,000 m^3 of Sand

Under this scenario 3,000,000 m^3 of sand will be deposited along 12.9 km of beach. The impacts of this alternative to piping plovers will likely be very similar to those discussed under Sections 4.3 and 4.4.1.

4.5 Alternative 5 - Construct 2.9-m Dune Along 9.2 km of Shore

Under this alternative a dune will be constructed at elevation 2.9 m for a distance of 9.2 km along the island. The difference between this alternative and that presented in Section 4.3 is that the final elevation of the dune crest will be 0.4 m lower. This lower dune height would likely allow a greater frequency of overwashes at least in the initial stages of sand placement. However, due to the non-maintenance protocol proposed, it is likely that both proposed heights may decrease in elevation following wave activity capable of toppling the dunes. It is unknown, however, if the overwashes will be capable of maintaining and creating unvegetated habitats preferred by plovers. Based on CERC's storm event data, of the 14 storms that occurred during the last six years, 12 would have potentially overwashed a 2.9-m-high dune. Based on the 3.3-m dune elevation, only 6 of 14 storms would have had waves potentially overwashing the dune. The magnitude and duration of storm will determine whether waves will overtop the dune crest with sufficient water volume to substantially contribute to the maintenance of corridors to interior or bayside plover brood-rearing and foraging habitats.

4.5.1 Width Based on 1,500,000 m^3 of Sand

If this alternative is implemented it is possible that the desired overwash frequency will be met in the short-term. These overwashes should maintain habitat conditions favorable for plovers, similar to those discussed under Alternatives 1 & 2.

All of the potential dune and berm construction activities that may impact plovers, described in Section 4.3 and 4.4, would be pertinent under this alternative as well. Depending on how, when, and where construction activities take place, there could be impacts to plovers.

4.5.2 Width Based on 3,000,000 m^3 of Sand

The potential impacts to plovers under this alternative are very similar, but greater, to those just described. Impacts would likely be greater because twice as much sand will be used to build the dune. The area occupied by the dune would be larger and would have the potential to displace more pairs of plovers. In addition the amount of time and level of effort to build the dune would also be greater, which could cause more impacts to plovers if work is conducted from March-August.

4.6 Alternative 6 - Construct 2.9-m Dune Along 12.9 km of Shore

Under this alternative a dune will be constructed at elevation 2.9 m for a distance of 12.9 km. This alternative is very similar to that described in Section 4.5 except that the proposed dune would extend for 3.7 km further south.

4.6.1 Width Based on 1,500,000 m^3 of Sand

Based on the CERC model, overwash would have occurred during 12 out of 14 storms in a six-year period, given the 2.9 m high dune. This indicates that preferred plover habitat may be maintained in the short-term if water traveled through the overwash corridors. In addition, because the 1,500,000 m^3 of sand would be deposited over a longer area, the footprint width of the dune would be smaller than that of the alternative described in Section 4.5.1. This would indicate that less plover habitat would be impacted by construction activities than under all other alternatives except for the no action alternatives. All of the potential impacts to plovers from construction of the dune described above would also apply under this alternative. If construction activities take place in March-August, and heavy equipment is used to build the dune and berm, there is a high likelihood that plovers will be negatively impacted.

4.6.2 Width Based on 3,000,000 m^3 of Sand

The potential impacts from implementation of this alternative are similar to those described in Section 4.6.1, except for the fact that a much larger area of plover habitat may potentially be impacted. The primary reason that there is a potential for more impacts is that the footprint of the constructed dune will be much larger.

4.7 Summary of Potential Impacts

A summary of potential impacts is provided in Table 3.

4.8 Mitigation Measures

Mitigation measures designated to lessen the severity of adverse impacts to piping plovers would be incorporated into the project alternatives. A summary of mitigation measures is listed in Table 4.

5.0 SEABEACH AMARANTH IMPACT ASSESSMENT

Seabeach amaranth is an annual plant endemic to the barrier island beaches of the Atlantic Coast. Its primary habitat consists of overwash flats at accreting ends of islands, lower foredunes, and upper strands of noneroding beaches (USFWS 1995b). This species prefers temporary habitats and does not occur on well-vegetated beaches. Due to its high dispersal ability, it can persist in newly disturbed habitats (USFWS 1995). In these ways, its habitat requirements are very similar to those of piping plovers. Just like plovers, its habitat is maintained by overwash actions, which prevent establishment of competing vegetation, yet hurricane flooding generally curtails seed production and may locally eliminate seabeach amaranth populations.

Impacts on seabeach amaranth from the proposed alternatives are very similar to those on piping plovers, but the analysis is more speculative because no populations currently exist on the island. However, if this species was re-established on Assateague Island, one of the major factors limiting its survival is anticipated to be grazing by horses.

5.1 Alternative 1 - No Action

Given that the current habitat on northern Assateague Island is being maintained by overwash frequencies that are preventing establishment of woody vegetation and perennial dominance in the overwash corridors, a no action alternative would likely impact seabeach amaranth the least of all the alternatives in the short term. This species' zone of growth is extremely narrow, typically about 10 m wide. Although it requires unvegetated habitats, it may be intolerant of occasional flooding during its growing season (May into the Fall). It needs extensive areas of barrier beaches and inlets, functioning in a relatively natural and dynamic manner. This allows it to move around in the landscape to occupy suitable habitat as it becomes available.

However, due to seabeach amaranth's dependency upon noneroding beaches, it may not become established along the upper berm along the shoreline due to the high erosion rate that northern Assateague Island is currently experiencing.. Due to the current rate of beach erosion, upper beach zone habitats are uncommon along northern Assateague. Although this habitat is currently available on northern Assateague Island at a few locations, the no action alternative may result in an increase in overwash activity over a greater area than currently exists, reducing the availability of these habitats.

If a breach occurs and creates an inlet, more desirable habitat for seabeach amaranth may be created if upper beach habitat results from the presence of the inlet. Higher densities of this plant are usually encountered along island-end flats and inlet edges as opposed to

Table 3. Summary of Potential Impacts to Piping Plovers from Proposed Alternatives

Alternatives	***Potential Impacts***
4.1 No Action	1. Increase in suitable nesting and foraging habitats as overwash zone continues to expand southward and increases in size. 2. Increase in number of breeding pairs as suitable habitat is maintained and created by current overwash frequencies. 3. Temporary decrease in productivity from egg loss due to flooding in certain areas. 4. Decrease in plover habitat if hurricane occurs. 5. Increase in isolation of plovers from predators on north side of breach if breach occurs. 6. Increase in mortality of eggs and/or chicks if storm/breach occurs during nesting season.
4.2 No Action Breach repair	1. Increase in nesting and foraging habitats if beach is subject to annual overwash after repair. Repair is restricted to pre-nesting season. 2. Stable high productivity if travel corridors are maintained and predation levels remain low. 3. Increase in mortality of eggs and/or chicks if breach occurs during nesting season. 4. Increase in direct impacts from construction activities; if repair occurs between mid-March and September when plovers are present. 5. Reduction in formation of excellent nesting and foraging habitats, due to forestalling natural inlet migration.
	The following are potential impacts from all dune construction alternatives.
4.3 3.3m dune along 9.2km 4.3.1 1,500,000 m3 4.3.2 3,000,000 m3 4.4 3.3m dune along 12.9km 4.4.1 1,500,000 m3 4.4.2 3,000,000 m3 4.5 2.9m dune along 9.2km 4.5.1 1,500,000m3 4.5.2 3,000,000 m3 4.6 2.9m dune along 12.9km 4.6.1 1,500,000 m3 4.6.2 3,000,000 m3	1. Increase in number of breeding pairs due to increase in berm width. 2. Decrease in effects of overwash compared to current conditions. 3. Increase in formation of discontinuous dunes providing more upland habitat for woody vegetation and den sites for predators. 4. Adverse impacts are likely if dune construction occurs during nesting season e.g., disturbance, mortality, and habitat destruction. 5. Increase in chick mortality, and subsequent decrease in breeding pairs, if travel corridors are not maintained with adequate overwash. 6. Destruction or decrease in habitat quality for macroinvertebrates due to depositional material in the intertidal zone resulting a decrease in value of foraging habitats for piping plovers. 7. Forestalling of potential nesting habitat due to downdrift of material to southern portion of Seashore where suitable habitat is recently forming from overwash activity. 8. Decrease in likelihood of piping plover habitat loss through a hurricane or major storm 9. Increase in duration of impacts, as amount of depositional material increases.

Table 4. Mitigation Measures to Minimize Impacts Based on Alternatives Involving Sand Placement and Construction

1. All construction activities involving placement of sediment on the terrestrial portion of the island (dune or berm construction would not be conducted between mid-March and September, or until piping plovers are no longer observed using the Maryland portion of Assateague Island. Construction in areas that are not used by piping plovers, such as the State Park, could be initiated within this window as long as the area is being monitored to ensure that no plovers are present.

2. Earth-moving equipment (bulldozers, etc.) would be restricted to use on the island to avoid the nesting season. The creation of trenches for trapping sand and dune configuration would be done outside of the nesting season. Bulldozers may be used to assist in moving pipelines in piping plover-free areas, but would not be allowed to cross occupied habitats to reach work area.

3. A piping plover expert would be present during sand placement into the intertidal zone to insure that restoration can proceed within the nesting window on certain reaches along the shoreline. This assumes that no plover activity is observed along the target reach of the shoreline prior or during the pumping action, and that all construction equipment is located on the water (hopper dredges, booster pumps). Large buffer zones would be established around the pumping activity to insure no direct impact to nesting or foraging plovers. It is critical that plover monitors are on site to insure that there is no disturbance from the placement and movement of the steel pipelines.

4. A piping plover monitoring plan would be prepared prior to construction to protect plovers and chicks from predatory animals, including gulls and crows, which are attracted to dredged material pumped along the shoreline.

5. Impacts to other state endangered species, especially beach tiger beetles, would also be considered. Staff of the Maryland Department of Natural Resources would be consulted concerning potential impacts to these other species.

6. A vegetation control program would be developed to prior to construction and implemented should the predicted overwash not be realized and rapid vegetation encroachment occurs in the nesting and travel corridor habitats, or important habitats, such as ephemeral pools and moist, flat, low-lying portions of the island, become dryer.

7. A monitoring study of the re-establishment of seabeach amaranth as well as the behavior of plovers would be developed and implemented as part of the proposed alternatives.

8. Any mitigation measures and monitoring options need to be coordinated with the policies of the National Park Service as part of a long-term management plan and agreement between the Seashore and the USACE.

beaches (USFWS 1995b). If a breach occurs, suitable habitat for seabeach might be created on the accreting edges of the new inlet. During inlet migration, one side is experiencing accretion of sand while the other side is eroding. On the eroding side of the inlet, habitat for seabeach amaranth is usually small or absent. Accreting sides of inlets are the most favorable habitat for the plant. However, it is possible that if a breach occurs and is followed by a large storm during the growing season, re-established populations on Assateague could be destroyed.

5.2 Alternative 2 - No Action but Repair Future Breaches

If breaches occur and are repaired, populations of seabeach amaranth may or may not be affected depending on their location and distribution in relation to the breaches. There would likely be no direct impact from this action as long as no sediment was placed on top of the plants or the habitat configuration where the plants occurred was not altered (i.e. upper beach habitats were maintained). As long as the topography after repair was similar to the pre-breach character, and woody and/or perennial plant invasion did not occur, overwash activities would likely continue to maintain habitats for seabeach amaranth. However, filling of the new inlet would eliminate some of the best potential habitats for seabeach amaranth reestablishment.

5.3 Alternatives 3-6 - Dune Construction

Seabeach amaranth continues to be threatened by destruction or adverse alteration of its habitat. The primary reason it has been eliminated from approximately two-thirds of its historic range is beach stabilization efforts and storm-related erosion. The absence of this species along certain Atlantic coast habitats are thought to be due to artificial construction and maintenance of continuous barrier dunes.

Beach replenishment projects and placement of dredged material can have impacts on seabeach amaranth (USFWS 1995b). If dredging and placement of material occurs during the winter when amaranth exists primarily as seeds, impacts on individual plants are likely to be minor. However, if seeds are buried the population could suffer adverse impacts depending the this species' seedbanking capabilities, which need further study.

Seabeach amaranth does not occur on eroding beaches. Beach replenishment has been known to rebuild habitats for seabeach amaranth and have long-term benefits. At two beaches in North Carolina, Wrightsville Beach and Atlantic Beach, placement of large amounts of material apparently aided in the reestablishment of seabeach amaranth populations. At one site, plants were reestablished four years after renourishment. However, another large renourishment project at Carolina Beach failed to help seabeach amaranth.

As long as accreting areas are present (along inlet edges or beach berm), overwash is frequent enough to maintain habitats, and off-road vehicle activity is kept to a minimum during the growing season, amaranth populations may do well along the shoreline of Assateague Island if sand was placed along the nearshore and berm habitats. Because seabeach amaranth is typically a front-line plant (occurring on the outer edge of the accreting berm or inlet) close to the water, it is especially vulnerable to wave action. Major storms during the growing season can cause severe mortality of plants, but winter storms have less impact on mortality.

Efforts to reestablish populations in the southern portion of the National Seashore may be futile. Recently, overwash activity at the south end has created habitats which could potentially support seabeach amaranth. However, downdrift of the newly-placed sand as proposed in the "dune construction" alternatives may potentially effect the maintenance of these habitats by reducing the amount of overwash. Overwash corridors need to be maintained to prevent colonization of woody vegetation and perennials to promote habitats which will support populations of seabeach amaranth. However, sites which historically supported populations of this species have experienced re-established populations as a result of sediment being deposited in areas that contained a seed bank (pers. comm., N. Murdock, USFWS, to L. MacIvor, 30 May 1996). Reproductive success for these plants, however, is unknown.

Considerations for reintroducing seabeach amaranth populations to Assateague Island (except on an experimental basis) should be delayed until: (a) results from implementing the long-term restoration project (sand by-pass) can be evaluated, and (b) the horse population has been largely reduced or eliminated. Under current conditions, experimental and small-scale introductions may be helpful in determining if habitats on Assateague Island can support this species.

6.0 OTHER SPECIES OF CONCERN

Barrier beach habitats used by piping plovers are dynamic, storm-maintained ecosystems. Other species, considered threatened or endangered by the State of Maryland, share these habitats with piping plovers on Assateague Island and are similarly affected by man's activities. These species include state endangered least terns (*Sterna antillarum*), and beach tiger beetles (*Cicindela dorsalis media*). Breeding populations of both species occur in the proposed project area. State listed species that historically occurred on Assateague Island include seabeach amaranth, seaside knotweed (*Polygonum glaucum*), and Wilson's plover (*Charadrius wilsonia*). These species could potentially be affected by the proposed project if populations become extant. Maryland Department of Natural Resources should be consulted concerning potential impacts to state listed species. Observations of federally-listed roseate terns (*Sterna dougallii*), bald eagles (*Haliaeetus leucocephalus*), and peregrine falcons (*Falco peregrinus*) within the proposed project area have also been recently recorded, but adverse impacts to these species from the proposed project are unlikely. If the proposed alternatives are modified, potential impacts to these additional federally listed species should be addressed.

7.0 CUMULATIVE IMPACTS

Three existing water resource projects by USACE are located in the Ocean City Area. One, the Atlantic Coast Shoreline Protection Project, is located along the southern 8.6 miles of Fenwick Island's shoreline. This project included adding significant volumes of sand, which increased height and width to this portion of the island, and involved constructing a 16 foot high artificial vegetated dune to provide protection against a 100-year storm on the Atlantic Ocean. Periodic beach nourishment and dune maintenance occurs every four years. The Ocean City Harbor and Inlet and Sinepuxent Bay Project provides dredged channels for boat travel between the Atlantic Ocean and the bays and harbors west of the barrier islands. Portions of these channels are dredged approximately every three years. The Isle of Wight Bay Project resulted in the construction of stone toe bulkhead protection and a new tie-back system to stop the bayward movement of the bulkhead in Ocean City, Maryland.

Land adjacent to northern Assateague Island is primarily urban and is developed. Private marinas are scattered along the mainland shoreline. There has been a significant increase in proposed and constructed marinas within Worcester county, some of which have resulted in increased boat traffic to Assateague Island.

Assateague Island is the only large undeveloped area remaining in Worcester County. Land-use and development, and increased shoreline stabilization efforts in the Ocean City area continue to have cumulative impacts on the barrier island system of Assateague Island.

8.0 DISCUSSION

Expansive sections of open beaches along the mid-Atlantic coast are typically results of large-scale environmental forces (e.g., hurricanes, extratropical storms, surge tides) (Dolan *et al.* 1988), and are primarily formed by dune overwash. These sparsely vegetated habitats used by piping plovers for foraging and nesting are relatively short-lived within the mid-Atlantic region (Watts and Bradshaw 1991) because dune recovery and plant succession can occur rapidly within barrier systems (Godfrey *et al.* 1979). Overwash areas on North Carolina barriers may be nearly revegetated by buried *Spartina patens* only one year after the initial overwash disturbance. Vegetation began to invade old overwash areas on northern Assateague Island within 1-2 years due to the lack of major storms. Piping plover habitat availability over any extended period may be only possible on beaches that are subjected to high rates of disturbance. For example, beaches with an elevation of less than 0.5 m will be washed over twice daily by normal tides and higher beaches with greater than 3 m elevation will be reopened only once every few decades (Watts and Bradshaw 1991). Overwash frequency and impact of the disturbance will largely depend on the storm's magnitude and duration. Between 1985-91 on northern Assateague Island, vegetation invasion was rapid and severe due to lack of overwash events. As overwash areas filled in with vegetation, travel corridors for chicks became less available resulting in high mortality of chicks (Loegering and Fraser 1995). Following the major storms in 1991 and 1992, large overwash areas were created on northern Assateague. Since then storms and even some high tides have maintained these habitats. Northern Assateague Island currently supports the highest productivity and number of breeding pairs since monitoring began ten years ago. However, one large overwash area towards the south end of the project area (Figure 9) is now characterized by low topographical relief and almost no vegetation. Nesting plovers in this area experienced lower fledging success than other areas during the 1995 nesting season (Brady *et al.* 1995). Recently during the 1996 season, some nests in this area were lost to flooding (pers. comm., P. Railey, MD Dept. of Natural Resources, to L. MacIvor, 3 June 1996). Flooding has been an uncommon cause of egg mortality on northern Assateague Island. In general, piping plovers would likely benefit the most on beaches with a high enough overwash rate to maintain open habitats but infrequent enough during the breeding season to allow for successful incubation. For early successional species, such as piping plovers and seabeach amaranth, a disturbance regime is an important determinate of habitat distribution and availability. From a biological perspective, promoting these dynamics should be one of the primary considerations for the development of long and short-term beach restoration projects.

Alternative 1, the "no action" alternative, will likely benefit piping plovers in the short-term (within the next 5 years) because suitable habitat currently exists and is being maintained by natural processes. Assateague Island now provides large expanses of overwash areas and access to bayside feeding sites for plovers. Given current conditions, if a breach occurs on Assateague, use by piping plovers for nesting and foraging will likely increase along the accreting ends of barrier islands and sandflats adjacent to inlets, or in the area of old inlets that have closed in (Elias-Gerken 1995, USFWS 1995c). These old inlets typically consist of large moist sandflats and sparse vegetation. During 1994 in North Carolina, 28 percent (15 of 54) of the entire State's nesting population was located on either side of an inlet at Cape Lookout National Seashore (McConnaughey *et al.* 1990). Between 1929 and 1941, storms breached sections of the Long Island barrier in New York forming inlets along a 28 km stretch. During this time numbers of plover breeding pairs increased from approximately 4 pairs (prior to the formation of inlets) to 64 pairs after sections were breached (Wilcox 1959). Numbers then gradually decreased, a decline that Wilcox attributes to deposition of dredged material to rebuild dunes, planting of beach grass, and construction of homes and roads. Given the potential likelihood of a breach in the near future on northern Assateague, there may be an increase in the numbers of breeding pairs and use by adults and broods, particularly along the edges and recurved spits of the inlet. The disruption of key coastal processes that contribute to the creation of piping plover (and seabeach amaranth) habitat has been identified as a major factor contributing to these species' decline (USFWS 1995a,b). One of the priority one recovery tasks in the 1995 Draft Revised Piping Plover Recovery Plan is to "discourage interference with natural inlet formation, migration, and closure processes".

However, the low-lying and sparsely vegetated topography that piping plovers prefer can also reach a habitat quality that becomes counter productive for good nesting success. A few areas that currently exist on northern Assateague Island are so low and completely void of vegetation that nests at these sites may become susceptible to flooding during summer high tides, and shade and resting areas may become less available for chicks. For the short term, adding sand to these specific areas to slightly increase height (as long as overwash areas are maintained) and especially width could benefit productivity at these sites.

Alternative 2, the no action with future breach repair, is likely to have minor adverse impacts on piping plovers as long as there are no direct construction activities in areas where plovers are engaged in courtship, nesting, or brood-rearing. If construction activities occur near plover use areas, dredging and construction operations may prevent plovers from using the area, forcing them to relocate into less favorable habitats. There may also be a loss of productivity due to construction, disturbance, and harassment. Further, there could be direct loss of piping plover nests or chicks. As long as construction activities do not disturb plovers and the repair site is returned to its pre-breach character, there should be no adverse effects.

Increases in numbers of nesting pairs have been reported to occur when breaches have been filled (USACE 1995). Five pairs of piping plovers nested during 1993 prior to the closure of Pikes Inlet on Long Island, New York. The USACE closed the inlet and created an "artificial overwash". During 1994, 1995, and 1996, numbers of nesting pairs increased to 14, 19, and 24, respectively. All broods had access to bay tidal flats (Elias-Gerken and Fraser 1994). Number of breeding pairs at Westhampton, Long Island, increased threefold (5 to 15 pairs) following a breach closure by USACE, with several pairs nesting on the sand used to fill the breach (USACE 1995). The USACE speculates that the characteristics which provide piping plovers with the most suitable habitat including flat berms, overwash fans, spits, and open travel corridors for chicks, are the result of storm events, not necessarily the continued existence of a breach. However, biologists have expressed concern that artificial habitat formed in this way may be susceptible to accelerated plant succession that will decrease the long-term carrying capacity compared to what it might have been if the inlet had been allowed to persist, migrate, and eventually close on it own (Elias-Gerken and Fraser 1994b).

Alternatives 3-6, the proposed alternatives involving deposition of sand on the island, have the potential to result in adverse impacts to piping plovers depending on the magnitude and duration of future storms along Assateague Island. Increasing island height and sand deposition along the nearshore to increase width may be either beneficial or detrimental to piping plovers. On beaches that have become heavily vegetated, deposition of material along the beach can substantially improve the quality and availability of plover habitat by creating nesting areas that are higher, wider, and less vegetated than before (Melvin *et al.* 1991). However, benefits to piping plovers are typically very short-term because encroachment of vegetation can begin as early as one to two years after beach nourishment takes place.

One of the primary concerns for artificial stabilization of areas supporting piping plovers is the increased susceptibility for accelerated plant succession, which over time becomes unsuitable for nesting and foraging. Wilcox (1959) observed plovers colonizing beaches with storm-created, early successional stage habitats. As the establishment of vegetation reached later successional stages, plovers failed to return to the area. Following the 1938 hurricane, piping plovers reached a 20th century peak in Rhode Island, but declined as habitat was lost due to post-World War II stabilization efforts and summer home construction (Raithel 1984). A recent hurricane along the east coast leveled dunes at a beach on Martha's Vineyard, Massachusetts resulting in a low, flat beach profile with a wide overwash area between ocean and the bayside. To reduce the probability of breaching, the county placed snow fencing along the beach berm resulting in sand accretion and an increase in beach elevation (peak elevation = approx. 2.4 m - 2.9 m) (pers. comm., R. Culbert, Dukes County Beach Manager, Martha's Vineyard, MA, to L. MacIvor, 24 May 1996). This height increase resulted in reduced overwash action from the ocean to the bayside. Since that time, vegetation has increased in certain areas along the bayside. Although the banning of off-road vehicle activity may have confounded effects, the lack of overwash is thought to be the primary factor for the invasion of vegetation. If vegetation continues to increase at the same rate for the next 2-4 years at this site, nesting habitat for plovers may become unsuitable or degraded (pers. comm., S. Melvin, MA Div. of Fisheries and Wildlife, to L. MacIvor, 11 April 1996).

Although increases in breeding pair and productivity numbers following major storm events have been well documented, factors such as predation and off-road vehicles can confound the effects of the presence of optimal habitat on nesting and foraging success. On Assateague Island, numbers of piping plovers and productivity substantially increased following the 1991 and 1992 winter storms (Bottitta *et al.* 1993). These increases are primarily due to overwash action and lower predation rates. Due to the occurrence of cross-island overwashes since 1992, northern sections of Assateague Island currently provide optimal nesting habitats, sparsely-vegetated travel corridors between ocean and bayside for foraging access, and quality brood rearing habitats consisting of resting areas and shade for broods. These changes have resulted in a large increase in the breeding population, increased reproductive success, and likely higher recruitment rates into the overall population. Providing changes to northern Assateague Island, by depositing a large amount of sand at one time, may jeopardize the current success of the piping plover population if the current overwash frequency is reduced such that travel corridors are not maintained.

If one of the proposed "dune construction" alternatives (involving placement of sand on the island) was selected, it is essential that the frequency of cross-island overwash is sufficient to maintain open nesting areas, travel corridors, ephemeral pools, and bayside mudflats. The greater volume of material that is deposited on the island, the greater potential for longer duration of impacts. Potential impacts include the creation of upland habitats for predatory species (currently, there is a scarcity of potential den sites), greater chance for establishment of vegetation, and the larger storm that may be required to remove it once established. Given the unpredictability of storm frequency, duration, and magnitude in the next five years, it may be impossible to accurately assess impacts from placement of sand along northern Assateague Island.

Alternative 6, however, would likely be the least disruptive to plovers on Assateague Island. This configuration would provide a dune with the smallest volume of sand (less construction time) and lowest dune elevation (increased potential for overwash). An even smaller volume of sand would likely adversely impact northern Assateague Island's piping plover population less and may provide some habitat benefits to low relief areas that are becoming more vulnerable to flooding during the nesting season.

Assuming the newly placed dune/berm material will not be maintained after initial placement, it is possible that following the first overwash event, a rapid lowering of the constructed area will occur over portions of northern Assateague Island, resulting in sections of the restored area becoming prone to overwash. Due to the likelihood that the "dune construction" alternatives will result in some discontinuous dunes being formed along the berm, it is unknown how much area will experience overwash even if the initial dune height becomes quickly lowered after the first overwash event. Following the 1962 breach at the north end of the island, almost 1.2 million m^3 of sand was placed to fill the breach only to breach again 2-3 years later. An unknown volume of material was added again to repair the breach. Since that time, island width has increased or remained stable in the northern end, yet island height appears to have decreased. It is unknown what grain size of the sand was used to fill the breach. If grain size was too large, it is likely that much of the material was rapidly washed away.

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ANNEX A, PART 6

Biological Assessment for Sea Turtles and Whales

The Corps is currently preparing a biological assessment for Sea Turtles and Whales. The following summarizes the purpose of the assessment and the issues being dealt with:

The Baltimore District, U.S. Army Corps of Engineers, in cooperation with the National Park Service; the Maryland Department of Natural Resources; the Town of Ocean City, Maryland; and Worcester County, Maryland; are conducting a study to determine how to restore sand that Assateague Island has been deprived of due to the construction of the jetties at the Ocean City Inlet in 1934. The Corps is currently preparing a biological assessment of impacts that the project may have on endangered and threatened species of sea turtles and whales.

The proposed project raises two concerns: (1) the entrainment of endangered and threatened species of sea turtles by hopper dredge dragheads and (2) vessel collisions with endangered species of whales. Sea turtles do not normally nest in the project area and are not as plentiful as in many other coastal areas. However, there are some data that indicate that sea turtles, including the rare Kemps Ridley, may use the area for migrating up and down the Atlantic Coast when the water temperature is 11 degrees centigrade (52 degrees F.) or warmer. This condition could occur during the spring, summer, and fall seasons in the project area. Right whales are of particular concern because the Atlantic coast population has been reduced to approximately 300 individuals, and collisions with hopper dredges are possible. Previous dredging for the Ocean City Beach Replenishment Project has not indicated any impacts to endangered or threatened sea turtles and whales. The national Marine Fisheries Service (NMFS) has requested that the Atlantic Coast of Maryland Hurricane Protection Project (which includes beach replenishment at Ocean City) be included in this Biological Assessment because both the Assateague and Ocean City projects will occur in the same general area, are similar in design, and could potentially affect the same protected species.

For the Corps and other Federal agencies, the implementation of the Endangered Species Act centers on the Section 7 consultation process. Section 7 requires the USACE to consult with NMFS or U.S. Fish and Wildlife Service, as appropriate, on all actions that may affect threatened or endangered species. As a result of this consultation, the Baltimore District, in cooperation with the U.S. Department of the Interior Minerals Management Service (which has responsibility for Outer Continental Shelf resources), is preparing the *Biological Assessment of Potential Impact to Endangered and Threatened Species of Sea Turtles and Whales That May Result from Dredging Offshore Shoals and Placement of Material on Assateague Island and Ocean City, Maryland*. A biological assessment is the evaluation of potential effects, both direct and indirect, of the proposed action on such species and habitat.

Coordination with NMFS has indicated that after a Biological Assessment is prepared, if the Corps uses safeguards such as turtle deflectors, specially equipped hopper dredges, NMFS-approved observers, adherence to NMFS protocols, and dredge crew training, then significant adverse impacts to these species or their habitats is unlikely, and a non-jeopardy biological opinion would likely be issued.

ANNEX A, PART 7

Public Involvment and Agency Coordination

ANNEX A, PART 7

PUBLIC INVOLVEMENT AND AGENCY COORDINATION

The following is a list of key correspondence, meetings, and other communications with a brief description of the action or response to the topics addressed. Several of the regular monthly team meetings are also listed. Team meetings were attended by representatives from the Corps and project sponsors - Ocean City, NPS, DNR, and Worcester County, as well as by technical experts presenting information and interest group representatives. Topics addressed and actions taken at the meetings listed are examples of the tasks accomplished at each team meeting. Compliance coordination activities, such as Federal Register notices, are highlighted in the list. Copies of compliance documents are included as part of this Annex. Copies of other correspondence and records included in the list, as well as comments made by citizens at public meetings, are not included, but are available from the Baltimore District Corps of Engineers.

July 6, 1996	Signing ceremony for the Feasibility Cost Sharing Agreement, attended by project sponsors, Senator Sarbanes, and representatives of other Congressional staffs. **Action/response:** Following the ceremony, sponsors and other attendees discussed the importance of the project
July 17, 1995	Letter from the Minerals Management Service (MMS) of the U.S. Department of the Interior to the DNR Boating Administration requesting information on the study and providing information on the MMS' responsibilities and work efforts in the Ocean City area. **Action/response:** Coordination between the project team and MMS continued in the form of a letter and information from the DNR, phone conversations between MMS and the project team, and a working meeting on October 8, 1996.
Aug 17, 1995	Letter from MDNR Boating Administration responding to the MMS letter and providing information on water resource problems in the Ocean City area. **Action/response:** A number of documents pertinent to the study were forwarded to the MMS.
Dec 1, 1995	E-mail message to Corps from Dr. James Fraser, Virginia Polytechnic Institute and State University regarding habitat requirements of the piping plover population. Dr. Fraser explained that nesting and foraging habitat and a vegetation-free connection between the two areas is key to plover success. He suggests that overwash events should be adequate to maintain those conditions. He also recommended several publications as a source of additional information

Action /response: Suggestions and information provided by Dr. Fraser were considered in the design of the restoration project.

Dec 4, 1995 Study Team meeting to introduce team members, to review the status of tasks underway and CERC work efforts, and to discuss the goals, alternatives for the Assateague Island restoration. Possible objectives/perspectives/considerations included short or long-term effects, restoration of sediment supply, restoration of barrier island function, and the target completion condition and date.
Action/response: Team members were directed to begin developing objectives for Assateague Island restoration.

Dec 13, 1995 Letter to the Corps from the Oregon State University Department of Fisheries and Wildlife responding to a request for comments on restoration of Assateague Island. The writer, who had done plover research for several years on Assateague, provided information on plover habitat and answers to specific questions pertaining to the plover population and project alternatives.
Action/response: Information from a number of sources was considered and incorporated into the study process.

Jan 4, 1996 Phone conversation between Corps biologist and Mark Homer who manages the DNR Hatchery at Piney Point. Mr. Homer provided information on shellfish populations in the Ocean City area as well as recommending other contacts for additional information.
Action/response: It was agreed that the study team and Mr. Homer would maintain contact, especially concerning the siting of wildlife habitat islands in the coastal bays.

Jan 12, 1996 E-mail message from John P. Loegering, graduate student at Oregon State University. Mr. Loegering formerly studied the Assateague Island plover population and was responding to a question about the effect of increased island width on plover chicks.
Action/response: Mr. Loegering’s suggestions were considered during design of the Assateague Island restoration.

Jan 17 , 1996 Study Team meeting to review status of study tasks, to identify goals and objectives for Assateague restoration, determine alternative restoration solutions, and discuss public involvement plan.
Action/response: After reviewing and discussing lists of possible goals and objectives prepared by the four project sponsors, the team agreed on a goal and a draft list of objectives. The goal: to restore Assateague Island to mitigate for ongoing adverse impacts caused by past Corps projects.

Jan 24, 1996	**COORDINATION LETTER** announcing the initiation of the feasibility phase of the study was sent from Baltimore District to approximately 80 agency representatives. **Action/response:** Agencies responded by providing information relevant to the study area and by identifying POCs for the project.
Jan 31, 1996	Phone conversation between Corps biologist and Andy Moser, FWS, regarding the inclusion of several species (roseate terns and seabeach amaranth) in the Biological Assessment. Mr. Moser recommended contact with and provided the names of several scientists who are involved with both species. **Action/response:** Information noted.
Jan 31, 1996	Letter from Baywatch acknowledging their participation in the study. **Action/response:** Baywatch representatives were an important source of information and served as meeting participants and informal reviewers throughout the study.
Feb 5, 1996	E-mail message from Anne Hecht, FWS piping plover expert, to Corps biologist regarding maintenance of plover habitat on Assateague Island. Topics addressed in her message included the migration of the erosion-prone area southward on the island and the frequency of overwash necessary to prevent vegetation from becoming established and disrupting plover habitat. **Action/response:** The study team did research to determine the likely future changes in the island without the project.
Feb 5, 1996	Meeting with Coastal Bays Focus Group, which included approximately 20 representatives of natural resource management agencies and the coastal bay interest group. Purpose was to begin interaction between technical experts and citizen groups, review study status, identify problems and opportunities, determine information needs and availability, and recommend project actions. **Action/response:** Focus group representatives participated throughout the study process.
Feb 7, 1996	Phone conversation between Corps biologist and Andy Moser, FWS. Mr. Moser advised that the Biological Assessment should discuss the impacts on habitat of both seabeach amaranth and the roseate tern. Because there is a proposed plan to reintroduce seabeach amaranth on the north end of Assateague Island, impacts on its recovery should be addressed. He recommended Dave Brinker as a source of information on the roseate tern and stated that the only in-depth work required for the Biological Assessment would be on the piping plover.

	<u>Action/response</u>: Mr. Moser's recommendations were followed. Mr. Brinker and Mr. Tindall were contacted and provided information on bird populations and the presence of seabeach amaranth on Assateague Island.
Feb 7, 1996	Phone conversation between Corps biologist and Mr. Dave Brinker, Maryland Heritage Program, regarding roseate tern population on Assateague Island. Mr. Brinker explained that roseate terns found in the area are probably late migrants stopping to rest. He indicated that the project should not have a negative impact on the terns because there are many other resting areas. **<u>Action/response</u>:** Information noted.
Feb 7, 1996	Phone conversation between Corps biologist and Andy Moser, FWS, reporting Dave Brinker's view that roseate terns need not be included in the Biological Assessment, however, they should be included in the EIS. **<u>Action/response</u>:** Following recommendations, the Biological Assessment under preparation by Corps biologists is focused on piping plover and seabeach amaranth.
Feb 8, 1996	**COORDINATION LETTER** announcing the initiation of the feasibility phase of the study was sent from Baltimore District to Congressional representatives and other government office holders. **<u>Action/response</u>**: Congressional representatives have shown support for the project. The study manager made a study presentation to Senator Mikulski during a visit to Assateague Island in May 1996.
Feb 8, 1996	Letter from Maryland Board of Public Works Wetland Administration regarding the availability of data useful to the study. **<u>Action/response</u>**: The study team received data from individuals and agencies identified by the Wetlands Administration.
Feb 9, 1996	Meeting with Corps managers to define problem statement for Assateague Island restoration, discuss long-term objectives, prioritize objectives, identify project baseline, identify alternatives, and begin alternatives evaluation. **<u>Action/response</u>**: The discussion resulted in a clearer definition of the draft objectives.
Feb 15, 1996	Study Team meeting to discuss study funding, and to review status of and future actions for plan formulation, hydraulics, geotech, environmental, economics, and real estate tasks. **<u>Action/response</u>**: Discussion resulted in decisions regarding Assateague alternative plans, dune heights to be modeled by WES, and most promising offshore shoals as material source. The Assateague project component received additional emphasis to meet the accelerated schedule.

Feb 20, 1996 **COORDINATION LETTER** announcing the initiation of the feasibility study mailed to Senators Mikulski and Sarbanes, Governor Glendening, and Representative Gilchrest.
Action/response: Information on the study has been provided to state and Federal legislators on a regular basis.

Feb 20, 1996 **LETTER FROM MARYLAND HISTORICAL TRUST** in response to the Baltimore District's initiation efforts on behalf of cultural resources in the study area. The Trust provided guidance on necessary cultural resource actions and maps showing locations of inventoried historic properties and archaeological sites and surv eys in Worcester County.
Action/response: Appropriate cultural resources surveys were completed by a qualified professional archaeologist. Sonar investigations of the offshore shoals indicated no cultural resources.

Feb 23, 1996 Phone conversation between Corps biologist and Mr. Wayne Tindall, Maryland Natural Heritage regarding the proposed recovery plan for seabeach amaranth on Assateague Island. The amaranth recovery project is being led by Ms. Nora Murdock, FWS, who is surveying the island for existing plants and working to determine which of several genetic populations to reintroduce.
Action/response: Ms. Murdock provided a copy of the amaranth recovery plan and the information was incorporated into the project design.

Feb 23, 1996 Letter from NMFS/NOAA commenting on the need for care in disturbing highly sensitive or ecologically productive sites and offering available data for the project area.
Action/response: Communication with NMFS/NOAA, as well as with many other natural resource management agencies was on-going throughout the study.

Feb 24, 1996 Letter from Ocean City resident, Mrs. Edward T. Smith, regarding the negative impacts of dredging in the shallow coastal bays. Mrs. Smith feels that sedimentation in the bays keeps large boats out and protects "this fragile area."
Action/response: Planning and coordination meetings have included much discussion regarding the necessity, desirability, and practicality of dredging the back bays. Boaters generally support this dredging; however, the Corps is not authorized to dredge non-channel areas. As a result, environmental concerns have not been addressed in depth.

Feb 29, 1996 **NOTICE OF INTENT (NOI) IN FEDERAL REGISTER**.

Feb 1996 First Newsletter distributed.

	Action/response: A number of comment cards were returned with requests for names to be placed on the mailing list.
Mar 5, 1996	E-mail memo to Study Manager from Corps biologist rega rding conversation with Mr. George Ruddy, FWS, about impact evaluation for offshore shoals. Mr. Ruddy indicated that enough general information was available to evaluate the impacts of mining the shoals for material for the immediate restoration of Assateague Island. In Mr. Ruddy's opinion, more biological data might need to be collected if the shoals were to be periodically mined for long-term restoration. **Action/response:** In concurrence with Mr. Ruddy, a decision was made that additional data on the shoals was not needed for the immediate restoration.
Mar 8-9, 1996	Delmarva Coastal Bays Conference, sponsored by a number of businesses, agencies, and organizations, addressed preservation of the coastal bays watersheds. The conference was attended by approximately 300 individuals and representatives of coastal interest groups, including six Corps members of the OCWR study team. Study manager presented OCWR as part of a group discussion. **Action/response**: Participation in the conference provided an opportunity for study team members to gather information and to discuss with many other interested individuals issues relating to the coastal bays.
Mar 14, 1996	Study Team meeting to review project status, results of CERC simulations, and findings of cultural investigations on offshore shoals. **Action/response**: Future actions were identified as preparation for the first public workshop, determination of a final borrow site, and selection of habitat restoration sites in the coastal bays.
Mar 18, 1996	Letter from the Maryland Department of the Environment (MDE) regarding the Corps' coordination letter to the Governor's office, MDE's continuing participation in the Ocean City Water Resources Study and MDE's new status as a participant in the National Estuary Program, **Action/response**: Study team coordinated with MDE throughout the study.
Mar 22, 1996	**CORRECTION TO NOI** appears in Federal Register. Correction explained the accelerated schedule of the Assateague Island project component and that programmatic EIS addressing general impacts of the overall project would be prepared first, followed by a separate supplemental EIS addressing the remaining project components.

Mar 25, 1996	Letter from the Worcester Environmental Trust endorsing the request of Mrs. Edward T. Smith (in her letter of 24 February) and asking that her views are considered "when contemplating future work in the Coastal Ba ys area." **<u>Action/response</u>:** Large-scale dredging of coastal bays was not given strong consideration in the study for economic as well as environmental reasons.
April 9, 1996	Briefing on Assateague Island restoration for Worcester County Commissioners, by Study Manager and Project Manager. **<u>Action/response</u>:** The County supports the restoration project and requested that the short-term restoration be completed on an accelerated schedule.
April 12, 1996	Copy of letter from Worcester County to Senator Mikulski identifying the urgent need for restoration of the northern end of Assateague Island and requesting assistance in accelerating completion of the portion of the study addressing the short-term restoration of the island. **<u>Action/response</u>:** The OCWR study manager met with Senator Mikulski during the Senator's visit to Assateague Island in late May 1996.
Apr 16, 1996	Letter (copy) to EPA from Mr. Ray Nornes, commercial dredging contractor, offering his assistance in studying problems in the coastal bay area caused by a combination of strong winds and low tide conditions. **<u>Action/response</u>:** Information noted.
April 17, 1996	Assateague Focus Group meeting in Annapolis, Maryland. Meeting purpose was to compare and evaluate potential solutions for the immediate restoration of Assateague Island. Emphasis was on determining the objectives of both the physical and environmental scientists and biologists and facilitating discussion betwee n the two groups. **<u>Action/response</u>**: After discussion by both groups, the physical/structural group identified a prioritized list of alternative solutions. The environmental/biological group did not come to consensus; however, group members were asked to review and rank potential alternatives on their own and to send responses to Corps for incorporation into an evaluation.
April 22, 1996	Study Team meeting to review the draft list of potential "without project" future conditions on Assateague Island and to discuss the associated environmental and economic conditions. **<u>Action/response</u>:** Team selected the "without project" future scenario in which a breach would occur.
April 24, 1996	Meeting with representatives of various stakeholder groups to provide information on the project and to identify ideas, issues, and concerns

regarding the project. Individuals invited to attend the informal meeting included representatives of commercial and recreational fishing interests, tourism, neighborhood associations, state and county planning boards, state and city engineers, environmentalists, and real estate developers.
Action/response: Meeting participants identified a range of interests and concerns that reflected their perspectives.

May 9, 1996 — First public information workshop held in Ocean City to provide information on the four project components and project status and to gather ideas on interests, issues, and concerns regarding the project. Many meeting participants appeared to focus on the lack of a plan to improve recreational boating conditions by dredging the coastal bays.
Action/response: Although dredging the coastal bays was not a project component, questions asked by attendees were answered and their comments noted. In addition, comments by the public encouraged the study team to revisit the problems of recreational boaters. The newsletter that was prepared following this meeting responded to specific questions and statements made at the meeting.

May 13, 1996 — Letter from Carolyn Cummins of the West Ocean City Association outlining the response of that organization to the May 9 public workshop. Priority issues were the sedimentation of the bays and channels, the loss of commercial fishing vessels in the area (because of navigation problems), and economic factors governing Corps policy.
Action/response: Based on the comments of participants at the public workshop and in this letter, a draft of the subsequent newsletter was routed for review to Carolyn Cummins of the West Ocean City Association for review and comment. The purpose was to ensure that questions raised at the meeting were adequately addressed. Ms. Cummins provided a number of valuable suggestions that were incorporated into the revised newsletter.

May 15, 1996 — Letter to the Corps from Maryland House of Delegates member Charles McClenahan requesting consideration in accelerating the short-term restoration of Assateague Island.
Action/response: The Assateague Island short-term restoration portion of the study is being completed on an accelerated schedule.

May 15, 1996 — Letter to the Corps from the Oregon State University Department of Fisheries and Wildlife providing comments on alternatives developed by the study team for material placement for the Assateague short-term restoration and information on maintenance of piping plover habitat.
Action/response: Information from a number of sources was considered and incorporated into the study process.

May 20, 1996	Letter from Senator Mikulski to the Corps regarding the need to protect the north end of Assateague Island. **<u>Action/response</u>:** Response letter was sent stating that the Corps understands the need to protect Assateague Island and that they are fast-tracking that portion of the project.
May 21, 1996	Phone conversation between study manager and chief building official of Ocean City regarding the benefits of using material dredged from private canals to construct bay islands for wildlife habitat. **<u>Action/response</u>:** The concept of using material dredged from various areas of the coastal bays by state, county, city, and private entities to be placed in a common area that would be developed into wildlife habitat has strong support. The site would be developed under the guidance of the Corps and other regulatory agencies and provide a win-win solution to a bay-wide problem.
May 21, 1996	E-mail memo from Corps biologist to study manager regarding phone conversations with Ms. Pat Schrawder of Baywatch and Mr. Phil Hager of Worcester County as well as other sources of information. Ms. Schrawder offered to provide information on recreation areas, bathymetry of the coastal bays, and possible placement sites for dredged material islands. Mr. Hager was providing leads for information on the airport flyway. Digitized information on the NPS boundary was being obtained and Corps structural and sediment specialists were providing opinions on the benefits of creating dredged material placement islands in shallow areas of the coastal bays. **<u>Action/response</u>:** Ms. Schrawder provided useful information including aerial photos.
May 23, 1996	Letter from the West Ocean City Association to the Corps regarding the need to "repair the emergency situation" in the area of the Route 50 bridge and Ocean City Inlet. The letter states that rocks placed around the pilings of the bridge have narrowed the channel and caused increased water velocity and sedimentation. The result is limited navigability for larger boats and unsafe conditions for small boats. **<u>Action/response</u>:** The problem identified in the letter was the subject of a limited investigation by the Corps and the State Highway Administration. The findings were that navigation through the bridge requires alert attention to the conditions but is not considered a hazard to navigation. The current velocities are not unusual for a channel near an inlet. The Corps is running a model of the currents in the area, however, and could make recommendations for improvements.
May 24, 1996	Letter from the community of Harbor Island regarding navigation problems in the vicinity of the Route 50 bridge. **<u>Action/response</u>:** See response above.

May 29, 1996	On-site briefing for Senator Mikulski by Study Manager. Specific topic was the Assateague Island restoration. **<u>Action/response</u>:** Senator Mikulski strongly supports the project.
June 12, 1996	Briefing for the Assateague Coastal Trust on the Assateague Island restoration **<u>Action/response</u>:** The Assateague Coastal Trust appreciated learning about the project and being part of the public participation.
June 14, 1996	Steering Committee meeting, including representatives of the Corps, Ocean City, NPS, DNR, and Worcester County, met to review study progress and discuss the plan formulation process. **<u>Action/response</u>:** The Steering Committee identified the recommended level of mitigation for the Assateague Island short-term restoration. It was decided that restoring the volume of material lost since 1965 would be appropriate mitigation, however, based on cost and benefit information outlined in the decision matrix tables (included as part of Section 5 of the main report), restoring a volume of material less than the 1965 amount, based on environmental considerations, would be ade quate mitigation.
June 21, 1996	Message from Corps to West Ocean City Association requesting review of draft information to be included in second newsletter. **<u>Action/response</u>:** Comments were provided and incorporated into the newsletter.
June 24, 1996	E-mail message from Corps biologist to Dr. Leatherman, University of Maryland, regarding the selected alternative for the Assateague Island restoration and requesting his comments. **<u>Action/response</u>:** Message was part of the continuing information-sharing process among the study team and scientists/experts in fields related to the study.
June 24, 1996	E-mail message from Dr. James Fraser to Corps biologist suggesting that vegetation removal be addressed as part of the long-term management strategy for Assateague Island. **<u>Action/response</u>:** The following e-mail message on June 26 responded to Dr. Fraser's suggestion.
June 26, 1996	E-mail message from Corps biologist to Dr. James Fraser, regarding the reluctance of the NPS to include vegetation management as part of the long-term restoration plan for Assateague Island .

	<u>Action/response</u>: The dialogue among the study team and outside scientists/experts concerning post-construction management of the site ultimately resulted in development of a monitoring and management plan for the Assateague Island restoration.
June 26, 1996	E-mail message from Corps biologist to Ms. Anne Hecht, FWS, regarding the varying heights of Assateague Island during t he past 30 years. Also excerpted was a message to Ms. Laurie McGiver (contractor preparing piping plover report) providing information on the effects of placing material to the proposed height of 3.3 m NGVD. **<u>Action/response</u>:** Message was part of the continuing information-sharing process among the study team and scientists/experts in fields related to the study.
July 1, 1996	Memo regarding phone conversation between Corps economist and commercial fishing interests on use of the offshore shoals. **<u>Action/response</u>:** Conversation was a preliminary inquiry into the potential effects on commercial fishermen that would result from dredging the offshore shoals. After further phone calls, meetings were set up by DNR staff to discuss impacts on the shoals and the preferences of fishermen.
July 2, 1996	E-mail message from Dr. Lenore Fahrig, Carleton University, Ottawa, Canada, to Corps biologist regarding the effects of barrier island overwash frequency on vegetation distribution. **<u>Action/response</u>:** Information provided by Dr. Fahrig was incorporated into the report.
July 8, 1996	Study team meeting to discuss Assateague Island restoration and review the plan formulation process for the short-term restoration, discuss the selection of the preferred plan, and get input on how dune elevation, placement, configuration, or construction times might be used to optimize the preferred plan. **<u>Action/response</u>:** Agreement was reached on critical dune height, maintenance, and monitoring details.
July 9, 1996	E-mail message from Dr. James Fraser to Corps biologist regarding the likelihood of managing the Assateague site to control vegetation and offering research assistance. **<u>Action/response</u>:** Information and offer of assistance considered.
July 10, 1996	Phone conversation between Corps biologist and Mr. John Foster, DNR artificial reef program coordinator, regarding meeting to be held with reef experts and Oceanside Fisheri es Advisory Committee (commercial

	fishermen) to discuss mining sand from offshore shoals for Assateague Island restoration. **<u>Action/response</u>:** Meetings with commercial fishermen and DNR representatives were scheduled for September 11, 1996.
July 10, 1996	Phone conversation between Corps biologist and John Nichols, NMFS, regarding restrictions on the use of hopper dredges on the offshore shoals. Informal consultation and possibly a formal Section 7 Endangered Species consultation would be required if use of hopper dredges is proposed. In addition, there is a May - November time of year restriction for hopper dredging. **<u>Action/response</u>:** The Corps study team began researching equipment needs for mining the offshore shoals.
July 25, 1996	Focus group meeting held in Annapolis to discuss offshore sand shoal sources for Assateague restoration. Discussed DNR's position on which shoal could be utilized. DNR will determine preference. Decided to exclude shoals B and C as sources because of value to commercial clammers. Discussed, but came to no agreement on, potential mitigation measures for recreational fishery. Discussed potential dredging schemes. NMFS noted that consultation will be required regarding potential sea turtle and whale impacts if hopper dredge is used. **<u>Action/Response</u>**: Decided to schedule meetings with commercial and recreational fishermen to discuss proposed project and consider need for mitigation.
July 29, 1996	Memo to Corps from NPS providing preliminary outline of monitoring and mitigation program for the Assateague short-term restoration project. **<u>Action/response</u>:** The NPS provided a draft program to be presented at a focus group meeting on September 12.
July 29, 1996	Plan Formulation Meeting held with Corps Division to review study status and Quality Control Plan and address critical issues. **<u>Action/response</u>:** Decision was made to pursue the restoration of Assateague Island under Section 111 of the River and Harbor Act of 1968, since it will most likely be authorized by the Water Resources Development Act of 1996.
July 31, 1996	Phone conversation between Corps biologist and John Nichols, NMFS, who is to develop a list of pros and cons for offshore shoal site selection. Mr. Nichols will also consult with other NMFS personnel on sea turtles and whales in the Ocean City area.

Action/response: Message was part of the continuing information-sharing process among the study team and scientists/experts in fields related to the study.

July 31, 1996	Phone conversation between Corps biologist and Mr. Bill McInturff, DNR, manager of several Wildlife Management Areas (WMA) in the coastal bay area, regarding restoration plans for the WMAs. **Action/response:** A visit was scheduled for the Corps biologist to visit the WMAs and review potential restoration sites.
Aug 5, 1996	E-mail message from F. Phillip Wirth, III, graduate student at University of Maryland on the Eastern Shore, to Corps biologist, regarding the development of fish habitat and the development of dredged material islands for bird habitat. **Action/response:** Information noted.
Aug 7, 1996	Phone conversation between Corps biologist and John Nichols, NMFS, regarding his recommendation to prepare a Biological Assessment for use of the offshore shoals in order to provide some protection from litigation. The Assessment should include use of hopper dredges and any other vessels, and size, speed, and number of beach-to-shoal trips of vessels. Turtle species to discuss include Kemps-Ridleys, Leatherback, and Loggerhead. Whale species to discuss include Right, Menke, and Humpback. Concerns are alleviated if hydraulic dredging is used or if dredging occurs at other times of the year than April through November. **Action/response:** A Corps biologist was tasked with preparation of a Biological Assessment.
Aug 9, 1996	Phone conversation between Corps biologist and Mr. George Ruddy, FWS, regarding Ocean City area turtle populations and the use of hopper dredges; grain size of material used to create habitat islands; location of dredged material islands; and use of the offshore shoals by commercial fishermen. **Action/response:** Information noted.
August 1996	Approximately 500 copies of the second Newsletter distributed. **Action/response:** The newsletter received positive comments from the public.
Aug 20, 1996	Phone conversation between Corps biologist and John Nichols, NMFS, regarding Mr. Nichol's comments on island and wetland creation. Mr. Nichols will provide comments. **Action/response:** Message was part of the continuing information-sharing process among the study team and scientists/experts in fields related to the study.

Aug 20, 1996	Phone conversation between Corps biologist and Mr. Marcel M. Montane, Virginia Institute for Marine Science, regarding the design of dredged material placem ent island, the depths of shallow water for small fish, and the need to avoid impacts to SAV. **<u>Action/response</u>:** Message was part of the continuing information-sharing process among the study team and scientists/experts in fields related to the study.
Aug 20, 1996	Phone conversation between Corps biologist and Ms. Laurie Silva, NMFS, regarding background information on use of dredging offshore shoals, potential impacts to nesting and migrating turtles, and possible actions to reduce liability and meet legal requirements. **<u>Action/response</u>:** Project information was provided to Ms. Silva.
Aug 21, 1996	Phone conversation between Corps biologist and Mr. Bill Lake, Ocean Pines Association, regarding potential parcels to be used for salt marsh restoration. **<u>Action/response</u>:** Information noted.
Aug 27, 1996	Study team meeting to discuss monitoring and mitigation plan for immediate restoration of Assateague. **<u>Action/response</u>:** Group discussion resulted in some changes to the draft plan and identification of matters that remained unresolved, such as monitoring of vegetation, predation by foxes, and invertebrate populations.
Aug 22, 1996	Phone conversation between Corps biologist and Mr. Ed Ambrogio, EPA, who indicated his objection to the idea of filling healthy SAV beds to create wildlife habitat islands. Mr. Ambrogio felt that filling marginally healthy SAV bed might be acceptable if mitigation were done. **<u>Action/response</u>:** Information noted.
Aug 22, 1996	Phone conversation between Corps biologist and Mr. Bill McInturff, DNR, regarding the extent and importance of recreation in Isle of Wight Bay. **<u>Action/response</u>:** Information noted.
Aug 22, 1996	Phone conversation between Corps biologist and Mr. Brooks Clayville, NCRS, regarding NEP interest in assisting habitat restoration component of project by locating forested wetland sites to restore. **<u>Action/response</u>:** Project information was provided to Mr. Clayville.
Aug 23, 1996	Phone conversation between Corps biologist and Mr. John Nichols, NMFS, regarding request for site specific information for habitat island creation.

	NMFS is concerned about loss of/disturbance to summer flounder and hard clam habitat, as well as recreation impacts. **<u>Action/response</u>:** Information on the sampling program developed by Mr. Philip Wirth, University of Maryland graduate student, was provided to Mr. Nichols.
Sept 5, 1996	Letter to Corps from Mr. Ray Nornes, commercial dredging contractor, regarding his endorsement for the use of geotubes on Assateague Island. **<u>Action/response</u>:** Information noted.
Sept 11, 1996	Two meetings with headboat captains and representatives of commercial fishing interests in Ocean City area held at the White Marlin Club in West Ocean City. Meeting purpose was to present the project status and discuss the impacts of using Little Gull and/or Great Gull shoals as a sediment source for the Assateague restoration. Headboat captains expressed a preference for dredging the back bays and ebb shoal for restoration material rather than either offshore shoal. They stated that smaller boats (including headboats) fish near Little Gull because it is closer to shore. After the meeting, several individuals stated that dredging on either shoal would have little effect on them, because they usually fish in between the shoal and the shore. Commercial fishing representatives stated that dredging either shoal would have little impact on commercial fishing interests. **<u>Action/response</u>:** Based on input from many sources, including these meetings, the decision was made to remove material from Great Gull shoal for the short-term restoration of Assateague Island.
Sept 12, 1996	Focus group meeting with project sponsors and piping plover experts to determine details of sediment placement for the Assateague Island short-term restoration; review a draft monitoring and mitigation program; and discuss options for sources of borrow material. **<u>Action/response</u>**: Consensus was reached on placement amount, location, configuration, and construction times for restoration of the island; comments were provided on the draft monitoring and mitigation plan. The groups had no objections to the use of Little Gull or Great Gull shoals as sources of borrow material.
Sept 18, 1996	E-mail message to Corps from Mr. Dave Brinker, DNR, providing recommendations for location, configuration, and materials to be used in construction of wildlife habitat island. **<u>Action/response</u>:** Information will be incorporated into the site selection process for dredged material island created for wildlife habitat.

Sept 19, 1996	E-mail memo from Dena Dickerson at WES providing information on presence of turtles in Delaware Bay and the possibility that dredging after mid-September might be acceptable to NMFS. **<u>Action/response</u>:** Information noted.
Sept 24, 1996	Phone conversation between Corps biologist and Ms. Danielle Algazi, EPA, regarding process for steering documentation through EPA and Federal Register. Five copies should be sent to EPA and EPA will place NOA in Register. **<u>Action/response</u>:** Information noted. EPA specialist contacted for guidance in Federal Register process.
Sept 24, 1996	Letter to Corps from Mr. Lee W. Williams, director of Assateague Point Home Owners Association, endorsing further investigation of the use of geotubes for the Assateague Island restoration. **<u>Action/response</u>:** Information noted
Sept 25, 1996	E-mail memo with information from Mr. Carl Zimmerman, NPS, regarding his view that presence of sea turtles in Assateague area is not sufficient to interrupt project. Mr. Zimmerman suggests contact with NMFS for specific numbers of turtle strandings/ mortalities. He believes that strandings in area are primarily a result of seasonal fishing intensity. **<u>Action/response</u>:** Information noted.
Sept 25, 1996	Informal presentation at a meeting of the Mid-Atlantic Chapter of the Maryland Saltwater Sportfishing Association. A member of the DNR Department of Fisheries coordinated and participated in the meeting. General information on the four project components was presented, with detailed information provided on the Assateague Island restoration and possible use of offshore shoals as a restoration sediment source. Corps representatives also informed the group that, based on input from other fishing interests, the Corps was investigating the possibility of addressing sediment-related navigation problems in the back bays. A question and answer period following the presentation provided an opportunity for a discussion. No major objections were made to the use of either Little or Great Gull shoals. **<u>Action/response</u>:** This audience agreed that using Great Gull shoal as a source of sand for the short-term restoration of Assateague Island was somewhat preferable to the use of Little Gull.
Sept 27, 1996	E-mail message to Corps biologist from Ms. Anne Hecht, FWS Endangered Species Biologist, regarding assessment of restoration project impacts on foraging ecology of Assateague Island piping plovers. Ms. Hecht requested comments on the "very rough cut at a draft memo". The draft recommends that an evaluation of the impacts on plover foraging

ecology be completed as part of the Assateague Island restoration project in addition to the monitoring and mitigation plan under preparation by the NPS. The suggestion was that a study to estimate critical factors in the process of plover brooding on the north end of the island be completed before and after implementation of the immediate restoration. Factors to be estimated include the availability of various plover foraging habitats; plover brood habitat use, time budgets, and foraging rates in various habitats; and arthropod abundances. Ms. Hecht suggested that two years of pre-project field data be collected and that post-project data collection begin 3 or 4 years after project construction.
Action/response: Mr. Chris Spaur, Corps biologist, provided comments on Ms. Hecht's draft memo, including suggestions that the memo emphasize the value of the study to Endangered Species Act compliance, and the importance of coordinating with other studies in order to minimize redundancy. A monitoring plan for invertebrates will be developed by Ms. Hecht.

Sept 30, 1996 — Memo to Corps from NPS providing a revised monitoring and mitigation plan for Assateague short-term restoration project. The revised plan incorporates the comments of Focus Group members, and other reviewers at the September 12 meeting.
Action/response: This document is an interim final plan providing information on tasks to be completed to maintain plover habitat and to repair any breaches in the dune. Additional information regarding funding and responsibility for tasks are to be determined.

Oct 9, 1996 — E-mail memo regarding an October 8 coordination meeting between Corps study team members and representatives of the Mineral Management Service (MMS), which manages resources such as oil, gas, and minerals, that occur on the Outer Continental Shelf. The meeting was a step in the process of developing a Memorandum of Agreement in order for the Corps to use sand from Great Gull Bank for the Assateague Island immediate restoration at no cost.
Action/response: Corps team members met with the Acting Program Director of the Office of International Activities and Marine Minerals and 3 members of his staff to discuss the status of the project and how the EIS would address use of and impacts to offshore shoals for the Assateague Island short-term restoration. It was agreed that portions of the EIS would be submitted to the MMS in draft form to insure that environmental and NEPA-related questions were adequately addressed and that questions from the MMS were answered.

October 17, 1996 — E-mail from Dave Brinker of DNR Heritage and Biodiversity Conservation Program regarding tiger beetles on northern Assateague. Discussed desire

	to limit beach disturbance north of 3 km south of inlet to provide refugium for tiger beetle. **Action/Response**: Information noted.
October 18, 1996	Information received from MMS regarding MMS standards for EISs. These standards are used by MMS to support negotiated agreements for offshore borrow areas. **Action/Response**: Corps biologist sent E-mail back indicating that MMS standards looked compatible with Draft EIS with the exception of MMS requirements for calculating air emissions. Air emissions aren't calculated because the project is expected to be exempt from such considerations because it is temporary in nature.
October 18, 1996	E-mail received from USFWS commenting on draft Monitoring and Action Plan. Comments focused on decision-making authority , performance indicator no. 3 for which an elevation has not yet been determined, and Piping Plover predator (i.e., fox) management. **Action/Response**: Information noted.
Nov 4, 1996	**COORDINATION LETTER TO MARYLAND HISTORICAL TRUST,** providing a copy of the Phase I archaeological report to partially fulfill requirements of the National Historic Preservation Act for the Ocean City Water Resources project. The letter summarized the four project components and (1) concluded that no cultural resources would be affected in the Assateague Island restoration project area; (2) provided a report on the results of a survey done on the offshore shoals which were considered as a source of dredged material for the Assateague short-term restoration; (3) restated the MHT's conclusion that there was a low probability that the inlet would contain cultural resources that could be affected by dredging or sand by-passing actions; and (4) states that reconnaissance investigations will be conducted in the coastal bays during the site selection process for the environmental restoration portion of the project. **Action/response:** As described in the letter, further actions on the part of the Corps include the coastal bay investigations and completion of a Phase II investigation of a ship wreck on Assateague Island.
November 5, 1996	Letter from USFWS regarding need for monitoring of Piping Plover foraging ecology. Letter included functions that monitoring would s erve and suggested research objectives. **Action/Response**: Information noted.
November 8, 1996	E-mail received from MMS regarding MMS comments on Draft EIS

	Action/Response: Most of comments addressed in updated version of Draft EIS. Several comments will require future discussion to resolve.
Nov 11, 1996	Copy of report on re-establishment of seabeach amaranth, prepared by Ms. Nora Murdock, provided to Corps. Information in the seabeach amaranth report was incorporated into the EIS.
Nov 13, 1996	Phone conversation between John Nichols, NMFS, and Corps biologist regarding threatened and endangered sea turtles which migrate through the offshore shoal area. Mr. Nichols stated that use of an approved turtle deflector and the presence of observers would be adequate protection for turtles during dredging for material to be used in the Assateague restoration. He stated that there will be no seasonal restrictions on dredging if those conditions are met and that after completion of the Biological Assessment NMFS will prepare a Biological Opinion including an "incidental take" statement. **Action/response:** NMFS guidance will be followed.
Nov 18, 1996	**FISH AND WILDLIFE COORDINATION ACT** (FWCA) letter from FWS. **Action/response:** Project is in compliance with FWCA.
January 14, 1997	Phone conversation with John Nichols of NMFS regarding need for pre- and post-dredging assessment of Great Gull Bank, as well as mitigation for potential impacts to recreational fishery. NMFS believes that a controlled fishing study is needed to evaluate impacts of dredging Great Gull Bank. **Action/Response**: Information noted
January 17, 1997	Conference call with MMS and USFWS regarding need for pre- and post-dredging assessment of Great Gull Bank, as well as mitigation for potential impacts to recreational fishery. MMS and USFWS believe that sediment and bathymetric monitoring should be conducted post-project to evaluate impacts. **Action/Response**: Information noted

PERTINENT CORRESPONDENCE

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Washington, DC 20240

JUL 17 1995

Mr. Robert Gaudette
Natural Resources Department
Boating Administration, Waterway Improvement
Tawes State Office Building
Annapolis, Maryland 21401

Dear Mr. Gaudette:

On June 2, 1995, the Washington Post printed an article titled, "Maryland's Atlantic Coast in Line for $4 Million Ecological Study." Among other things, the three-year study proposes to investigate ways to maintain Ocean City beaches, an objective the State of Maryland and this office has been pursuing since 1992. For that reason, I am interested in obtaining additional information on the proposed study and would like to make you aware of our complementary efforts with the State.

In the way of background, the Department of the Interior's Minerals Management Service (MMS) is responsible for the management and stewardship of all marine minerals on the Federal Outer Continental Shelf (OCS), including the issuance of leases and collection of royalties and fees. Within MMS, the Office of International Activities and Marine Minerals (INTERMAR) specifically manages nonenergy minerals, including sand, gravel and shell.

The near-term focus of INTERMAR's Marine Minerals Program is on sand for coastal restoration. With diminishing onshore and nearshore resources, cooperative projects are designed to provide a means for States to identify and assess suitable offshore sand deposits with potential to meet their coastal needs. Such collaborative efforts by coastal States and INTERMAR, in conjunction with other agencies, simultaneously address common concerns for both coastal and marine resources and environments.

The objective of our cooperative agreement with Maryland's Department of Natural Resources (Geological Survey) is to inventory sand deposits containing material suitable for beach nourishment in areas 3-15 miles offshore. During our 1993 studies, we examined the "Northern Shoal Field", the area between an offshore extension of 40th Street in Ocean City and the Maryland/Delaware line. Two large shoals were identified and contain an estimated 154 million cubic yards of beach-quality sand. The "Middle Shoal Field", which extends from 40th Street southward to North Ocean Beach on Assateague Island, was studied during 1994. Three shoals which were identified contain 178 million cubic yards of beach-quality sand. The project is currently looking at the third and final area, North Ocean Beach to the Maryland/Virginia line. Results of the 1993-1994 work are available at the Maryland Geological Survey while results of the work in progress are not expected to be available until early 1996. Similar projects are also underway with Maryland's neighbors, Delaware and Virginia.

Lastly, pursuant to the OCS Lands Act, as amended in October 1994 by P.L. 103-426, use of Federal sand for qualifying public works projects (e.g., beach nourishment) may be made available through a new negotiated agreement procedure. Previously, rights to OCS sand could only be acquired through a competitive lease sale. This expanded authority is an important change in that it allows INTERMAR to work directly with the State and local governments when Federal sand is needed for coastal restoration needs.

I would appreciate receiving copies of the proposed ecological study plans, agreements with other agencies and any other pertinent material which is available. If you would be interested in additional information on our program or the new legislation, please contact me at (703) 787-1291 or by mail at:

Minerals Management Service
Office of International Activities
and Marine Minerals
381 Elden Street (MS 4030)
Herndon, Virginia 22070

Sincerely,

Donald W. Hill

Donald W. Hill
Deputy Program Director
Marine Minerals Activities
Office of International Activities and Marine Minerals

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John R. Griffin
Secretary

Ronald N. Young
Deputy Secretary

August 17, 1995

Mr. Donald W. Hill
Minerals Management Service
Office of International Activities and Marine Minerals
381 Elden Street (MS 4030)
Herndon, VA 22070

Reference: Letter of July 17, 1995

Dear Mr. Hill:

This letter and the enclosures provide information about the Ocean City, Maryland and Vicinity Water Resources Feasibility Study as you requested. The Department of Natural Resources (DNR) is undertaking this study in partnership with the U.S. Army Corps of Engineers, Baltimore District, the Town of Ocean City, Worcester County and the National Park Service.

The Town of Ocean City and the adjacent mainland areas and coastal bays have experienced a variety of water resource problems related to the presence of large populations and extensive development in a relatively small, dynamic area. In response to these problems and through the efforts of Senators Barbara Mikulski and Paul Sarbanes, a Resolution of the Committee on Environment and Public Works of the U.S. Senate was adopted May 15, 1991 that authorized the Corps of Engineers to develop a comprehensive water resources plan for the area.

In January 1993, the Corps initiated a 17 month Reconnaissance Study that investigated a broad range of water resource problems. The study area encompassed about 625 square miles and included the Town of Ocean City, Assateague Island, the Ocean City Inlet, Assawoman, Little Assawoman, Isle of Wight, Sinepuxent, and Chincoteague Bays and their watersheds. Based on reconnaissance-level investigations, five projects were shown to be feasible and environmentally acceptable and were recommended for detailed investigation during a Feasibility Study.

Telephone: (410) 974-2936
DNR TTY for the Deaf: 410-974-3683

During the Feasibility Study, the following five projects will be investigated for construction:

- Restoration of the northern end of Assateague Island.

- Long-term sand placement along the coasts of Ocean City and Assateague Island.

- Restoration of fish and wildlife habitat by the creation of tidal and non-tidal wetlands, and islands for shorebirds.

- Deepening and widening the navigation channel through the Ocean City Inlet and Harbor.

- Navigation improvements to Thorofare Channel.

A Feasibility Cost Sharing Agreement (FCSA) between the Corps and DNR was signed on July 6, 1995. Formal agreements between DNR, Ocean City and Worcester County and between DNR and the National Park Service were signed prior to the signing of the FCSA. These agreements outline the financial obligations of the other Sponsors.

Enclosed you will find a copy of the FCSA, a Summary of the Study Projects and a copy of the Project Study Plan. Further information can be obtained by contacting Stacey Marek, Coastal Section, Project Development Branch, Planning Division, Baltimore District, USACOE, Attn: CENAB-PL-PC, P.O. Box 1715, Baltimore, MD 21203-1715, (410) 962-4977, Fax (410) 962-4698. The Maryland Geological Survey is participating in the study. For details of their activities you may contact Darlene Wells or Randy Kerhin, MD Geological Survey, 2300 St. Paul St., Baltimore, MD 21218-5210, (410) 554-5544, Fax 554-5502. For more information on the Assateague Island Restoration, contact Carl Zimmerman, Asssateague Island National Seashore, 7206 National Seashore Lane, Berlin, MD 21811, (410) 641-1443, Fax (410) 641-1099.

If you have further questions about this study or DNR's participation in it, please contact Kathleen Ellett, (410) 974-2936.

Sincerely yours,

Robert Gaudette, Director
Waterway Services, Boating Administration

RG/ke
cc: Stacey Marek
enclosures

January 24, 1996

Planning Division

Dr. L. Donaldson Wright
Director
Virginia Institute of Marine Science
College of William & Mary
Gloucester Point, Virginia 23062

Dear Dr: Wright:

I am writing to advise you that the Baltimore District Corps of Engineers has initiated the Ocean City, Maryland and Vicinity Water Resources Feasibility Study. The purpose of this letter is to begin coordination with your agency and request your participation in establishing goals, gathering data, developing alternatives, and identifying a recommended plan. The study area includes Ocean City and Assateague Island, adjacent coastal bays and nearshore waters of the Atlantic, and Maryland mainland areas within the coastal watershed boundary. We are requesting information on biological resources, and environmental, aesthetic, historic, cultural, economic, and social conditions in the study area. The enclosed fact sheet and map provide additional background information.

The Feasibility Study includes four separate components that address different water-related problems in the Maryland coastal bay area. These components were identified in a comprehensive Reconnaissance Study, completed in May 1994. The Reconnaissance Study was fully coordinated with appropriate interests and included a number of potential projects implementable by other local, state, and Federal agencies. The scheduled completion date for the draft Ocean City Water Resources Feasibility Report is June 1997.

It is expected that the components will be addressed separately in the study; however, they will be linked within the overall water resources feasibility study. The four components of the study include the following (the timeframe noted indicates when data for each feature is requested):

- Restoration of the northern end of Assateague Island (data is requested within 30 days of the date of this letter);
- Long-term sand placement opportunities along Ocean City and Assateague Island shorelines (60 days);
- Creation and restoration of terrestrial and aquatic habitat (30 days); and
- Navigation improvements to the harbor, inlet, and Thorofare channel (60 days).

An accelerated schedule for several portions of the feasibility study necessitates an early emphasis on data collection for the Assateague Island restoration. We recognize that many agencies possess or are currently developing valuable data on historic and existing conditions concerning the study area and we are requesting available written and digital information. All digital information will be used in the development of a comprehensive Geographic Information System database for the study area. At the completion of the feasibility study, we will make all new information available to your office in support of current and future activities.

In addition to providing information relevant to the study area, it is requested that you provide an agency point of contact within 30 days from the date of this letter to facilitate future coordination. We anticipate that individual agencies may have several representatives with different areas of expertise who will participate in the study. Your response to this request for support will ensure that your agency's ideas and concerns are addressed during the plan formulation and evaluation process. Coordination letters are also being sent to the individuals and organizations on the enclosed list. If you have any questions regarding this matter, please call Ms. Stacey Marek, at 410-962-4977.

Sincerely,

Dr. James F. Johnson
Chief, Planning Division

Enclosures

CF:
PDB reading file

ANDERSON-AUSTRA/ses/CENAB-PL-PC
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MS. KATHLEEN ELLETT
MDDNR BOATING ADMINISTRATION
TAWES STATE OFFICE BLDG.
580 TAYLOR AVENUE
ANNAPOLIS, MD 21401

MR. JORDAN LORAN
PROJECT MANAGER
PROJ. DEV. & OCEAN CITY BEACH REPL. PROJ
BOATING ADMIN., MD. DEPT. NAT. RES.
TAWES STATE OFFICE BUILDING, E-4
ANNAPOLIS, MD 21401

MR. JAMES F. CASEY
MARYLAND DEPARTMENT OF NATURAL RESOURCES
COASTAL BAYS FISHERIES PROJECT
MATAPEAKE TERMINAL - FISHERIES
301 MARINE ACADEMY DRIVE
STEVENSVILLE, MD 21666

MR. FRED BEDELL
CHIEF, FIELD OPERATIONS
NAVIGATION DIV./MATAPEAKE DIV.
BOATING ADMINISTRATION, MDDNR
303 MARINE ACADEMY DRIVE
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PROGRAM CHIEF, NAT. RES. IMPACT ASSMT.
CHESAPEAKE & COASTAL WATERSHED ADMIN.
MARYLAND DEPARTMENT OF NATURAL RESOURCES
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ANNAPOLIS, MD 21401

MR. RANDALL T. KERHIN
CHIEF, COASTAL & ESTUARINE GEOLOGY
MARYLAND GEOLOGICAL SURVEY
MARYLAND DEPARTMENT OF NATURAL RESOURCES
2300 SAINT PAUL STREET
BALTIMORE, MD 21201

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MARYLAND DEPARTMENT OF NATURAL RESOURCES
WILDLIFE DIVISION
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ANNAPOLIS, MD 21401

MR. THOMAS WEISS
MARYLAND OFFICE OF PLANNING
P.O. BOX 183
SALISBURY, MD 21803

DR. CLEMENT L. COUNTS III
DIRECTOR
COASTAL ECOLOGY RESEARCH LABORATORY
THE UNIVERSITY OF MARYLAND
EASTERN SHORE CAMPUS
PRINCESS ANNE, MD 21853

MR. DAVID J. MISTER
WORCESTER SOIL CONSERVATION DISTRICT
P.O. BOX 97
SNOW HILL, MD 21863

WATER FOWLERS OF AMERICA
P.O. BOX 369
OCEAN CITY, MD 21842

MR. BRUCE NICHOLS
DISTRICT CONSERVATIONIST
SOIL CONSERVATION SERVICE
301 BANK STREET
SNOW HILL, MD 21863

MS. JEANNE LYNCH
WORCESTER COUNTY COMMISSION
COURTHOUSE, ROOM 112
SNOW HILL, MD 21863

MR. & MRS. JOSEPH FEHRER
WORCESTER ENVIRONMENTAL TRUST
110 WEST FEDERAL STREET
SNOW HILL, MD 21863-1238

MR. GERALD MASON
WORCHESTER COUNTY COMMISSION
COURTHOUSE, ROOM 112
SNOW HILL, MD 21863

DEPARTMENT OF THE ARMY
BALTIMORE DISTRICT, U.S. ARMY CORPS OF ENGINEERS
P.O. BOX 1715
BALTIMORE, MD 21203-1715

Planning Division

FEB 2 0 1996

Honorable Wayne T. Gilchrest
House of Representatives
Washington, DC 20515-2001

Dear Mr. Gilchrest:

I am writing to advise you that the Baltimore District, U.S. Army Corps of Engineers has initiated the Ocean City, Maryland, and Vicinity Water Resources Feasibility Study. A draft Environmental Impact Statement (EIS) is being prepared as part of the feasibility study. The study is being cost-shared with the Maryland Department of Natural Resources, the National Park Service, Worcester County, and Ocean City. The study area includes Ocean City and Assateague Island, adjacent coastal bays and nearshore waters of the Atlantic, and Maryland mainland areas within the coastal watershed boundary. The enclosed fact sheet and map provide additional background information about the project.

The feasibility study includes four separate components that address different water-related problems in the Maryland coastal bay area. These components were among those identified in a comprehensive reconnaissance report, completed in May 1994. The *Ocean City, Maryland, and Vicinity Water Resources Reconnaissance Report* was fully coordinated with the public, with government agencies, and with other appropriate interests, and included a number of potential projects implementable by local, state, and Federal agencies in addition to the Corps. It is expected that the four components will be addressed separately in the feasibility study; however, all of the components will be linked within the overall water resources feasibility report.

The four components of the study include the following:

- Restoration of the northern end of Assateague Island;
- Long-term sand placement opportunities along Ocean City and Assateague Island shorelines;
- Restoration of terrestrial and aquatic habitat; and
- Navigation improvements to the harbor, inlet, and Thorofare channel.

The scheduled completion date for the draft *Ocean City, Maryland, and Vicinity Water Resources Feasibility Report,* including all four study components, is June 1997. Due to the potential imminent breach of Assateague Island, the study component addressing restoration of the northern end of the island will be developed on an accelerated schedule.

We will continue to keep you informed concerning our progress and welcome your participation in the study process. If you have any questions regarding this matter, please call me or have a member of your staff contact my action officer, Dr. James F. Johnson, Chief, Planning Division, at (410)962-4900.

Sincerely,

Randall R. Inouye, P.E.
Colonel, Corps of Engineers
District Engineer

Enclosures

Ocean City, Maryland and Vicinity
Water Resources Feasibility Study

Project Information

- **Restoration of the northern end of Assateague Island**

The Ocean City inlet was formed in 1933 during a severe storm. In 1934 the Army Corps of Engineers constructed jetties to protect the newly formed waterway in an effort to provide for navigation between the coastal bays and the ocean. The inlet has functioned as a thorofare for boating traffic for the past 60 years; however, the jetties have disrupted the sediment supply between Ocean City and Assateague Island. Prior to the formation of the inlet, the sand generally traveled from Ocean City to Assateague Island, but the north jetty has been preventing a portion of the sand from reaching Assateague Island. Consequently, the island, particularly the northern six miles, has been eroding at an accelerated rate and is extremely vulnerable to breaching (forming another inlet). This component of the study will involve investigating methods for a one-time restoration of the northern end to a more natural condition. Due to the imminent threat to Assateague Island, this portion of the study is being fast-tracked and an interim draft report will be completed for this component prior to the overall draft report.

- **Long-term sand placement opportunities**

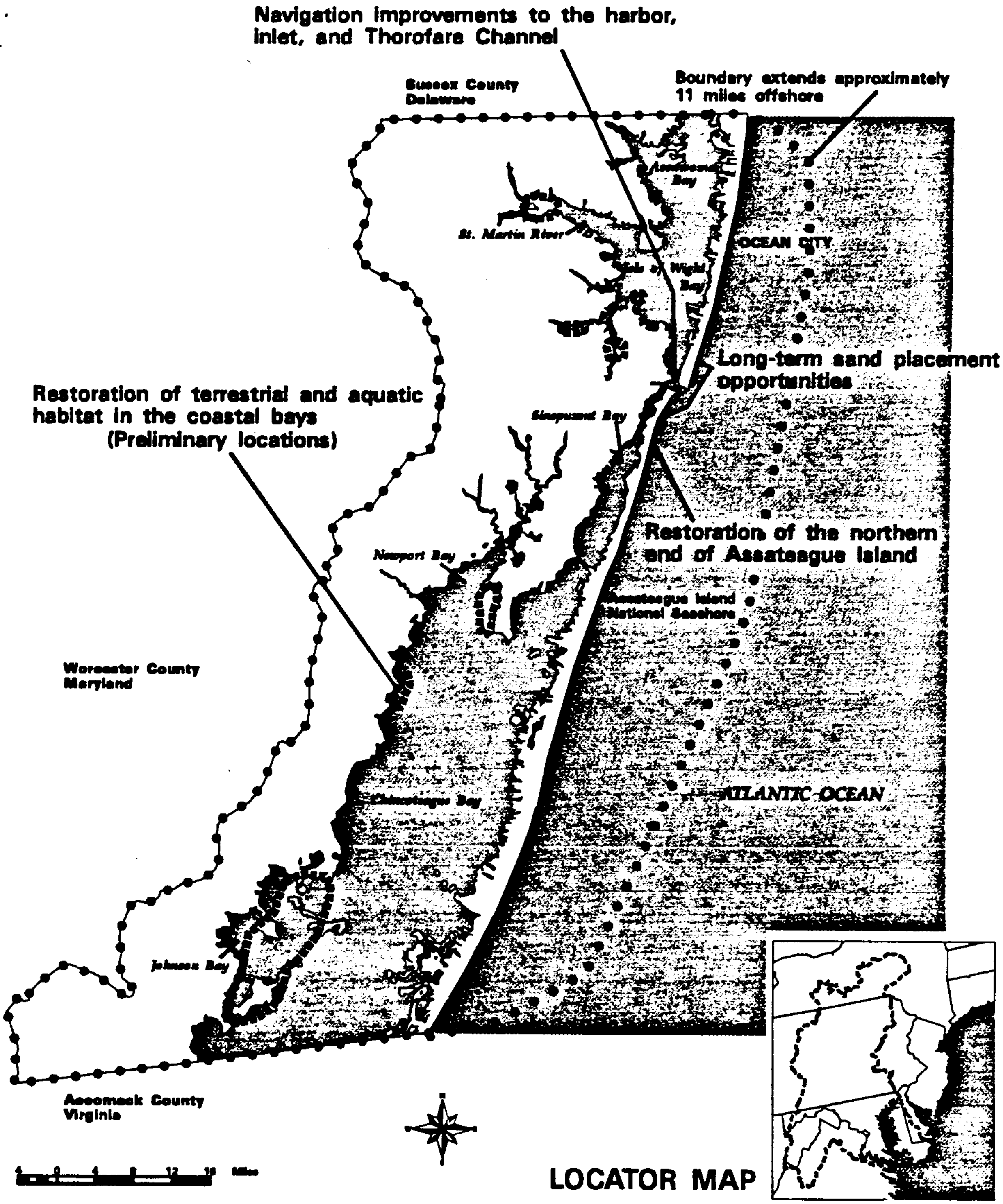
Once we have determined how to restore the northern portion of Assateague Island (as discussed above), we will determine the best method for continuing the sediment supply to the island. The study team will look at the future sand needs for both Ocean City (where we currently have a shoreline protection project) and Assateague Island and will determine a long-term plan that will address the future needs of both.

- **Restoration of terrestrial and aquatic habitat in the coastal bays**

During the study, we will determine methods for restoring wetlands and islands throughout the coastal bays for fish and wildlife habitat . The investigation will begin with a large array of locations and types of projects. Data will be collected for each site through literature searches and field work. The data will be analyzed and evaluated. Following the evaluation, the potential projects will be ranked and the best projects will be selected.

- **Navigation improvements to the harbor, inlet, and Thorofare Channel**

Many waterway users are experiencing problems navigating through the Ocean City inlet, harbor and Thorofare Channel (adjacent to the Ocean City Fishing Center). Substantial shoals exist that cause damages to both commercial and recreational vessels and create extended travel time for the vessels navigating the channels. This part of the study will investigate deepening and widening the existing channel through the inlet and harbor, and creating and maintaining a new channel through Thorofare Channel.



US Army Corps of Engineers
Baltimore District

Ocean City Water Resources Feasibility Study

Map of Potential Projects

• • • Project Area

▪▪▪▪▪▪ Potential Habitat Restoration Areas (Preliminary Locations)

MARYLAND HISTORICAL TRUST

Archaeology Office

Parris N. Glendening
Governor

Patricia J. Payne
Secretary, DHCD

February 20, 1996.

Dr. James F. Johnson
Chief, Planning Division
Department of the Army
Baltimore District, U.S. Army Corps of Engineers
P.O. Box 1715
Baltimore, MD 21203-1715

RE: Ocean City, Maryland and Vicinity
Water Resources Feasibility Study

Dear Dr. Johnson,

Thank you for your letter of 24 January initiating coordination with this office of efforts to address cultural resources within the four main areas of potential impact relevant to this feasibility study. Although the Trust's GIS system is still being brought up to date, I am able to include some data about remains and studies in the area. On these maps Blue indicates National Register sites, Yellow represents Easements and Red symbolizes archaeological sites and surveys. From these maps it is obvious that large portions of the area of potential effect have not yet been surveyed. Many vessels potentially eligible for the National Register of Historic Places are known to have foundered, ground or otherwise sunk in these areas and historic and prehistoric non-vessel sites have been inadequately documented though known to exist.

Minimally, all areas where undertakings are planned require Phase I underwater survey. This should be carried out by a qualified professional archaeologist and performed in accordance with the "Standards and Guidelines for Archaeological Investigations in Maryland" (Shaffer and Cole 1994) and with Archaeology and Historic Preservation: Secretary of the Interior's Standards and Guidelines (1983). Based upon the results of the survey, we will be able to determine whether or not the project will affect any submerged archaeological resources and make appropriate recommendations. Further consultation with our office will be necessary to fulfill compliance with Section 106 of the National Historic preservation Act of 1966; and we will discuss field methods and techniques with the archaeologist selected to perform the requested survey.

With regard to terrestrial archaeology, archival and field investigations may be necessary for some of the four main projects, but only after more parameters are known. The northern end of Assateague Island where restoration is planned contains no inventoried archaeological sites. Once a restoration method is identified, it will be necessary to consult with us on additional actions. Regarding long-term sand placement opportunities and improvements to the Thorofare Channel, further coordination with the Trust will be needed to examine sand sources and dredge disposal areas, respectively. Finally, larger scale plans of proposed coastal bay habitats slated for restoration are critical for us to provide useful comments.

If you have any questions or require further information, please contact me for underwater archaeology concerns at (410) 514-7662 or Dr. Gary Shaffer for terrestrial archaeology at (410) 514-7638.

Sincerely,

Susan B.M. Langley, Ph.D.
State Underwater Archaeologist

9600248
encl.
SBL/GDS

cc. Mr. Timothy E. Goodger
Mr. Marc Koenings
BSM Steven Hearn

UNITED STATES DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
NATIONAL MARINE FISHERIES SERVICE
Habitat and Protected Resources
Division
904 South Morris Street
Oxford, Maryland 21654

23 February 1996

Dr. James F. Johnson
Chief, Planning Division
Baltimore District
Corps of Engineers
P. O. Box 1715
Baltimore, Maryland 21203

Dear Dr. Johnson:

Reference is made to your letter, dated 24 January 1996, requesting information relative to the proposed Ocean City, Maryland and Vicinity Water Resources Feasibility Study.

The Maryland coastal bays provide habitat to a host of shell- and finfish of ecological, commercial, and recreational importance. Consequently, we are concerned with the locations and designs of the proposed habitat restoration and creation sites. Care must be taken that these projects are not located in sites that are highly sensitive or productive ecologically. Examples of such habitats include, but are not limited to, concentrated spawning and nursery areas, SAV and shellfish beds, vegetated wetlands, shell reefs, and intertidal flats.

We have no digitized data; however, we have some information in hard copy that can be searched once the study begins to focus on specific sites. We would be pleased to help screen sites and to participate in designing field studies as the study progresses.

If you wish to discuss these comments, or need additional information, please call me at (410) 226-5771.

Sincerely,

Timothy E. Goodger

Timothy E. Goodger
Assistant Coordinator

Headquarters Air University, Maxwell Air Force Base, Alabama (5 seats available).

The purpose of the meeting is to give the board an opportunity to review Air University educational programs and to present to the Commander, a report of their findings and recommendations concerning these programs.

For further information on this meeting, contact Dr. Dorothy Reed, BOV Coordinator, Air University, Maxwell Air Force Base, Alabama 36112–6335, telephone (334) 953–5159.

Patsy J. Conner,

Air Force Federal Register Liaison Officer.

[FR Doc. 96–4662 Filed 2–28–96; 8:45 am]

BILLING CODE 3910–01–M

Department of the Army

Availability of Non-Exclusive, Exclusive or Partially Exclusive Licenses (Recombinant DNA Molecules for Producing Terminal Transferase-like Polypeptides)

AGENCY: U.S. Army, Intellectual Property Law Division, Virginia.

ACTION: Notice.

SUMMARY: The Uniformed Services University of the Health Sciences Announces the general availability of exclusive, partially exclusive or non-exclusive licenses under the following patent application and any continuations, divisions or continuations in part of the same—

U.S. Patent No. 5,037,756

Subject: Recombinant DNA Molecules for Producing Terminal Transferase-like Polypeptides

'nventors: Frederick J. Bollum, et al.

'ssued: 5 August 1991

Licenses shall comply with 35 U.S.C. :09 and 37 CFR 404.

OR FURTHER INFORMATION CONTACT: Mr. arl T. Reichert, Acting Chief, ıtellectual Property Law Division, .TTN: JALS–IP, 901 North Stuart treet, Suite 700, Arlington, VA 22203– 337. Phone: (703) 696–8113.

IPPLEMENTARY INFORMATION: Written ›jections must be filed within three (3) onths from the date of this notice in e **Federal Register.**

egory B. Showalter,

my Federal Register Liaison Officer.

ɩ Doc. 96–4657 Filed 2–28–96; 8:45 am]

.ING CODE 3710–08–M

Department of Army, Corps of Engineers

Intent to prepare a Draft Environmental Impact Statement (DEIS) for the proposed Ocean City, Maryland, and Vicinity Water Resources Feasibility Study at Ocean City, in Worcester County, Maryland

AGENCY: Army Corps of Engineers, DOD.

ACTION: Notice of intent.

SUMMARY: The Baltimore District, U.S. Army Corps of Engineers is initiating the Ocean City, Maryland, and Vicinity Water Resources Feasibility Study to investigate potential solutions to several water resources problems in Ocean City, Maryland. The study area includes Ocean City and Assateague Island, adjacent coastal bays and nearshore waters of the Atlantic, and Maryland mainland areas within the coastal watershed boundary. The Feasibility Study will address four different water-related problems in the Maryland coastal bay area as separate report components, including (1) the restoration of the northern end of Assateague Island; (2) long-term sand placement opportunities along Ocean City and Assateague Island shorelines; (3) restoration of terrestrial and aquatic habitat; and (4) navigation improvements to the harbor, inlet, and Thorofare channel. Cost-sharing partners in the study include the Maryland Department of Natural Resources, the Town of Ocean City, Worcester County, and the National Park Service (Assateague Island National Seashore). The scheduled completion date for the draft Ocean City, Maryland, and Vicinity Water Resources Feasibility Report and DEIS is June 1997.

FOR FURTHER INFORMATION CONTACT: Questions about the proposed action and DEIS can be addressed to Ms. Stacey Marek, Project Manager, Baltimore District, U.S. Army Corps of Engineers, ATTN: CENAB–PL–PC, P.O. 1715, Baltimore, Maryland 21203–1715, telephone (410) 962–4977. E-mail address:

ocwr@ccmail.nab.usace.army.mil

SUPPLEMENTARY INFORMATION:

1. The study was authorized by a resolution of the Committee of Environmental and Public Works of the U.S. Senate, adopted 15 May 1991.

2. The Ocean City inlet was formed in 1933 during a severe storm. In 1934 the Army Corps of Engineers constructed jetties to protect the newly formed waterway in an effort to provide for navigation between the coastal bays and the ocean. The inlet has functioned as a thoroughfare for boating traffic for the past 60 years; however, the jetties disrupt the normal movement of sediment along the coast from Ocean City to Assateague Island. Lacking this sediment supply, approximately 6 miles of the northern Assateague shoreline have been eroding at an accelerated rate and the island is vulnerable to breaching, or forming one of more new inlets. The first two of the four study components listed below address this problem.

3. Restoration of the North End of Assateague Island—This study component will address the short-term restoration of Assateague Island by investigating methods for a one-time placement of sediment on the north end of the island. The sediment placement will mitigate the historic impacts of the jetty-induced sediment deficit. Due to a potentially imminent breach of the island, this component of the study will be completed as a separate draft report prior to completion of the other three components.

4. Long-Term Sand Placement Opportunities—A second component of the study will address the long-term placement of sand to restore a normal sediment budget to the north end of Assateague Island. After analysis and evaluation, a method will be selected to provide a sand supply adequate to maintain the integrity of the northern portion of Assateague Island. This portion of the study will also review current Corps' shoreline protection activities at Ocean City to determine whether there is a more cost-effective method of re-nourishing the beach.

5. Restoration of Terrestrial and Aquatic Habitat in the Coastal Bays—This study component will identify the best methods for creating and restoring wetlands and islands throughout the coastal bay area for fish and wildlife habitat. It is expected that between 80 and 200 acres of habitat will be created or restored.

6. Navigation Improvements to the Harbor, Inlet, and Thorofare Channel—This study component will determine the best methods for improving navigation through the harbor, inlet, and Thorofare Channel. Existing shoals cause damage to both commercial and recreational vessels and extend travel time for vessels navigating the channels. It is expected that the study will investigate deepening and widening the Corps of Engineers' channel through the inlet and harbor, and creating and maintaining a Federal channel through the existing Thorofare Channel.

7. The Baltimore District is preparing a DEIS that will describe the overall public interest and the impacts of the

proposed project on environmental resources in the area. The DEIS will also apply guidelines issued by the Environmental Protection Agency, under authority of Section 404 of the Clean Water Act of 1977 (P.L. 95–217). Potential effects of the project on water quality and on recreational, aesthetic, cultural, economic, social, fish and wildlife, and other resources will also be investigated.

8. The public involvement program will include workshops, meetings, and other coordination with interested private individuals and organizations, as well as with concerned Federal, state, and local agencies. Coordination letters and a newsletter have been sent to appropriate agencies, organizations, and individuals on an extensive mailing list. Additional public information will be provided through print media, mailings, and radio and television announcements.

9. In addition to the Corps, the Maryland Department of Natural Resources, the National Park Service, the Town of Ocean City, and Worcester County, current participants in the DEIS process include the U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Maryland Department of the Environment, Maryland Geological Survey, the Worcester Environmental Trust, and the Assateague Coastal Trust. The Baltimore District invites potentially affected Federal, state, and local agencies, and other organizations and entities to participate in this study.

10. The DEIS is tentatively scheduled to be available for public review in June of 1997.

James F. Johnson,

Chief, Planning Division.

[FR Doc. 96–4672 Filed 2–28–96; 8:45 am]

BILLING CODE 3710–41–M

DEPARTMENT OF EDUCATION

Proposed Information Collection Requests

AGENCY: Department of Education.

ACTION: Submission for OMB review; comment request.

SUMMARY: The Director, Information Resources Group, invites comments on the proposed information collection requests as required by the Paperwork Reduction Act of 1995.

DATES: Interested persons are invited to submit comments on or before April 1, 1996.

ADDRESSES: Written comments should be addressed to the Office of Information and Regulatory Affairs, Attention: Wendy Taylor, Desk Officer, Department of Education, Office of Management and Budget, 725 17th Street NW., Room 10235, New Executive Office Building, Washington, DC 20503. Requests for copies of the proposed information collection requests should be addressed to Patrick J. Sherrill, Department of Education, 600 Independence Avenue SW., Room 5624, Regional Office Building 3, Washington, DC 20202–4651.

FOR FURTHER INFORMATION CONTACT: Patrick J. Sherrill (202) 708–8196. Individuals who use a telecommunications device for the deaf (TDD) may call the Federal Information Relay Service (FIRS) at 1–800–877–8339 between 8 a.m. and 8 p.m., Eastern time, Monday through Friday.

SUPPLEMENTARY INFORMATION: Section 3506 of the Paperwork Reduction Act of 1995 (44 U.S.C. Chapter 35) requires that the Office of Management and Budget (OMB) provide interested Federal agencies and the public an early opportunity to comment on information collection requests. OMB may amend or waive the requirement for public consultation to the extent that public participation in the approval process would defeat the purpose of the information collection, violate State or Federal law, or substantially interfere with any agency's ability to perform its statutory obligations. The Director of the Information Resources Group publishes this notice containing proposed information collection requests prior to submission of these requests to OMB. Each proposed information collection, grouped by office, contains the following: (1) Type of review requested, e.g., new, revision, extension, existing or reinstatement; (2) Title; (3) Summary of the collection; (4) Description of the need for, and proposed use of, the information; (5) Respondents and frequency of collection; and (6) Reporting and/or Recordkeeping burden. OMB invites public comment at the address specified above. Copies of the requests are available from Patrick J. Sherrill at the address specified above.

Dated: February 23, 1996.

Gloria Parker,

Director, Information Resources Group.

Office of Postsecondary Education

Type of Review: Revision.

Title: Confirmation Report for the Patricia Roberts Harris Fellowship Program Report.

Frequency: Annually.

Affected Public: Not-for-profit institutions.

Annual Reporting and Recordkeeping Hour Burden:

Responses: 100.

Burden Hours: 1,100.

Abstract: Institutions of higher education that have received Patricia Roberts Harris grants are required to demonstrate their compliance with statutory requirements for distribution of fellowships. Information collected will be used by institutions of higher education to document the eligibility characteristics of students who are scheduled to receive fellowships under the program and the amount of each student stipend.

Office of Postsecondary Education

Type of Review: Revision.

Title: Application for Ability-to-Benefit Testing Approval.

Frequency: Annually.

Affected Public: Individuals or households; Business or other for-profit; Not-for-profit institutions.

Annual Reporting and Recordkeeping Hour Burden:

Responses: 150,180.

Burden Hours: 75,090.

Abstract: The Secretary of Education will publish a list of approved tests which can be used by postsecondary educational institutions to establish the ability-to-benefit for a student who does not have a high school diploma or its equivalent.

[FR Doc. 96–4611 Filed 2–28–96; 8:45 am]

BILLING CODE 4000–01–M

Submission of Data by State Educational Agencies

AGENCY: Department of Education.

ACTION: Notice of dates for submission of State revenue and expenditure reports for fiscal year 1995 and of revisions to those reports.

SUMMARY: The Secretary of Education announces a date for the submission by State educational agencies (SEAs) of preliminary expenditure and revenue data and average daily attendance statistics for fiscal year (FY) 1995 and establishes a deadline for any revisions to that information. The Secretary sets these dates to ensure that data are available to serve as the basis for timely distribution of Federal funds. The U.S. Bureau of the Census is the data collection agent for the Department's National Center for Education Statistics (NCES). The data will be published by NCES and will be used by the Secretary in the calculation of allocations for FY 1997 appropriated funds.

DATE: The suggested date for submission of preliminary data is March 15, 1996.

DEPARTMENT OF DEFENSE **Billing Code 3910-41**

CORPS OF ENGINEERS, DEPARTMENT OF ARMY

Intent to prepare a Draft Environmental Impact Statement (DEIS) for the proposed Ocean City, Maryland, and Vicinity Water Resources Feasibility Study at Ocean City, in Worcester County, Maryland.

AGENCY: U.S. Army Corps of Engineers, DOD

ACTION: Notice of Intent

SUMMARY: The Baltimore District, U.S. Army Corps of Engineers is initiating the Ocean City, Maryland, and Vicinity Water Resources Feasibility Study to investigate potential solutions to several water resources problems in Ocean City, Maryland. The study area includes Ocean City and Assateague Island, adjacent coastal bays and nearshore waters of the Atlantic, and Maryland mainland areas within the coastal watershed boundary. The Feasibility Study will address four different water-related problems in the Maryland coastal bay area as separate report components, including (1) the restoration of the northern end of Assateague Island; (2) long-term sand placement opportunities along Ocean City and Assateague Island shorelines; (3) restoration of terrestrial and aquatic habitat; and (4) navigation improvements to the harbor, inlet, and Thorofare channel. Cost-sharing partners in the study include the Maryland Department of Natural Resources, the Town of Ocean City, Worcester County, and the National Park Service (Assateague Island National Seashore). The scheduled completion date for the draft Ocean City, Maryland, and Vicinity Water Resources Feasibility Report and DEIS is June 1997.

FOR FURTHER INFORMATION CONTACT: Questions about the proposed action and DEIS can be addressed to Ms. Stacey Marek, Project Manager, Baltimore District, U.S. Army Corps of

Engineers, ATTN: CENAB-PL-PC, P.O. 1715, Baltimore, Maryland 21203-1715, telephone (410) 962-4977. E-mail address: ocwr@ccmail.nab.usace.army.mil

SUPPLEMENTARY INFORMATION:

1. The study was authorized by a resolution of the Committee of Environmental and Public Works of the U.S. Senate, adopted 15 May 1991.

2. The Ocean City inlet was formed in 1933 during a severe storm. In 1934 the Army Corps of Engineers constructed jetties to protect the newly formed waterway in an effort to provide for navigation between the coastal bays and the ocean. The inlet has functioned as a thoroughfare for boating traffic for the past 60 years; however, the jetties disrupt the normal movement of sediment along the coast from Ocean City to Assateague Island. Lacking this sediment supply, approximately 6 miles of the northern Assateague shoreline have been eroding at an accelerated rate and the island is vulnerable to breaching, or forming one or more new inlets. The first two of the four study components listed below address this problem.

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to maintain the integrity of the northern portion of Assateague Island. This portion of the study will also review current Corps' shoreline protection activities at Ocean City to determine whether there is a more cost-effective method of re-nourishing the beach.

5. Restoration of Terrestrial and Aquatic Habitat in the Coastal Bays - This study component will identify the best methods for creating and restoring wetlands and islands throughout the coastal bay area for fish and wildlife habitat. It is expected that between 80 and 200 acres of habitat will be created or restored.

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7. The Baltimore District is preparing a DEIS that will describe the overall public interest and the impacts of the proposed project on environmental resources in the area. The DEIS will also apply guidelines issued by the Environmental Protection Agency, under authority of Section 404 of the Clean Water Act of 1977 (P.L. 95-217). Potential effects of the project on water quality and on recreational, aesthetic, cultural, economic, social, fish and wildlife, and other resources will also be investigated.

8. The public involvement program will include workshops, meetings, and other coordination with interested private individuals and organizations, as well as with concerned Federal, state, and local agencies. Coordination letters and a newsletter have been sent to appropriate agencies, organizations, and individuals on an extensive mailing list. Additional public information will be provided through print media, mailings, and radio and television announcements.

9. In addition to the Corps, the Maryland Department of Natural Resources, the National Park Service, the Town of Ocean City, and Worcester County, current participants in the DEIS process include the U.S. Environmental Protection Agency, U.S. Fish and Wildlife Service, National Marine Fisheries Service, Maryland Department of the Environment, Maryland Geological Survey, the Worcester Environmental Trust, and the Assateague Coastal Trust. The Baltimore District invites potentially affected Federal, state, and local agencies, and other organizations and entities to participate in this study.

10. The DEIS is tentatively scheduled to be available for public review in June of 1997.

Dr. James F. Johnson
Chief, Planning Division

OCWR Bulletin
Ocean City, MD and Vicinity Water Resources Feasibility Study
A Joint Publication of Federal, State and Local Governments
February 1996

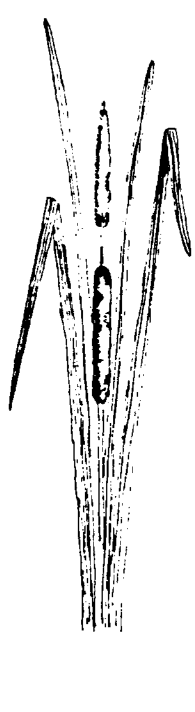
INTRODUCTION TO THE STUDY

The Town of Ocean City, Maryland, and the adjacent mainland areas and coastal bays are experiencing a variety of water resource problems related to the presence of large populations and extensive development in a relatively small, dynamic area. Existing Federal, state and local projects combined with development and agriculture have caused extensive degradation to the coastal bay environment.

In response to the problems, needs and opportunities in the area, the U.S. Army Corps of Engineers (COE), with the cooperation of state and local governments, initiated a study to develop a comprehensive water resources plan in January 1993.

Through the efforts of Senator Paul Sarbanes (D.MD), a Senate Resolution was adopted on May 15, 1991, which reads:

"RESOLVED BY THE COMMITTEE ON ENVIRONMENT AND PUBLIC WORKS OF THE UNITED STATES SENATE, that the Secretary of the Army is hereby requested to review existing reports of the Chief of Engineers for the Atlantic Coast of Maryland with a view to study....the changing coastal environment of the barrier islands, the Ocean City inlet, the Chincoteague, Sinepuxent, Assawoman, and Isle of Wight Bays and adjacent mainland areas. Included in this study will be the development of physical, environmental, and engineering data on coastal changes and processes to evaluate needed water resources improvements to navigation, flood control, hurricane protection, erosion control, wetlands protection, water supply, and other allied purposes to preserve and enhance the water resources infrastructure which is being severely taxed and degraded by growth, development and other factors."



The area in that study encompassed approximately 625 square miles and includes the Town of Ocean City, Assateague Island, the Ocean City Inlet, Assawoman, Little Assawoman, Isle of Wight, Sinepuxent and Chincoteague Bays and their watersheds.

CORPS STUDY PROCESS

Army Corps of Engineers projects are developed through a two-phase study process followed by a preconstruction engineering and design phase and finally, the construction phase.

Reconnaissance

The first step is the reconnaissance phase which involves preliminary investigations generally based upon readily available information. The Ocean City Water Resources reconnaissance study was completed in May 1994. It was based on a 17-month report process which involved public involvement through agency meetings, newsletters, steering committees and public workshops. A wide range of people and organizations were represented in these activities.

Feasibility

The second phase, or feasibility study, began in July 1995. The feasibility study involves more detailed investigations and includes necessary additional data collection.

During the feasibility phase, projects are formulated to address the problems. A recommendation to proceed to the next phase, pre-construction engineering and design is then made. The maximum study period for the feasibility phase is three years.

The draft Ocean City Water Resources Feasibility Report will be completed in June 1997 and the final report will be available by June 1998.

RECAP OF RECONNAISSANCE PHASE

The purposes of the reconnaissance study were to review water resources problems; develop and evaluate plans to address these problems; determine if there was a Federal interest and non-Federal support in proceeding into a feasibility phase, and estimate the cost for conducting the feasibility phase.

The comprehensive plan as developed consisted of specific project features implementable by various local, state and Federal agencies in addition to private citizens and groups. The projects implementable by the COE were evaluated in the most detail in order to demonstrate Federal interest in investigating the projects further.

In addition to the potential COE projects, numerous other recommendations that could be implemented by other Federal, state and local agencies were included in the comprehensive water resources plan. Several of the solutions would solve multiple purposes such as establishing an interagency watershed committee to promote watershed management and environmental safeguards, evaluating zoning and setback requirements, encouraging best management practices, reducing the impacts of watercraft on environmentally sensitive areas, identifying specific use areas in the coastal bays, and incorporating sea level rise into all planning actions.

Collectively, the recommendations included in the comprehensive water resources plan would alleviate the significant problems in the Ocean City and coastal bay region. The solutions are feasible and there are negligible negative project impacts. The comprehensive plan must be implemented with the full cooperation of local, state and Federal agencies.

The District Engineer recommended that the COE proceed with a feasibility-level study to further investigate the features with the Corps authority. In order to assure the viability of the comprehensive plan, the District Engineer also recommended that other Federal and state agencies and local interests continue in their efforts to implement portions of the plan within their areas of responsibility.

The Ocean City Water Resources Study moved forward with the help of Senator Barbara Mikulski, Senator Paul Sarbanes, Congressman Wayne Gilchrest, the National Park Service, the Maryland Department of Natural Resources, Worcester County and the Town of Ocean City. The feasibility study is cost shared 50%/50% between the COE and the other sponsors.

On June 1, 1995, the Maryland Board of Public Works made up of Governor Parris N. Glendening, Comptroller Louis L. Goldstein and Treasurer Lucille Maurer, approved the use of funds from the Ocean City Beach Replenishment Fund to pay for Worcester County's and the Town of Ocean City's shares of the costs for the feasibility phase of the study.

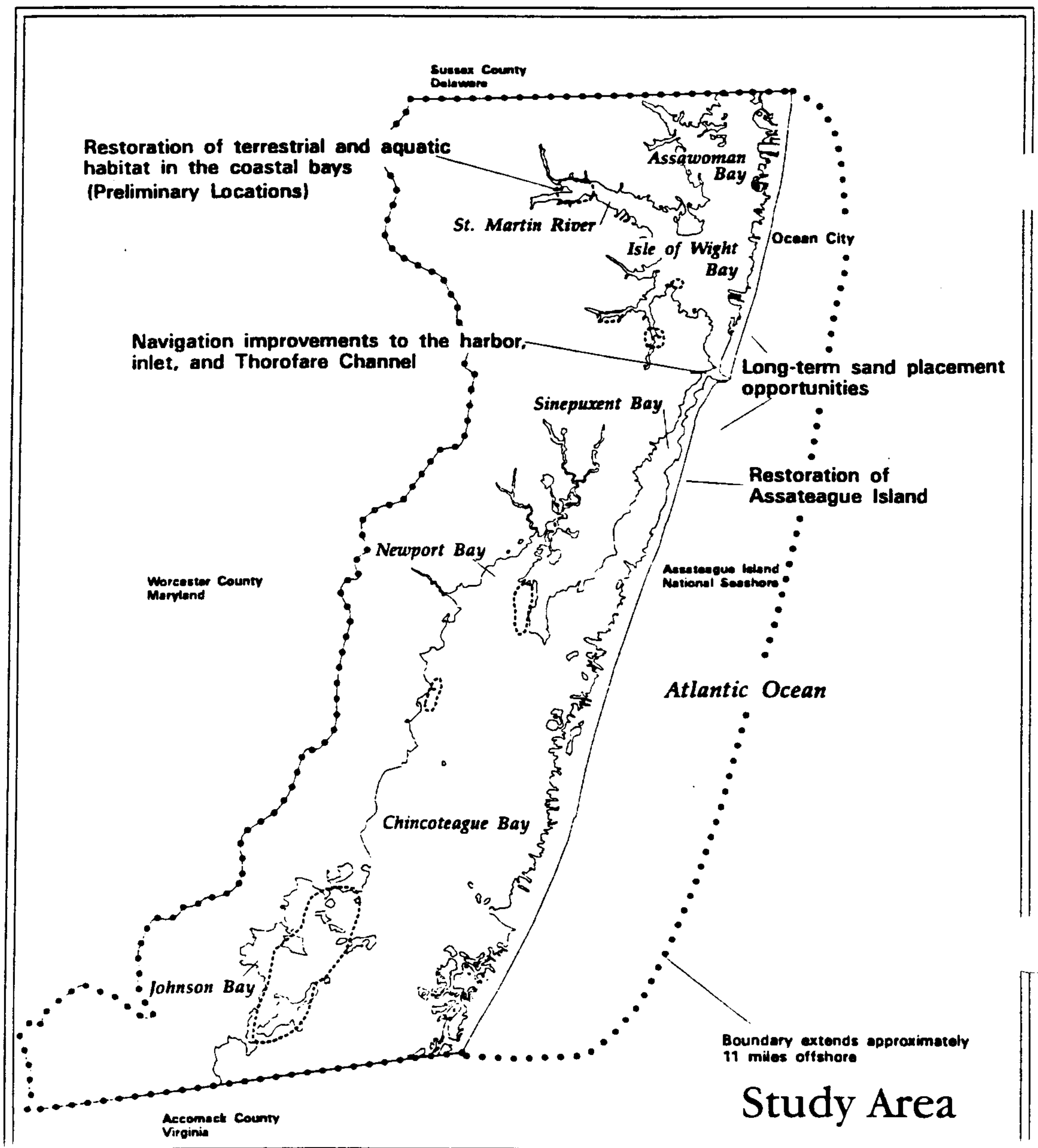
On July 6, 1995, a special signing ceremony, including all major players of the study, was held in Ocean City to initiate the feasibility study.

Many local individuals and organizations have participated in the OCWR study to date. Their continued involvement is appreciated and expected to continue.

FEASIBILITY STUDY PROJECTS

The feasibility study is focusing on four projects:

- **Restoration of the northern end of Assateague Island**
- **Long-term sand placement along ocean beaches**
- **Restoration of fish and wildlife habitat**
- **Navigation improvements to the harbor, inlet and Thorofare Channel**



Study Area

•Restoration of the northern end of Assateague Island

This feature of the study will involve investigating methods for a one-time restoration of the northern end of Assateague Island to a more natural condition. Due to the imminent threat to the Island, this portion of the study is being fast-tracked.

The Ocean City Inlet was formed in 1933 during a severe storm. In 1934 the Army Corps of Engineers constructed jetties to protect the newly-formed waterway in an effort to provide for navigation between the back bays and the ocean. The inlet has functioned as an avenue for boating traffic for the past 60 years; however, the jetties have disrupted the sediment supply between Ocean City and Assateague. Prior to the formation of the inlet, the sand generally traveled from Ocean City to Assateague but the north jetty has been preventing a portion of the sand from reaching Assateague. Consequently, the island, particularly the northern six miles, has been eroding at an accelerated rate and is extremely vulnerable to breaching.

•Long-term sand placement opportunities

Once it has been determined how to restore the northern portion of Assateague Island, the best method for continuing the sediment supply to the island will be decided.

The future needs of the current Ocean City Beach Replenishment Program as well as Assateague Island will be addressed.

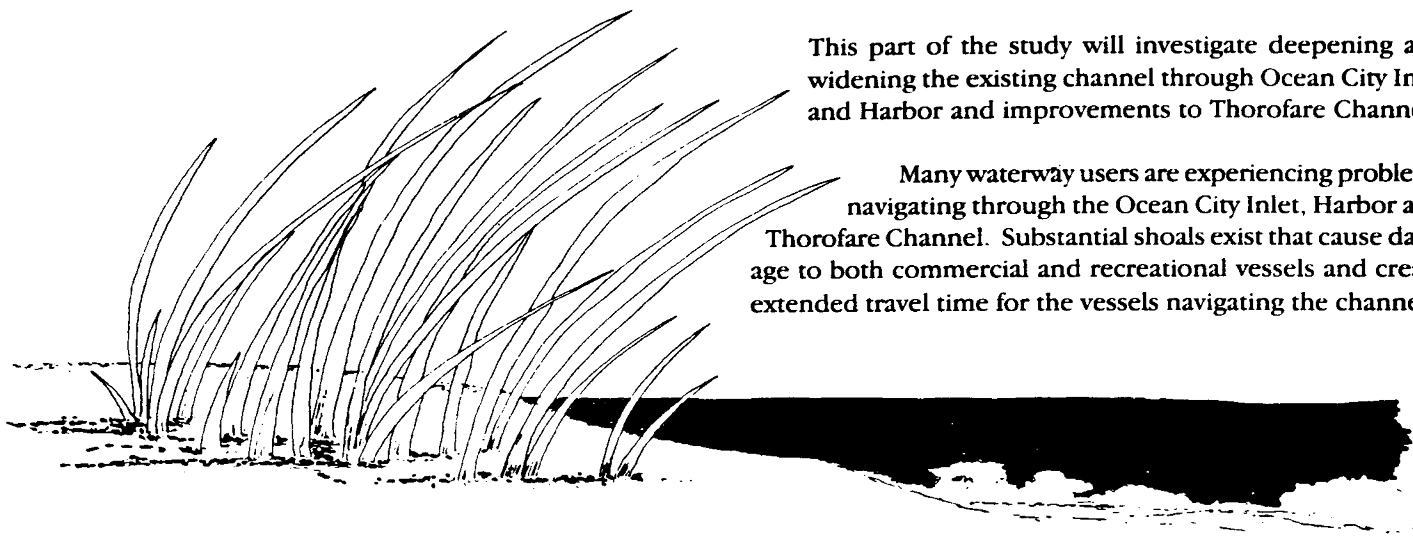
•Restoration of terrestrial and aquatic habitat in the back bays

During the study, methods will be investigated for restoring wetlands and islands throughout the coastal bays for fish and wildlife habitat. The investigation will begin with a large array of locations and types of projects. Data will be collected for each site. The data will be analyzed and evaluated. Following the evaluation, the potential projects will be ranked and the best projects will be selected.

•Navigation improvements to the harbor, inlet and Thorofare Channel

This part of the study will investigate deepening and widening the existing channel through Ocean City Inlet and Harbor and improvements to Thorofare Channel.

Many waterway users are experiencing problems navigating through the Ocean City Inlet, Harbor and Thorofare Channel. Substantial shoals exist that cause damage to both commercial and recreational vessels and create extended travel time for the vessels navigating the channels.



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Name (Please Print) ____________________

Title ____________________

Company/Organization ____________________

'dress ____________________

City ____________________ State ____________ Zip ____________

Telephone Number (______) ____________________

PUBLIC INVOLVEMENT

As with the reconnaissance study, coordination and public involvement will be an integral part of this study. Corps of Engineers staff is and will continue to work closely with its partners throughout the study.

Additionally, there will continue to be an opportunity for private citizens' involvement through public workshops during the course of the study. It is anticipated that the first public workshop will be held in June 1996 in order to inform the public of the study's progress, to gather information on the public's perception and to answer any questions.

The Corps places a high value on the comments and participation of the public in their study process. This news bulletin is an example of the Corps ongoing public involvemer program. As the study progresses, meetings will be schedule A citizen can voice concerns through these public involvement methods, through elected officials, or by making comments by letter or on the form at the bottom of this newsletter. You may also fax your comments by addressing them to the Ocean City Water Resources Study Team at (410) 962-4698, by calling Pete Noy at (410) 962-3372, or by sending comment via our e-mail address (ocwr@ccmail.nab.usace.army.mil).

Delmarva's Coastal Bay Watersheds: Not Yet "Up the Creek" *A Conference on Ecology and Economy Friday and Saturday, March 8-9, 1996 Carousel Hotel, Ocean City, Maryland*
For more information call the Assateague Coastal Trust at 410-821-0305

Kathleen Ellett
Maryland Department of Natural Resources
CZM E-2
580 Taylor Avenue
Annapolis, MD 21401

ATTN: CENAB-PL-PC
U.S. Army Corps of Engineers, Baltimore District
P.O. Box 1715
Baltimore, MD 21203-1715

MDE

MARYLAND DEPARTMENT OF THE ENVIRONMENT
2500 Broening Highway ● Baltimore, Maryland 21224
(410) 631-3000

Parris N. Glendening
Governor

Jane T. Nishida
Secretary

March 18, 1996

Colonel Randall R. Inouye
Baltimore District
U.S. Army Corps of Engineers
P.O. Box 1715
Baltimore MD 21203-1715

Dear Colonel Inouye:

Governor Glendening received your recent letter regarding your notification of the progress and schedule for the Ocean City Feasibility Study, and requested that I respond to you directly. With the new focus on Maryland's Coastal Bays brought about by winning National Estuary Program status, this study is very timely.

Maryland Department of the Environment (MDE) is already working with your staff by providing information from our files that are relevant to the feasibility study. We will continue to assist in any way we can. Please continue to keep the Governor and MDE informed of the progress you are making and how we can help.

Please feel free to contact me at (410) 631-3680 if you need to discuss any study issues with MDE.

Sincerely,

M S Haire

Michael S. Haire
Director
Technical and Regulatory
Services Administration

MSH/re

cc: Jane T. Nishida, Secretary, Maryland Department of the Environment
Governor Parris N. Glendening

detailed analysis in the National Environmental Policy Act/California Environmental Policy Act document.

3. *Scoping Process:* Potential impacts associated with the proposed action and alternatives will be fully evaluated. Resource categories that will be analyzed include: geology, oceanography/water quality, air and noise quality, marine resources, cultural resources, socioeconomics, land/water use, recreation, ground and vessel traffic and safety, energy, and aesthetics. The Los Angeles District will be conducting a public scoping meeting with the Port of Hueneme on 28 March 1996, at 7:00 pm, in the Board Room of the Oxnard Harbor District, 105 East Hueneme Road, Port Hueneme, California.

4. *Significant Issues:* The only possible significant issue at this time may be related to disposal of dredged material if testing shows sediments are contaminated and require special handling.

5. *Other Environmental Review and Consultation:* Environmental review and consultation as required by Sections 401 and 404 of the Clean Water Act, as amended, (33 U.S.C. 1341 and 1344); the Fish and Wildlife Coordination Act (16 U.S.C. 661 *et seq.*); the National Historic Preservation Act of 1966, as amended (16 U.S.C. 470 *et seq.*); the Endangered Species Act of 1973, as amended (16 U.S.C. 1531 *et seq.*); Executive Order 11990, "Protection of Wetlands," (24 May 1977); and other applicable statutes or regulations will be conducted concurrently with the EIR/EIS review process.

6. *Schedule:* We estimate the draft EIR/EIS will be made available to the public in Spring of 1997.

Gregory D. Showalter,

Army Federal Register Liaison Officer.

[FR Doc. 96–6930 Filed 3–21–96; 8:45 am]

BILLING CODE 3710–KF–M

Corps of Engineers

Intent To Prepare a Draft Environmental Impact Statement (DEIS) for the Proposed Ocean City, Maryland, and Vicinity Water Resources Feasibility Study at Ocean City, in Worcester County, Maryland; Correction

AGENCY: U.S. Army Corps of Engineers, DOD.

ACTION: Correction to Notice of Intent.

SUMMARY: Reference NOI published in **Federal Register** on Thursday, February 29, 1996, Volume 61, number 41, pages 7778–9. This document contains corrections to the Notice of Intent published for the Ocean City, Maryland, and Vicinity Water Resources Feasibility Study and Draft Environmental Impact Statement (EIS). The corrections relate to the types of documents to be prepared and the dates that the draft documents will be available for public review.

FOR FURTHER INFORMATION CONTACT: Questions about the proposed actions, draft Programmatic EIS, and Supplemental EIS's can be addressed to Ms. Stacey Marek, Study Manager, Baltimore District, U.S. Army Corps of Engineers, ATTN: CENAB–PL–PC, P.O. 1715, Baltimore, Maryland 21203–1715, telephone (410) 962–4977. E-mail address: ocwr@ccmail.nab.usace.army.mil.

SUPPLEMENTARY INFORMATION:

Background: The Ocean City feasibility study will address four different water-related problems in the Maryland coastal bay area as separate report components. The components include (1) the restoration of the northern end of Assateague Island; (2) long-term sand placement opportunities along Ocean City and Assateague Island shorelines; (3) restoration of terrestrial and aquatic habitat; and (4) navigation improvements to the harbor, inlet, and Thorofare channel. The Assateague Island Restoration component will be completed earlier than the other 3 components due to a potentially imminent breach of Assateague Island. The original schedule completion date for the draft Ocean City, Maryland, and Vicinity Water Resources Feasibility Report and DEIS was June 1997.

Need for Correction: As published, the original NOI failed to clarify that a Programmatic EIS, addressing general impacts of the overall project and specific impacts of the Assateague Island restoration, would be available first, followed by a separate supplemental EIS addressing the remaining project components, and to identify the dates the documents would be available for public review.

Correction of Publication: Accordingly, the **Federal Register** published on Thursday, February 29, 1996, Volume 61, number 41, pages 7778–9, is corrected as follows: On page 7778, in the Summary paragraph, substitute the following for the final sentence:

A Programmatic EIS addressing the general actions and impacts of the overall proposed study and the specific actions and impacts of the Assateague Island Restoration component will be prepared and provided for public review in March 1977. Subsequently, separate Supplemental EIS will be prepared for the study components addressing long-term sand placement; restoration of terrestrial and aquatic habitat; and navigation improvements to the harbor, inlet, and Thorofare channel. The Supplemental EIS will be provided for public review in October 1997.

On page 7778, in item number 7, line 2; and on page 7779, in item 7, line 2: substitute "environmental documents" for "DEIS." On page 7779, in item number 10, substitute the following: The draft Programmatic EIS addressing the general actions and impacts of the overall Ocean City, Maryland, Water Resources Feasibility Study and the specific actions and impacts of the Assateague Island Restoration is scheduled to be available for public review in Mar. 1997; a Supplemental EIS addressing the specific actions and impacts of the remaining 3 study components are scheduled to be available for public review in October 1977.

Gregory D. Showalter,

Army Federal Register Liaison Officer.

[FR Doc. 96–6924 Filed 3–21–96; 8:45 am]

BILLING CODE 3710–41–M

DEPARTMENT OF EDUCATION

National Assessment Governing Board; Public Forum

AGENCY: National Assessment Governing Board, Education.

ACTION: Notice of information collection activity.

SUMMARY: In compliance with the Paperwork Reduction Act (44 U.S.C. 3501 *et seq.*), this notice announces that the National Assessment Governing Board (NAGB) has submitted an Information Collection Request (ICR) to the Office of Management and Budget for approval of the collection abstracted below. The ICR describes the nature of the information collection and its expected cost and burden; it includes the actual data collection instrument and explanatory materials.

DATES: Comments must be submitted on or before April 22, 1996.

FOR FURTHER INFORMATION OR A COPY CONTACT: Susan Cooper Loomis, NAEP ALS Project Director, American College Testing, 2201 N. Dodge Street, Iowa City, Iowa 52243. Copies of the complete ICR and accompanying appendices may be obtained from the NAEP ALS Project Director at the address above.

DEPARTMENT OF DEFENSE **Billing Code 3710-41**

CORPS OF ENGINEERS, DEPARTMENT OF ARMY

Intent to prepare a Draft Environmental Impact Statement (DEIS) for the proposed Ocean City, Maryland, and Vicinity Water Resources Feasibility Study at Ocean City, in Worcester County, Maryland; Correction.

AGENCY: U.S. Army Corps of Engineers, DOD

ACTION: Correction to Notice of Intent.

SUMMARY: Reference NOI published in Federal Register on Thursday, February 29, 1996, Volume 61, number 41, pages 7778-9. This document contains corrections to the Notice of Intent published for the Ocean City , Maryland, and Vicinity Water Resources Feasibility Study and Draft Environmental Impact Statement (EIS). The corrections relate to the types of documents to be prepared and the dates that the draft documents will be available for public review.

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The draft Programmatic EIS addressing the general actions and impacts of the overall Ocean City, Maryland, Water Resources Feasibility Study and the specific actions and impacts of the Assateague Island Restoration is scheduled to be available for public review in March 1997; a Supplemental EIS addressing the specific actions and impacts of the remaining 3 study components are scheduled to be available for public review in October 1997.

Dr. James F. Johnson
Chief, Planning Division

CF:
CENAB-IMO
CENAB-PP
CENAB-EN
CENAB-PA
CENAB-OC
CENAB-OP
CENAB-PL-P

OCWR Bulletin

Ocean City, MD and Vicinity Water Resources Feasibility Study

A Joint Publication of Federal, State and Local Governments

August 1996 **Issue No. 2**

WATER RESOURCES PROJECT STATUS

The Corps of Engineers' feasibility phase of the Ocean City, Maryland, and Vicinity Water Resources (OCWR) Study is well on its way. Cost-sharing partners for the study include the National Park Service/Assateague Island National Seashore, the Maryland Department of Natural Resources, Worcester County, and the Town of Ocean City. The study team is developing four water resources projects that were identified during the 1994 reconnaissance phase. The four potential projects are being developed by the Corps of Engineers because each fits within the mission that the Corps is authorized to fulfill. The projects include (1) restoration of the northern end of Assateague Island; (2) long-term sand placement; (3) improvements to Federal navigation channels; and (4) restoration of wetlands and islands for wildlife habitat. Other agencies are responsible for completion of the remaining tasks identified during the reconnaissance phase. A table listing the actions identified in the reconnaissance report and the agency responsible for each is enclosed.

The short-term restoration of Assateague Island is being completed earlier than other study components due to the possibility of a breach (forming another inlet) on the island. Preliminary tasks such as agency coordination, public involvement, data gathering, identification of alternative plans, and evaluation of these plans have been accomplished for the Assateague restoration.

A number of important tasks remain to be completed for the Assateague Island restoration. These include selection of a recommended alternative from among the seven "finalists," which include —

1. Restoring the island to the configuration it would have if the jetties had not been constructed, and implementing a long-term sediment supply process.
2. Replacing the volume of material lost since 1934* because of the jetties' construction, and implementing a long-term sediment supply process.
3. Replacing the volume of material lost since 1965* because of the jetties' construction, and implementing a long-term sediment supply process.
4. Replacing some volume of material (based on environmental considerations) less than that lost since 1965* because of the jetties' construction, and implementing a long-term sediment supply process.
5. Replacing only enough material to construct a low dune, and implementing a long-term sediment supply process.
6. Doing no immediate restoration, but implementing a long-term sediment supply process.
7. Doing nothing. This is a requirement of the Corps planning process and is called a "No Action" plan.

(* 1934 = jetties constructed; 1965 = National Seashore established)

A number of tasks still need to be completed before construction can begin on the Assateague restoration, including selecting and developing the recommended alternative plan, preparing detailed construction plans, and finding contractors to do the work. The draft interim feasibility report will be available for public review in January 1997. The construction schedule is dependent on Congressional approval and funding for the project. Similar tasks also must be completed for the study components addressing habitat restoration and navigation improvements.

PUBLIC MEETING HELD

The first public information meeting for the feasibility phase of the OCWR study was held at the Ocean City Elementary School on May 9. Displays provided information about the four project components and a brief presentation provided an update on the project status. A number of issues were raised during the discussion period following the presentation. Topics ranged from general questions on the study and the public involvement processes to the needs of specific groups, such as recreational boaters. Responses to a number of the concerns expressed at the meeting appear on the next page.

CORPS STUDY PROCESS

Reconnaissance Study → Feasibility Study → Plans and Specifications → Project Construction

PUBLIC MEETING QUESTIONS AND ANSWERS

Q. *Why do the studies that the Corps conducts cost so much and take so much time?*

A. The Corps' study process takes a substantial amount of time for several reasons, including the process required to produce a thorough study and the constraints of fitting the study process within the Federal authorization and funding cycles.

The study process is divided into two phases: reconnaissance and feasibility. The reconnaissance study determines whether the project will provide benefits that have national importance and, therefore, warrant Federal participation. The reconnaissance study gathers existing information about the problem or opportunity and also presents a variety of potential solutions. The feasibility study (the second study phase) defines, analyzes, and evaluates a number of alternative plans. The feasibility report presents the alternatives, documents their impacts, and recommends a project for construction.

In addition to the two-part study phase, time is required to receive Congressional authorization for the project and to fit the study process within Federal funding cycles. Congress usually authorizes new projects once every two years; funding of studies occurs once each year. In order to satisfy the requirements of Congress, other agencies, and the public, the Corps must investigate and analyze every aspect of a project and address the concerns of multiple, sometimes conflicting, interests during the feasibility study. For instance, for the restoration of Assateague Island, some of the necessary tasks that are being performed include a bathymetric survey, geotechnical drilling, and a cultural survey of the offshore shoals; a topographic survey of Assateague Island; an investigation of the threatened and endangered species that inhabit the island; computer modeling to determine suitable configurations of the island; identification of property owners; identification of a variety of alternative solutions; evaluation of each of the alternative plans based on environmental and economic impacts; preparation of an Environmental Impact Statement (EIS); preparation of cost estimates of alternative plans; public involvement; and final design. All of these tasks take time and money. Throughout the study, the Corps needs to verify for Congress, and for the taxpayers it represents, that the project is beneficial and that any adverse impacts are minimized. The recommended project must be locally supported, environmentally acceptable, economically justified, and engineeringly feasible. Based on the information gathered and the funds available, Congress determines which projects are in the best interest of the nation and authorizes funds for those that are.

Q. *What navigation projects can the Corps implement?*

A. Questions from the public have raised concerns about navigation needs in the back bays. Current Administration policy restricts the dredging of navigation channels to those used for commercial purposes or that produce commercial "outputs."

Commercial users are defined as fishermen who sell their catch (such as crabbers, clammers, and oystermen), or charter boats that take a number of people out to fish. Channels used predominantly by recreational boaters cannot be dredged by the Corps because "recreation" is not a high Administration priority. Therefore, State and local governments or private citizens must dredge these channels.

The Corps currently has the authority to maintain navigation channels in the Ocean City inlet and harbor, on the east side of Isle of Wight Bay (behind Ocean City), and in Sinepuxent Bay. The feasibility study will evaluate the need to deepen and widen the inlet and harbor channels. The need will be based upon the amount that each channel is used and the costs of operation borne by users of the channels. Costs of operation are defined as damages to either commercial or recreational vessels, as delays to commercial vessels due to shoaling in the navigation channels, or as reduction in catch due to inadequate depth. Our evaluation will determine whether it is cost effective to improve these channels based on current costs of operation.

Q. *Is the Corps investigating storm protection for mainland communities behind Assateague Island? Will the restoration of Assateague Island protect these homes?*

A. During the reconnaissance phase of the study, the Corps investigated storm protection for the communities in the project area. Snug Harbor was identified as an area with high storm damages. The Corps evaluated various types of storm protection for Snug Harbor, including the construction of flood walls or an inflatable dam. However, Federal projects require $1.00 in benefits for every $1.00 of cost, and an economic analysis showed that for every $1.00 of cost to protect Snug Harbor, only $0.10 in damages would be prevented. Because benefits that would justify a Federal project are lacking, a storm protection option is not being further developed in the study. The Corps encourages flood-proofing of structures or relocation to reduce damages.

The restoration of the northern portion of Assateague Island, currently being investigated, will afford the mainland some additional protection and is expected to reduce the probability of the island breaching; however, it is not considered a storm protection project. The purpose of the project is to restore the integrity of the island by replacing some of the sand it has been deprived of since the construction of the jetties.

Q. *Where will the material be taken from to place on Assateague Island? Can the material from the back bays be used?*

A. In the past, when the Corps has dredged suitable material from the Federal channels, the material has been placed on the beaches of both Assateague Island and Ocean City. The Corps will continue to do this in the future. However, a substantial portion of the material in the bays is too fine and is not suitable for the beaches. In addition, the quantity of material available in the navigation channels is rather small compared to the millions of cubic yards needed to restore Assateague Island. Also, extensive dredging throughout the back bays would not be environmentally acceptable.

The offshore shoals are being investigated as a source of material to be placed on Assateague. Preliminary investigations indicate no significant cultural resources in the area that would be dredged. Other investigations include on-going coordination with commercial fishermen to determine the impacts of dredging the shoal on commercial fishing and computer modeling to determine impacts on waves and on Assateague Island. It is anticipated that only a small amount of the shoal would be impacted during the initial restoration.

As part of this study, the team is investigating the use of material from the back bay navigation channels that is not suitable for the beaches but that may be suitable for creating/restoring islands and wetlands for wildlife habitat. In addition, the Corps is analyzing other potential dredging methods (such as the "sand sorter") for use in beach nourishment.

Q. *What is being done to address the problem of fast currents under the Route 50 bridge?*

A. Several years ago the State Highway Administration (SHA) placed rocks around the pilings of the Route 50 bridge to reduce scouring of the pilings. This increased the flow of water through the channel, causing navigation difficulties. The SHA has recently contacted the Corps about this problem and the SHA is looking into a way to correct the problem. In the meantime, as part of the Ocean City Water Resources Study, the Corps is using a computer model to determine whether the Federal channel could be modified, or if other channels could be dredged to reduce the speed of the currents. Based on the SHA's and Corps' findings, a determination will be made on how to proceed.

Q. *How is the public input used in these studies?*

A. A comprehensive public involvement program is a required part of any Federal project. The public helps to identify the problems, potential solutions, and impacts of the project on their lives and their environment. Throughout the reconnaissance and feasibility phases of the study, the public provides information and comments on issues and ideas that are then incorporated into the project development process. Public views expressed at meetings, in letters, phone conversations, and through electronic mail are documented and included in the report and EIS. As a result of the public concern expressed at the May public meeting regarding shoaling and navigation problems in the back bays, the Corps is meeting with the State and local governments to find solutions.

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Name (Please Print) ______________________

Title ______________________

Company/Organization ______________________

Address ______________________

City ______________________ State __________ Zip __________

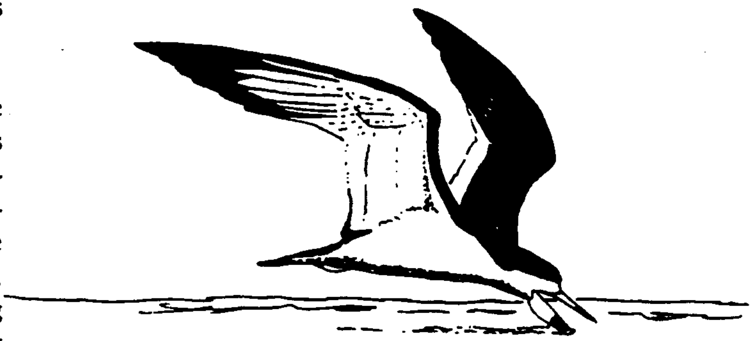
Telephone number (________) ______________________

PUBLIC INVOLVEMENT

As with the reconnaissance study, coordination and public involvement will be an integral part of this study. Corps of Engineers staff continues to work closely with its partners.

There will also continue to be an opportunity for private citizens' involvement through public workshops during the course of the study.

In their study process, the Corps places a high value on the comments and participation of the public. This news bulletin is one element of the Corps' ongoing public involvement program. As the study progresses, additional meetings will be scheduled. A citizen can voice concerns through these public involvement avenues, through elected officials, by calling the Corps Planning Division at 1-800-295-1610, or by making comments by letter or on the form included in this newsletter. You may also fax your comments by addressing them to the Ocean City Water Resources Study Team at (410) 962-4698, by calling Pete Noy at (410) 962-6100, or by sending comments to our e-mail address (ocwr@ccmail.nab.usace.army.mil).



Kathleen Ellett
Maryland Department of Natural Resources
CZM E-2
580 Taylor Avenue
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P.O. Box 1715
Baltimore, MD 21203-1715

STATUS OF POTENTIAL ACTIONS

The table below presents the potential projects developed during the reconnaissance study. The purpose of the "recon" was to survey as many actions that would improve water resources in the Ocean City area as possible. At the conclusion of the recon, responsibility for completion of each potential project was assigned to an agency or group. Responsibility for several of the projects requiring construction, the traditional mission of the Corps of Engineers, was assigned to the Corps. Other agencies or groups assumed responsibility for tasks that matched their missions. The table lists 28 of the potential projects or actions recommended in the recon, the responsible agency or group, the status of the work effort, and the name of a contact person for further information. The tasks are listed under five different headings: multi-purpose actions, environmental quality, navigation, storm damages, and infrastructure. Tasks that are the responsibility of the Corps are being further developed in the feasibility study, which is now underway. The Maryland Coastal Bays Program (MCBP) is also conducting a study addressing many of the water resources issues and actions that are not within the Corps mission.

ACTION:	AGENCY OR GROUP RESPONSIBLE:	CURRENT STATUS:	CONTACT PERSON:
ENVIRONMENTAL QUALITY ACTIONS			
Restore/create wetlands and islands for wildlife habitat in the coastal bays	Corps/Study Team	Plans for wetlands and island creation or restoration are being prepared as part of the Feasibility Study.	Stacey Marek/Corps (410) 962-4977
Monitor water quality in the coastal bays	Maryland Coastal Bays Program	Monitoring plan will be designed as part of MCBP.	John Trumpower/DNR (410) 213-7517
Encourage environmental resources education	MCBP	Education will be an important component of MCBP.	John Trumpower/DNR (410) 213-7517
Restore and/or protect forested and wooded habitat	MCBP	Forest management will be addressed as part of the MCBP.	John Trumpower/DNR (410) 213-7517
Encourage comprehensive environmental planning	MCBP	The County Comprehensive Plan is being updated. The County is negotiating with DNR for long-range assistance with preparation of sensitive areas component of plan. The County plan will dovetail with MCBP plans.	John Trumpower/DNR (410) 213-7517 or Phil Hager/Worcester County (410) 632-1200
INFRASTRUCTURE IMPROVEMENTS ACTIONS			
Implement regional wastewater management program	MCBP	Wastewater management will be investigated by MCBP.	John Trumpower/DNR (410) 213-7517
Implement septic system management program	MCBP	Septic system management will be investigated by MCBP.	John Trumpower/DNR (410) 213-7517
Implement water conservation program	Worcester County and Town of Ocean City	Water conservation is being encouraged through the adjustment of water rates.	Phil Hager/Worcester County (410) 632-1200 or Terry McGean/Town of Ocean City (410) 289-8221
Locate saltwater interface for management of saltwater intrusion and consider additional water sources	Town of Ocean City	A number of studies have been completed and are regularly updated in order to maintain Ocean City water supplies.	Terry McGean/Town of Ocean City (410) 289-8221
Develop comprehensive stormwater management plan	MCBP	Stormwater management will be investigated by MCBP.	John Trumpower/DNR (410) 213-7517
Modify stormwater management regulations	MCBP	Stormwater management will be investigated by MCBP.	John Trumpower/DNR (410) 213-7517
NAVIGATION ACTIONS			
Implement navigation improvements to harbor, inlet and Shantytown Channel	Corps/Study Team	Navigation improvements are being addressed in Feasibility Study.	Stacey Marek/Corps (410) 962-4977
Create additional recreational channels, as needed	State can fund local dredging projects.	Local interests can contact the DNR for technical and funding assistance.	Jordan Loran/DNR (410) 974-3666

ACTION:	AGENCY OR GROUP RESPONSIBLE:	CURRENT STATUS:	CONTACT PERSON:
MULTI-PURPOSE ACTIONS			
Restore north end of Assateague Island	Corps/Study Team	Restoration plans are being developed in the Feasibility Study.	Stacey Marek/Corps (410) 962-4977
Model water and sand movement on shoreline and in coastal bays	Corps/Study Team	Information from the model will be included in the Feasibility Study.	Stacey Marek/Corps (410) 962-4977
Improve interagency cooperation on water resources issues	All study participants	Increased cooperation is occuring among Federal, State, and local agencies.	John Trumpower/DNR (410) 213-7517 or Stacey Marek/Corps (410) 962-4977
Reduce non-point pollution by encouraging use of best management practices	MCBP	Non-point source pollution will be addressed by MCBP.	John Trumpower/DNR (410) 213-7517
Reduce impacts of watercraft on shoreline	MCBP	Impacts of watercraft on shoreline will be investigated by MCBP.	John Trumpower/DNR (410) 213-7517
Establish vegetated buffers along waterways	Corps/Study Team and MCBP	Vegetated buffers will be addressed by MCBP.	John Trumpower/DNR (410) 213-7517 or Stacey Marek/Corps (410) 962-4977
Investigate long-term sand placement needs on Assateague Island and Ocean City	Corps/Study Team	Feasibility Study team is reviewing alternative sources of material and placement methods.	Stacey Marek/Corps (410) 962-4977
Evaluate zoning and setback requirements	Worcester County and MCBP	Effective setback requirements and other zoning issues will be investigated as the Worcester County Comprehensive Plan is updated.	Phil Hager/Worcester County (410) 632-1200 or John Trumpower (410) 213-7517
Incorporate sea-level rise in planning action	All participants	Information on sea-level rise is being incorporated as plans are developed by all agencies.	All agencies
Beneficial use of dredged material	Corps/Study Team	The study team is coordinating with other agencies to develop a plan for using dredged material to create islands in the coastal bays.	Stacey Marek/Corps (410) 962-4977
Monitor water wells	MCBP	A monitoring plan will be designed as part of the MCBP.	John Trumpower/DNR (410) 213-7517
On-site control of stormwater	MCBP	Stormwater control will be addressed as new land management plans are prepared and existing plans are updated. .	John Trumpower/DNR (410) 213-7517
STORM DAMAGE REDUCTION ACTIONS			
Floodproof structures	Private groups and individuals.	Floodproofing of structures is the responsibility of private residents. Contact the Corps for information.	Robyn Colosimo/Corps (410) 962-6137
Install tidal gages	Various Federal, State, and local agencies can install gages.	The National Park Service is installing three gages in Sinepuxent and Chincoteague Bays to document high water levels, especially during storms.	Carl Zimmerman/NPS (410) 641-1443
Improve responses to storm and flood emergencies by increasing public awareness and better traffic management during evacuations.	Town of Ocean City	The Emergency Evacuation Plan is updated every 3 years.	Clay Stamp/Ocean City Emergency Management (410) 723-6802

MEMORANDUM FOR THE RECORD August 14, 1996

SUBJECT: Minutes from 25 July 1996 Meeting held in Annapolis to Discuss Offshore Shoal Sand Sources for Assateague Island Restoration.

FROM: Christopher Spaur
Corps of Engineers, Baltimore District, Planning Division

TO:	Carol Anderson-Austra	Corps of Engineers
	Jim Casey	Maryland Department of Natural Resources
	Kathleen Ellett	Maryland Department of Natural Resources
	John Foster	Maryland Department of Natural Resources
	Phil Hager	Worcester County
	Randy Kerhin	Maryland Department of Natural Resources
	Jordan Loran	Maryland Department of Natural Resources
	Stacey Marek	Corps of Engineers
	Terry McGean	Ocean City
	Greg Nielson	Corps of Engineers
	John Nichols	National Marine Fisheries Service
	George Ruddy	U.S. Fish and Wildlife Service
	Jarrell Smith	Corps of Engineers, WES
	Jim Snyder	Corps of Engineers
	Carl Zimmerman	National Park Service

MEETING ATTENDEES: See attached list

MINUTES:

1. Stacey Marek stated that the purpose of the meeting was to discuss Little Gull and Great Bull Banks as potential sand sources for the immediate restoration of Assateague Island. Stacey Marek provided an overview of the Ocean City Water Resources Feasibility Study.

2. Jim Snyder presented a brief overview of geotechnical work done on the offshore shoals to date. Jim Snyder noted that the shoals are nearly flat; maximum slopes on the existing shoals are 2 to 5%. Jim Snyder stated that from a sand quality perspective Great Gull Banks is marginally better than Little Gull Banks, but that both are acceptable. The southerly landward side of both shoals has the best sand.

3. Jim Casey and John Foster stated that the surface of both shoals is littered with the remains of poorly planned artificial reef-building efforts. Remains of the artificial reefs include tires (some filled with concrete) and cable used to string the tires together. They

also noted that the area is littered with boat wrecks. Chris Spaur commented that a magnetometer survey of Little Gull and Great Gull Banks completed earlier this year for the study indicated that there are no cultural resources, including wrecks, within either shoal.

4. A discussion followed regarding DNR's position on which shoal could/should be selected as a sand-source for the project. Kathy Ellett said that Howard King's position is that DNR will support selection of Little Gull. Randy Kerhin said the decision was made because of closeness of Little Gull, and because of lesser environmental impacts. Jim Casey and John Foster said that they were not involved in the decision-making process, nor were fishermen consulted. John Foster said that they had a meeting with fishermen in April and had discussed the entire project. Little time was spent discussing the shoals, however. Instead, fishermen's concerns presented at the meeting focused on shoaling in the back bays. The DNR personnel attending said that the matter of DNR's position would be resolved internally, for now assume Little Gull Banks is preferred.

5. The relative environmental values of the offshore shoals were discussed. John Nichols and George Ruddy noted that the shoals further off (B and C) are utilized by clammers, but Little Gull and Great Gull are not currently being harvested for clams. George Ruddy said that the commercial fishery value of other offshore shoals previously used as sand sources (i.e., for projects to maintain Ocean City beaches) has apparently declined. John Foster said that the hydrodynamics of the shoal areas attracts fish. Chris Spaur asked whether certain shoals could be set aside for preservation in perpetuity, whereas others could be selected as future sand sources.

6. A discussion of the possibility of dredging sand from the back bays to nourish Assateague followed. John Foster said that fishermen and boaters want the back bays dredged. George Ruddy suggested that some dredging could be done there to alleviate public concerns over shoaling. John Nichols and Jim Casey stated that the shallow water habitat of the back bays is of great value as nursery habitat, however. Corps personnel noted that the quantity of utilizable sand in the back bays suitable for placement on the ocean beach is limited.

7. Discussion shifted to who owns/manages the mineral rights to the shoals. Randy Kerhin said that within 3 mi the state makes its own decision. The location of the 3 mi boundary may require some research - it may be drawn out from a historical shoreline. Outside of this 3 mi limit the Minerals Management Service (MMS) has authority to lease the sand. For mining of sand from these sites for public works projects there is no cost. The procedure is that MMS negotiates an agreement with the state, and then the Corps would get an MOU with MMS. The state hasn't yet negotiated such an agreement. Stacey Marek asked whether the process of dealing with MMS is difficult. The group agreed that the process should be started regardless of which shoal is selected and that avoiding the process of dealing with MMS should not be a screening step. John Foster commented that MMS needs to be involved in any decisions to mitigate for impacts to fisheries; construction of an artificial reef could serve as mitigation.

8. Jim Casey and John Foster were concerned over how fishermen would react. Jim Casey said that the borrow proposal needs a good selling point, an example of this would be a guarantee not to use the shoals again in the future. Stacey Marek said that no such guarantee could be given. Randy Kerhin asked whether construction of fish habitat could be done in a non-shoal area. John Foster said that the existing stuctures of the shoals attract fish, there's no way to predict whether mitigation done at a non-shoal site would create conditions that would attract fish. John Nichols, John Foster, and Jim Casey were very concerned over cumulative impacts that will occur as more shoals are lost. Jim Casey emphasized that sand cannot continue to be taken from the offshore shoals year after year without risking incurring detrimental impacts to commercial and recreational fisheries, as well as risking other ecological impacts. Other sources of sand, perhaps from flat bottom areas in deeper water, and other methods of beach preservation must be considered. People need to be aware of the economic costs of maintaining an inherantly unstable barrier island. John Foster said that if the fishery declines after the project, the Corps will be blamed, regardless of whether the project causes the problem. Chris Spaur stated that measures to avoid or minimize impacts should be considered prior to discussing mitigation. John Foster and Jim Casey emphasized proposing mitigation up front to sell the project to people. They said that receiving public approval to dredge the shoals shouldn't be treated as just a foregone conclusion. Both agreed that there's no way to determine the appropriate amount of mitigation required, instead just propose something that's positive and significant. They proposed that an artifical reef could be constructed in the area of the 28th Street fishery. With roughly $500,000 structures 3 ft high covering an area of 50 acres could be constructed. These structures would benefit reef-oriented fish, plus pelagics; flounder will occur downstream. The 28th Street site was proposed in part because Little Gull Bank is too dynamic an area for enhancement to be done on. John Foster said that the mitigation can be paid for in a cost-sharing arrangement by the state, city, and county. The Corps did not necessarily think mitigation was needed for the initial restoration of Assateague Island as the initial dredging would comprise only a minor portion of the volume of sand in the shoal. However, if the shoals are used for additional borrow then mitigation would be more appropriate.

9. John Nichols said that monitoring would be necessary to determine hydrodynamic and sedimentation changes. Jim Casey and John Foster noted that the state lacks the capability to regularly study/monitor the shoals. Jim Snyder noted that post-dredge surveys are available for the Ocean City shoals, but that the sites have not been resurveyed. Thus, no long-term information is available as to how the area responds to mining of sand. Jim Casey said that that bottom topography might be dynamic - swales have developed recently where there weren't any.

10. Jim Casey and John Foster said that the fishermen will have a strong voice on this project, and will need to have their concerns mitigated. Kathy Ellett said that navigation improvements will benefit them. John Foster and Jim Casey said that there's no way to determine which shoal is better from a fisheries perspective. Sport fishermen will be concerned about loss of Little Gull Banks more than Great Gull. Stacey Marek said that

the next step is meeting with the fishermen. John Foster said that sport fishermen won't buy minimization efforts. Instead, compensation is needed.

11. How to excavate material from the shoal was discussed. For commercial fishermen uniform lowering of the shoal might be best - removal of a thin layer from a wide area. Jim Snyder said that for the dredger the contract will stipulate an area to be used. Jim Snyder said that the Coastal Engineering Research Center (CERC) has said that minimal impacts to the shoreline will occur from mining either shoal with regard to waves. Jim Casey said that maintaining the basic shape of the shoal is probably best. George Ruddy noted that deeper areas adjacent to the shoals may have high biological value. Jim Snyder said that CERC indicated that making a trench across or perpendicular to the shoal crest may have a greater effect on the shoreline than if the crest is left more or less intact. John Nichols noted that maintaining the crest is of importance. Jim Snyder said that for now we can generate a number of mining options, but that the final design will be selected later. Further geotechnical work will be done next summer. Jim Casey noted that every effort should be made by the dredging contractor to avoid leaving behind or disposing of any gear or debris on the shoals. This has happened in dredging off Ocean City and has engendered ill feelings from local fishermen who snag debris and gear in their lines.

12. John Nichols said that if a hopper dredge is used that we'll need to work with Laurie Silva of the National Marine Fisheries Service (NMFS) Gloucester office. Hopper dredges move fast and may place endangered/threatened sea turtles at risk if dredging is done from April through November when turtles are likely to be in the area. John Nichols asked if a cutter head could be used instead. Jim Snyder noted that if excavation is restricted to use of a cutter head dredge that this will greatly increase cost. John Nichols said that there's also a risk of vessels striking marine mammals; however, the closer the vessel is to shore the lower the risk. Jordan Loran asked if the risk to marine fisheries would be greater if the work was done all at once or if spread out over several seasons. John Nichols said that the less time you're out on the water the less risk to turtles. Jim Casey noted that the dredges attract fish, rather than repelling marine life. Jordan Loran said that the seas are too rough for dredging work from October onward until spring, and noted that the time of year during which work can be done is already limited by restrictions to protect Piping Plover. John Nichols said that turtle excluders can be used, but that NMFS is skeptical whether they work. Instead, having an oberver on board might be an option. However, observers can not prevent the taking of turtles, but only note mortalities. If sea turtles are taken during the borrow operation, and the Corps has not adequately consulted with NMFS on Endangered Species Act issues, nor has a take statement been issued, then the Corps will be potentially liable for any subsequent turtle mortalities linked to the dredging operation. NMFS would recommend hydraulic pipeline dredging, or an April through November time-of-year restriction on hopper dredging, to alleviate Endangered Species Act concerns. If hopper dredging is to be further pursued, it may require that the Corps go through formal consultation with NMFS on Endangered Species Act issues associated with this project. Additional concerns exist over the project. John Nichols said that according to the Mid-Atlantic Fisheries Council that juvenile flounder use the shoals most in October. With regard to surf zone impacts, it's recognized

that organims there can recover from beach nourishment projects, however impacts to all resources and habitats should be minimized to the greatest extent practicable.

13. Meeting with fishermen was discussed. John Foster said that an evening meeting with commercial fishermen can easily be arranged. Dave Martin is a good contact. For sport fishermen talk to the Maryland Saltwater Sportfishermen's Association (MSSA). Dale Timmins (sp?) paper goes out to weekend and vacation sportfishermen. Can also arrange to meet with head-boat captains. They don't have a leader or spokesman. If we wait until September we can get more of them together. They make their living by working 7 days a week for about 100 days a year during the season. Separate meetings should be held with sport and commercial fishermen. Jim Casey said that DNR could/should participate in meetings with commercial people. John Foster and Jim Casey suggested providing a one page summary with options, plus a map.

If you have any questions, or would like to make additions or corrections please contact me at (410) 962-6134. Comments on a draft version of the minutes were received from Jim Snyder, Stacey Marek, Jim Casey, Randy Kerhin, and John Nichols and were incorporated into this final version.

Sincerely,

Christopher Spaur

November 4, 1996

Planning Division

Ms. Elizabeth J. Cole
Maryland Historical Trust
Division of Historical and Cultural Programs
100 Community Place
Crownsville, Maryland 21032-2023

Dear Ms. Cole:

The purpose of this letter is to provide your office with a copy of the report entitled "Phase I Archeological Study, Ocean City Water Resources Study, Ocean City, Maryland." This report was prepared under the direction of the Baltimore District to partially fulfill the requirements of the National Historic Preservation Act for the Ocean City Water Resources project.

The potential Ocean City Water Resources project consists of four main components. The first is the placement of sand on the Assateague shoreline, to restore the shore to a more stable condition. We have determined that the migration of the northern portion of Assateague Island precludes the existence of cultural resources within the area of effect. A detailed description of the analysis we prepared to reach this conclusion is enclosed (enclosure 1). We identified the need to perform an underwater survey of the offshore shoals selected as possible borrow sites for sand to be placed on Assateague Island. The results of this survey are provided in the enclosed report (enclosure 2). The second project component, long term sand placement, could consist of the construction of a device to move sand across the Ocean City Inlet to Assateague Island and placement of sand on the beach at Ocean City. The third project consists of the widening and deepening of the Ocean City inlet channel to improve navigation. Previous correspondence with your office has indicated that the Ocean City inlet has a low probability of containing cultural resources and we do not plan to do further cultural surveys in this area. The fourth project component will be the restoration of inland bay environments in Assawoman, Isle of Wight, Sinepuxent, and Chincoteague Bays. We will be conducting reconnaissance investigations during the site selection process and will report to you the results of the surveys for potential work in the bays.

Regarding the identification of the "Dune Wreck" located within the area of potential effects for the Assateague Restoration project, we are preparing to conduct a Phase II investigation of the site, to determine its extent and National Register status. We will be providing the report of this investigation as soon as possible.

We request your concurrence that there are no historic properties within the borrow areas surveyed and reported in the enclosed report. If you have any questions regarding this matter, please contact Mr. Kenneth Baumgardt, at (410) 962-2894.

Sincerely,

Dr. James F. Johnson
Chief, Planning Division

Enclosures

CF:
CENAB-PL-PC (S. Marek)

CPD Reading File

BAUMGARDT/ar /2894/CENAB-PL-PP
MAREK/CENAB-PL-PC
COLEMAN/CENAB-PL-PP
LADD/CENAB-PL-P
JOHNSON/CENAB-PL-E

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United States Department of the Interior

TAKE PRIDE IN AMERICA

FISH AND WILDLIFE SERVICE
Weir Hill Road
Sudbury, Massachusetts 01776

Memorandum

November 5, 1996

To: Christopher Spaur, Baltimore District, U.S. Army Corps of Engineers

From: Anne Hecht, Endangered Species Biologist

Subject: Study to Assess Impacts of Assateague Island Restoration Project on Foraging Ecology of Piping Plovers

As you know, one of the most difficult issues we have dealt with in the course of planning the restoration project for northern Assateague Island is the risk of accelerating processes that degrade early succession habitats, including unvegetated and sparsely vegetated bayside sand and mudflats, recently healed inlets, blowouts, and overwashes. These features furnish extremely valuable habitats for piping plovers, least terns, seabeach amaranth, beach tiger beetles, and other rare beachstrand species. In the case of the piping plovers, there is an additional risk that, even if these habitats persist on northern Assateague, developing vegetation will prevent access by the flightless chicks to foraging habitats during critical stages in their development, thereby increasing chick mortality.

While substantial effort has been exerted during planning of this project to balance storm damage protection and wildlife needs, the ultimate effectiveness of the project will depend, in large measure, on the unpredictable number and intensity of coastal storms in the years following the project. Therefore, the monitoring and mitigation plan under preparation by the National Park Service is a key project component. As currently conceived, this plan relies on measures of piping plover abundance, productivity, and "key habitat characteristics" to assess post-project impacts on this vulnerable species. While I agree that these factors are appropriate project performance indicators, I believe that a more detailed evaluation of impacts on plover *foraging ecology* should be incorporated into this project (see my August 15, 1996 letter to Carl Zimmerman). In a 1988-1990 study of piping plovers on Assateague, Loegering and Fraser (1995[1]) concluded that foraging resources are the key determinant of plover breeding success on that site. A U.S. Army Corps of Engineers (Corps)-sponsored plover habitat modelling effort currently underway on Long Island is also looking at invertebrate availability as the primary indicator of physically suitable plover habitat. Several

[1] Loegering and Fraser classified plover habitats on Assateague into only three rough categories (ocean beach, interior, and bay beach). The study proposed in this memorandum would involve a substantially more rigorous identification of habitat types and quantify vegetative cover within each category.

studies show that plovers select foraging habitats where invertebrates are most abundant, and that plover chicks that forage in these areas have the highest survival rates. A large number of plover researchers believe that, with further research, direct assessment of foraging resources will become the most reliable and efficient means of measuring and predicting changes in suitability of plover habitat due to both coastal stabilization projects and natural processes. The Atlantic Coast Piping Plover Recovery Plan (USFWS 1996) specifically articulates the need to evaluate the impacts of artificial inlet closure and other beach stabilization projects on piping plover breeding habitat suitability (see task 3.23). Because of its role as the principal Federal agency planning and implementing shoreline stabilization projects, the recovery plan identifies the Corps, as a "responsible organization" for this task.

While contributing to the broader goal of improved understanding of impacts of coastal stabilization activities, such a study on northern Assateague Island would serve several additional important functions:

1. Provide a substantially more refined assessment of impacts of this project on the quality and quantity of plover foraging habitat on northern Assateague Island. This would help the Corps meets its responsibilities under the Endangered Species Act to monitor "incidental take" that might occur due to this project. "Take" as defined under the ESA includes 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.

2. Advance our ability to fine-tune any needed mitigation for the short-term restoration project, particularly if there are problematic issues involved in reconciling wildlife and storm-damage protection objectives.

3. Contribute to our information base for future consultation on the long-term restoration project.

In order to achieve the purposes stated above, I d above, I recommend a study with the following research objectives:

A. Estimate availability of plover *foraging* habitats on northern Assateague Island before and after implementation of the short-term project.

B. Estimate plover brood habitat use, time budgets, and foraging rates in various habitats before and after implementation of the short-term project.

C. Estimate arthropod abundances[2] in various plover habitats before and after implementation of the short-term project.

D. Compare the quantity, quality, and accessibility of plover foraging habitat before and after the short-term project and assess the impact of any changes on plover nest distribution, density and productivity.

E. Recommend planning considerations for this and other shoreline stabilization projects that will minimize and mitigate adverse impacts on piping plovers throughout their Atlantic Coast range.

As formulated above, these objectives assume that information on plover abundance, nest locations, and productivity would be obtained under the National Park Service monitoring and mitigation plan and be available for analysis by persons performing this work. One strategy would be collect two years of pre-project data. Ideally, this would be done in 1997 and 1998; however, since it may not be possible bring a study on-line by the spring of 1997, work could extend through 1999, when little or no vegetation changes are likely to have taken place. Post-project impacts should be assessed beginning the third or fourth season after its completion and compared with 1997-99 conditions.

Costs of this study could vary substantially, depending on the organization selected to do the work. The only option that I have explored to date would be to use the U.S. Geological Survey (USGS), Biological Resources Division's Cooperative Research Unit at Virginia Polytechnic Institute. Direct costs of funding a master's level graduate student for a two years of field work and report preparation would be approximately $85,000, and assumes that free or nominal cost housing for the researcher is provided at the Seashore during the field season. This does not include any indirect costs that might be assessed by the University or the USGS. It is possible that another Cooperative Research Unit, the Maryland Department of Natural Resources, or the National Park Service might be able to do the same work at less cost.

I hope that this information is useful to you. Please let me know if you have any questions about this matter.

Enclosures

cc: Andy Moser, AFO
Dave Brinker, MDNR
Carl Zimmerman, NPS (with enclosures)

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[2] One concern expressed by Carl Zimmerman regarding invertebrate sampling focused on the intensity of sampling required to obtain statistically significant results. I am enclosing data from two studies that sampled plover prey resources elsewhere on the Atlantic Coast. While a more refined set of habitat classifications might present more of a challenge in this regard, I do not believe this will be an insurmountable problem.

Literature Cited

Loegering, J.P. and J.D. Fraser. 1995. Factors affecting piping plover chick survival in different brood-rearing habitats. Journal of Wildlife Management 59(4): 646-655.

U.S. Fish and Wildlife Service. 1996. Piping Plover (*Charadrius melodus*), Atlantic Coast Population, Revised Recovery Plan. Hadley, Massachusetts. 258 pp.

\uthor: Michael Del-Colle at ~MMS-Herndon-Adm
ate: 11/08/96 09:22 AM
?riority: Normal
Receipt Requested
TO: christopher.c.spaur@ccmail.nab.usace.army.mil at ~SMTP
CC: Barry Drucker at ~MMS-Herndon-OCS2
CC: Roger Amato at ~MMS-Herndon-OCS2 roger.amato@smtp.mms.gov
CC: Donald Hill at ~MMS-Herndon-OCS2
Subject: Draft Feasibility Report and Programmatic EIS: Assateague
------------------------ Message Contents ----------------------------

The attached file summarizes our review of the referenced draft document. These comments were originally requested by 10/31/96; however, scheduled and unscheduled events made that quick a turn around difficult to meet.

I believe if you compare our comments on this draft with the standards provided by Barry earlier in October you'll have a better appreciation for some of our concerns.

Some of our concerns may be a matter of process/culture differences that we simply need to work out. Others will require a bit more effort and consultation. Where we request copies of existing documents we'll be happy to make arrangements to have the material picked up to keep things moving.

If this programmatic EIS is the only "place" where borrow site issues will be presented and reviewed then we going to have to be fairly insistent on meeting our standards. If, on the other hand, the site specific EIS will not only deal with the coastal engineering placement issues but the borrow site as well then some latitude might be possible. Barry speaks to the basic issue in the opening comments of his memo.

You'll note that we suggest a mitigation technique option since it is our sense of the material (Section 7) that no biological reconnaissance has been accomplished.

Our comments notwithstanding, I personally am pleased with the efforts all are making to work cooperatively. First time efforts such as this always require some additional consideration of differences in culture, process and work products.

MINERALS MANAGEMENT SERVICE
Office of International Activities and Marine Minerals

NOTE

Date: November 6, 1996

To: Mike Del-Colle

From: Barry Drucker

Subject: Draft Integrated Feasibility Report I and Draft Programmatic Environmental Impact Statement (DEIS): Restoration of Assateague Island

Roger Amato and I have reviewed the above referenced subject document, dated November 1996, sent to us by the Baltimore District of the U. S. Army Corps of Engineers.

The opening discussion states that this document is programmatic in nature and that this EIS will be followed by site-specific EISs that contain site-specific information on the environmental setting and impacts of the proposed actions. It is unclear to me whether or not additional information relative to the impacts on the offshore borrow site or transportation zone will be contained in these site-specific documents.

Relative to the environmental analyses and information contained in this particular EIS, the document evaluates the impacts, but does not support the conclusions using available studies or references or the supporting information has not been provided.

- In terms of impacts to the borrow area relative to cultural resources, to the Corps' credit, they have apparently undertaken a cultural resource study of the offshore area (referred to as the Phase 1 Cultural Resource Reconnaissance). The MMS needs to see this report and have a review of the analysis undertaken by the Agency's Historic Preservation Officer/Archaeologist. The Corps has also apparently decided not to include this material as an appendix to the programmatic EIS. Including this material with the DEIS would greatly enhance its credibility.

- – Relative to impacts on the local wave climate after dredging of the shoals, the Corps indicates that modeling work has been completed. The DEIS states that this has been included as an appendix. It is not here. The MMS needs to review this material as to the methodology and conclusions. As with the cultural resource study report, we believe this information should be included as an appendix to the DEIS.

- In Section 7, conclusions as to the impacts on water quality, specifically in terms of increased turbidity are not supported by references or available studies.

- Also in Section 7, impacts to benthic resources are discussed. However, there is no indication that any biological reconnaissance work has been accomplished in the proposed borrow area.

Technically, in order to make conclusive statements relative to biological impacts, site-specific information must be collected prior to dredging. This is why the MMS Environmental Studies Program projects to support future sand and gravel activities on the Federal Outer Continental Shelf all include collection of benthic organism data. Therefore, the conclusions reached on effects and repopulation in this DEIS are not adequately supported. If the Corps believes that these shoal areas are low in species richness, faunal density, and biomass, supporting information must be provided.

If site-specific information from the proposed borrow area is not available, one possible mitigation option is to monitor the site to measure the impacts of the dredging operation on the benthic organisms. A stipulation was attached to the negotiated agreement for access to Federal sand to renourish Jacksonville Beach (Duval County, Florida) which required just such a study. The Corps' Jacksonville District office is currently overseeing this study with guidance from the MMS.

- Biological Assessments (BA) are being prepared relative to impacts on whales and turtles. The BAs will need to be reviewed by the MMS.

- The references section was not provided, making it impossible for us to check what references were actually used during the DEIS preparation. We also need to ensure that the Maryland report documenting their work on Great Gull Bank and other shoals in the Central Shoal Field is listed in the EIS's references.

- The DEIS (after P. 2-4 or 6-6) needs a detailed map of Great Gull Bank showing the outline of the borrow site and its dimensions.

- We need to see the appendix D that apparently documents the geologic work and resource assessment done for Great Gull Bank.

The Corps should also be advised that MMS stands for Minerals Management Service, not Mineral Management Service.

If you have any questions relative to these comments, please do not hesitate to ask me.

Barry Drucker
Physical Scientist

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
841 Chestnut Building
Philadelphia, Pennsylvania 19107-4431

NOV 19 1996

Ms. Stacey Marek
Department of the Army
Corps of Engineers
Baltimore District
P.O. Box 1715
Rte: CENAB-PL-E
Baltimore, MD 21203-1715

RE: Ocean City, Maryland and Vicinity Water Resources Feasibility Study, Scoping Letter.

Dear Ms. Marek:

EPA appreciates the opportunity to review and comment on the above referenced project early in the NEPA process. We have attached guidance for developing a NEPA document.

EPA has been involved in the development of this project, and will continue to work with you to provide you with information and guidance as you develop the project.

Please continue sending us information regarding this project as the project develops. The contact on specific water quality issues for this project is Edward Ambrosio. He can be reached at (215) 566-2758. For NEPA related issues, please send all correspondence to Roy E. Denmark, Jr., NEPA Program Manager.

Sincerely,

Danielle Algazi
NEPA Project Coordinator

Enclosures

United States Department of the Interior

FISH AND WILDLIFE SERVICE
Chesapeake Bay Field Office
177 Admiral Cochrane Drive
Annapolis, MD 21401

November 19, 1996

Colonel Randall R. Inouye
District Engineer
U.S. Army Corps of Engineers
P.O. Box 1715
Baltimore, MD 21203-1715

Attn: Chris Spaur

Re: Assateague Island Restoration

Dear Colonel Inouye:

This constitutes the draft report of the U.S. Fish and Wildlife Service on the proposed beach replenishment project for the north end of Assateague Island, Worcester County, Maryland. It is submitted in accordance with Section 2(b) of the Fish and Wildlife Coordination Act (48 Stat. 401, as amended; 16 U.S.C. 661 *et seq.*) The Service previously submitted planning aid reports dated August 1993 and April 1996. The present report summarizes pertinent information from our previous reports and sets forth the Service's official position on the Corps' recommended plan as described in the preliminary draft feasibility report dated November 1996.

PROJECT DESCRIPTION

The project is known as the "short-term restoration" plan for Assateague Island. It involves the one-time placement of 1.4 million cubic meters of sand on the north end of Assateague Island to restore a measure of geologic integrity and to provide temporary protection against the possibility of an island breach. This project is part of a larger ongoing study, the Ocean City, Maryland, and Vicinity Water Resources Study, which is investigating long-term solutions to the accelerated erosion which the north end of Assateague Island experiences due to the interruption of littoral sand transport caused by the stabilization of the Ocean City Inlet. The current project has been separated from the main study and placed on an accelerated schedule in order to prevent the island from breaching before a long-term project can be implemented.

The project plan involves dredging 1.4 million cubic meters of sand from an offshore shoal, Great Gull Bank, and depositing the material along a section of the Assateague beach between 2.5 and 11.5 kilometers south of the inlet. The sand would primarily be used to widen the beach berm (elevation 2.5 m NGVD) by up to 49 meters. The constructed berm is expected to be rapidly redistributed seaward by wave action reaching an equilibrium profile having a maximum berm width of 29 m.

Approximately 285,000 cubic meters of the sand would be used to create a low relief "storm berm" with an elevation of 3.3 m NGVD, extending from 2.5 km to 10 km south of the inlet. This berm would have a crest width of 5 m, side slopes of 1:20, and a base footprint of 45 m. It would be constructed along an alignment located approximately 30 to 50 m landward of the existing beach berm's seaward face. It is intended to reduce the frequency of island overwash to approximately one substantial occurrence every one or two years.

The widening of the beach berm in conjunction with the construction of the storm berm will provide a buffer that should prevent erosion of the existing island profile for at least five years. By this time it is anticipated that a long-term project to restore transport of sand from Ocean City across the inlet to Assateague Island should be implemented.

FISH AND WILDLIFE RESOURCES WITHOUT THE PROJECT

Assateague Island

The north end of Assateague Island where the project is proposed is a narrow, low profile barrier island that undergoes frequent overwash. The area, which is managed by the National Park Service as part of the Assateague Island National Seashore, has experienced severe erosion since the Ocean City Inlet was stabilized by jetty construction in the early 1930's. The stabilization of the inlet interrupted the natural southward transport of sand from Ocean City, and resulted in accelerated erosion of the Assateague shoreline. For the most part the width of the north end of the island is currently only between 120 and 215 meters. Overwash has increased to the extent that it is now a common occurrence during spring tide periods. Storms in late 1991 and early 1992 overwashed the area and removed much of the herbaceous and shrub vegetation. The remaining upland area is currently sparsely vegetated primarily with herbaceous species. Substantial stands of saltmarsh vegetation exist along portions of the bay side.

The conditions resulting from increased overwash have discouraged habitation by mammals. A small but ecologically significant population of foxes was largely eliminated following the January 1992 storm. However, feral horses sometime wander into the area from further south on the island. The area's relative isolation and lack of predators provides excellent habitat for certain ground nesting birds. During the 1996 breeding season the area supported approximately 300 pairs of least tern (*Sterna antillarum*), 61 pairs of piping plover (*Charadrins melodus*), 8 pairs of oyster catcher (*Haematopus palliatus*) and a few common terns (*Sterna hirundo*). The presence of the nesting piping plovers is particularly noteworthy because of their status as a "threatened" species under the Endangered Species Act. The Assateague population has been showing a substantial increasing trend over the last several years, and provides an important contribution to the species' recovery goals.

The intertidal and surf zone contains a productive invertebrate community. As is typical of surf zone communities, diversity is limited by the unstable sand substrate. The benthic organisms provide a food source for a variety of shorebirds, fish, and crabs which periodically feed in this zone. The beach tiger beetle (*Cicindela dorsalis media*), which is classified as endangered by the state of Maryland, has a breeding population on the beach in the project area. Surveys performed from 1990 to 1992 found that the beetles were primarily located on the northernmost 2.2 km section of the barrier beach (Hill and Knisley, 1994.)

Future Without the Project

The Corps' projection indicates that, without active intervention, it is likely that the island will be breached within the next ten years. The fate and consequences of a breach are not known. A breach could be plugged naturally, or by man's actions. Alternatively, given the reduced sand supply in the area, the breach could persist or even expand. If the breach persisted, barrier island habitat would be converted into a tidal inlet and the north end of Assateague would become a separate island. New islands and/or shoals could be created in the back bay, although the narrowness of Sinepuxent Bay would be a limiting factor. Tidal circulation in the back bays would be altered potentially having adverse impacts on fishery resources and their habitats.

The effect of a breach on upland biological resources is also unknown. While the amount of island habitat for nesting birds would decrease, this could be counterbalanced by an improvement in the value of the remaining habitat due to enhanced isolation from mammalian predators or improved feeding areas. Even if a breach does not develop, the habitat value for some nesting birds could decline if the extent and frequency of overwash continues to increase.

Offshore Borrow Site

The proposed borrow area is an unspecified area of Great Gull Bank, which is a large, linear shoal located approximately 8 km offshore. Water depths range from 5.8 m on the crest to 9.2 m in the adjacent waters. The shoal supports an invertebrate community composed primarily of infaunal species typical of the mid-Atlantic coastal region. Surf clams (*Spisula solidissima*), an important commercial species, are expected to be present as juveniles, but the area does not support a commercially harvestable population. Whelks (*Busycon spp.*) and horseshoe crabs (*Limulus polyphemus*) are occasionally commercially harvested from the area.

Many species of fish occur in the area depending on the time of year. Winter is a time of low abundance as most species leave the area for warmer waters offshore and southward. Spring brings a progressive influx of species which reach a peak in fall. Commercial fishing occurs at the shoal as well as throughout the general region. Trawling is the primary method, with gill nets and pots secondary. The most important finfish species taken in terms of dollar value include summer flounder, dogfish, weakfish, and black sea bass.

Great Gull Bank also supports a significant recreational fishery. The fishing activity, which includes both private recreational fishing vessels and commercial party boats, is most active in the late summer and fall when species such as weakfish, croaker, summer flounder, and striped bass are available. Fish appear to be attracted to the elevated bottom profile as well as the shoal edges. A fish haven has been established at the northwest area of the shoal. Tire bundles and a barge have been placed there to serve as artificial reefs. Black sea bass, tautog, and triggerfish are structure orientated species which occur there.

Bird species which may be found feeding and/or resting in the vicinity of Great Gull Bank include gulls, terns, scoters, oldsquaw, red-throated loon, red-breasted merganser, and northern gannet. Sea turtles, especially loggerhead, but also Kemp's ridley, green, and leatherback, occur in the area from June to November. While several species of marine mammals occur in the area on a rare or occasional basis, the bottlenose dolphin is relatively common.

Threatened and Endangered Species

The project area supports a significant breeding population of piping plover (*Charadrius melodus*) with 61 breeding pairs recorded in 1996. The Atlantic Coast population of this small shorebird is listed as threatened under provisions of the Endangered Species Act. The birds typically arrive at Assateague in mid-March. They select nesting sites in open or sparsely vegetated areas on the upper beach, and egg laying commences in late April. Shortly after hatching the precocial young leave the nest to begin foraging. Preferred foraging areas are moist sand and mud flats on the bay side of the island. The birds may also forage along the ocean beach, although studies at Assateague have indicated that the forage base is less adequate there. Vegetation can prevent the chicks from reaching the preferred foraging areas on the bay side. A major concern is that the project would reduce overwash and promote the growth of vegetation to an extent that would adversely affect the birds by altering their nesting areas, foraging areas, travel corridors, and predator populations.

The project area contains habitat suitable for seabeach amaranth (*Amaranthus pumilis*) which is a plant Federally listed as threatened. The plant does not currently exist in the project area, although it was reported from the Maryland part of Assateague Island in 1967. The Maryland Heritage Program is considering a reintroduction program on Assateague Island. Seabeach amaranth is an annual plant that occurs on the beach at elevations of from 0.2 to 1.5 m above mean high tide. It often favors overwash areas similar to those occupied by piping plover, and is not found on well vegetated beaches.

Several species of Federally listed threatened and endangered sea turtles occur in the vicinity of the proposed borrow site from June to November. The loggerhead (*Caretta caretta*) is the most common, and is also a rare nester on Assateague Island. Other turtle species which occur in the vicinity of Great Gull Bank include Kemp's ridley (*Lepidochelys kempii*), green (*Chelonia mydes*), and leatherback (*Demochelys kempii*). The loggerhead, Kemp's ridley, and green are known to be subject to entrainment by hopper dredges (Dickerson et al. 1991; Nelson and Shafer, 1996).

Other Federally listed species may occur within the project area on an occasional or transient basis. These would include certain migratory birds and marine mammals that are not expected to be affected by the project.

BIOLOGICAL EFFECTS OF THE PROJECT

In a general sense the project would function to offset the accelerated erosion at the north end of Assateague Island caused by the stabilization of the Ocean City Inlet. This will preserve the physical integrity of the barrier island and forestall unpredictable changes to the back bays that would result if the island were breached.

The most important potential impact is to the piping plover. In accordance with Section 7 of the Endangered Species Act a Biological Assessment was conducted to identify potential effects of various project alternatives on piping plover. The assessment concluded that piping plover would be adversely affected if the frequency of cross-island overwash was not sufficient to maintain open nesting areas, travel corridors, and foraging areas. In order to minimize impacts to piping plover the Corps' recommended alternative has been designed to allow one substantial overwash event every one to two years. In theory this should be sufficient to maintain the plover habitat. However, the Corps' ability to accurately predict the overwash frequency is uncertain. The resulting effects on vegetative succession are also difficult to predict.

In order to overcome these uncertainties the project includes a 5-year program to monitor physical and biological factors that will indicate whether it is having an unacceptable impact on piping plover. The program has been structured to have specific threshold performance levels to assist in this determination. It includes a provision for performing corrective action if the project results in a significant adverse effect on the plover. Direct conflicts with nesting birds will be minimized because the project has been specifically scheduled to occur in the fall after September 1, when the birds have fledged.

A formal Section 7 Consultation pursuant to the Endangered Species Act is underway to evaluate the effect of the selected project alternative on piping plover. The outcome of this process will be the issuance of a Biological Opinion by the Service that will determine whether the project is likely to jeopardize the continued existence of the species or its recovery efforts. The Biological Opinion may also recommend reasonable and prudent measures to minimize take of the plover.

The impacts to the populations of nesting least terns, oyster catchers, and other birds should be minimized by the measures taken to protect piping plover. The storm berm will be constructed on an area that has a sparse cover of vegetation. The loss of this vegetation should be temporary and not have significant adverse consequences to wildlife or the ecology of the area.
The benthic invertebrate community along the shoreline will be impacted by sand placement, but based on studies of other projects most species will repopulate within a few months (National Research Council, 1995). The beach tiger beetle (*Cicindela dorsalis media*) would be

particularly susceptible to impact because of its low population numbers, disjunct distribution, and vulnerable two-year larval stage. However, the project's effect on this species should not be significant because no sand placement is proposed in the northern 2.5 km of the shoreline where its primary population is located.

The details of the dredging plan have not been determined. Assuming that the entire 1.4 million cubic meters of material is taken from Great Gull Bank, and that a 3-meter deep layer was dredged, the dredged area would be approximately 90 hectares. Since the shoal encompasses approximately 1,376 ha, the dredged portion would comprise approximately 6 percent of the shoal. Consequently, it is expected that the basic shoal profile would not be significantly altered. The Corps' preliminary tests indicate that the bottom substrate which is left exposed after dredging will be similar to present conditions. Since no deep pits will be created, there is no reason to expect any substantial changes in water quality or sedimentation patterns.

The dredging will remove the existing benthic invertebrate community, but natural recolonization over the following year should restore the area to pre-project conditions. The disturbance during dredging and the disruption of the invertebrate food supply may result in temporary avoidance of the area by finfish. However, assuming dredging does not occur within the fish haven area, finfish should not be significantly affected. In previous dredging projects debris left on the bottom by the dredging contractor (eg. cables, anchors, pipes, and tires) has been a hindrance to commercial trawling.

If a hopper dredge is used to do the dredging, sea turtles could be subject to entrainment. Since they are Federally listed as threatened or endangered, we understand that the Corps has initiated consultation under Section 7 of the Endangered Species Act with the National Marine Fisheries Service which has jurisdiction.

CONCLUSIONS

The project will restore a portion of the sand volume to the north end of Assateague Island that was lost after the stabilization of the Ocean City Inlet interrupted littoral transport. The design appears to provide an appropriate balance between the objectives of providing temporary breach protection and of maintaining sufficient overwash to retain the area's early successional habitat characteristics. The latter objective is vital for maintaining the nesting population of the Federally listed piping plover which uses the area. A Section 7 Consultation for the piping plover is underway and should be completed within the next few months.

Because of limitations in the ability to predict how well the project will meet its objectives, the Service considers the proposed program for monitoring and corrective action to be absolutely critical. The Service is interested in maintaining close coordination as project details relating to the piping plover (including the monitoring program) and the dredging at the borrow site are developed.

Sincerely,

for John P. Wolflin
Supervisor
Chesapeake Bay Field Office

References

Dickerson, D.D., J.I. Richardson, J.S. Ferris, A.L. Bass, and M. Wolff. 1991. Entrainment of sea turtles by hopper dredges in Cape Canaveral and King's Bay ship channels. Environmental Effects of Dredging, Information Exchange Bulletin, Vol. D-91-3, Waterways Experiment Station, U.S. Army Corps of Engineers.

Hill, J.M. and C.B. Knisley. 1994. A study of possible effects of dredged material placement in the surf zone at Assateague Island, Maryland on two beach macro-invertebrates, the tiger beetle (*Cicindela dorsalis media*) and the ghost crab (*Ocypode guadrata*). Submitted to Baltimore District, Army Corps of Engineers.

National Research Council. 1995. Beach nourishment and protection. Academic Press: Washington, D.C.

Nelson, D.A. and D.J. Shafer. 1991. Effectiveness of a sea turtle-deflecting hopper dredge draghead in Port Canaveral Entrance Channel, Florida. Miscellaneous Report D-96-3, Waterways Experiment Station, U.S. Army Corps of Engineers.

TELEPHONE CONVERSATION RECORD

DATE: 1/14/97 FILE NAME: phonnic.wpd

NAME OF PERSON(S) CONTACTED: John Nichols

ORGANIZATION: National Marine Fisheries Service

PHONE NO.: (410) 226-5771

SUBJECT: Ocean City Water Resources Study -- Need for Pre-Dredging Biological Condition Assessment of Great Gull Bank

CONVERSATION SUMMARY:

I called John to follow up on a previous conversation in which I had asked John Nichols to provide a NMFS opinion as to whether a pre-dredging assessment of the biological condition of Great Gull Bank should be performed.

John said he will provide the Corps with a formal written response regarding this matter in the near future. John has formed a preliminary opinion regarding this based in part on recent conversations he had with Jim Casey and John Foster of the Md. Dept. of Natural Resources (DNR). Jim Casey suggested that a creel survey would be adequate, but John Foster believes that a controlled fishing study is required. John (Nichols) agrees with John Foster and believes that a statistically valid study which records total catch and also keys in on select species commonly sought after by recreational fishermen on Great Gull Bank should be conducted. The study would be carried out by the Corps, and would involve fishing Great Gull Bank prior to and following dredging in "treatment" areas (i.e., areas where borrow dredging will occur) and control areas on the Bank. The fishing could be carried out by volunteers, perhaps, but observers (i.e., biologists with fishing skills and knowledge) will need to be on hand to control activities and record data. Species that the study might focus on could include bluefish, sharks, striped bass, and weakfish.

John said that NMFS is also interested in having post-dredging monitoring of bathymetry and surface sediments on Great Gull Bank. The baseline condition is probably covered by the Corps' geotechnical analysis, and no additional work is necessary.

John raised the issue of whether mitigation for potential impacts to Great Gull Bank was being proposed as a component of the Assateague immediate restoration project. (Mitigation had been discussed at a July 25th, 1996 meeting of the Corps, NMFS, DNR, and Maryland Geological Survey which focused on using the offshore shoals as sand sources for the restoration of Assateague Island). I said that mitigation is not included in the November 1996 version of the *Restoration of Assateague Island DRAFT Integrated Feasibility Report I and Programmatic EIS*. John noted that John Foster believes that mitigation, perhaps in the form of enhancement of the existing artificial reef off Ocean City, is critical to getting support of local sport and recreational fishermen.

I asked John whether he agrees with the opinion of George Ruddy of the USFWS that sufficient information is available from previous biological studies of nearby offshore shoals to adequately characterize the benthos of Great Gull Bank. John said that he has no problem with using existing data on benthos and fish species derived from previous studies of other offshore shoals in the Ocean City vicinity as the basis of characterizing the biota of Great Gull Bank.

ACTION TAKEN: Documented conversation, provided copy to John Nichols for his review, and incorporated John's suggested changes.

NAME OF PERSON DOCUMENTING CONVERSATION: Christopher C. Spaur

SIGNATURE:

MEMORANDUM FOR THE RECORD January 31, 1997

Minutes from 17 January 1997 Conference Call between Representatives of Minerals Management Service, U.S. Fish and Wildlife Service, and Corps of Engineers

CONFERENCE CALL SUBJECT: information needs to characterize biota and analyze potential dredging impacts to Great Gull Bank for the Immediate Restoration of Assateague Island Project.

CONFEREES: Roger Amato and Barry Drucker (MMS) [(703) 787-1290]; George Ruddy (USFWS) [(410) 573-4528]; Christopher Spaur (USACE) [(410) 962-6134]

FROM: Christopher Spaur
Corps of Engineers, Baltimore District, Planning Division

TO:

Roger Amato	Minerals Management Service
Jim Casey	Maryland Department of Natural Resources
Barry Drucker	Minerals Management Service
John Foster	Maryland Department of Natural Resources
Phil Hager	Worcester County
Jordan Loran	Maryland Department of Natural Resources
Stacey Marek	Corps of Engineers
Terry McGean	Ocean City
John Nichols	National Marine Fisheries Service
George Ruddy	U.S. Fish and Wildlife Service
Jarrell Smith	Corps of Engineers, WES
Carl Zimmerman	National Park Service

MINUTES:

1. Chris Spaur stated that the purpose of the conference call was to discuss MMS comments from November 1996 on the October 1996 version of the Draft EIS for the Immediate Restoration of Assateague Island. MMS has standards which they expect of EISs which they believe weren't met with regard to being able to evaluate biological impacts that may occur to Great Gull Bank as a result of the proposed dredging activity. The November 1996 version of the DEIS still fails to meet this expectation (although it did correct a number of other MMS identified deficiencies).

Chris stated that the following excerpt from MMS's 11/8/96 comments would be a focus of discussion:

"Technically, in order to make conclusive statements relative to biological impacts, site-specific information must be collected prior to dredging. This is why the MMS Environmental Studies Program projects to support future sand and gravel activities on the Federal Outer Continental Shelf all include collection of benthic organism data. Therefore, the conclusions reached on effects and repopulation in this DEIS are not adequately supported. If the Corps believes that these shoal areas are low in species richness, faunal density, and biomass, supporting information must be provided.

If site-specific information from the proposed borrow area is not available, one possible mitigation option is to monitor the site to measure the impacts of the dredging operation on the benthic organisms. A stipulation was attached to the negotiated agreement for access to Federal sand to renourish Jacksonville Beach (Duval County, Florida) which required just such a study. The Corps' Jacksonville office is currently overseeing this study with guidance from the MMS."

2. George Ruddy stated that he investigated benthic resources information and considered whether pre-dredge surveys were necessary. [George is the author of the Planning Aid Report prepared by the U.S. Fish and Wildlife Service for the Ocean City, Maryland and Vicinity Water Resources Feasibility Study. This planning aid report is titled: *Baseline Biological Resources and Potential Impacts of Dredging at Four Candidate Offshore Sand Borrow Sites*]. He determined that the benthos consists of an infaunal community that would recover relatively quickly to pre-project levels of diversity, organism numbers, and biomass. In addition, no high profile benthic species are likely to be present. Thus, a pre-dredge study is unnecessary. However, George cautioned that although the biomass and numbers of benthos on Great Gull Bank would likely be low, the value to the marine foodweb of these organisms is unknown.

3. Roger and Barry stated that they tended to agree with this perspective on the relative value of the benthos, but they thought the sampling methodology of the studies that George referenced in his report is statistically questionable. Roger and Barry agreed that benthos would have no trouble recolonizing the site. George stated that it's very difficult to get a statistically valid characterization of benthos, and Roger and Barry agreed.

4. Chris then turned the discussion to other potentially unresolved issues, and stated that John Nichols of NMFS had suggested that a pre- and post-dredging controlled fishing study be conducted, as is currently being conducted by the Maryland Environment Service for the Poole's Island project. In addition, John suggested that post-dredging monitoring of bathymetry and surface sediments should be done. Roger and Barry thought that the finfish survey would be interesting, however they're more concerned with the benthos. To address this, they stated that MMS would be more interested in post-dredging monitoring of bathymetry and surface sediments, and that including this as a component of the project

would help to insure timely approval of the proposed dredging by MMS. They indicated that sediment monitoring would provide useful information with regard to likely project impacts upon benthos. George said that he wasn't familiar with the details of the Poole's Island study, but was concerned that natural year to year variation in finfish populations is so great that it would likely obscure the results of such a study. George thought that the bathymetric monitoring and grain-size analysis suggested by John would be of greater value, and that more sound conclusions could be drawn. Roger and Barry agreed with George's contention, and wondered whether the presence of the artificial reef might also confound the results of a finfish study.

5. Roger and Barry said that the MMS has still not received the results of the cultural study contracted by the Corps. And, that they need an update on the status of the whales and turtles Biological Assessment being prepared by the Baltimore District. Chris said that he will provide an answer to these questions, and will also provide information on what the length of the public review will be for the EIS, and will find out when construction is likely to begin.

If you have any questions, or would like to make additions or corrections please contact me at (410) 962-6134. Comments on a draft version of the minutes were received from Barry Drucker and George Ruddy, and were incorporated into this final version.

Sincerely,

Christopher Spaur

ANNEX A, PART 8

List of Preparers

LIST OF PREPARERS

Carol Anderson-Austra	*Landscape Architect* USACE, Baltimore District
Gregory Bass	*Engineering Technician* USACE, Baltimore District
Ken Baumgardt	*Historian* USACE, Baltimore District
Angela Blizzard	*Real Estate Specialist* USACE, Baltimore District
Kristin Budzynski	*Attorney* USACE, Baltimore District
Wesley E. Coleman	*Oceanographer* USACE, Baltimore District
Kathryn Conant	*Biologist* USACE, Baltimore District
Bruce Ebersole	*Supervisory Research Hydraulic Engineer* CERC
Barbara Grider	*Editor* USACE, Baltimore District
Phillip Hager	*Planner* Worcester County Planning Commission
Dennis Klosterman	*Economist* USACE, Baltimore District
Oliver Leimbach	*Cost Estimator* USACE, Baltimore District
Stacey Marek	*Civil Engineer, Study Manager* USACE, Baltimore District

Mark Mendelsohn	*Biologist* USACE, Baltimore District
Gregory Nielson	*Civil Engineer/Design Manager* USACE, Baltimore District
Peter Noy	*Geographer* USACE, Baltimore District
Julie Rosati	*Research Hydraulic Engineer* CERC
S. Jarrell Smith	*Hydraulic Engineer* CERC
James Snyder	*Geotechnical Engineer* USACE, Baltimore District
Christopher Spaur	*Biologist* USACE, Baltimore District
Don Stauble	*Research Physical Scientist* CERC
Harry Wang	*Research Physical Scientist* CERC
Greg Williams	*Research Hydraulic Engineer* CERC
Carl Zimmerman	*Resource Management Specialist* National Park Service

Annex A, Part 9

Public Comments and Responses

Restoration of Assateague Island
Integrated Interim Report and
Environmental Impact Statement, May 1997
Response to Comments

Minerals Management Service

1 a. Comment: Page ix: "The Draft EIS section entitled, "Coordination with the MMS" should be re-titled "Coordination/Cooperation with the MMS."

Response: *Concur. Section has been modified.*

1 b. Comment: Page 7-6, Section 7.1.1.c, Bathymetry: The MMS' policy is to structure the lease for the borrow area such that deep pits or depressions will not be dug. This generally serves to ensure that no adverse changes to the local physical environment occur. It also precludes the deposition of fine-grained material into the dredged hole.

Response*:* *During dredging, the 93-ha (230-acre) borrow area on Great Gull Bank will be lowered from the existing depths of 6 to 9m (19.7 to 29.5 feet) to an average 9-m (29.5-foot) depth. Dredging will thus deepen the borrow area by 3m (10 feet). A detailed dredging plan will be developed in collaboration with the U. S. Fish and Wildlife Service, National Marine Fisheries Service, and the Minerals Management Service. In keeping with current MMS policy, the area will not be dredged to the extent that deep pits or depressions will form. This will ensure that no adverse impacts to the local physical environment will occur and will preclude the deposition of fine-grained material into the dredged hole.*

1 c. Comment: Page 7-7, Section 7.1.1.e, Surface Water Quality: A general condition of the lease for the dredging activity is that turbidity in the water column is not to exceed 29 NTUs to preclude any adverse or short-term impacts on the water column organisms.

Response: *Condition noted. The Corps expects very little turbidity on the surface. Turbidity will be localized at the cutter head during dredging activity. Further discussion between representatives of the Corps of Engineers and the Minerals Management Service in March 1998 resolved this issue.*

1 d. Comment: According to the MMS Headquarters archaeologist, the shipwreck survey and analysis in the draft EIS is adequate. However, even though the potential for offshore prehistoric resources is mentioned in the background section, there are no data collected, no analysis, and no conclusions regarding prehistoric resources for the offshore borrow areas. The MMS will review available shallow seismic data and/or core data for the offshore borrow prior to issuance of a lease.

Response: *Comment noted. No action is required on the part of the Corps of Engineers because Great Gull Bank is outside the territorial waters of the United States and was not considered by the State Historical Preservation Officer to require cultural resource investigations.*

1 e. Comment: Annex A, Part 1, Page 9 states that the project will not significantly impact in a detrimental manner any endangered species or its critical habitat, and therefore the project is in compliance with the Endangered Species Act. However, no biological opinion has been issued yet from the Fish and Wildlife Service or National Marine Fisheries Service. The Corps will have to monitor Piping Plover nesting areas and food sources over a period of time to determine whether there is an impact (1) on nesting due to loss of suitable nesting habitat and (2) on survival of young due to loss of food.

Response: *The Biological Opinion was prepared by the USFWS and dated May 23, 1997. This Opinion notes that incorporation of the Monitoring and Action Plan into the proposed project was critical to obtaining project acceptance by the USFWS and MD DNR. The Monitoring and Action Plan is critical because it is impossible to predict impacts of the project on Piping Plover; project performance and impacts on plover will largely be a function of the frequency and severity of storm events following project construction. Since the Monitoring and Action Plan is included, the USFWS concluded that implementation of the project is not likely to jeopardize the continued existence of the Atlantic coast population of Piping Plover. The time-of-year restrictions on project construction will prevent direct impacts to plover. Indirect impacts following project construction are expected by USFWS to take six chicks per year. As a consequence, the USFWS stipulated several nondiscretionary reasonable and prudent measures that must be undertaken by the Corps to ensure compliance with the Endangered Species Act: the time-of-year restriction must be followed, the monitoring problem must be implemented, and mitigative action must be taken if the indirect impacts of the project are significant and adverse (as spelled out in the Monitoring and Action Plan).*

The USFWS Biological Opinion stipulates that a March 15th to Sept. 1st Time of Year Restriction must be honored. The Monitoring Program evaluates project performance with regard to its impact on overwash frequency. This is to be accomplished by monitoring change in vegetative cover and island elevation within the project area. If overwash frequency is too high, then the risk of breaching is also assumed to be high. In that case mitigative actions could include work to raise the elevation of the constructed berm. If vegetative cover increases drastically, then overwash frequency is assumed to be too low, and mitigative measures could include berm elevation reduction or vegetative management.

1 f. Comment: Page 6-6, Description of Recommended Plan: The DEIS states that after 7 years, the majority of placed material will have been effectively removed if no long-term solution is implemented, which is expected to be implemented after year 2. This is a foreseeable action that should be covered in the cumulative impact analysis. According to the Council of Environmental Quality (CEQ) regulations, cumulative impacts are the

impacts of the environment that result from the incremental impact of the action when added to other past, present, and foreseeable future actions regardless of which agency (Federal or non-Federal) or person undertakes them.

Response: *A cumulative impact analysis will be provided in the EIS for the long-term sand management portion of the study. The short-term plan will not be constructed unless the long-term sand management plan is approved.*

Environmental Protection Agency

2 a. Comment: EPA has given the DEIS a rating of LO-1 (Lack of Objections - Adequate). No further comments.

National Park Service

3 a. Comment: Section 5-1-2, Last Paragraph: The National Seashore is opposed to the use of the ebb shoal as a borrow source until a long-term sediment transport system is in place to supply an amount of sand to Assateague as would be naturally transported if the jetties did not exist. Information developed as part of the Coastal Engineering Analysis suggests that the ebb shoal is having significant influence on Assateague by modifying wave climate and contributing some amount of sand through "bypassing." We do not believe it appropriate to perturb the shoal and risk additional impacts to Assateague Island until a long-term solution has been implemented.

Response: *The Corps understands that the NPS has concerns over the use of the ebb shoal as a borrow source for the short-term restoration. Great Gull Bank is a viable borrow source, and the plan is to use it as the primary source for the short-term project. The ebb shoal, if used at all for the short-term restoration, would only be used as a secondary source and most likely only as the short-term solution is nearing its end and the long-term solution is about to be implemented. It is also possible that the ebb-shoal will not be used at all for the short-term project.*

3 b. Comment: Annex C, Proposed Estates: If this section is intended to describe the easements/right-of-ways needed by the Corps from the NPS to conduct the project, then it is not at all clear why perpetual easements are the desired estate for the Assateague Island beach restoration and storm berm lands (assuming that the proposed project is a one time only action, without long-term maintenance requirements or obligations by the Corps). Why would a temporary work area easement not suffice for the duration of construction and the follow-up monitoring period? The Corps and the NPS will need to discuss this issue further.

Response: *The National Park Service will obtain a fee estate to the required parcels. Once this has been done and the PCA/MOU has been signed for the project, the NPS will only need to issue the Corps a permit to go on its lands.*

3 c. Comment: Section 1.1, Last Sentence of Fourth Paragraph: Since the park was established in 1965, more than 65 million people have visited Assateague Island National Seashore.

Response: *Concur. Correction has been made.*

3 d. Comment: Section 2.4.1.c, fifth Sentence of Second Paragraph: It is incorrect to state that Assateague "possesses minimal woodland areas." This statement would, however, be a correct assessment of Northern Assateague.

Response: *Concur, the sentence has been modified to: "The northern end of Assateague has historically been dominated by dune grassland zone vegetation, and possesses minimal woodland areas."*

3 e. Comment: Section 2.4.2.b, Second to Last Sentence in Coastal Bays Section: Incomplete sentence ending with "....few."

Response: *Concur. The sentence has been modified to read, "Sinepuxent Bay in general possesses low finfish species richness and few juvenile finfish."*

3 f. Comment: Section 2.4.2.d, Last sentence of third paragraph under Coastal Bays Mainland and Barrier Islands section: The correct name of the organization is "The Western Hemisphere Shorebird Reserve Network."

Response: *Concur. The sentence has been modified to read, "Chincoteague National Wildlife Refuge ranked second in diversity of shorebird species from among all 450 sites in the Western Hemisphere Shorebird Reserve Network and, in 1990, the barrier islands of Virginia and Maryland were dedicated as part of the International Shorebird Preserve."*

3 g. Comment: Section 2.9.5, Third Sentence of Second Paragraph: The correct name for the state park is Assateague State Park.

Response: *Concur. The sentence has been modified to read, "The Sinepuxent Bay Wildlife Management Area, the Assateague State Park, and the Assateague Island National Seashore and Wildlife Refuge border Sinepuxent Bay."*

3 h. Comment: Tables 5-5 and 5-8: In both tables, the description of Alternative #3/5d includes the statement that beach width increases approximately 30-40 feet. It would be more meaningful to state this as the average increase in beach width, or else state the range of widths within the project area - essentially 0-90 feet depending on location.

Response: *Concur. The tables have been modified to read, "Average island width increases to approximately 30 to 40 feet; low storm berm constructed."*

<u>**Worcester Environmental Trust**</u>

4 a. Comment: WET requests that all work be conditioned on the fact that there be a sand by-pass system from south Ocean City to the north Assateague Island beach in order that a steady supply of sand guarantees replacement of what the jetties capture or deflect onto the shoals.

Response: *Concur. Corps Headquarters has requested that an implicit linkage between the short-term and long-term portions of the study be created. The short-term solution will not be constructed unless the long-term plan is approved.*

4 b. Comment: WET would like to see an effective buffer easement along the Bayside of the mainland to prevent storm damage and flooding and to ensure the landward migration of wetlands.

Response: *Comment noted. However, land-use controls are outside the authority of the U.S. Army Corps of Engineers. This is a local governmental function.*

4 c. Comment: Page 2-12, Section 2.3.1.b: Request the Corps include Trappe Creek along with the other degraded coastal tributaries. Trappe Creek has several point source pollutant discharges coming from a chicken processing plant, a landfill, a municipal sewage treatment plant and others, in addition to agriculture and residential non-point runoff.

Response: *Concur. The sentence has been modified to include Trappe Creek.*

4 d. Comment: Page 2-16, Section 2.4.1.c: WET wishes to point out that barrier island vegetation accommodates overwash, which is a natural process.

Response: *Concur.*

4 e. Comment: Page 2-36, Section 2.10.2: Habitat for birds and other species could be guaranteed by acquisition of mainland bay frontage, which would allow wetlands and habitat to migrate landward. There are many acquisition programs available, some of which are the Land and Water Conservation Fund, Program Open Space, and the Rural Legacy Program, to name a few.

Response: *Comment noted. However, land-use controls are outside the authority of the U. S. Army Corps of Engineers. This is a local governmental function.*

4 f. Comment Page 2-37, Section 2.10.3: Building the beach on north Assateague will give a false sense of security to mainlanders. When, not if, a major storm occurs, low mainland areas will be severely impacted. We feel it is better to see, deal with, and learn from overwash, than to encourage mainland growth in hazardous areas, assuming that a static barrier island will always be there. Acquisition of Bayside buffers will ensure that new salt marsh will flourish.

Response: *Comment noted. The Corps has repeatedly informed the public that the purpose of the project is to restore the northern part of the island to a more natural condition, not to provide storm protection to the mainland. Healthy barrier islands inherently afford some protection to coastal bays and the mainland, but the Corps has clearly stated that the project will not prevent or significantly reduce damages on the mainland. This project will allow normal overwash and in no way will create a static barrier island. Again, land-use controls are outside the authority of the Corps of Engineers. This is a local governmental function.*

4 g. Comment: Figure 3-1: Shows that the mainland, particularly on South Point, has already suffered upland loss due to wave energy and sea-level rise.

Response: *The figure is provided for illustrative purposes. It is not meant to provide exact quantitative information. This disclaimer has been placed on Figure 3-1.*

4 h. Comment: Page 3-10, Section 3.2.2.c: Inundation of the mainland due to storm surge should not justify this project. Jeopardizing the safety of Bayside property owners is the result of poor county land use decisions. It would be far better to use some of the multimillion dollar beach nourishment money to acquire bay front mainland properties and move people out of danger. In addition, this would slow marina construction and have greater water quality and wildlife benefits. This would be a sustainable way of encouraging tourism by protecting what many visitors come to enjoy, as well as providing additional access to the bay.

Response: *The short-term restoration of Assateague Island was authorized in order to mitigate for environmental degradation that has resulted from the existing Corps jetties. It was not authorized for the purpose of protecting bayside property. The limited storm-damage reduction that the project will provide is an incidental benefit only.*

4 i. Comment: Page 3-10, Section 3.2.2.d: WET opposes the use of the shoal off the north end of Assateague for Ocean City beach Nourishment.

Response: *At this time, the Town of Ocean City has no plans to use the Ebb Shoal. They currently utilize shoals offshore Ocean City for beach nourishment.*

4 j. Comment: Page 3-11, Section 3.3.1: Deepening the inlet to accommodate deeper draft vessels would be a self-fulfilling action. This could change the hydrodynamics of the area, increasing flooding potential.

Response: *Comment noted. Navigation improvements will be discussed in detail in the second part of the Ocean City, Maryland and Vicinity Water Resources Feasibility Study, which addresses the remaining components of the study.*

4 k. Comment: Page 3-13, Section 3.4.1: The fact that so many acres of wetlands have been lost within the coastal bays may have been the result of poor decision on the part of the Corps of Engineers. Developing a "rolling easement" strategy along the mainland could ensure survival of wetlands.

Response: *Comment noted. However, land-use controls are outside the authority of the U. S. Army Corps of Engineers. This is a local governmental function.*

4 l. Comment: Page 4.2, Section 4.3.1: With the exception of number 5, we support the goals listed. Re number 5, reducing the impact of storm damage/erosion is the responsibility of the county government.

Response: *There are several program authorities that allow the Corps of Engineers to provide solutions in regards to reduction of storm damage and erosion. These include Section 14 of the Flood Control Act of 1946 (Emergency streambank and shoreline erosion protection), Section 103 of the River and Harbor Act of 1962 (Hurricane and Storm Damage Reduction), and Section 111 of the River and Harbor Act of 1968 (Mitigation of shoreline eorosion damage caused by Federal navigation projects).*

4 m. Comment: Page 5-1, Section 5.1.1: WET supports 3/5d, 3/5e, or 8. A long-term sediment supply is the key to maintaining the northern beach of Assateague. Without a long-term plan which would include a sand by-pass system, the cost of maintaining the north end of Assateague will be prohibitive.

Response: *Concur. Corps Headquarters has requested that an implicit linkage between the short-term and long-term portions of the study be created. The short-term solution will not be constructed unless the long-term plan is approved.*

4 n. Comment: Page 7-18, Section 7.2: WET supports the attempt to improve the north end of Assateague as habitat for the beach tiger beetle, sea beach amaranth, and Piping Plover. It is important to increase habitat areas along with the coast since manmade and natural disasters, such as oil spills and storms, can quickly wipe out these species in certain areas.

Response: *Concur. The Corps agrees that increasing coastal habitat is extremely important to address these concerns.*

4 o. Comment: Page 7-19, Section 7.2: WET supports the creation of mainland habitat for submerged aquatic vegetation, wetlands, and colonial nesting birds. WET also urges that the Corps consider acquisition of a Bayside buffer to ensure the future of wetlands as they respond to sea-level rise. Again, WET urges the Corps to study the use of "rolling easements" as a solution for preserving mainland wetlands.

Response: *Comment noted. However, land-use controls are outside the authority of the Corps of Engineers. This is a local governmental function.*

4 p. Comment: Page 7-20, Section 7.4: WET suggests that in the next phase of this study, the Corps give serious consideration to the creation of natural habitat adjacent to or near the eroding sides of the Isle of Wight, a state-owned Natural Resources Management Area in the Isle of Wight Bay.

Response: *Concur. These areas are under consideration as part of the environmental restoration effort in the second part of the Ocean City, Maryland, and Vicinity Water Resources Study.*

4 q. Comment: Will the timing of sand placement be done at a period of low potential impact to the wildlife?

Response: *The project area is of notable value to shorebirds, including several rare species, but is not of notable value to other wildlife. The time-of-year restriction therefore focuses on avoiding disturbance to shorebirds during their nesting and brood rearing seasons. The short-term restoration project will avoid construction during March 15th to Sept. 1st to meet this need.*

4 r. Comment: Why is the dredged material from routine dredging not deposited on the Assateague Island National Seashore when the sand is suitable. And the "poor material," why not use it for back bay spoil island now?

Response*: Poor quality (fine-grain size) material for beach nourishment poses special problems if it is to be placed in aquatic ecosystems. Because of requirements to protect water quality, it can't be placed without first having engineering measures in place to minimize turbidity impacts. At this time there are no established containment sites for these materials, and if they were placed in open water there could be substantial water quality impacts, and material would be vulnerable to erosion and off-site transport.*

During routine dredging conducted by the Corps of Engineers, representatives from the Town of Ocean City and Assateague Island National Seashore are consulted regarding their needs for dredged material. There are times when the material is provided to Ocean City; at other times, it is provided to Assateague Island National Seashore. The decision as to where the material is sent is often made in consideration of such factors as the cost of transport.

4 s. Comment: Will snow fencing and beach grass plantings be employed in conjunction with the sand pumping and dune formation?

Response: *Snow fencing and beach grass plantings are not included as components of the Short-term Restoration project because of the need to maintain sparsely-vegetated habitat for rare shorebird species that nest and forage in areas with very little vegetation. Snow fencing and beach grass plantings could accelerate vegetative succession on the island, causing detrimental impacts to the rare shorebirds. Snow fencing would also interfere with natural wind sand transport processes, and it is desired to allow the island to respond to natural forces unencumbered to the degree possible.*

4 t. Comment: Removing sand from Great Gull Bank will disturb fish habitat. The sand will not stay and this sounds like a waste of money. Great Gull Bank helps to protect Assateague.

Response: *The Corps of Engineers, supported by the Fish and Wildlife Service and other agencies, concluded that impacts to finfish resulting from dredging on Great Gull Bank are expected to be minimal provided that impacts to the shoal's profile (height off the seafloor and area covered) are minimal. At this time, dredging proposed for the short-term restoration of Assateague will have minimal impacts on the shoal's profile. If dredging is proposed on the shoal in the future beyond that considered in the May 1997 Draft EIS, then additional analysis would be warranted to ensure that impacts to finfish are minimized. It is correct that the sand will not "stay put," but putting a monetary value on restoring the geological integrity of the island is not possible. However, the Draft EIS concluded that the short-term restoration project would provide public benefits. Impacts to the shoreline that could result from dredging Great*

Gull Bank were carefully considered, and a full study of this issue is included in Appendix A1, Wave Transformation and Potential Longshore Sediment Transport Modeling. This study concluded that no adverse impacts to the shoreline would be expected by the removal of even 10,000,000m^3 of sand (the short-term project will remove only 1,400,000 m^3 of sand).

<u>Department of the Interior.</u>

5 a. Comment: The Department of the Interior requested an extension for comments until mid-July 1997. As of April 1998, no comments had been received for DOI. However, we did receive comments separately from NPS, FWS, and MMS, which are addressed in this document.

<u>Assateague Coastal Trust (Judith Johnson)</u>

6 a. Comment: It is agreed that the Great Gull Bank is the best area from which to take sand. The Ebb Tidal Shoal should not be used as a source of sand under any circumstances because the shoal provides a measure of protection for the northern end of Assateague Island. Overwash of the northern end of the island has discouraged predation by foxes and raccoons and has improved the area for Least Tern, Piping Plover, Oystercatcher, Common Tern, and the beach tiger beetle.

Response: *The ebb shoal was excluded as a major source of sand for the short-term restoration because of unknown impacts that could result to Assateague Island. The ebb shoal provides some degree of wave protection to the northern end of the island. Because of this, the National Park Service strongly advocates that the ebb shoal not be dredged without a long-term restoration program in place. However, in the context of this study where the long-term project must be approved prior to approval to implement the short-term project, any dredging of the ebb shoal for the short-term restoration would be done only shortly before implementation of the long-term project.*

<u>Maryland Office of Planning</u>

7 a. Comment: The Maryland Department of Natural Resources (MD DNR) sought further coordination with the applicant about this project.

Response: *The Corps will continue to coordinate with the MD-DNR as requested.*

7 b. Comment: The Maryland Historical Trust expressed the need for further consultation with the applicant concerning Phase I work on the Little Gull Bank, a Phase II investigation of Site 18W0154, and habitat restoration activities in Sinepuxent Inlet.

Response: *Additional survey of the Little Gull Bank is unnecessary because this site is no longer being considered as a sand source, and therefore will not be disturbed by the project. Site 18W0154 lies outside the project area, so it, too, will remain undisturbed by the project. Therefore, no additional investigation of Site 18W0154 is required. Since these comments were received, further coordination with the Maryland Historical Trust has occurred, and a site tour of the area, including Sinepuxent Inlet, has been planned to enable the SHPO to confirm the no-effect determination before construction.*

The impact area is restricted to that of previous dredged material deposits on the beach, which have since eroded away. No impacts outside that footprint are planned. Although underwater resources are apparently present off South Point, this project is limited to previously disturbed areas and will have no effect on those resources.

U. S. Fish and Wildlife Service

8 a. Comment:

Provided a biological opinion on several species:

a. Piping Plover: Service's biological opinion that implementation of the project, as currently proposed by the Corps, is not likely to jeopardize the continued existence of the Atlantic coast population of the piping plover.

b. Seabeach Amaranth: Service's biological opinion that implementation of the project, as currently proposed by the Corps, is not likely to jeopardize the continued existence of the seabeach amaranth.

The USF&WS states that the following conditions must be adhered to:

a. No construction, earth moving, or placement of materials or equipment will occur on National Park between March 15 and September 1 of any year.

b. No refueling on intertidal areas of the beach.

c. Request a 5 year monitoring plan after construction (by Corps or its cooperators).

d. An annual report on the monitoring program will be provided to FWS.

e. Detrimental impacts to piping plovers will be corrected for based on performance indicators on page E-5 of the Monitoring and Action Plan.

f. Increase in predator population will be monitored and dealt with by Corps or its cooperators.

Response: *Comments a through e above are addressed in Annex E. An increase in predator population is not anticipated from the project, as the project is not designed to increase habitat or other conditions to benefit predators. The plan is to return the island to its historical conditions, and to restore its former configuration.*

As stated above, monitoring the predator population is not a Corps responsibility. The wildlife monitoring program currently conducted by the NPS will continue.

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Washington, DC 20240

JUN 26 1997

Ms. Stacey A. Marek
U. S. Army Corps of Engineers
Baltimore District
Attn: CENAB-PL-P
P.O. Box 1715
Baltimore, Maryland 21203-1715

Dear Ms. Marek:

The Minerals Management Service (MMS) has reviewed the Draft Integrated Interim Report and Environmental Impact Statement (EIS) on the restoration of Assateague Island. As you are aware, if sand resources within Federal waters, such as those at Great Gull Bank, are to be used as borrow material for beach nourishment purposes, MMS is required by law to issue a non-competetive lease. Accordingly, we must ensure that dredging at the Federal borrow site will be conducted in an environmentally safe and sound manner and that all provisions of the National Environmental Policy Act (NEPA) are such that the MMS can make a reasoned decision as to issuance of a lease.

The MMS Office of International Activities and Marine Minerals has been working very closely with your office over the last several months to coordinate, rather than duplicate, analyses to meet our NEPA responsibilities. My staff has reviewed the document and expect that we can adopt the final EIS as our decisionmaking NEPA document. As you may recall, the MMS and the Corps agreed that our comments would be included in the Final EIS. We believe that the draft document is very complete and concise.

The few comments we do have follow:

- The Draft EIS section entitled, "Coordination with the MMS" should be re-titled "Coordination/Cooperation with the MMS."

- Page 7-6, Section 7.1.1.c, Bathymetry: The MMS' policy is to structure the lease for the borrow area such that deep pits or depressions will not be dug. This generally serves to ensure that no adverse changes to the local physical environment occur. It also precludes the deposition of fine-grained material into the dredged hole.

- Page 7-7, Section 7.1.1.e, Surface Water Quality: A general condition of the lease for the dredging activity is that turbidity in the water column is not to exceed 29 NTUs to preclude any adverse or short-term impacts on water column organisms.

- According to our Headquarters archaeologist, the shipwreck survey and analysis in the Draft EIS are adequate. However, even though the potential for offshore prehistoric resources in their background section is mentioned, there are no data collected, no analysis, and no conclusions regarding prehistoric resources for the offshore borrow areas. The MMS will review available shallow seismic data and/or core data for the offshore borrow areas prior to issuance of a lease.

- Annex A, Part 1, page 9 says the project will not significantly impact in a detrimental manner any endangered species or its critical habitat and therefore the project is in compliance with the Endangered Species Act. However, no biological opinion has yet been issued yet from the Fish and Wildlife Service or National Marine Fisheries Service. The Corps will have to monitor piping plover nesting areas and food sources over a period of time to determine if there is an impact on nesting due to loss of suitable nesting habitat and survival of young due to loss of food.

- Under description of the recommended plan, page 6-6, the DEIS states that after 7 years the majority of the placed material will have been effectively removed if no long term solution is implemented, which is expected to be implemented after year 4. This is a foreseeable action that should be covered in the cumulative impacts analysis. According to the Council on Environmental Quality regulations, cumulative impacts are the impacts on the environment which result from the incremental impact of the action when added to other past, present, and foreseeable future actions regardless of which agency (federal or non-federal) or person undertakes them.

We think that working together early on is resulting in a streamlined approach to our NEPA responsibilities. We look forward to continuing that cooperation with you in the future. If you have any specific questions relative to this letter, please call Mr. Barry Drucker at 703-787-1300.

Sincerely,

[signature], for

Carol Hartgen
Chief, International Activities and Marine Minerals Division

cc: Colonel Randall R. Inouye
District Engineer
U. S. Army Corps of Engineers
Baltimore District
Attn: CENAB-PL-P
P.O. Box 1715
Baltimore, Maryland 21203-1715

United States Department of the Interior

MINERALS MANAGEMENT SERVICE
Washington, DC 20240

JUL 18 1997

Ms. Stacy Underwood
U.S. Army Corps of Engineers
Baltimore District
Attn: CENAB-PL-P
P.O. Box 1715
Baltimore, Maryland 21203-1715

Dear Ms. Underwood:

Enclosed is our review of the Archaeological Report for the Assateague Island Restoration project prepared by Melanie Stright, staff Archaeologist. The marine archaeological survey covered only Little Gull and Great Gull banks; if other shoals are eventually selected as borrow sites, a marine archaeological survey will need to be conducted for these areas as well. As the archaeological report did not really assess the potential for prehistoric resources at the proposed offshore borrow areas, we have included an analysis of the potential for such resources to occur in the area. Since the geology and origin of all of the shoals are similar, the conclusions drawn regarding prehistoric site potential are applicable to all of the potential borrow areas for the Assateague Island Project. The conclusions and recommendations include a standard stipulation we attach to all leases regarding the discovery of archaeological resources during operations.

If you have any questions regarding this review, contact Roger Amato at 703-787-1282 or Melanie Stright at 703-787-1736.

Sincerely,

Carol A. Hartgen

Carol A. Hartgen
Chief, International Activities and Marine Minerals Division

Enclosure

Baumgardt

ARCHAEOLOGICAL RESOURCE ANALYSIS FOR THE PROPOSED ASSATEAGUE ISLAND SAND AND GRAVEL BORROW AREAS

Historic Archaeological Resources

The Phase I Archaeological Analysis prepared by Watts (1997) for Little Gull Bank and Great Gull Bank sand and gravel borrow areas lists 48 known shipwrecks within the vicinity of these two banks. However, a marine remote-sensing survey of the two banks recorded only three magnetic anomalies; all within the Little Gull Bank survey area. Each anomaly was ground-truthed by divers, and determined to not be related to historically significant cultural material.

Prehistoric Archaeological Resources

The Phase I Archaeological Analysis prepared for Little Gull Bank and Great Gull Bank by Watts (1997) acknowledges the potential for submerged prehistoric sites within the offshore borrow areas, but includes no data, analysis, or conclusions with regard to prehistoric sites. The proposed borrow areas lie south of the drowned and buried ancient Delaware River Valley that traversed the continental shelf in a general east-west direction during the late Wisconsinan glacial epoch (Roberts, 1979). There are no other major relict shelf features within the vicinity of the proposed borrow areas (Roberts, 1979).

This portion of the Atlantic shelf is a relatively high-energy shelf environment. A transgressive Holocene sand sheet overlies an erosional surface across most of the project area. The sand sheet was formed by erosion at the shoreface during the marine transgression at the end of the late Wisconsinan (Conkwright and Gast, 1994; Kraft, Belknap, and Kayan, 1983). The shoals that are being considered for borrow areas most likely formed as ebb-tidal shoals, seaward of the coastal barrier islands (Conkwright and Gast, 1994). The sediments comprising these offshore shoals are constantly reworked as the shoals migrate at rates of 2 to 120 meters per year (U.S. Army Corps of Engineers, 1997). These shoals are the target material to be used in beach enrichment. The shoals have little potential for preserved archaeological resources.

A review of the core logs from the vibracores collected across the proposed borrow areas showed no sedimentary units of archaeological interest. Based on a review of the geologic report and vibracore logs, it is concluded that no impact will occur to prehistoric archaeological resources as a result of the proposed sand and gravel dredging operations.

Conclusions and Recommendations

There is a low potential for preserved prehistoric archaeological deposits to exist within the proposed borrow areas. Therefore, no further mitigation for prehistoric archaeological sites is recommended.

I concur with the conclusions of the archaeological report by Watts (1997) that the magnetic anomalies recorded within the Little Gull Bank potential borrow area represent isolated objects that are very unlikely to be related to historic shipwreck debris or other culturally significant material. However, because of the numerous ships known to have wrecked in the vicinity of the project area, the following stipulation should be placed on any lease or permit issued that would result in bottom-disturbing activity:

> If the permittee/lessee discovers any archaeological resource while conducting sand, gravel, or shell exploration, development, or production activities within the project area, the permittee/lessee shall immediately halt activities within the area of the discovery and report the discovery to the Associate Director, Offshore Minerals Management (ADOMM). If investigations determine that the resource is significant, the ADOMM will inform the permittee/lessee how to protect it.

If borrow areas other than Little Gull Bank or Great Gull Bank are to be used to supply material for the project, a marine remote sensing survey employing both a magnetometer and side-scan sonar should be conducted to detect any potential shipwreck remains prior to initiating bottom disturbing activities.

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JUN 27 1997

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Baltimore District
Attn: CENAB-PL-P
P.O. Box 1715
Baltimore, MD 21203-1715

RE: Draft Integrated Interim Report and Draft Environmental Impact Statement (DEIS), Restoration of Assateague Island

Dear Ms. Underwood:

In accordance with the National Environmental Policy Act (NEPA) and Section 309 of the Clean Air Act, EPA has reviewed the Draft Environmental Impact Statement (DEIS) for the above referenced project. EPA believes that the Army Corps of Engineers has provided a thorough evaluation of the resources of Assateague Island, a National Seashore, and the potential impacts of the proposed project and alternatives on these resources in the DEIS. Also the issues and concerns raised during project development have been adequately addressed through extensive agency coordination and public involvement.

The DEIS provides an objective evaluation of a wide range of alternatives for the short term restoration of Assateague Island by sand placement for beach nourishment. We have rated the recommended plan, alternative 3/5d-option 2, as LO (Lack of Objections). We concur with the alternatives screening process used to develop and evaluate the recommended plan and alternatives 3/5a, 3/5b, 3/5c, 3/5e and 8. We have assigned the rating of EC (Environmental Concerns) to these other alternatives and the No Action alternative. EPA has assigned an overall rating of 1 (Adequate) to the overall adequacy of the document. A copy of the EPA rating system is enclosed for your reference.

Construction of the jetties at Ocean City, Md. has resulted in the disruption of the long shore transport of sediment between Ocean City and Assateague Island resulting in an accelerated rate of shoreline erosion and overwash on the northern 11 km (6.8 miles) of the island. The erosion has resulted in salt marsh loss, infill and navigation difficulties in Sinepuxent Bay and a decrease of habitat diversity on the island. The northern end of the island is especially significant since it provides habitat for the beach nesting Piping Plover, a Federally listed threatened and endangered bird species. The continued lack of sediment supply could result in a breach of the island creating additional inlets, cause increased storm damage and navigation problems, reduce the overwash-prone and bare sand habitat required by the Piping Plover and cause considerable wetland losses. The short term restoration plan will partially mitigate for the impacts caused by jetty construction and prevent further impacts in the near term. A long term plan for restoration will subsequently be developed.

We agree that alternatives 3/5a, 3/5b, 3/5c, 3/5e, and 8 either do not meet the project's main objective of mitigating for impacts caused by jetty construction or are not within the constraints of minimizing impacts to the Piping Plover. The No Action alternative does not meet the project's objective and although the Piping Plover would not be affected by this alternative in the near term, there could be significant impacts to the species from reduction of available habitat if the island breached or overwashed with greater frequency in the future.

EPA concurs with the selection of Alternative 3/5d as the recommended plan to achieve the short term restoration of Assateague Island. This alternative will place 1.8 million cubic yards of material in the area between 2.5 km and 11.5 km (1.6 and 7 miles) south of the Ocean City Inlet. A low storm berm will be constructed to an elevation of 3.3 m (10.8 ft) NGVD (average 0.8 m or 2.5 ft in height) on that portion of the beach south of the inlet. The plan proposes that the beach fill material will be dredged from Great Gull Bank. The borrow area covering 93 ha (230) acres on Great Gull Bank will be lowered from existing depths of 6 to 9 m (19.7-29.5 ft) to an average 9 m (29.5 ft) depth which is an average deepening of 3 m (10 ft). The cost of this alternative, including a five year monitoring component is $17 million.

Our review of the plan and DEIS has determined that no major adverse environmental impacts are likely to occur from the proposed project. Placement of sand will restore the integrity of the island and provide protection from further erosion. We are in agreement that this option although reducing overwash habitat somewhat will have minimal detrimental impacts to the Piping Plover and other rare species dependent on this habitat type. It will maintain some overwash frequency which is critical to the nesting and foraging needs of the plover. Time of year restrictions for sand placement will further minimize impacts to Plover populations. This alternative will also provide some increase in dune grassland and salt marsh habitat which in turn will result in increases in wildlife diversity. A 5 year monitoring plan will assess project performance and impacts on the Piping Plover. Changes in reproductive success or breeding population size will indicate the need for mitigation which will be achieved by modifying configuration of the storm berm. The low storm berm will provide protection to the mainland and slow the infilling of Sinepuxent Bay. Water quality and SAV habitat in the in the Bay are of special concern to EPA. Our review has determined that water quality will be unaffected while the reduction in overwash frequency may promote SAV development in the Bay. Consideration should be given to include SAV monitoring in the 5 year plan.

Direct and indirect impacts are expected to occur from dredging of material from Great Gull Bank. Direct impacts include short term increases in turbidity, destruction of nekton and dislocation of fishes. We agree that these impacts are temporary and not expected to be significant. Benthic invertebrates will be destroyed in a 93 ha area but recolonization of the borrow area is expected within several months to a year following dredging. EPA requests the opportunity to review the dredging plan that will be developed in conjunction with U.S. Fish and Wildlife Service, National Marine Fisheries Service and Minerals Management Service. Pre and post project monitoring of benthic invertebrates would assess the impacts of dredging on these organisms and could be part of the dredging plan. Although cumulative impacts to the offshore shoals of the project area are expected to be minimal the cumulative impacts to the habitat value of offshore shoals and consumption of mineral resources due to the increasing use as sand sources for beach nourishment should be examined from a regional stand point.

Thank you for the opportunity to comment on this project. We look forward to reviewing the long-term project to be subsequently developed for sand placement on Assateague Island. Please contact Marria O'Malley Walsh at (717) 628-9687 if you have any questions regarding our comments.

Sincerely,

John Forren, Program Manager
NEPA & Wetlands Regulatory Review

United States Department of the Interior

OFFICE OF THE SECRETARY
Office of Environmental Policy and Compliance
Custom House, Room 244
200 Chestnut Street
Philadelphia, Pennsylvania 19106-2904

IN REPLY REFER TO:

ER-97/0299

July 17, 1997

Dr. James F. Johnson
Chief, Planning Division
U.S. Army Corps of Engineers, Baltimore District
Attn: Stacey Underwood, CENAB-PL-P
P.O. Box 1715
Baltimore, MD 21203-1715

Dear Dr. Johnson:

The Department of the Interior (Department) has reviewed the Draft Integrated Interim Report and Environmental Impact Statement (EIS) for the Restoration of Assateague Island in Worcester County, Maryland. The Department offers the following comments for your consideration in preparing the Final Environmental Impact Statement.

GENERAL COMMENTS

The National Park Service (NPS) has been a participant in preparing portions of this document as a member of the Ocean City, Maryland and Vicinity Water Resources Feasibility Study Team.

Taken as a whole, the EIS adequately characterizes the Assateague beach erosion problem, and describes the decision-making and articulates the rationale and justification for the recommended project.

The NPS and the Department agree with the EIS findings, and we fully support the recommended short-term restoration project, subject to the following comments.

SPECIFIC COMMENTS

Recreation Resources

Section 5.1.2, last paragraph - The NPS/National Seashore are opposed to use of the ebb shoal as a borrow source until a long term sediment transport system is in place to supply an amount of sand to Assateague as would be naturally transported if the jetties did not exist. Information developed as part of the Coastal Engineering Analysis suggest that the ebb shoal is having a significant influence on Assateague by modifying wave climate and contributing some amount of sand through "bypassing". We do not believe it appropriate to perturb the shoal and risk additional impacts to Assateague Island until a long term solution has been implemented.

Annex C, Proposed Estates - If this section is intended to describe the easements/right-of-ways needed by the Corps of Engineers (Corps) from the NPS to conduct the project, then it is not clear why perpetual easements are the desired estate for the Assateague Island beach restoration and storm berm lands (assuming that the NPS acquires title to those lands). The EIS makes it abundantly clear that the proposed project is a one time only action, without long term maintenance requirements or obligations by the Corps. A temporary work area easement should suffice for the duration of construction and the follow-up monitoring period. The Corps must discuss this issue with the NPS.

Section 1.1, last sentence of fourth paragraph - Since the Park was established in 1965, more than 65 million people have visited Assateague Island National Seashore.

Section 2.4.1.c., fifth sentence of second paragraph - It is incorrect to state that Assateague "possesses minimal woodland areas". This statement would, however, be a correct characterization of northern Assateague.

Section 2.4.2.b., next to last sentence in Coastal Bays Section - Please complete the sentence ending with "...and few."

Section 2.4.2.d., last sentence of third paragraph under "Coastal Bays Mainland and Barrier Islands" section - The correct name of the organization is "The Western Hemisphere Shorebird Reserve Network".

Section 2.9.5, third sentence of second paragraph - The correct name of the state park is Assateague State Park.

Tables 5-5 and 5-8 - In both tables, the description of Alternative #3/5d includes the statement that beach width increases approximately 30-40 feet. It may be more meaningful to state this as the average increase in beach width, or else state the range of widths within the project area - essentially 0-90' depending upon location.

Fish and Wildlife Resources

Section 2.4.3.b., page 2-23 - The final EIS should note that a nesting colony of approximately 300 pairs of least terns (*Sterna antillarum*), a species which is State listed as threatened, was located on the north end of Assateague Island in 1996.

Section 2.4.3.b., page 2-25 - The final EIS should clarify that the white tiger beetle is State listed as endangered.

Section 7.8., page 2-23 - The available information is not sufficient to assess the cumulative impacts of dredging offshore shoals. The project should provide for post-construction monitoring of the offshore borrow site. We suggest that, at a minimum, measurements of the site bathymetry and bottom substrate composition be conducted after a stabilization period of two to three years. This will reveal the nature of any changes in the benthic habitat or in the shoal's crest profile. This information will be needed to evaluate future sand dredging operations.

Section 7.9, page 7-23 - The final EIS should note that in accordance with Section 7 of the Endangered Species Act, the Fish and Wildlife Service completed a 'biological opinion', dated May 23, 1997, on the effects of the project on the piping plover and sea beach amaranth. This opinion should be incorporated into the statement.

Thank you for the opportunity to provide these comments.

Sincerely,

Don Henne

Don Henne
Regional Environmental Officer

Worcester Environmental Trust

A COUNTY COMMITTEE OF THE MARYLAND ENVIRONMENTAL TRUST

POST OFFICE BOX 38
SNOW HILL, MARYLAND 21863
632-2640

June 2, 1997

Ms. Stacey Marek Underwood
Attn: CENAB-PL-P
U. S. Army Corps of Engineers
Baltimore District
P. O. Box 1715
Baltimore, MD 21203-1715

Re: DRAFT - Ocean City, Maryland, and Vicinity
Water Resources Study
Restoration of Assateague Island

Dear Ms. Underwood,

Thank you for the opportunity to comment on the above referenced draft.

Erosion, overwash and breaching of barrier islands is a normal process. They are part of the dynamics of barrier islands. Unfortunately, we feel that Assateague is being held hostage by the development community which fears devaluation of real estate due to increased flooding. Consequently, we feel the managers of Assateague fear that without a response plan they may have to harden the north end of Assateague in response to political pressure, a position they are trying to avoid.

Breaching could enhance fisheries in Chincoteague Bay by providing better water circulation, thereby improving water quality. Breaching could further protect the endangered piping plovers by reducing human intrusion.

In order to maintain habitat for endangered species we support any of the following alternatives: 3/5d, 3/5e, or 8, which would remedy problems caused by interruption of sand supply due to the Ocean City inlet jetties.

Any work should be conditioned on the fact that there be a sand by-pass system from south Ocean City to the north Assateague beach in order that a steady supply of sand guarantees replacement of what the Ocean City jetties capture or deflect onto shoals or into the present Corps inlet.

We would also like to see effective buffer easements along the bay side of the mainland to prevent storm damage and flooding, and ensure the landward migration of wetlands.

Many local bay side property owners feel that Assateague should be protected to save them from the ravages of wave energy and flooding. Taxpayers at large should not be held responsible for protecting low-lying bay side development by constantly stabilizing a dynamic barrier island.

The barrier flats caused by overwash and devoid of much vegetation seems to be ideal habitat for piping plover. In addition, sediment has to wash into the bay in order to provide a substrate for the island to move landward to accommodate sea-level rise. Many of the Virginia barrier islands are rapidly moving landward; they seem to be healthy and they provide shorebird nesting without interference.

Re page 2-12, Section 2.3.1.b, we ask that you include Trappe Creek along with the other degraded coastal tributaries. Trappe Creek has several point source pollutant discharges coming from a chicken processing plant, a landfill, a municipal sewage treatment plant and others, in addition to agriculture and residential non-point runoff.

Re page 2-16, Section 2.4.1.c, we wish to point out that barrier island vegetation accommodates overwash, which is a natural process.

Re page 2-36, Section 2.10.2, habitat for birds and other species could be guaranteed by acquisition of mainland bay frontage, which would allow wetlands and habitat to migrate landward. There are many acquisition programs available, some of which are the Land and Water Conservation Fund, Program Open Space, and the Rural Legacy Program, to name a few.

Re page 2-37, Section 2.10.3, building the beach on north Assateague will give a false sense of security to mainlanders. When, not if, a major storm occurs, low mainland areas will be severely impacted. We feel it is better to see, deal with, and learn from overwash, than to encourage mainland growth in hazardous areas, assuming that a static barrier island will always be there. Acquisition of bay side buffers will ensure that new salt marsh will flourish.

Figure 3-1 shows that the mainland, particularly on South Point, has already suffered upland loss due to wave energy and sea-level rise.

Re page 3-10, Section 3.2.2.c, inundation of the mainland due to storm surge should not justify this project. Jeopardizing the safety of bay side property owners is the result of poor county land use decisions. It would be far better to use some of the multi-million dollar beach nourishment money to acquire bay front mainland properties and move people out of danger. In addition, this would slow marina construction and have greater water quality and wildlife habitat benefits. This would be a sustainable way of encouraging tourism by protecting what many visitors come to enjoy, as well as providing additional public access to the bay.

Re page 3-10, Section 3.2.2.d, we would oppose the use of shoals off the north end of Assateague for Ocean City beach nourishment.

Re page 3-11, Section 3.3.1, deepening the inlet to accommodate deeper draft vessels would be a self-fulfilling action. This could change the hydrodynamics of the area, increasing flooding potential.

Re page 3-13, Section 3.4.1, the fact that so many acres of wetlands have been lost within the coastal bays may have been the result of poor decisions on the part of the Army Corps of Engineers. Developing a "rolling easement" strategy along the mainland could ensure survival of wetlands.

Re page 4.2, Section 4.3.1, with the exception of number 5 we support the goals listed. Re number 5, reducing the impact of storm damage/erosion is the responsibility of the county government.

Re page 5-1, Section 5.1.1, we support 3/5d, 3/5e or 8. A long term sediment supply is the key to maintaining the northern beach of Assateague. Without a long term plan which would include a sand by-pass system, the cost of maintaining the north end of Assateague will be prohibitive.

Re page 7-18, Section 7.2, we support the attempt to improve the north end of Assateague as habitat for the beach tiger beetle, sea beach amaranth, and piping plover. It is important to increase habitat areas along the coast since man-made and natural disasters, such as oil spills and storms, can quickly wipe out these species in certain areas.

Re page 7-19, Section 7.3, we support the creation of mainland habitat for submerged aquatic vegetation, wetlands, and colonial nesting birds. We also urge you to consider acquisition of a bay side buffer to ensure the future of wetlands as they respond to sea-level rise. Again, we urge you to study the use of "rolling easements" as a solution for preserving mainland wetlands.

Re page 7-20, Section 7.4, we suggest that in the next phase of this study you seriously consider the creation of natural habitat adjacent to or near the eroding sides of the Isle of Wight, a state-owned Natural Resources Management Area in the Isle of Wight Bay.

We may submit additional comments following the June 4th meeting.

Thank you and best regards.

Sincerely yours,

Ilia J. Fehrer

Ilia J. Fehrer
Chairman

6/4/97 [illegible] – CC Pub Mtg
Shantytown [illegible] – cost shared by private [illegible]?

will [illegible]
Baseline monitoring of env. rest project & [illegible]?

Fixed plant = more [illegible] solution for [illegible] Island

rep of Shantytown [illegible] this year, [illegible] glass mat. on [illegible] vessels reported through Water borne [illegible]

Have proposed [illegible]

Comment Sheet for Ocean City Water Resources Feasibility Study

The comment period for the Assateague Island Short-Term Restoration project closes on June 30, 1997. Do you have comments on the recommended plan?

Short-Term Restoration of Assateague Island

The restoration of sand to the North End - will the timing of the sand placement be done at a period of low impact to the wildlife? (Not during the breeding bird nesting seasons)

Routine dredging: Why is the dredged material (for routine maintenance) not deposited on AINS North End when the sand is suitable? And the "poor material", why not use it for back bay spoil ~~?~~ islands now?

Recommended plans for the following 3 components of the project have not been finalized, however, you may wish to comment on the likely plan as presented this evening.

Long-Term Sand Management

If a sand-bypass were considered, would the turbulance of the system damage the water quality of the inlet + bay areas? ~~[illegible]~~

Navigation Improvements to the Harbor, Inlet, and Shantytown Channel

Environmental Restoration

What would the "fill" material at the Rt 90 bridge base be?

Are there examples of successfully restored wetlands (meaning wetlands used by wildlife, not just uninhabited by humans?)

(Please place comment sheets in box on table.)

Comment Sheet for Ocean City Water Resources Feasibility Study

The comment period for the Assateague Island Short-Term Restoration project closes on June 30, 1997. Do you have comments on the recommended plan?

Short-Term Restoration of Assateague Island

It has been stressed over & over how much the island has receded from its original shoreline. Nothing has been said about how much the island has grown on the bay side. Also, will snow fencing & beach passings be employed in conjunction with the sand pumping & dune formation.

Recommended plans for the following 3 components of the project have not been finalized, however, you may wish to comment on the likely plan as presented this evening.

Long-Term Sand Management

Navigation Improvements to the Harbor, Inlet, and Shantytown Channel

Environmental Restoration

(Please place comment sheets in box on table.)

Tom Patton

Comment Sheet for Ocean City Water Resources Feasibility Study

The comment period for the Assateague Island Short-Term Restoration project closes on June 30, 1997. Do you have comments on the recommended plan?

Short-Term Restoration of Assateague Island

O.K.

Recommended plans for the following 3 components of the project have not been finalized, however, you may wish to comment on the likely plan as presented this evening.

Long-Term Sand Management

O.K.

Navigation Improvements to the Harbor, Inlet, and Shantytown Channel

O.K.

Environmental Restoration

We do not believe that maintenance dredging of the Sinepuxent Bay is currently necessary for navigational purposes. However, Island creation for habitat is desirable. A second preferred site would be enlargement of the existing island opposite snug harbor.

Selective dredging in the northern portion of the S. Bay might improve the flushing characteristics -- an issue [illegible] facilitating navigation and the [illegible]

(Please place comment sheets in box on table.)

Comment Sheet for Ocean City Water Resources Feasibility Study

The comment period for the Assateague Island Short-Term Restoration project closes on June 30, 1997. Do you have comments on the recommended plan?

Short-Term Restoration of Assateague Island

Off shore Jetties for Assateague SAND replenishment, is it feasible, instead of short term storm prone dredging.

Recommended plans for the following 3 components of the project have not been finalized, however, you may wish to comment on the likely plan as presented this evening.

Long-Term Sand Management

Navigation Improvements to the Harbor, Inlet, and Shantytown Channel

Environmental Restoration

PLEASE! KEEP GOLF COURSES OFF The BAY LINE THEY ARE CAUSING PROBLEMS! CALAGED SAND (SUCH AS RUM POINTE) & BIRD...

(Please place comment sheets in box on table.)

- [x] Please add my name to the study mailing list, IF NOT ALREADY.
- [ ] Please remove my name from the study mailing list

6-4-97

Name RICHARD P. MUELLER
Address 12311 VIVIAN ST.
BISHOPVILLE MD
21813
Phone No. 410 352-5025
FAX 410-352-5661

Comments: THE ST MARTIN RIVER IS WITHIN THE STUDY AREA BOUNDARY. HAS THE RIVER BEEN STUDIED?
WHAT, IF ANY, ARE THE PLANS FOR THIS RIVER'S RESTORATION?
I UNDERSTAND THE RIVER BOTTOM IS CONTAMINATED. WILL IT JUST BE LEFT THAT WAY?

Worcester Environmental Trust

A COUNTY COMMITTEE OF THE MARYLAND ENVIRONMENTAL TRUST

POST OFFICE BOX 38
SNOW HILL, MARYLAND 21863
632-2640

June 27, 1997

Ms. Stacy Marek
Project Manager
Ocean City, Maryland and Vicinity Water
Resources Feasibility Study
U. S. Army Corps of Engineers
Baltimore District
P. O. Box 1715
Baltimore, MD 21203-1715

Re: Ocean City Water Resources Feasibility Study

Dear Ms. Marek,

Thank you for the opportunity to submit additional comments regarding the oral presentations at the June 4th public information meeting in West Ocean City. These comments follow the format set forth on the yellow handout received at the meeting.

Long-Term Sand Management should

- benefit habitat for rare and endangered species,
- discourage shoaling of the Federal navigation channels by installing a sand by-pass system from Ocean City to Assateague,
- not use the Assateague shoal sand for Ocean City beach nourishment, and
- recognize that there has been a lull in major storm activity along the Atlantic Coast. Areas such as Ocean City, Maryland, are probably considerably out of adjustment with sea level change (Leatherman, 1985).

Navigation Improvements to the Harbor, Inlet, and Shantytown Channel should

- only apply to existing Federal channels, otherwise could set costly precedents, both environmentally and financially,
- recognize that deepening the inlet could increase mainland flooding,
- recognize that deeper draft vessels, encouraged by a deeper channel, can result in overfishing of an already stressed ocean fishery,
- increase demand for spoil sites,
- carefully control any dredging in the inlet or back bays,
- be reviewed by State and regulatory agencies such as the National Marine Fisheries and the U. S. Fish and Wildlife Service, and
- study the impact dredging the Sinepuxent channel would have on the natural roll-over of Assateague Island.

Environmental Restoration should

- not be at the expense of submerged aquatic vegetation, juvenile fish nursery areas or benthic organisms,
- be reviewed by the State DOE Water Quality and Wetlands Division,
- consider acquisition and preservation of existing islands, such as Mills, Tizzard, Rattlesnake, Big Bay Point, Cropper, etc. in Chincoteague Bay, as well as those in Isle of Wight and Assawoman Bays,
- address the importance of beaches rather than riprap on these islands, and
- develop a response to the impact rising sea level will have on the mainland in order to encourage the migration of wetlands, thereby avoiding conflicts with property owners which may arise from the hardening of shorelines.

We urge you to keep other regulatory agencies involved in your planning process rather than just those seeking a "free lunch" at Federal expense.

Please keep us apprised of your progress in this matter. Thank you.

Sincerely yours,

Ilia J. Fehrer

Ilia J. Fehrer
Chairman

United States Department of the Interior

OFFICE OF THE SECRETARY
Washington, D.C. 20240

MAY 19 1997

In Reply Refer To:
ER 97/299

Mr. James F. Johnson
Chief, Planning Division
U.S. Army Corps of Engineers
Post Office Box 1715
Baltimore, Maryland 21203-1715

Dear Mr. Johnson:

This is in regard to the request for the Department of the Interior's comments on the draft EIS for the Restoration of Assateague Island, Worcester County, Maryland.

This is to inform you that the Department may have comments, but will be unable to reply within the allotted time. Please consider this letter as a request for an extension of time in which to comment on the document.

Our comments should be available by mid July 1997.

Sincerely,

Terence N. Martin

Terence N. Martin
Team Leader, Natural Resources Management
Office of Environmental Policy and Compliance

Mrs. Judith C. Johnson
13801 York Road, Apt. K-17
Cockeysville, MD 21030

June 30, 1997

Ms. Stacey Marek Underwood
Attn.: CENAB-PL-P
U.S. Army Corps of Engineers
Baltimore District
P. O. Box 1715
Baltimore, MD. 21203-1715

Re: Ocean City, Maryland, and Vicinity Water Resources Study - 1997 DRAFT:
Integrated Interim Report and Environmental Impact Statement
RESTORATION OF ASSATEAGUE ISLAND

Dear Ms. Underwood:

First, I would like to commend the Corps on the very thorough thought and study that have gone into the Draft Report, and the clarity of the explanations concerning the complex issues and alternatives considered.

Barrier Islands are fragile rivers of sand and naturally move according to whether sea level is rising or decreasing. It is very important to permit a certain amount of overwash to take place for, as this occurs and sand is deposited in the coastal bays, these islands are able to retain their width as they roll over themselves. If this is not permitted, the side of the island facing the ocean is eroded more and more by storm damage, and with overwash and sand stopped from rolling into the bay, in time the whole island would be eroded away.

On pages 6-4 and 6-5, it is stated that elevations along the northernmost 1.2 to 1.9 miles of Assateague Island had recently been increasing and vegetative succession has been occurring. What is not mentioned is that coastal scientists have suggested for some years that as the ebb shoal off the north end of the island grew it might develop a sand bridge and send sand back to Assateague. Dr. Stephen P. Leatherman was the first coastal geologist to document that this has been occurring for several years, and he has taken dramatic photographs showing where the accretion is occurring. The Corps study wisely concludes that since this area of the island is currently accretional, the storm berm should start at a distance approximately 2.5 km south of the inlet and extend south to the existing dunes near the beginning of the State Park, approximately 10 km south of the inlet. This area will continue to be monitored, and an exact determination of the northern storm berm tie-out will be accomplished during the plans and specification phase. This makes good sense.

It is exciting to read how the National Park Service, MD Department of Natural Resources (Geological Survey), U.S. Fish & Wildlife Service (Annapolis office) and the Corps have agreed on the best way to place the sand. It is agreed that Great Gull Bank is the best area from which to dredge the sand, and I concur. The study mentions the possibility of taking some sand from the Ebb Shoal. This should not be done under any circumstances because:

1) The Ebb Tidal Shoal has been growing for a number of years and has risen to the extent that storm waves break over it so that the power of the waves is dissipated and they do

less damage to the north end of Assateague than would happen if the shoal were not there. Fishermen and other people with boats object to the growth of the shoal, saying that it blocks their entrance into the inlet when approaching from the south, making it necessary for them to go along the east side of the shoal and its north end before heading into the inlet. It may take them longer to do this, but with the protection the shoal is giving the island, no sand should be taken from it and no dredging of sand done between it and Assateague as this would interfere with the barrier of protection it is giving to the north end of the island and with the sand it is sending to Assateague. Considering what is happening, with sand flowing from the shoal to Assateague, it is natural that the depth of the ocean south of the inlet would become more shallow and a possible hazard to boats.

2) With the shoal sending sand back to Assateague and causing accretion at the north end, nothing should be done that might interfere with what is naturally happening. The storms of 1991 and 1992 not only overwashed the north end, but they removed much of the herbaceous and shrub vegetation. These conditions discouraged habitation by mammals (the foxes and raccoons were serious predators), which helped improve the area for the nesting shorebirds. During the 1996 breeding season the area supported approximately 300 pairs of least tern, 61 pairs of piping plover, 8 pairs of oystercatcher and a few common terns. This makes that section extremely important as the piping plovers are listed as "threatened" under the Endangered Species Act and the population of least terns has been decreasing at an alarming rate. The beach tiger beetle, which is classified as endangered by the state of Maryland, has a breeding population on the northernmost 2.2 km section of the beach.

When the state adopted legislation requiring a 100 ft. setback for development along the Chesapeake Bay, and a buffer of forest and vegetation between the the shore's edge and farm fields or other development, it is wicked that the same requirement was not mandated for the coastal bay area. Worcester County has a setback requirement of 50 ft. but it is abiguous. It calls for a 25' wooded buffer while saying site lines can be used in the design. Conformity will be checked before occupancy permit, not building permit. It speaks of indigenous vegetation excluding weeds.

It is splendid that the study plans include the goal: "Restore fish and wildlife habitat and eco-system functions in the coastal bay watershed", in addition to providing nesting habitat for colonial waterbirds. However, in looking into increasing nesting areas by placing spoil from dredging boat channels, on such places as the spoil island near South Point, it must first be determined whether this would affect submerged aquatic vegetation in the area, shellfish beds, etc.

It should be remembered that the Delmarva Intracoastal Waterway was deauthorized by Congress back in the '70's, if I remember correctly, because it was recognized that increased dredging and boating would cause irreparable damage to shellfish beds, fish nursery grounds, SAVs and nesting areas for shorebirds, water birds and the Brown Pelicans. These bays are richly productive and many commercially important fish caught in the ocean spend part of their lives in the coastal bays. Their health must be protected and their needs to be a strict limit on dredging operations

Alternative Plan 3/5d is definitely the best plan to choose for immediate action. It would replace a volume of material less than the amount the island has been deprived of since 1965 based on environmental considerations, and implement a long-term sediment supply process. It is extremely important that the area be closely monitored not only up to the time that the long-term plans are adopted, but indefinitely. It would meet both the mitigation objective and the Piping Plover constraint.

The groups who worked on the plans are to be congratulated and thanked for a job well-done and I look forward to receiving the final plans which can be activated approximately three years after this work has been completed. Thank you for giving me the opportunity to go review the report, and thank you for producing such a splendid Environmental Impact Statement.

Sincerely yours,

Judith C. Johnson,
Founding President,
Assateague Coastal Trust

MARYLAND *Office of Planning*

Parris N. Glendening
Governor

Ronald M. Kreitner
Director

February 09,1998

Ms. Stacey Marek Underwood
ATTN: CENAB-PL-P
Baltimore District
U.S. Army Corps of Engineers
P.O. Box 1715
Baltimore, MD 21203-1715

REVIEW AND RECOMMENDATION

State Application Identifier: MD970609-0503
Description: Draft Integrated Interim Report & EIS: Restore Assateague Island/ Ocean City & Vicinity Water Resources Feasibility Study
Applicant: U.S. Army Corps of Engineers
Location: Worcester County , Town of Ocean City
Approving Authority: ARMY
Funds: Federal: $ S17.154.823.00

Recommendation: **Endorsement With Qualifying Comments And Contingent Upon Certain Actions**

Dear Ms. Underwood:

In accordance with Presidential Executive Order 12372 and Code of Maryland Regulation 14.24.04, the State Clearinghouse has coordinated the intergovernmental review of the referenced project. This letter with attachments constitutes the State process review and recommendation based upon comments received to date. This recommendation is valid for a period of three years from the date of this letter. As of this date, the Towns of Berlin and Snow Hill have not submitted comments. This endorsement is contingent upon the applicant considering and addressing any problems or conditions that may be identified by their review. Any comments received will be forwarded.

Review comments were requested from the Maryland Departments of Natural Resources, Business and Economic Development, Environment, and Housing and Community Development including the Maryland Historical Trust; Town of Berlin, and Town of Snow Hill; and the Maryland Office of Planning.

The Maryland Departments of Business and Economic Development, and Environment; and the Maryland Office of Planning found this project to be **consistent** with their plans, programs, and objectives.

The Maryland Department of Natural Resources found this project to be **generally consistent** with their plans, programs, and objectives, but included certain qualifying comments summarized below.

The Maryland Departments of Housing and Community Development, including the Maryland Historical Trust stated that their findings of consistency are contingent upon the applicant taking the actions summarized below.

Summary of Comments:

The Maryland Department of Natural Resources sought further coordination with the applicant about this project.

The Maryland Historical Trust expressed the need for further consultation with the applicant concerning Phase I work on the Little Gull Bank, a Phase II investigation of Site 18W0154, and habitat restoration activities in Sinepuxent Inlet. See the attached letter.

Any statement of consideration given to the comments should be submitted to the approving authority, with a copy to the State Clearinghouse. Additionally, the State Application Identifier Number must be placed on any correspondence pertaining to this project. The State Clearinghouse must be kept informed if the recommendation cannot be accommodated by the approving authority.

Please remember, you must comply with all applicable state and local laws and regulations. If you have any questions about the comments contained in this letter or how to proceed, please contact the State Clearinghouse at (410) 767-4490. **Also please complete the attached form and return it to the State Clearinghouse as soon as the status of the project is known.** ***Any substitutions of this form must include the State Application Identifier Number.*** **This will ensure that our files are complete.**

We appreciate your attention to the intergovernmental review process and look forward to your continued cooperation.

Sincerely,

Linda C. Janey

Linda C. Janey, J.D.
Manager, Clearinghouse & Plan Review Unit

LCJ:BR:vh
Enclosures
(* indicates with attachments)
cc: Ray Dintaman - DNR*
Jim Gatto - DBED*
Steve Bieber - MDE*
Sue Hartman - DHCD*
James King - Town of Berlin*
Dolores Warren - Town of Snow Hill*
Mary Abrams - OPC*
Scrib Sheafor - OPL*

MARYLAND *Office of Planning*

Parris N. Glendening
Governor

Ronald M. Kreitner
Director

MEMORANDUM

Please complete this form and return it to the State Clearinghouse upon receipt of notification that the project has been approved or not approved by the approving authority.

TO: **Maryland State Clearinghouse**
Maryland Office of Planning
301 West Preston Street
Room 1104
Baltimore, MD 21201-2365

DATE: ____________________
(Please fill in the date form completed)

FROM: ______________________________
(Name of person completing this form.)

PHONE: (____)______________
(Area Code & Phone number)

RE: **State Application Identifier:** MD970609-0503
Project Description: Draft Integrated Interim Report & EIS: Restore Assateague Island/ Ocean City & Vicinity Water Resources Feasibility Study

PROJECT APPROVAL

This project/plan was:

☐ Approved ☐ Approved with Modification ☐ Disapproved

Name of Approving Authority:	Date Approved:

FUNDING APPROVAL

The funding (if applicable) has been approved for the period of

______________________, 199___ to ______________________, 199___ as follows:

Federal:	Local:	State:	Other:
$	$	$	$

OTHER

☐ Further comment or explanation is attached

RESPONSE FORM TO:

Scribner H. Sheafor
Chief, Planning Assistance and Review Unit
Maryland Office of Planning
301 West Preston Street, Room 1104
Baltimore, Maryland 21201-2365

State Application Identifier:	MD970609-0503	*Clearinghouse Contact Person:*	Bob Rosenbush
Location:	WRCS Town of Ocean City	*Clearinghouse Telephone:*	(410) 767-4490
Applicant:	U.S. Army Corps of Engineers		
Description:	Draft Integrated Interim Report & EIS: Restore Assateague Island/ Ocean City & Vicinity Water Resources Feasibility Study		

Based on a Review of the Information Provided, We Have (✓) Checked the Appropriate Determination Below

CONSISTENT RESPONSES - FOR USE BY *STATE AGENCIES* ONLY

	C1	It is consistent with our plans, programs, and objectives.
	C2	It is consistent with the policies contained in Executive Order <u>01.01.1992.27</u> (Maryland Economic Growth, Resource Protection, and Planning Act of 1992) <u>and</u> our plans, programs, and objectives.
	C3	**(MHT ONLY)** It has been determined that the project will have "no effect" on historic properties and that the federa and/or state historic preservation requirements have been met.
	C4	**(DNR ONLY)** It has been determined that this project is in the Coastal Zone and is not inconsistent with the Maryland Coastal Zone Management Program.

CONSISTENT RESPONSES - FOR USE BY *COUNTY & LOCAL AGENCIES* ONLY

	C5	It is consistent with our plans, programs, and objectives.
	C6	It is consistent with the Economic Growth, Resource Protection, and Planning Visions (Planning Act of 1992) <u>and</u> our plans, programs, and objectives.

OTHER RESPONSES - FOR USE BY *ALL AGENCIES*

	R1	**GENERALLY CONSISTENT WITH QUALIFYING COMMENTS:** It is generally consistent with our plans, programs and objectives, <u>but</u> the attached qualifying comment is submitted for consideration.
X	R2	**CONTINGENT UPON CERTAIN ACTIONS:** It is generally consistent with our plans, programs and objectives <u>contingent upon</u> certain actions being taken as noted in the attached comment.
	R3	**NOT CONSISTENT:** It raises problems concerning compatibility with our plans, programs, objectives, or Planning Act visions/policies; or it may duplicate existing program activities, as indicated in the attached comment. If a meeting with the applicant is requested, please check here. ☐
	R4	**ADDITIONAL INFORMATION REQUESTED:** Additional information is required to complete the review. The information needed is identified below. If an extension of the review period is requested, please check here. ☐

Attach additional comments if necessary <u>OR</u> use the spaces below for brief comments.

See attached MHT letter of 19 June 1997 to James F. Johnson, Corps of Engineers.

Name: Gary Shaffer
Organization: DHCD
Address: Crownsville, MD

Signature: Gary Shaffer
Phone: (410) 514-7638
Date Completed: 7/15/97

(✓) ☑ Check here if additional comments attached.

MARYLAND
HISTORICAL
TRUST

Archaeology Office

June 19, 1997

James F. Johnson, Ph.D.
Chief, Planning Division
Department of the Army
Baltimore District, U.S. Army Corps of Engineers
P.O. Box 1715
Baltimore, Maryland 21203-1715

Dear Dr. Johnson,

This office has reviewed the *Ocean City, Maryland, and Vicinity Water Resources Study. Draft Integrated Interim Report and Environmental Impact Statement. Restoration of Assateague Island*. In addition, I attended the public meeting held Wednesday, June 4, 1997 at the Ocean City Elementary School. Because the Corps has decided not to use Little Gull Bank as a source of sand, the Trust concurs that it is unlikely that historic resources will be affected. However, it should be noted that the draft report contains only this office's letter of February 20, 1996 and not the letter of November 19, 1996 wherein the Trust notes that the Phase I work undertaken on this shoal was insufficient (copies of both of these letters are appended). Should any undertaking in this area be considered in the future, coordination with this office will be necessary and further work may be required.

At the public meeting I was informed that beach nourishment activities on the northern portion of Assateague Island would begin 1.5 miles south of the inlet and will not involve any preparatory grading or other disturbance to the ground but that, subsequent to placement, materials may be configured with earthmoving vehicles. At this time, this office has no objection to the placement of materials but may have concerns if terraforming disturbs cultural remains. Please coordinate any scope of work for soil reconfiguration activities with this office. As noted in the draft report, Phase II investigation is necessary at the site 18WO154 ("Dune Wreck"). We look forward to receiving a report on this project that will address the *Standards and Guidelines for Archeological Investigations in Maryland* (Shaffer and Cole 1994).

Recent survey work by the Maryland Maritime Archaeology Program in Sinepuxent Inlet, off South Point, indicates that there are submerged cultural resources in this area. Our letter of November 19, 1996 noted that, "As stated previously, consultation with this office will be necessary to develop a scope of work for all phases of this project to provide acceptable consideration of prehistoric cultural remains, both submerged and terrestrial, and one which also ensures adequate survey coverage and study of all potential historic remains (not just shipwrecks)." Therefore, when habitat restoration activities are undertaken the scopes of work for these endeavors will also need to be coordinated through this office.

If you have any questions or require further information, please contact Dr. Gary Shaffer for terrestrial archaeology, at 410-514-7638, or me, for underwater archaeology, at 410-514-7662.

Sincerely,

Susan B.M. Langley, Ph.D.
State Underwater Archaeologist

9701249
SBML/GDS:sl

cc. Mr. Mark Baker
Mr. Kenneth Baumgardt
Mr. Timothy E. Goodger
BSM Steven Hearn
Mr. Marc Koenings
Mrs. Ricks Savage
Mrs. Howard Yerges

Chief, Planning Assistance and Review Unit
Maryland Office of Planning
301 West Preston Street, Room 1104
Baltimore, Maryland 21201-2365

State Application Identifier: *Location:*	MD970609-0503 WRCS Town of Ocean City	*Clearinghouse Contact Person:* *Clearinghouse Telephone:*	Bob Rosenbush (410) 767-4490
Applicant:	U.S. Army Corps of Engineers		
Description:	Draft Integrated Interim Report & EIS: Restore Assateague Island/ Ocean City & Vicinity Water Resources Feasibility Study		

Based on a Review of the Information Provided, We Have (✓) Checked the Appropriate Determination Below

CONSISTENT RESPONSES - FOR USE BY *STATE AGENCIES* ONLY

	C1	It is consistent with our plans, programs, and objectives.
	C2	It is consistent with the policies contained in Executive Order 01.01.1992.27 (Maryland Economic Growth, Resource Protection, and Planning Act of 1992) and our plans, programs, and objectives.
	C3	**(MHT ONLY)** It has been determined that the project will have "no effect" on historic properties and that the federa and/or state historic preservation requirements have been met.
	C4	**(DNR ONLY)** It has been determined that this project is in the Coastal Zone and is not inconsistent with the Maryland Coastal Zone Management Program.

CONSISTENT RESPONSES - FOR USE BY *COUNTY & LOCAL AGENCIES* ONLY

	C5	It is consistent with our plans, programs, and objectives.
	C6	It is consistent with the Economic Growth, Resource Protection, and Planning Visions (Planning Act of 1992) and our plans, programs, and objectives.

OTHER RESPONSES - FOR USE BY *ALL AGENCIES*

X	R1	**GENERALLY CONSISTENT WITH QUALIFYING COMMENTS:** It is generally consistent with our plans, programs and objectives, but the attached qualifying comment is submitted for consideration.

Based on a review of the information provided, we have determined that the above referenced project is generally consistent with our plans, programs and objectives. The following comment concerns coordination with the Department of Natural Resources.

We request that the applicant continue to coordinate with Heritage & Biodiversity Conservation Programs. Please contact Scott Smith (410) 827-8612.

Name: K. Meade
Organization: DNR
Address: Tawes Building, B-3
Annapolis, MD 21403

Signature: [signature]
Phone: (410) 260-8336
Date Completed: 1 Aug 97

(✓) ☐ Check here if additional comments attached.

cc: Scott Smith

MARYLAND *Office of Planning*

Parris N. Glendening
Governor

Ronald M. Kreitmer
Director

June 30, 1997

Ms. Stacey Marek Underwood
ATTN: CENAB-PL-P
Baltimore District
U.S. Army Corps of Engineers
P.O. Box 1715
Baltimore, MD 21203-1715

STATE CLEARINGHOUSE REVIEW PROCESS

Reply Due Date:	July 21, 1997
State Application Identifier:	MD970609-0503
Project Description:	Draft Integrated Interim Report & EIS: Restore Assateague Island/ Ocean City & Vicinity Water Resources Feasibility Study
State Clearinghouse Contact:	Bob Rosenbush

Dear Ms. Underwood:

This letter acknowledges receipt of the referenced project. We have initiated the Maryland Intergovernmental Review and Coordination Process (MIRC) as of the date of this letter. You can expect to receive review comments and recommendations on or before the reply date indicated. Please place the State Application Identifier Number on all documents and correspondence regarding this project.

This project has been sent to the following agencies or jurisdictions for comment: The Maryland Departments of Business and Economic Development and Housing and Community Development including the Maryland Historical Trust; Town of Berlin; Town of Snow Hill; and the Maryland Office of Planning.

Your participation in the MIRC process helps to ensure that this project will be consistent with the plans, programs, and objectives of State agencies and local governments. Issues resolved through this process enhance the opportunities for project funding and minimize delays during project implementation.

If you need assistance or have questions concerning this review, please contact the staff person noted above. Thank you for your cooperation.

Sincerely,

Scribner H. Sheafor

Scribner H. Sheafor
Chief, Planning Assistance and Review Unit

SHS:BR:bw

301 West Preston Street • Baltimore, Maryland 21201-2365
State Clearinghouse: (410) 767-4490 Fax: 767-4480

ANNEX B

ECONOMICS EVALUATION

ANNEX B

ECONOMICS EVALUATION

I. EXISTING CONDITIONS EVALUATION

Navigational Infrastructure

Many of the current social and economic characteristics of the study area have been shaped or influenced by the construction of the jetty system at the Ocean City Inlet. Constructed by the Corps of Engineers, the jetty system and the inlet channel provide relatively safe and effective navigation for commercial and recreational boat traffic between the coastal bays and the Atlantic Ocean. Commercial watermen use the channel as passage from moorings at the Fisherman's Marina at West Ocean City to Atlantic Ocean fishing waters. For recreational boaters, the inlet channel is the major artery feeding the coastal bay channels and the many marinas serving boating needs.

Construction of the jetty system created a need for navigable channels through the inlet and into the coastal bays. The Corps of Engineers built and maintains the inlet channel to an authorized depth of 3.06 m (10 feet) and a width of 61.2 m (200 feet). The inlet channel leads directly into the Fisherman's Marina commercial harbor at West Ocean City. The harbor is maintained to a depth of 3.06 m (10 feet) to provide adequate clearance for commercial users. Two other Corps-maintained projects provide navigation channels in Sinepuxent Bay, behind Assateague Island, and in the Isle of Wight Bay, behind Fenwick Island. These channels are maintained on an as-needed basis. The Sinepuxent navigation channel, for example, has not been dredged in over 20 years because of infrequent use by commercial watermen. These federally maintained channels, along with several non-Federal ones, comprise the basic waterway transportation system in the study area. As a by-product of jetty construction, this system has influenced the social and economic development patterns of the study area.

The provision of safe waterway passage for boaters between the Atlantic Ocean and the coastal bays has attracted considerable investment in the infrastructure needed to house, launch, and repair boats. According to Volume 4 of the 1994 *Boating Almanac*, 23 marinas operate in the Maryland portion of the coastal bays, offering a menu of services to both recreational and commercial users of the Ocean City Inlet and other navigation channels. There are 736 total boat slips available in the study area. Of these, approximately 15 percent are used by commercial concerns. The remainder are used primarily by recreational boaters and sport fishermen.

Commercial fishing is one of the mainstay industries in the study area. Most of the local watermen moor their vessels at the federally maintained Fisherman's Marina harbor in West Ocean City. There are about 30 year-round watermen operating from the harbor. In addition, many transient watermen fish the surrounding waters and land their catch in the marina. In support of the watermen, there are fueling and repair facilities in close proximity to Fisherman's Marina. The Ocean City county boat launch is also located near the harbor.

Another marina facility offering a similar array of services to commercial and recreational boaters is the Ocean City Fishing Center. Located north of the inlet on the mainland, the Fishing Center is the largest single boating facility in the study area. The center has a 220-slip marina and also houses 4 headboats and 30 charter boats in its facilities. An average of 150 transient boaters used Fishing Center facilities during the 1993 through 1995 time period. In addition, a 906.9 km (77-ton) travel lift is located in the Fishing Center harbor. In the first 7 months of 1996, the travel lift serviced more than 150 customers.

Mainland Development

As detailed above, the construction of the Ocean City Inlet jetty system has been a major impetus to development of a commercially significant navigation industry in the study area. Because boating, both commercial and non-commercial, attracts year-round residents and seasonal vacationers to the area, it seems reasonable to assume that the jetties have indirectly induced residential and non-residential development on the mainland westward of the coastal bays.

Many of the mainland residential communities located adjacent to the coastal bays throughout the study area are susceptible to damage incurred during storm surge events. When combined with the effects of tides and wave action, the resulting water levels can cause significant damage to structures. During the reconnaissance phase of the Ocean City Water Resources study, all residential and commercial developments located on the mainland behind the coastal bays were evaluated to determine levels of flood damage and to evaluate structural alternatives to address flooding problems. None of the solutions investigated resulted in a benefit-cost ratio greater than 1.0, the measuring criterion for project viability.

Despite a lack of benefit-cost ratio justification for a Federal flood control project in the area, the impacts of flooding on local mainland communities are significant. As recently as January 1992, four of the mainland communities located along Highway 611 inland of Sinepuxent Bay incurred substantial storm-induced flood damage to their structures and contents. This study of Assateague evaluated impacts from storm-induced flooding for the most flood-susceptible residential and recreational communities located on the mainland along Highway 611. These communities were identified as flood-prone communities because of their location directly landward of the section of Assateague Island most likely to be breached. Two of the communities flooded in January 1992, Snug Harbor and Porfin Drive, are year-round residential communities. The others, Frontier Town and Eagles Nest, are primarily communities organized around the needs of seasonal mobile home and recreational vehicle users.

Because of their location landward of the northern end of Assateague, the residential communities of Mystic Harbor and Assateague Point, as well as the Ocean City Airport, were included in the feasibility flood damage investigation. These communities did not incur significant damage during the January 1992 storm. Mystic Harbor is a year-round, 200-home residential community. Assateague Point is a seasonal resort community of more than 500 structures. The Ocean City Municipal Airport is a small plane facility.

Because it is a recent major flood and information about its characteristics is readily available, the January 1992 storm event was used to define the probable impacts or storm-induced flooding under existing conditions. Although flooding characteristics in the study area seem to be highly variable because of the vagaries of tides, waves, and wind, the January 1992 storm event provided the best available information about flood damage and the probable location of damage centers. High water marks 2.45 m (8 feet) above the 1.53 m (5-foot) NGVD ground elevation were observed at the Snug Harbor community during the January 1992 event. Depending on the first floor elevation and flood susceptibility of the structure, this water level caused varying degrees of damage to 47 structures in the community. Structures at Assateague Point, on the other hand, despite its location adjacent to Snug Harbor, incurred only minor damage. Because of adherence to Flood Insurance Administration regulations regarding building codes and the floodproofing of structures, structures at Assateague Point avoided serious damage. Mystic Harbor, because of its location, is buffered by marshland to the bay side, and homes are generally elevated to a level of 3.98 m (13 feet) NGVD or greater above the level of the 1992 reference flood in that reach. Structures in the community did not incur flood damage in the 1992 event; however, both Eagles Nest and Frontier Town incurred significant damage to mobile homes and recreational vehicles in the 1992 storm. In order to minimize the likelihood of a recurrence of similar damage in the future, a policy to relocate mobile homes and recreational vehicles in Eagles Nest and Frontier Town to the west of Highway 611 during winter months has been instituted. Table B-1 provides an inventory of the existing development at five flood-susceptible mainland communities. It also provides information from the January 1992 flood damage assessment of those communities.

Table B-1

Types and Number of Structures on Mainland/ Number of Structures Damaged in 1/92 Storm

COMMUNITY NAME	COMMUNITY TYPE	NUMBER OF STRUCTURES	NUMBER DAMAGED IN 1/92 STORM
Mystic Harbor	Year-Round Residential	185	0
Snug Harbor	Year-Round Residential	53	47
Assateague Point	Residential Vacation	522	Minor Damage
Frontier Village	Mobil Homes/Rec Vehicles	400 Sites	150 Trailers
Eagles Nest	Mobil Homes/Rec Vehicles	100	30-40 Trailers

The gradual loss of volume and elevation on the northern section of Assateague Island has diminished its capacity to function as a barrier island in relation to protection of mainland development. Although documented evidence does not exist, the perception of many of the residents of these communities is that the island provides less protection against flooding than in decades past. Certainly, the effects of the 1992 flood event indicate that flooding is an existing problem for the mainland communities.

To assess damage to the communities on the mainland, local officials and residents of the communities were interviewed and a field survey was conducted to determine the characteristics of structures located in the communities. Local officials provided information regarding the effects of the January 1992 flood. Additional site-specific information regarding flood potential was gleaned from the files of community managers.

After completion of the field work, data were organized by community, and each individual structure subject to flood damage was categorized by type. In addition, elevations of ground and first floor were identified, and the effective age, condition, and building material of the structure was assessed. This information provided the basis for assessment of existing damage to structures.

Flood Damage Assessment by Community

Snug Harbor

According to information collected from post-flood damage assessments and interviews with residents, the average water surface level at Snug Harbor during the January 1992 storm was about 2.45 m (8 feet) above the ground elevation. To evaluate the damages incurred by these structures, the level of water in relation to the first-floor elevation was assessed based on interviews with residents and high water marks on the structures. For 32 of the 47 damaged structures, water levels reached the first-floor elevation. For the 10 structures incurring major flood damage, the storm surge reached 1.22 m (4 feet) above the first floor. For the 5 structures that were most severely damaged, the observed water levels were 2.45 m (8 feet) above the first floor level.

These water levels were used in conjunction with standard Flood Insurance Administration (FIA) depth to percent damage functions to determine the amount of damage at various levels of flooding. These curves were applied to the average structural value of $85,000, an assessment of local real estate agents. Damage to both structure and contents within the structure were assessed. For contents, the standard Corps of Engineers allowance of 50 percent contents to structure value ratio was used. The total damages at Snug Harbor for the January 1992 storm event amounted to $905,000. The results of this evaluation are displayed in Table B-2.

Table B-2

Snug Harbor 1992 Storm Event
Damages in thousands of dollars

Degree of Damage	# of Structures Flooded	Structural Damage	Contents Damage	Total Damage
Minor	32	$190.4	$81.6	$272.0
Major	10	$238.0	$114.8	$352.8
Most Severe	5	$187.0	$93.5	$280.5
TOTALS	**47**	**$615.4**	**$289.9**	**$905.3**

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Porfin Drive

According to information from post-storm damage assessments, there were 3 structures on Porfin Drive that incurred major damage during the January 1992 storm event. The average value per structure on Porfin Drive according to local real estate agents is estimated at $250,000. The observed high water marks were 1.22 meters (4 feet) above the first floor elevation. Standard FIA depth-damage curves were applied to determine damage to structures and contents damage. The following table displays the expected structural, content, and total damage for the 3 damaged structures. The contents-to-structure ratio used was 50 percent. Total storm damages under existing conditions amount to $311,000.

Table B-3

Porfin Drive 1992 Storm Event
Damages in thousands of dollars

Degree of Damage	# of Structures Flooded	Structural Damage	Contents Damage	Total Damage
Major Damage	3	$210.0	$101.3	$311.3

Frontier Town

According to information from post-storm damage assessments, there were 75 mobile homes (small trailers) that incurred major damage during the January 1992 storm event. The average value per structure at Frontier Town, according to local real estate assessments, is $15,000. The observed high water marks were .61 m (2 feet) above the first floor elevation. Standard FIA depth-damage curves were applied to determine damage to structures and contents. The following table displays the expected structural, content, and total damage for the 75 damaged structures. The contents-to-structure ratio used was 50 percent. Total storm damages under existing conditions amount to $988,000.

Table B-4

Frontier Town 1992 Storm Event
Damages in thousands of dollars

Degree of Damage	# of Structures Flooded	Structural Damage	Contents Damage	Total Damage
Major Damage	75	$712.1	$276.2	$988.3

Eagles Nest

According to information from post-storm damage assessments, there were 35 mobile homes (small trailers) that incurred major damage during the January 1992 storm event. The average value per structure at Frontier Town according to local real estate agents is $25,000. The observed high water marks were 1.07 m (3.5 feet) above the first-floor elevation. Standard FIA depth-damage curves for mobile homes were applied to determine damage to structures and contents. The following table displays the expected structural, content, and total damage for the 35 damaged structures. The contents-to-structure ratio used was 50 percent. Total expected storm damages under existing conditions amounts to $958,000.

Table B-5

Eagles Nest 1992 Storm Event
Damages in thousands of dollars

Degree of Damage	# of Structures Flooded	Structural Damage	Contents Damage	Total Damage
Major Damage	35	$664.1	$294.0	$958.1

Summary of Existing Conditions Flood Damages

Table B-6 summarizes the expected damage under existing conditions for a recurrence of the January 1992 storm event by community, categorized as structural or content damage.

Table B-6

Summary of Existing Conditions Damages
1992 Storm Event
Damages in thousands of dollars

Community	# of Structures Flooded	Structural Damage	Contents Damage	Total Damage
Snug Harbor	47	$615.4	$289.9	$905.3
Porfin Drive	3	$210.0	$101.3	$311.3
Frontier Town	75	$712.1	$276.2	$988.3
Eagles Nest	35	$664.1	$294.0	$958.1
TOTALS	**160**	**$2,201.6**	**$961.4**	**$3,163.0**

Recreation at Assateague Island National Seashore

A large percentage of Assateague Island is operated by the National Park Service (NPS) and is designated as a national seashore area. According to the NPS, annual recreational visitation days average 750,000. Most recreational activity takes place in the vicinity of the NPS visitor complex and the adjacent beach area. According to NPS visitation data, about 1 percent, or 7,500 visitor-days of recreational activity, takes place on the northern section of the island. This area offers a unique beach experience because no vehicular traffic is allowed and all visitation is by foot. Most of the users of this section of the national seashore value the natural beach experience and the unique shorebird viewing opportunities.

II. FUTURE WITHOUT-PROJECT ECONOMIC EVALUATION

The most probable future without-project condition is the northern section of Assateague Island being breached by a storm event. The effects of a breach of the island on flood damage, navigation in the channels, and recreation at the National Seashore were evaluated.

A. Impact of Breach on Navigation

A breach of Assateague Island is not expected to significantly impact the navigability of most channels in the area. It is expected that a breach would increase the volume of sand in the Sinepuxent channel behind Assateague Island, and shoals could develop in Sinepuxent Bay as sand migrated after the event. Shoaling would likely impact recreational boaters at marina developments located on the bay. These users could experience difficulty in both accessing and navigating the channel. In addition, users from marinas north of the Sinepuxent could be unable to access the channel from the north due to channel shoaling. Because of the probability of increased shoaling in the bay, the likelihood of recreational boats grounding when using Sinepuxent Bay would increase with a breach.

B. Impact of Breach on Flood Damages

To evaluate the expected flood damage to the mainland communities along Highway 611, inland of Sinepuxent Bay, water level response in the Sinepuxent Bay was measured by application of breach assessment information obtained from a hydrodynamic model (see Appendix A - Hydrodynamic Model). The model measured water surface elevations at specified locations on the mainland with occurrence of a breach of Assateague Island. The location and dimensions of the breach were assumed to be similar to those of the 1962 breach event. Table B-7 displays the impact of a potential breach on northern Assateague Island. The table shows the change in water surface elevation with the breach compared to existing conditions and the expected damages from a recurrence of the January 1992 flood event. The expected increase in damages amounts to $700,000, a 22 percent increase over the damages under existing conditions.

Table B-7

Future Conditions with Breach of Northern Assateague Island
Storm Damage Assessment
with Recurrence of January 1992 Storm

Community	Water Surface Elevation Increase	Expected Storm Damages (Jan. 1992 Storm) Existing Conditions	With Breach
Snug Harbor	+.41m (1.34 ft)	$905,000	$1,249,000
Porfin Drive	+.39m (1.27 ft)	$311,000	$ 368,000
Frontier Town	+.42m (1.37 ft)	$988,000	$1,214,000
Eagles Nest	+.46m (1.50 ft)	$958,000	$1,031,000
Total Expected Damages January 1992 Storm		**$3,163,000**	**$3,862,000**

C. Impact of Breach Event on Recreation

Recreation impacts due to a breach on the northern section of Assateague Island were viewed in terms of quantifying the expected change in the number of visitation days at the National Seashore and the consequential change in the value of the recreation experience. A breach of the island would impact recreational usage by visitors who use the northern section of the island for hiking and shorebird viewing. As identified in the existing conditions section, the estimated number of visitor days on the northern section is 7,500 (1 percent of total) on an annual basis. The economic impact of a breach of the island would be limited to a reduction in visitation by this set of users.

To quantify the value of such a loss of recreational opportunities, the unit-day value methodology was used. This decision was based on the small visitation population and the nature of the recreational experience at the site. The primary recreational activities on the northern section of Assateague are shorebird viewing and nature hiking. Although there are comparable recreational experiences available in the region, particularly on Chincoteague Island to the south, the experience on Assateague is enhanced by the relative isolation of the northern section due to vehicular traffic prohibition. This factor suggests the possibility that the loss of the type of recreational experience offered on northern Assateague is an NED loss, one that cannot be experienced in its totality at other sites.

Table 6-29, “Guidelines for Assigning Points for General Recreation,” from Engineering Regulation 1105-2-100, was used to develop point values for the recreational experience on northern Assateague. The general recreation experience of a visitor to the northern section was defined in terms of five criteria, assigning point values based on judgment fashioned from site visits and interviews with park personnel. Table B-8 displays the five criteria and the point values assigned to each.

Table B-8

Point Values For General Recreation
Northern Assateague Island National Seashore

Criteria	Points
Recreation Experience	4
Availability of Opportunity	8
Carrying Capacity	9
Accessibility	8
Environmental Quality	11
Total Points	**40**

The evaluation process for the recreational experience on northern Assateague resulted in a total point value of 40 points. The monetary value correlated with this point value was obtained from the fiscal year 1996 unit-day value for recreation guidance. The amount from the table to be applied in the evaluation is $4.52 per visitor-day. On an annual basis, the dollar amount associated with the loss of the 7,500 visitor-days lost with a breach of the northern section is $34,000. This is a measure of the economic impact to recreation in the without-project condition.

III. FUTURE WITH-PROJECT ECONOMIC EVALUATION

A. Impact of Project on Navigation

The project to restore a volume of sand to Assateague Island is not designed to benefit navigation in the channels of the bays and the inlet. One of the project objectives, however, is to reduce the probability of breaching of the island on the northern section. Provided it accomplishes this objective, the project will also reduce the incidence of shoaling and sand migration expected to occur with a breach of the island. Breach prevention will especially benefit users of the marinas at resort developments on the Sinepuxent Bay, who will not lose access to the channel if a breach does not occur. Also, the probability of shoal-induced groundings of recreational boaters will be reduced. Another effect will be that users from channels north of Sinepuxent will not lose access to the channel if a breach does not occur.

B. Impact of Project on Flood Damages

The project to restore a volume of sand to Assateague Island is not designed as an inundation reduction project. The project design includes construction of a storm berm to a height of 3.3 m NGVD, an increase over the existing average 2.6-m elevation. This feature was designed for purposes other than flood damage reduction. The 3.3-m storm berm elevation will not be maintained after the project is implemented; except, however, if there is a high potential for breaching again in an isolated area, the storm berm may be partially rebuilt as part of the monitoring and action plan. Because the project is not being designed for flood protection, no NED inundation reduction benefits can be claimed. One of the project objectives, however, is to reduce the probability of breaching of the island on the northern section. Provided it accomplishes this objective, the project will reduce the expected impact from flooding with a breach. The difference between flood damages under existing conditions and future without-project (the breach condition) for a recurrence of the January 1992 reference storm event is $700,000, a reduction of 22 percent. This reduction would occur as a result of breach prevention.

C. Impact of Project on Recreation

The project to restore a volume of sand to Assateague Island is not designed to increase or enhance recreational opportunities. One of the project objectives, however, is to reduce the probability of breaching of the island on the northern section. Provided it accomplishes this objective, the project will also prevent the loss of 7,500 visitor-days expected to occur with a breach of the northern section of the island. The monetized amount of this loss of visitor-days is $34,000 on an annual basis.

IV. SUMMARY OF ECONOMIC IMPACTS

The existing economic development in the study area has been significantly influenced by construction of the jetty system. The jetties spawned a network of navigation channels and an important commercial and recreational boating industry. The opportunities for boating, both as an occupation and as an avocation, induced demand for the development of year-round and seasonal mainland resort communities to serve the needs of boaters.

Some of the communities located along Highway 611 are susceptible to inundation from the effects of storm surge. The January 1992 storm resulted in damages of $3.2 million to four mainland communities landward of Sinepuxent Bay. An additional $700,000 in damages are expected to be incurred by these same communities with a breach of the northern section of Assateague Island. The effects of a breach on navigation are expected to be minimal because there is very little commercial navigation in the Sinepuxent Bay, where most of the post-breach sand accumulation is expected to occur. Recreational boaters in Sinepuxent Bay will likely experience channel access difficulties and potentially damaging shoal-induced groundings. A breach will impact the unique recreational opportunities for relatively isolated shorebird viewing and nature hiking provided on the northern section of the Assateague National Seashore Island. The loss of these opportunities will result in a loss of 7,500 visitor-days on an annual basis. The monetized loss of this opportunity is $34,000 on an annual basis.

The project purposes of the future with-project condition do not specifically include navigation, inundation reduction, or recreation. The immediate restoration of a lost volume of sand to Assateague Island will not provide navigation improvements, a project design for flood protection, or enhancement of recreational facilities on the island. The project design does purport to reduce the probability of breaching of the northern section of Assateague, which is the most significant project accomplishment from the perspective of maintenance of existing economic resources in the study area. As a by-product of accomplishment of this objective, potential navigation and storm inundation damages will be avoided and the loss of recreational activities currently enjoyed by users of the northern section will be prevented.

ANNEX C

REAL ESTATE PLAN

ANNEX C

OCEAN CITY WATER RESOURCES STUDY - INTERIM REPORT

REAL ESTATE PLAN

ANNEX C

REAL ESTATE PLAN

1.1 GENERAL

This Real Estate Plan is for the Ocean City, Maryland, and Vicinity Water Resources Study. The major elements of this study consist of short-term restoration of Assateague Island, navigation improvements, wetland and island creation/restoration, and long-term sand placement along Assateague Island and Ocean City.

The study area, which encompasses approximately 780 km (300 square miles), includes the Town of Ocean City and adjacent areas of Worcester County, including the Ocean City Inlet, Assateague Island, and Assawoman, Little Assawoman, Isle of Wight, Sinepuxent, and Chincoteague Bays. The Maryland portion of the watersheds of the aforementioned bays, which includes the eastern portion of Worcester County, was investigated. Also included were the shoals within 17.7 km (11 miles) offshore of Assateague Island.

This Real Estate Plan will cover only the short-term restoration of Assateague Island. The other elements will be addressed in the second report.

1.2 REAL ESTATE REQUIREMENTS

1.2.1 General Requirements

1.2.1.1 Restoration A short-term restoration is proposed for the northern portion of Assateague Island. For a distance of approximately 11.3 km (7 miles) south of the south jetty located at the Ocean City Inlet, the island is to be restored by placing 1.4 million cubic meters (1.8 million cubic yards) of material, constructing a storm berm to elevation 3.3 meters (10.8 feet) National Geodetic Vertical Datum, and widening the beach. The distance across the beach will be increased to varying widths based on the erosion rates.

Access to the site will be from the existing entrance road into the Assateague Island National Seashore.

The material to be used for this project will be obtained from the Great Gull Bank offshore shoal, which contains adequate material.

A standard estate, a Perpetual Beach Nourishment Easement, and a non-standard estate, a Perpetual Storm Berm Easement, will be required for the beach nourishment and berm, totaling 61.93 acres (25.063 hectares) and 78.24 acres (31.664 hectares), respectively. During construction, a Temporary Work Area Easement (Estate No. 15) will be required for an additional 3 meters (10 feet) outside the berm area totaling 90.10 acres (36.463 hectares). The temporary work area easement will be required for a two year period. No real estate interest will be acquired for the borrow site since it is located in navigable waters.

There was a development proposed, called Atlantic Estates, back in the early 1900's. A portion of Assateague Island was subdivided and private individuals purchased parcels, but the area was never developed. It is currently part of the Assateague Island National Seashore. The National Park Service (NPS) is the current owner of the area. There are 16 upland parcels that the NPS has not been able to acquire which will be affected by the short-term restoration work. Certain easements, as described in Section 1.8, will have to be acquired over these 16 parcels. There are other parcels that are now submerged that are not affected by our project. Our legal research has concluded that once lands are submerged, title reverts to the State and the land cannot be reclaimed by the former owner. As discussed below, navigational servitude also applies to these submerged parcels.

There is another parcel which will also be affected by the short-term restoration work. This parcel is located on the northern portion of the State Park property and the NPS will have to obtain an easement from the State of Maryland for work in this area.

1.2.2 Federally-owned land A portion of the study is located on Federal lands controlled by the NPS. Section 534(b) of WRDA 96 requires that the Secretary enter into an agreement with the Federal property owner (NPS) to determine the allocation of project costs. In this case, the Federal property owner is the NPS. It is on this basis that the Corps has identified the NPS as its Federal partner in the Assateague Island project.

1.2.3 Navigational Servitude This project is for mitigation of damages to Assateague Island caused by the Ocean City Harbor and Inlet project. Navigational Servitude is applicable to this project since the original project was a full Federal navigation project. Property within the navigational servitude (below the ordinary high water mark) was not included in the real estate acreage calculations and cost estimate.

1.3 PUBLIC LAW 91-646 RELOCATIONS

It is anticipated that there are no project features that will require relocations under Public Law 91-646, as amended.

1.4 SPONSOR'S ACQUISITION ABILITIES

The Federal partner for this project is the NPS. The NPS had attempted to finalize purchase of the 16 upland parcels described above about 10-15 years ago; however, many of the owners either were unwilling to sell their property or could not be located, so the NPS did not pursue the matter any further.

The NPS has indicated they will request the Corps to acquire the parcels on their behalf. The NPS does not have the authority to negotiate with the landowners above the fair market value determined. If the parcels have to be acquired through condemnation, the NPS condemnation process requires approval of the Director of the NPS. The Corps may be able to conduct the acquisitions in a more expedient manner. The Corps and the NPS would enter into an Memorandum of Agreement (MOA) for the real estate acquisition, and NPS would have to provide all funds up-front.

An assessment of the sponsor's acquisition capabilities is attached.

1.5 BASELINE COST ESTIMATE FOR REAL ESTATE

A detailed cost estimate for the restoration of Assateague Island, in MCACES format, is included in the Cost Estimate, Appendix C. The total project real estate cost estimate, with contingencies, is $283,000.

1.6 REAL ESTATE MAPPING

Real Estate mapping showing the project area is attached.

1.7 MINERAL ACTIVITY

There is no known mineral activity in the vicinity of the project.

1.8 PROPOSED ESTATES

The proposed estates to be acquired for the project, as referenced in Section 1.2, are listed below:

The recommended standard estate for the beach restoration is a Perpetual Beach Nourishment Easement: A perpetual and assignable easement and right-of-way in, on, over and across the land described in Schedule A, Tract No. __, to construct, operate, maintain, patrol, repair, renourish, and replace the beach berm and appurtenances thereto, including the right to borrow and/or deposit fill, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the easement; reserving, however, to the grantor(s), (his) (her) (its) (their) (heirs,) successors and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however, to existing easements for public roads and highways, public utilities, railroads and pipelines.

The recommended estate for the storm berm is a non-standard estate, a Perpetual Storm Berm Easement: A perpetual and assignable easement and right-of-way in, on, over and across the land described in Schedule A, Tract No. _ to construct, operate, maintain, repair, rehabilitate and replace a storm berm and appurtenances thereto; reserving, however, to the grantor(s), (his) (her) (its) (their) (heirs,) successors and assigns, all other rights and privileges as may be used 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.

Temporary Work Area Easement (Estate No. 15): A temporary easement and right-of-way in, on, over and across the land described in Schedule A, Tract No. __, for a period not to exceed two years, beginning with the date possession of the land is granted to the United States, for use by the United States, its representatives, agents, and contractors as a work area, including the right to move, store and remove equipment and supplies, and erect and remove temporary structures on the land and to perform any other work necessary and incident to the construction of the Ocean City Water Resources Project, together with the right to trim, cut, fell and remove therefrom all trees, underbrush, obstructions, and any other vegetation, structures, or obstacles within the limits of the right-of-way; reserving, however, to the landowners, their heirs and assigns, all such rights and privileges as may be used without interfering with or abridging the rights and easement hereby acquired; subject, however to existing easements for public roads and highways, public utilities, railroads and pipelines.

1.9 ACQUISITION SCHEDULE

The Memorandum of Agreement between the Corps and the NPS for construction of the project is scheduled to be executed by August 1997. Current proposed project milestones show advertisement will be in April 1998, with construction beginning in the summer of 1998, if funding is available. If condemnation is necessary, the advertisement may need to be postoned to July 1998. The NPS is proposing to request the Corps to do the acquisition on their behalf. They are currently looking at various avenues for funding. A detailed schedule of real estate acquisition activities with milestones is as follows:

ACTIVITY	INITIATE	COMPLETE
Execution of MOA	August 97	August 97
Obtain Title	August 97	September 97
Obtain Tract Appraisals	August 97	November 97
Conduct Negotiations	December 97	December 97
Perform Closings	January 98	January 98
Perform Condemnations	January 98	June 98
Obtain Possession	June 98	

The real estate milestones have been coordinated with the sponsor.

1.10 UTILITY AND FACILITY RELOCATIONS

There are no utility and facility relocations required in connection with this project.

1.11 ENVIRONMENTAL CONCERNS

Hazardous, toxic, and radioactive waste (HTRW) investigations have been performed at the site. There are no sites within or adjacent to the project area that have been identified as known or potential HTRW sites. The gross appraisal has been prepared considering project lands as clean.

1.12 ATTITUDE OF AFFECTED LANDOWNERS

The NPS and the State of Maryland are the landowners being directly affected by the proposed short-term restoration of Assateague Island. They are both very receptive to the proposed project and have been working closely with the Corps throughout the study process. The Town of Ocean City and Worcester County have been participating in the study process as well. Regarding the 16 upland parcel owners who are to be contacted by the NPS, it is unclear as to how they will respond.

ASSESSMENT OF SPONSOR'S
REAL ESTATE ACQUISITION CAPABILITY
OCEAN CITY, MARYLAND and VICINITY WATER
RESOURCE STUDY

1. Legal Authority

a. Does the sponsor have legal authority to acquire and hold title to real property for project purposes?

Yes.

b. Does the sponsor have the power of eminent domain for this project?

Yes.

c. Does the sponsor have "quick-take" authority for this project?

Yes.

d. Are there any 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?

No.

2. 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.

b. If the answer to 2a 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 workload, if any, and the project schedule?

No. If the sponsor is to do acquisition, they would have to detail other specialists from field offices.

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?

Yes. Because of the sponsor's other workload and limited regional authority for condemnation, it may be more expedient for the Corps to conduct the acquisition actions.

3. Other Project Variables:

a. Will the sponsor's staff be located within reasonable proximity to the project site?

Yes; they are located in Philadelphia.

b. Has the sponsor approved the project/real estate schedule/milestones?

Yes.

4. Overall Assessment:

a. Has the sponsor performed satisfactorily on other USACE projects?

N/A.

b. With regard to this project, the sponsor is anticipated to be: highly capable/fully capable/moderately capable/marginally capable/insufficiently capable?

Fully capable (with Corps support) .

. Coordination

a. Has this assessment been coordinated with the sponsor?

Yes.

b. Does the sponsor concur with this assessment?

Yes.

Prepared by:

____

Angie Blizzard
Realty Specialist

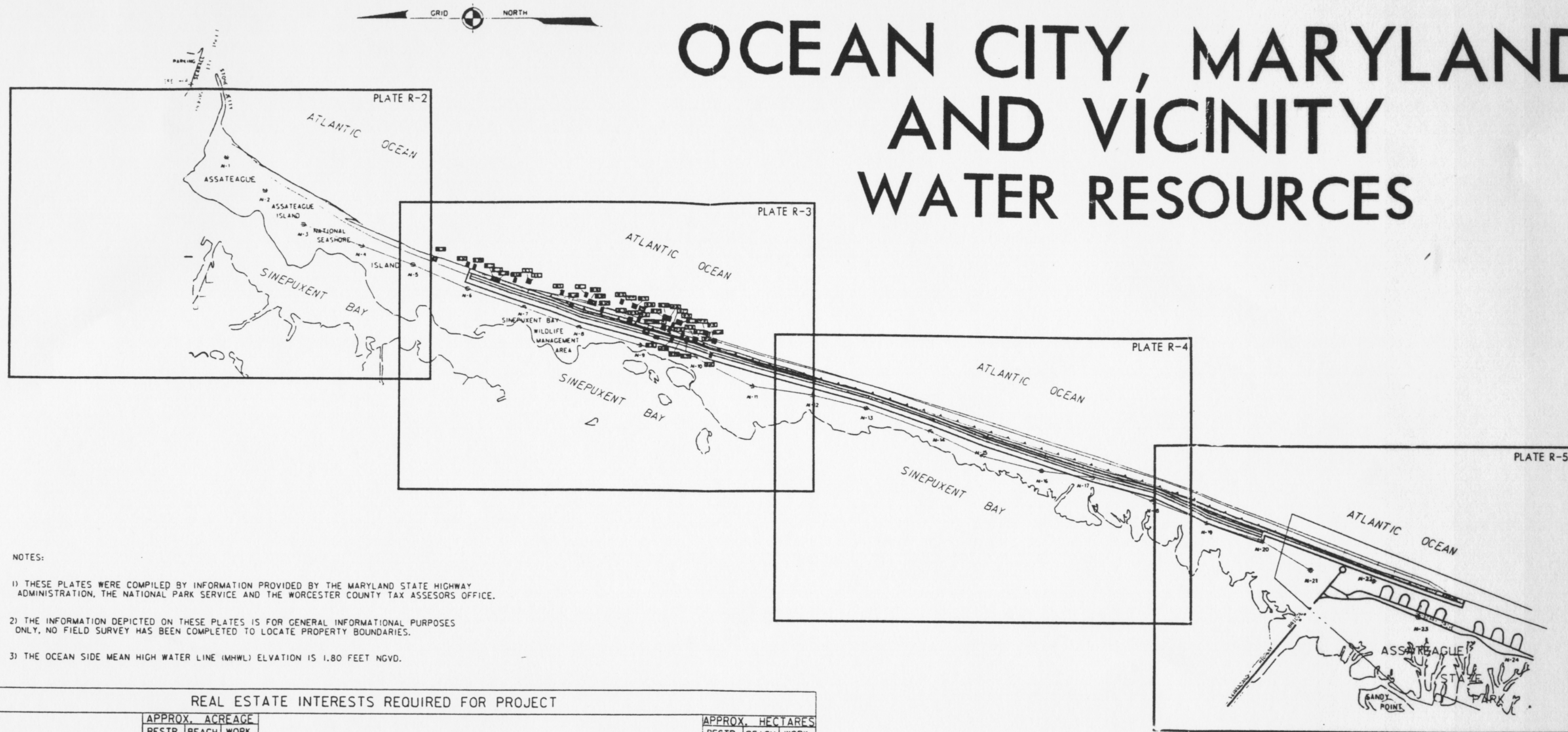
Reviewed and approved by:

____

Susan K. Lewis
Chief, Civil Projects Support Branch
Real Estate Division
CENAB-RE-C

CORPS OF ENGINEERS U. S. ARMY

OCEAN CITY, MARYLAND AND VICINITY WATER RESOURCES



NOTES:

1) THESE PLATES WERE COMPILED BY INFORMATION PROVIDED BY THE MARYLAND STATE HIGHWAY ADMINISTRATION, THE NATIONAL PARK SERVICE AND THE WORCESTER COUNTY TAX ASSESORS OFFICE.

2) THE INFORMATION DEPICTED ON THESE PLATES IS FOR GENERAL INFORMATIONAL PURPOSES ONLY. NO FIELD SURVEY HAS BEEN COMPLETED TO LOCATE PROPERTY BOUNDARIES.

3) THE OCEAN SIDE MEAN HIGH WATER LINE (MHWL) ELVATION IS 1.80 FEET NGVD.

REAL ESTATE INTERESTS REQUIRED FOR PROJECT

REPUTED LAND OWNER	APPROX. ACREAGE RESTR. DUNE ESMNT.	APPROX. ACREAGE BEACH NOUR. ESMNT.	APPROX. ACREAGE WORK AREA ESMNT.	REMARKS	APPROX. HECTARES RESTR. DUNE ESMNT.	APPROX. HECTARES BEACH NOUR. ESMNT.	APPROX. HECTARES WORK AREA ESMNT.
UNITED STATES OF AMERICA	77.634	49.073	77.312	DOES NOT INCLUDE PARCELS DESIGNATED AS BEING NOT ACQUIRED BY THE NATIONAL PARK SERVICE (SEE PLATES R-2- & R-3	31.597	19.972	31.466
STATE OF MARYLAND		11.878	12.691			4.834	5.165
[10-133] EDWARD S. BREZINA		0.240		SEE PLATE R-3 FOR LOCATION		0.098	
[10-110] JOSEPH & ELSIE ZENTMEYER		0.120		SEE PLATE R-3 FOR LOCATION		0.049	
[10-134] NUCKOLES		0.120		SEE PLATE R-3 FOR LOCATION		0.049	
[10-140] CHESTER L. WOZNIAK		0.120		SEE PLATE R-3 FOR LOCATION		0.049	
[10-19] VICTOR BOHINCE & CELIA BOHINCE		0.011		SEE PLATE R-3 FOR LOCATION		0.004	
[10-8] LAWRENCE LUZENSKI, ET AL		0.011		SEE PLATE R-3 FOR LOCATION		0.004	
[10-141] CHESTER L. WOZNIAK	0.350			SEE PLATE R-3 FOR LOCATION	0.142		
[10-56] LAWRENCE J. GANSER	0.090		0.030	SEE PLATE R-3 FOR LOCATION	0.037		0.012
[10-60] LAWRENCE J. GANSER	0.120			SEE PLATE R-3 FOR LOCATION	0.049		
[10-542] MADARIS		0.060		SEE PLATE R-3 FOR LOCATION		0.024	
[10-144] RUTH E. BORELLI		0.120		SEE PLATE R-3 FOR LOCATION		0.049	
[10-36] ROBERT L. MICHEL		0.050		SEE PLATE R-3 FOR LOCATION		0.020	
[10-37] HUMPREYS		0.050		SEE PLATE R-3 FOR LOCATION		0.020	
[10-64] UNSINN	0.050		0.070	SEE PLATE R-3 FOR LOCATION	0.020		0.028
[10-29] WALLS		0.043				0.018	
[10-30] KERSCH		0.037				0.015	
TOTALS	78.244	61.933	90.103		31.845	25.205	36.671

LEGEND

EXCEPT FOR THE SPECIAL SYMBOLS SHOWN BELOW MAP SYMBOLS ARE STANDARD IN DEFENSE MAPPING AGENCY TECHNICAL MANUAL NO. 23

- RESTRICTIVE DUNE EASEMENT
- BEACH NOURISHMENT EASEMENT
- TEMPORARY WORK AREA EASEMENT
- MEAN WIGH WATER LINE 1.80 FT NGVD
- NATIONAL PARK SERVICE TRACT DESIGNATION OF THE PARCELS NOT ACQUIRED BY THE NATIONAL PARK SERVICE — 10-547

DATE	REVISIONS (READ UP)	BY

PROJECT PLANNING MAP

DEPARTMENT OF THE ARMY	USING SERVICE
LOCATION OF PROJECT	TRANSPORTATION FACILITIES
STATE MARYLAND	RAILROADS
COUNTY WORCESTER	STATE ROADS
DIVISION NORTH ATLANTIC	FEDERAL ROADS
DISTRICT BALTIMORE	AIRLINES
ARMY AREA	

PROJECT SITE LOCATED APPROXIMATELY 1 MILE S OF OCEAN CITY, MARYLAND

PLATE INDEX

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
NORTH ATLANTIC DIVISION

DRAWN BY: GHB
TRACED BY:
CHECKED BY: GHB
SUBMITTED BY:
CADASTRAL
RECOMMENDED BY:
CHIEF, P&C BRANCH

REAL ESTATE
OCEAN CITY, MARYLAND AND VICINITY
WATER RESOURCES
ASSATEAGUE ISLAND

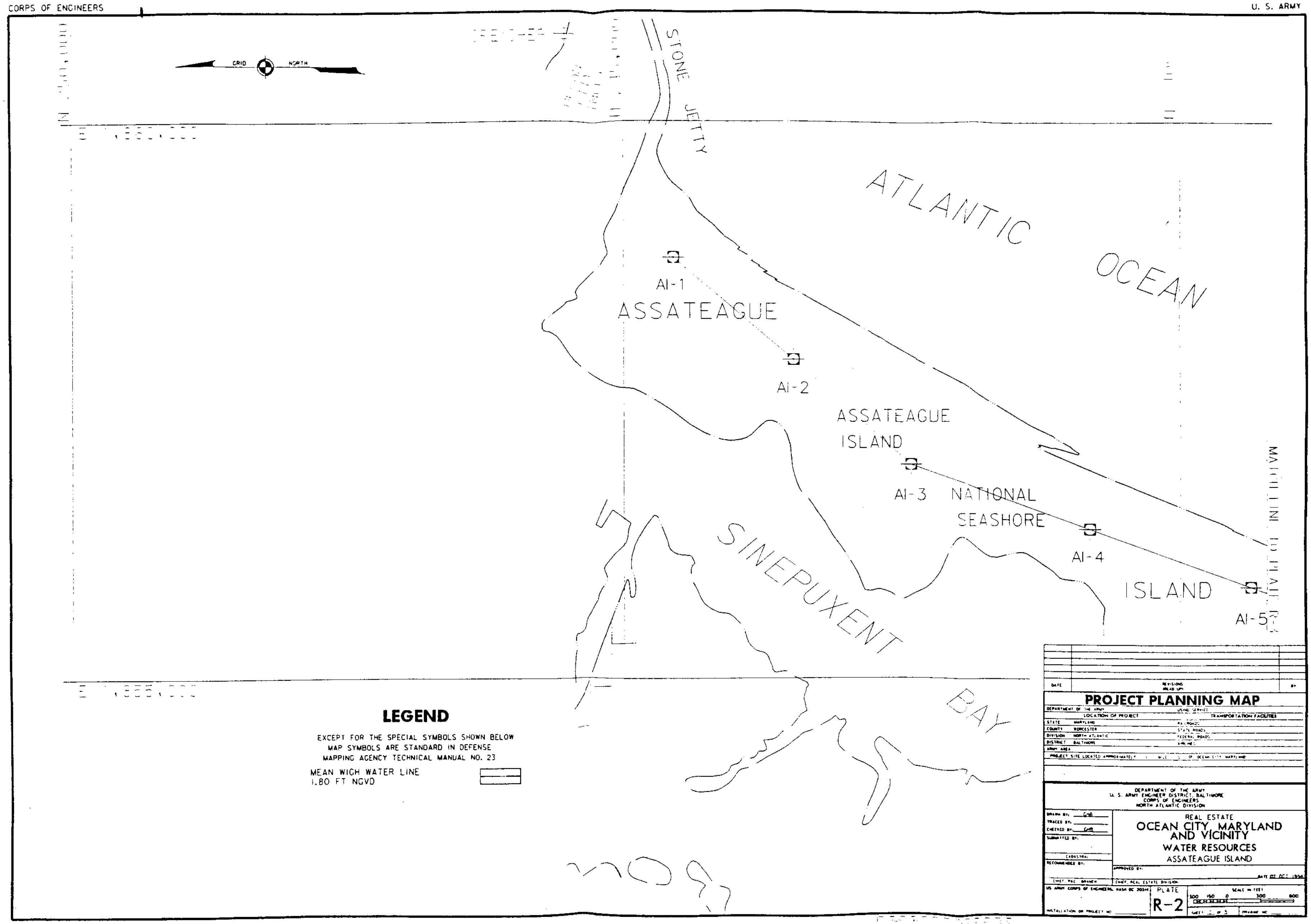
APPROVED BY:
DATE 02 OCT 1996
CHIEF, REAL ESTATE DIVISION

US ARMY CORPS OF ENGINEERS, WASH DC 20314
INSTALLATION OR PROJECT NO.

PLATE R-1

SCALE IN FEET 1200 600 0 1200 2400

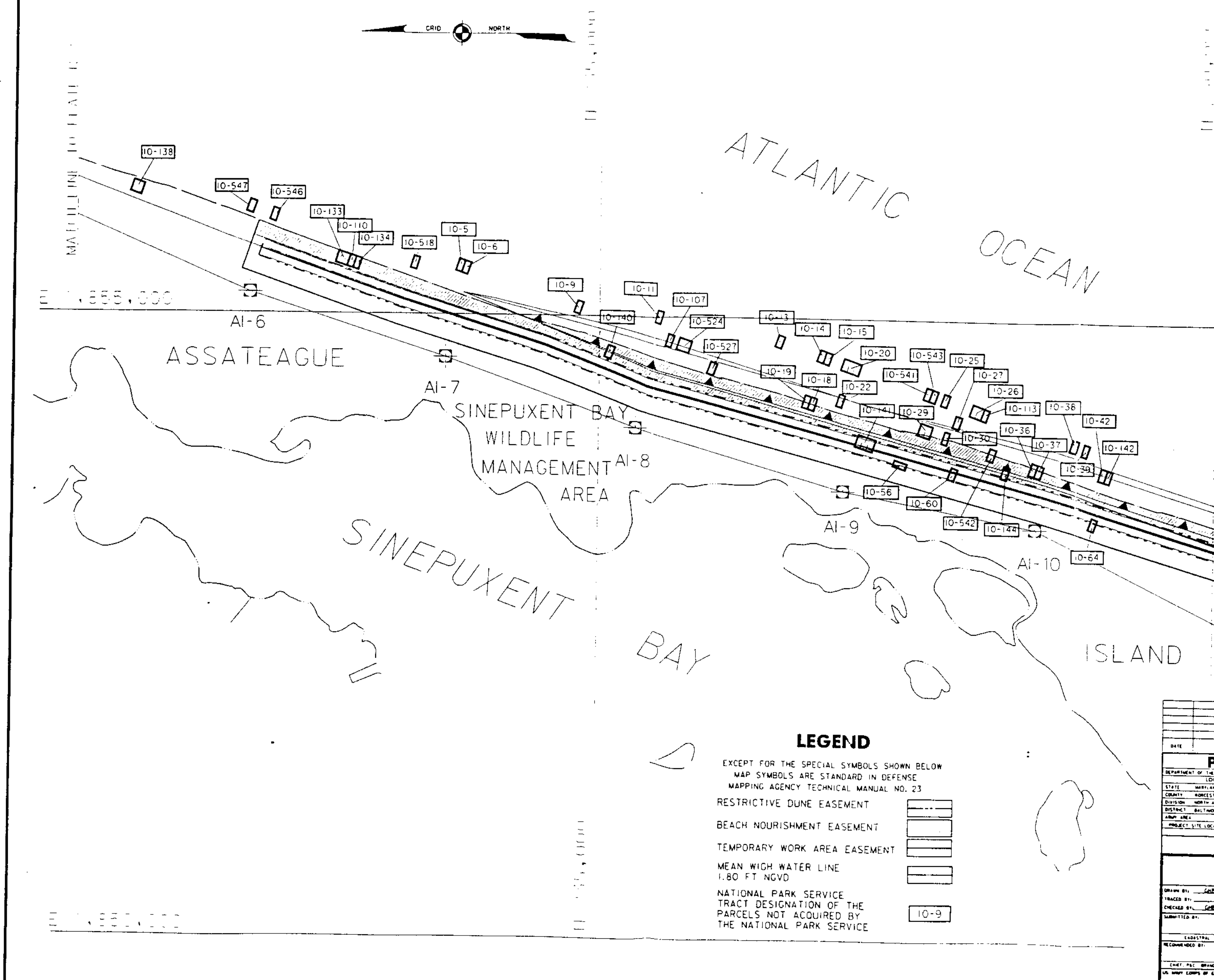
SHEET 1 OF 5 DRAWING NO.



CORPS OF ENGINEERS
U. S. ARMY
GRID NORTH
STONE JETTY
ATLANTIC OCEAN
MATCHLINE TO PLATE R-3
AI-1
ASSATEAGUE
AI-2
ASSATEAGUE
ISLAND
AI-3
NATIONAL
SEASHORE
AI-4
ISLAND
AI-5
SINEPUXENT BAY
LEGEND
EXCEPT FOR THE SPECIAL SYMBOLS SHOWN BELOW
MAP SYMBOLS ARE STANDARD IN DEFENSE
MAPPING AGENCY TECHNICAL MANUAL NO. 23
MEAN WIGH WATER LINE
1.80 FT NGVD
PROJECT PLANNING MAP
DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
NORTH ATLANTIC DIVISION
REAL ESTATE
OCEAN CITY, MARYLAND
AND VICINITY
WATER RESOURCES
ASSATEAGUE ISLAND
PLATE
R-2

CORPS OF ENGINEERS

U. S. ARMY



LEGEND

EXCEPT FOR THE SPECIAL SYMBOLS SHOWN BELOW MAP SYMBOLS ARE STANDARD IN DEFENSE MAPPING AGENCY TECHNICAL MANUAL NO. 23

- RESTRICTIVE DUNE EASEMENT
- BEACH NOURISHMENT EASEMENT
- TEMPORARY WORK AREA EASEMENT
- MEAN HIGH WATER LINE 1.80 FT NGVD
- NATIONAL PARK SERVICE TRACT DESIGNATION OF THE PARCELS NOT ACQUIRED BY THE NATIONAL PARK SERVICE — 10-9

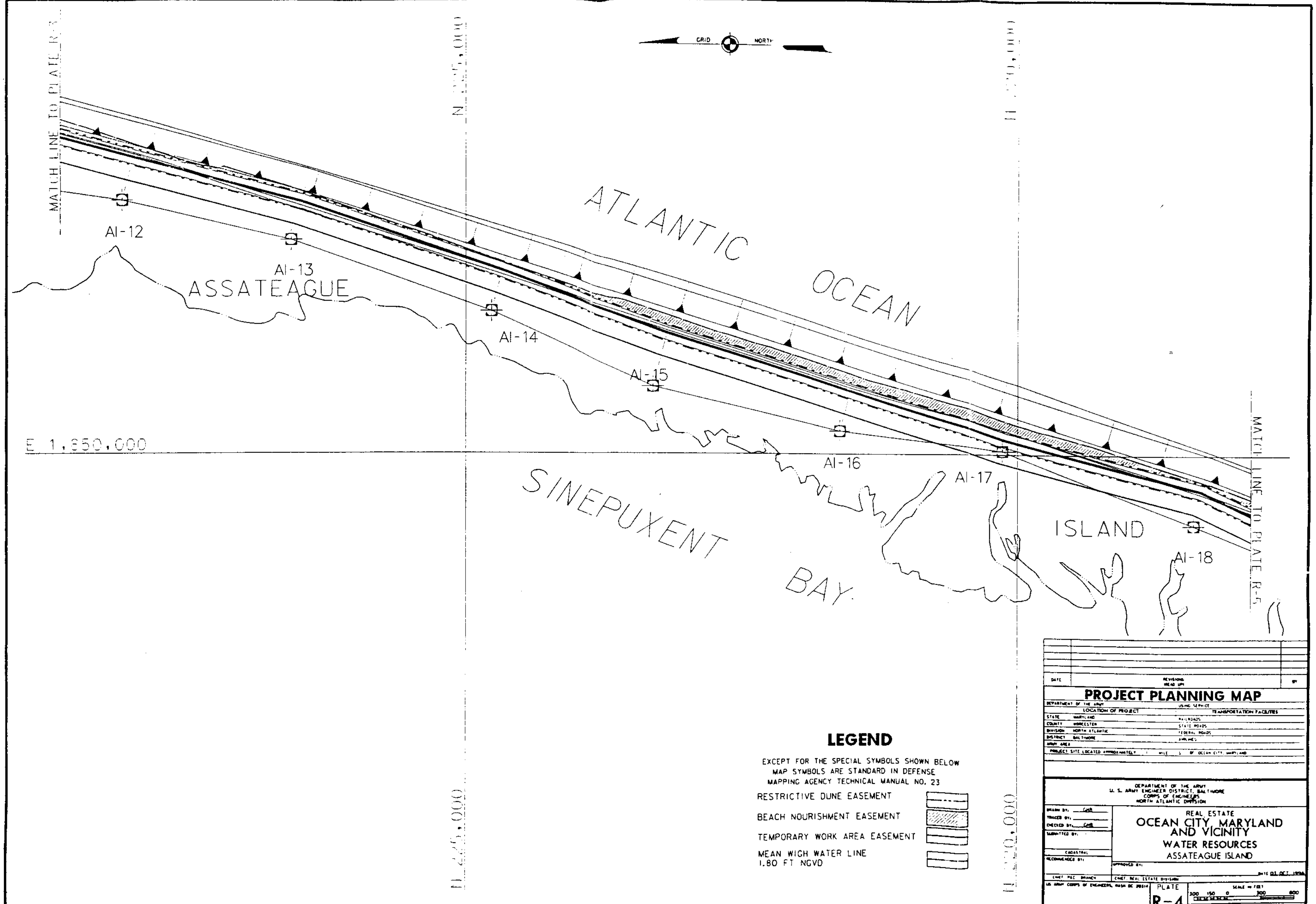
PROJECT PLANNING MAP

DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
NORTH ATLANTIC DIVISION

REAL ESTATE
OCEAN CITY, MARYLAND AND VICINITY
WATER RESOURCES
ASSATEAGUE ISLAND

PLATE R-3

SCALE IN FEET: 300 150 0 300 600



LEGEND

EXCEPT FOR THE SPECIAL SYMBOLS SHOWN BELOW MAP SYMBOLS ARE STANDARD IN DEFENSE MAPPING AGENCY TECHNICAL MANUAL NO. 23

- RESTRICTIVE DUNE EASEMENT
- BEACH NOURISHMENT EASEMENT
- TEMPORARY WORK AREA EASEMENT
- MEAN HIGH WATER LINE 1.80 FT NGVD

PROJECT PLANNING MAP

LOCATION OF PROJECT — STATE: MARYLAND; COUNTY: WORCESTER; DIVISION: NORTH ATLANTIC; DISTRICT: BALTIMORE

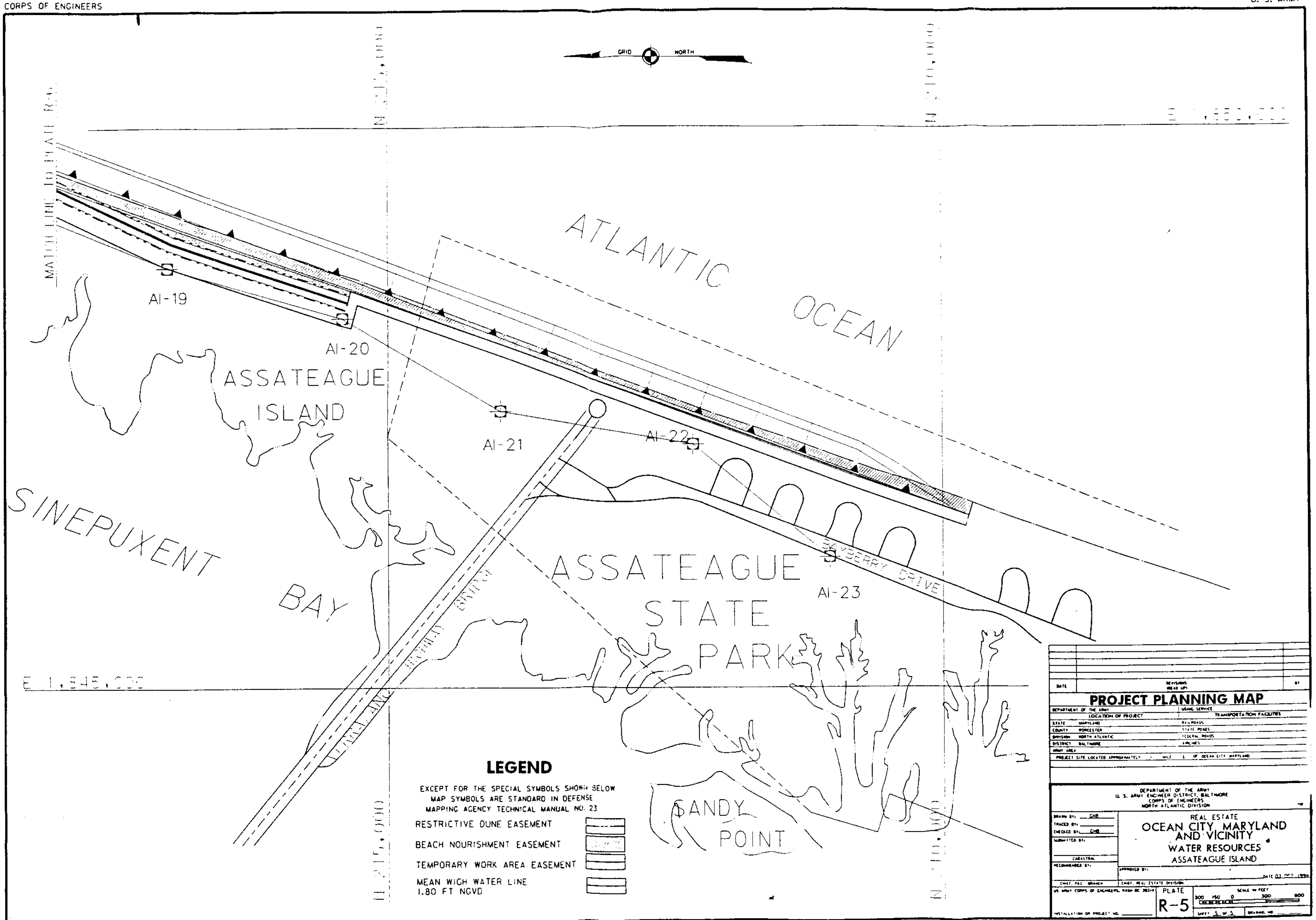
DEPARTMENT OF THE ARMY
U. S. ARMY ENGINEER DISTRICT, BALTIMORE
CORPS OF ENGINEERS
NORTH ATLANTIC DIVISION

REAL ESTATE
OCEAN CITY, MARYLAND AND VICINITY
WATER RESOURCES
ASSATEAGUE ISLAND

PLATE R-4

CORPS OF ENGINEERS

U. S. ARMY



ANNEX D

CULTURAL DOCUMENTATION

ANNEX D

CULTURAL RESOURCES INVESTIGATION

1.0 RESEARCH METHODOLOGY

1.1 Methodology

This report is the result of the collection and analysis of a wide range of information relating to cultural resources. Since most of the project actions will be conducted underwater, physical reconnaissance of the project areas were not feasible in many cases. For long-term planning purposes, information relating to the entire portion of Assateague Island and the coastal bays were collected and analyzed. Information collected for this study included the following: historic maps; charts prepared by the COE, NOAA, USGS, and others; the records of the State Historic Preservation Office; and secondary historical works.

1.2 Federal Compliance Responsibilities

Federal and state legislation require that a Phase I cultural resource survey be conducted prior to any project actions relating to the Ocean City Water Resources project. This Phase I survey was designed to identify both architectural and archeological resources that could be affected by the proposed project. The survey was specifically required under terms of Section 106 of the Historic Preservation Act of 1966 (P.L. 89-665; 80:915; 16 U.S.C. 470), as implemented under terms of Executive Order 11593, and codified under terms of 36 CFR 800, Procedures for the Protection of Historic and Cultural properties, 1974. The legislation described above requires Federal agencies, or project sponsors seeking federal funding and/or permits to conduct cultural resources surveys to locate, identify, and evaluate historic and prehistoric resources in advance of project approval.

1.3 Research Objectives

The objectives of this research are to identify the locations and nature of known and predicted cultural resources within the survey area, and to provide this information early in the planning process for the project to develop avoidance strategies for the project's implementation. In cases where avoidance is not possible, or survey limitations are present, recommendations are made within this report for further investigations. The Ocean City project involves potential impacts to Assateague Island and the offshore environments and to the inland coastal bays. Because these two areas are very different in their history, environmental nature, and cultural resource issues, these two areas have been treated separately within this report.

2.0 ASSATEAGUE ISLAND

2.1 Overview History of Island

Until its recent use as a recreational area and wildlife sanctuary, the northern portion of Assateague Island was unsettled and undeveloped, due to its poor suitability for agricultural or extractive exploitation. A sequence of maps was investigated, including the 1864 *Richmond* map and the 1901 U.S.G.S. map, *Ocean City Quadrangle*, which failed to show any structures, roads, or docking facilities in the northern portion of Assateague. However, they do show that during the 19th century, Assateague Island was in a state of relative stasis. Although Ocean City had been established by 1901, the areas to the south of the city were uninhabited barrier dunes. In 1933, a severe storm breached the island immediately south of Ocean City, and the northern three miles of Assateague Island began to shift rapidly to the west. An aerial photograph, dated to 1934, shows the location of northern Assateague at the onset of its migration. In the same year, jetties were constructed at the southern end of Ocean City to provide a protected waterway for navigation. By 1956, an aerial photograph illustrates that the northern portion of Assateague has translocated completely, a distance of approximately 230 meters (750 feet). Therefore, none of the present land comprising the northern 1.9 km (3 miles) of Assateague is older than 50 years, and it is unlikely that any cultural remains predating the 1933 storm event remain. Given the highly dynamic nature of the northern portion of Assateague Island since 1933, it is unlikely that any cultural resources are present within the restoration project boundaries. Not only has Assateague Island been uninhabited for most of its existence, but the northern portion of Assateague Island has been in its present position for only a few decades. Any potential cultural resources predating the 1933 storm event would have naturally fallen into the ocean as the dune line migrated westward.

2.2 Potential for Shipwrecks

A similar situation precludes the existence of any historic shipwrecks within the restoration project limits, whose boundaries are the pre-1933 beach line. Assateague Island has retreated more than 100 percent since the 1933 storm, so that the project limits are contained in the area that was Assateague Island before 1933. Any potential historic shipwrecks are further to the east of the proposed project work limits.

Another potentially important historic resource to be considered during the present study are shipwrecks. During the 18th and 19th centuries, it was accepted practice to closely follow coastlines when traveling along the Atlantic Coast. When sudden storms arose, the ships were often moved inland to be beached upon the shoreline or offshore shoals. Throughout the pre-Civil War era, Assateague Island was uninhabited, and only known as an obstruction to navigation. Historians estimate that as many as 600 ships have wrecked off the barrier islands of Maryland and Virginia. Due to the constant threat of wrecks along the coastal beaches, the U.S. government established the U.S. Life Saving Service in 1877, to provide immediate response to coastal wrecks. USLSS District Number 6 was established between Cape Henlopen, Delaware, and Cape Charles, VA. Between 1877 and 1912, 13 vessels were stranded off the Ocean City Life Saving Station. As with the historic land use of Assateague Island, the surf zone at Assateague is recent. The entirety of the present surf line was underneath Assateague Island until 50 years ago. Any shipwrecks, then, would postdate the 1933 storm event. It is likely that any wrecks in the northern part of Assateague after 1933 could have been completely removed. No records of wrecks or obstructions were found in the NOAA list for the vicinity.

The lower 4 miles of the project area consist of active erosion/accretion zones that have removed most evidence of cultural resources. The Maryland Historic Trust records no prehistoric sites within this portion of Assateague Island. There are, however, two historic shipwrecks near the southernmost portion of the project area, Site WO153 "Yankee," a shipwreck of a ca. 1780 privateer, and WO154, "Dune Wreck," a shipwreck of unknown type. Site WO153 is outside of the project area and will not be affected. Site WO154 is within the project area and may be affected by the project. The Corps is conducting a Phase II archeological survey of this site to determine whether it is eligible for listing on the National Register of Historic Places, and the level of effect by the proposed activity. If the site is historic, and will be affected, the Corps will mitigate the effect on the project on this site.

The proposed locations for sand dredging offered the potential to contain historic shipwrecks. These four shoals, Little Gull Bank, Great Gull Bank, Shoal B, and Shoal C, are located between 4,600 meters and 12,200 meters (15,000 and 40,000 feet) off Ocean City Inlet. Only one shoal, the Little Gull Bank, is sufficiently shallow to have posed a threat to navigation, and to have potentially caused historic shipwrecks. The one recorded wreck on the NOAA charts, the "Esther Ann" is noted just south of this shoal, but is reported to have been removed. Others are located on the NOAA charts to the south of the shoal. Great Gull Bank is also located in less than 15 feet of water, and as such, could have also posed an obstruction to historic shipping. Both shoals have the potential to have significant historic resources in the vicinity. Both Shoals B and C are in waters that vary from 4.6 m to 7.6 m (15 to 25 feet) of water, and therefore, are not sufficiently shallow to have posed a threat to historic shipping. Therefore, the potential for historic shipwrecks in the vicinity of these shoals is low. Due to the possibility of shipwrecks being encountered in Great Gull and Little Gull Banks, the Corps performed a Phase I reconnaissance of these potential borrow sites, reported in "Phase I Archeological Study, Ocean City Water Resources Study, Ocean City, Maryland." This report concluded that there were no cultural resources located in the area of effect. It was provided to the Maryland Historic Trust for review by letter dated November 4, 1996.

It is therefore concluded that the northern portion of Assateague Island is a recent dune formation, and does not contain any significant cultural resources, either on the island or within the 1933 boundaries of the island. There is, however, a recorded shipwreck near the southern terminus of the project on Assateague Island. The Corps is conducting the required investigation to determine whether the shipwreck is a significant cultural resource. Reconnaissance investigations did not identify any shipwrecks in the proposed borrow site locations.

3.0 REMAINDER OF STUDY AREA

Worcester County, Maryland, is on the eastern side of the peninsula that lies between the Atlantic Ocean and the Chesapeake Bay (Figure 1-1). It is the only county in Maryland on the Atlantic seacoast and is in that part of Maryland called the Eastern Shore. The county is bounded on the east by the Atlantic Ocean; on the south by Accomack County, Virginia; on the west by Somerset and Wicomico Counties, MD; and on the north by Sussex County, DE. The total land area is about 309,120 acres, or 483 square miles. Assateague and Fenwick Islands, barrier reefs between the Atlantic Ocean and the inland bays, are part of Worcester County. Snow Hill, the county seat, is near the center of the county (Hall 1973:1).

3.1 General Prehistoric and Historic Background

The prehistory and history of the occupation of Worcester County has left both archeological and architectural remains scattered throughout the county, spanning a period of ten to eleven thousand years. The purpose of this Cultural Resource Management Plan is to document the locations of the cultural sites throughout the county, and to predict the locations of other, as yet undiscovered, significant sites to the county's history. A further purpose of this plan is to develop implementable recommendations for the continued identification of cultural sites and for their management by the county.

3.1.1 Paleolithic Period

The Middle Atlantic area, like that of the Northeast, has a prehistory which has been subdivided into three periods: Paleo-Indian, Archaic, and Woodland, with the historical contact period following the Woodland period. These periods have been primarily defined from information based on cultural and environmental patterns.

Paleo-Indians had reached the eastern United States by 10,500 B.C. The current understanding of the Paleoindian cultural groups typifies them as hunting big game on a seasonal basis as the animals migrated along a north to south corridor. Rivers are generally easier to cross in the location of the Fall Line, and that area would have provided Paleo-Indians a place to wait and search for migrating game. It would have also been an area to search for the raw materials to manufacture stone tools. There are no Paleolithic sites recorded within the study area, but studies in Delaware have documented that Paleolithic coastal sites may have existed, but are now located off shore. While the Pleistocene is conventionally held to have ended about 10,000 years ago, in the Chesapeake Bay Region conditions actually approach modern conditions several thousand of years later. The drowning of the lower estuary of the Susquehanna, which formed the Chesapeake Bay, took place during this period. The Archaic period is often interpreted as a settling into the landscape during this time.

3.1.2 Archaic Period

The Archaic (9,500 B.P. to 3,200 B.P.) was marked by dramatic environmental change. The pre-Boreal conditions that existed during the late Paleo-Indian Period were transformed into a Boreal environment, producing vegetation similar to that surviving in the region at present. At this tire , prehistoric inhabitants of the area relied less on hunting and made more extensive use of plant food sources. While there is little evidence of settlement or subsistence pattern changes, the Middle Archaic evidence suggests a dramatic increase in population density. During the Archaic, significant changes in subsistence patterns and habitation site distribution occurred. Populations of the peninsula appear to have left the wetland environment associated with the headwaters and resettled near the confluence of major rivers and streams (Davidson 1982:16-17).

The Archaic Period is generally subdivided into three phases: Early, Middle, and Late Archaic, each represented by different point types and environmental adaptations. Subsistence strategies move from the hunting of large game to a more diversified hunting and gathering strategy, including the utilization of shellfish, fish, small mammals, deer, nuts, berries, and roots. Occupation sites or camps were inhabited for longer periods of time to more fully exploit the surrounding environment, increasing the exploitation of the floral environment. Archaic Indian settlements tend to be located near environmentally rich tidal streams and rivers, with increasing forays into inland areas for exploitation of the floral environment . A number of prehistoric sites within the Worcester County region are dated to the Early Archaic Period, suggesting early utilization of the rich environmental habitats by that period. These settlements continued through the Archaic period.

3.1.3 Woodland Period

The Woodland Period (3,200 B.P. to 1720 A.D.) corresponds to the earliest appearance of pottery on the Delmarva Peninsula. During the Middle Woodland there is evidence of an increase in contact with groups outside the Delmarva Peninsula. During the Late Woodland significant changes in both settlement and subsistence have been identified. Hunting,, gathering and the exploitation of fish and shellfish were augmented by the development of agricultural techniques and the production of corn. Permanent substantial house structures and palisaded village sites testify to a less transient existence (Davidson 1982:22). However, association with Europeans introduced both social and economic changes that continued to affect the Amerindian inhabitants until native culture was essentially obliterated on the peninsula during the eighteenth century. The Woodland period represents yet another adaptation by man of his environment. This is the time of the introduction of pottery, elaborate burial rituals, including burial mounds and/or ossuaries, and an increased emphasis on farming to establish a stable food resource. This period is also traditionally divided by archaeologists into three subperiods: the Early, Middle, and Late Woodland.

During the Early Woodland period, a shift to more settled occupation areas along riverain habitats began with access to areas for the gathering of forest resources (nuts, berries, and roots) and plant domestication. During the later Woodland periods (Middle and Late), the Indian population increased and greater emphasis was placed on the domestication and cultivation of plants. More permanent villages emerged as well as more stratified social organizations. Pottery became denser, more durable and various decorative motifs were employed. In addition to a more settled lifestyle, the Indian population continued to exploit the wild resources including: oysters and other shellfish, crabs, fish, waterfowl, deer, and small mammals, and nuts, berries, and roots found in the forest. Within the present study area, a number of the prehistoric settlements established during the Archaic Period continued and expanded during the Woodland Period.

3.1.4 Predictive Model of Aboriginal Settlement

The predictive model for Worcester County was developed utilizing a basic model of settlement preferences. This model directs that aboriginal peoples have utilized the land in relationship to the developing boreal forest that was dominating the Middle Atlantic region. Generally, Pleistocene hunters and gathers were situated within the upland regions, in a pursuit of both big game and readily available foodstuffs. As the Archaic Period developed, the movement towards sedentism resulted in a broader dispersion of settlement, to capitalize upon a wide variety of food sources. Archaic settlements are found within the outer coastal plain, where easily gathered fish and shellfish offered the most optimum balance between food collection and harvest time. As the Woodland Period developed, there was a general movement into the upper coastal plain, where the rich, loamy soils could be utilized to support the increasing focus upon horticulture and agriculture.

To develop a model of human behavior for the Worcester County region, a comprehensive survey of the known site locations within the region was undertaken. In total, there are aboriginal sites recorded within the Maryland State Site files for the project area and the immediate surrounding vicinity. A total of 60% were located within well drained soils, such as Sassafras, Fort Mott, Lakeland, and Matapeake. Other environmental characteristics were catalogued for this sites, specifically the elevation, and distance to the back bay, primary streams, and secondary streams. Of the sixty sites that could be catalogued, 65% were more than two miles from the back bay, and only thirteen sites were in close proximity to the bay. However, although only 10% were found to be directly associated with primary streams, more than 75% were found to be closely associated with secondary streams. The inference is that although the bay and the primary streams may have offered the richest ecosystems for food procurement, their nature to be surrounded by tidal wetlands was prohibitive to aboriginal movement. The inland, well-drained regions of the county, traversed by secondary streams, offered the most stable landscape for settlement and procurement activities. This region is clearly delineated to the west of the back bays, along the corridor presently identified with U.S. Route 113. Known sites locations suggest a aversion of moderately well drained soils, such as Mattapex, Plummer, Fallsington, and Woodtown soils, were only 15% of the recorded sites are located. The remainder of the prehistoric sites (25%) are located within the poorly drained soils of the area, such as the Elkton, Klej, Leon, Othello, Pocomoke, Portsmouth, Rutland, and St. John's soils. The aboriginal sites located within the poorly drained soils are exclusively located along the fringes of primary and secondary streams, at their outfall into the back bay. Their direct association with shell refuse piles suggest that these sites were not utilized for habitation, but were shell shucking sites for aboriginal harvesters.

Therefore, the evidence suggests that high priority locations for aboriginal use are limited to well drained soils in proximity to secondary stream courses, the fringes of moderately well drained soils, and inland waterways adjacent to poorly drained soils near the shell beds able to be readily harvested. However, it should be noted, that a majority of the site locational information is derived from the sites recorded by a single surface collector, a Mr. Hirst, who conducted unsystematic surveys of the region during the 1960s and 1970s.

3.1.5 History of the Region

A survey of secondary source materials confirms that Giovanni da Verrazano was the first European to visit what is today the Maryland coast. Verrazano landed on Assateague Island in the vicinity of Worcester County in 1524. Permanent settlements along the eastern shore of Virginia appeared during the middle of the seventeenth century when English colonists spread north from settlements along the James River. By the second decade of the eighteenth century other small settlements were established along the Maryland Eastern Shore. The inhabitants were engaged in raising horses and cattle, manufacturing salt, fishing, and salvaging shipwrecks. During the mid-seventeenth century, population pressures from both within (expanding coastal settlements) and without (increasing migration from Europe) resulted in the opening of the first inland regions of the Atlantic coast. However, as late as 1794, much of Worcester County was still undeveloped. Roadways had been constructed along the Pocomoke, but the town of Snow Hill was the only community large enough to be designated as a community on the Griffith map of that year. Otherwise, the county contained several meeting houses and inns, but not much else.

The 1865 Map of the county illustrates that the county had become settled during the previous sixty years. Although Snow Hill continued to be the largest center of population, other communities, such as Berlin, St. Martins, Newark, Sandy Hill, and Lindseyville had come into existence. The county had been interconnected by a rural road network, with the main thorofares being the 18th century post roads.

By the end of the nineteenth century, the established farms had reached a stasis in development, but the surrounding region was shifting towards industrial based economies. The development of the railroad transportation network, and subsequently the idea of recreation, led to the establishment of Ocean City as a site for vacations. Within the southern portion of the present community, the initial development of Ocean City was founded during the 1860s. Summer cottages, hotels, and boarding houses opened to visitors in 1875. A number of recorded historic structures survive within the southern portion of present Ocean City, evidence of the early summer community. Ocean City has witnessed virtually unrestrained growth during the 20th century. Currently, the expanding populations in the region has resulted in the development of summer residential communities to the west of Ocean City, along the Route 50 corridor.

Agriculture plays a small but stable role in the economy of Worcester County. About 9 percent of the work force is employed in this sector. Farms in the county have decreased in number but have increased in size. In 1964 there were 824 farms, a decrease of about 30 percent since 1950, and of about 58 percent since 1900. The size of the average farm, however, increased from 121.5 acres in 1900 to 169.6 acres in 1961. The production of broilers is the main farm enterprise. In 1964, the broilers sold amounted to 30,506,928, and other chickens amounted to 99,600. In addition turkeys were raised on a few farms. Only a small part of the farm income came from other livestock: and from dairy products in 1964. In that year there were only 13 dairy farms and 11,750 hogs reported in the county. Corn and soybeans are the principal crops. They are used chiefly as food for broilers, though some of the grain is eaten in the field by hogs. The acreage in corn increased by about 9 percent between 1959 and 1964. Yield per acre increased from 51 bushels in 1959 to 73 bushels in 1964.

3.2 Inland Bays Terrain

Worcester County lies in the physiographic province called the Atlantic Coastal Plain and is about 110 miles east of the fall line that separates the plain from the Piedmont Plateau. The soils of the county are underlain by sediment consisting chiefly of gravel, silt, clay, sand, and shell fragments. The sediment is relatively unconsolidated and generally is more than 1 mile thick, though that under Ocean City is more than 8,500 feet thick. Beneath the sediment is crystalline rock that dips to the southeast at a rate of about 150 feet per mile. Similarly most of the overlying sediment dips to the southeast at a rate of 10 to 73 feet per mile. The sediment was deposited mainly in a marine or shallow water environment, and this accounts for its dominantly gray or white color. The sediment most likely originated in the Appalachian Mountains and the Piedmont Plateau.

The county is a low, eroded plain, where differences in relief are slight. Although it appears to be monotonously level, the county actually includes terraces, stream channels, drowned valleys, basinlike depressions, remnant dunes, swamps, and marshes. The terraces were laid down by meltwater from the continental ice mass; they are evidence that the level of the sect was higher in recent geologic time than it is today.

The three main physiographic divisions of the county are the mainland, the coastal beaches, and the Tidal marshes. All of the farmland is on the mainland, where the soils generally are level to gently undulating, except for large level areas in the central and northern parts of the county. Many areas of the mainland are a few feet above the normal level of the streams, and in places they are adjacent to marshland. Many low swales surrounded by ridges make some parts of the mainland appear hummocky. In places the swales contain basins that are known locally as “whale wallows” or “Maryland basins.”

Most of the county is less than 40 feet above sea level, except for an area west of Whiton. The highest elevation is 57 feet, and the average elevation is about 35 feet. Dunes occur at all elevations in the county. All are capped by sand. The material that makes up the dunes, however, ranges from mostly sand to silt and clay.

All of the county is drained by streams that flow in a general southeasterly direction into tidewater embayments and then into the Atlantic Ocean. Most of the county is in the Pocomoke River Basin. This river crosses the county in a southerly and southwesterly direction and flows into the Chesapeake Bay. The Pocomoke River falls about 16 feet in its course throughout the county, and its flow is sluggish. Its tributaries have already reached base level and are even more sluggish.

Drainage is impeded in almost 75 percent of the acreage of soils of the county. About 6 percent of the soils in the county are Tidal marsh, about 4 percent are Muck, and nearly 2 percent are Coastal belches. About 20 percent of the soils in the county can be farmed without artificial drainage.

3.3 Soils

Soils are also crucial for the prediction of prehistoric cultural resources. Generally, a majority of prehistoric sites are located in areas of well-drained soils, with level terrain, and within 2000' (500' appears to have been preferred) of a fresh-water source. Reviewing the soil types located within Worcester County, the individual soil types can be classed into poor, moderate, and good environments based upon the soil types. These soil types are described below. They are grouped according to their ability for occupation, farming, and faunal habitats, all of which would have been attractive selection factors for the prehistoric inhabitants of the area.

Poor Environments: Unable to support wildlife and permanent settlement, due to sand soils, high water table, or poorly nourished soils. The environment was not used without alteration - CbB, CbC, LlB, LmB, LoB, LoC, Ls, MkE, My, Mz, SaE, Tm.

Moderate Environments: Able to support specific types of wildlife, but high water table or sandy soils makes permanent settlement difficult. The environment may have been used for foraging, but probably not for settlement - Ek, El, Em, Fa, Fg, FmC3, FmD, KsA, KsB, LaD, LkD, LkE, MkC3, MkD, Ot, Pe, Pk, Pm, Pr, Pt, Ru, St, Su, WdA, WoA, WdB, WoB.

Good Environments: Able to support one or more wildlife types, and also contains well drained or moderately drained soils capable to support permanent settlement - FmA, FmB, FmC, MdA, MeA, MdB, MdC, MeB, MeC, SaA, SmA, SaB2, SaC2, SmB2, SaC3, SaD.
Source: Hall 1973

3.4 Recommendations

The other project actions have a limited potential to affect historic properties. However, all proposed actions will be reviewed and, if necessary, appropriate levels of reconnaissance investigations will be performed.

ANNEX E

MONITORING AND ACTION PLAN

ANNEX E

ASSATEAGUE ISLAND SHORT-TERM RESTORATION

Monitoring and Action Plan

I. Overview

The purpose of the monitoring program is to document physical evolution of the Short Term Restoration Project and related changes in key physical and biological resources of northern Assateague Island in order to evaluate the project's overall performance in meeting stated objectives. Within this broad purpose, there is a need to develop information describing specific aspects of performance which will be used to determine if follow-up mitigation is warranted.

The proposed monitoring program is graphically depicted in Figure 1. The design targets a broad range of parameters (described below) including both physical processes believed to be "driving" the system as well as multiple measures of resource condition. The relationship between monitoring components and key ecosystem processes and conditions is depicted in Figure 2. This process oriented approach is expected to enhance the probability of correctly characterizing project performance and may facilitate the identification of causative factors should performance problems occur.

Figure 3 depicts a conceptual decision tree for evaluating the need for follow-up mitigation. For each of the two key issues - breach potential and piping plover impacts - multiple indicators of project performance provide the basis for decision making. In the case of breach potential, data on overwash frequency and extent, berm and storm berm elevation, and overall island topography describe different aspects of the island's susceptibility to breaching. Similarly, data on piping plover distribution, abundance, and reproductive success coupled with trends in vegetation cover, topography, and overwash frequency provide a multi-attribute basis for assessing impacts to plovers. In both cases, the determination that observed conditions are not acceptable results in a modification of the project.

Overall management of the monitoring program will be accomplished through a working group made up of representatives of the Ocean City, MD and Vicinity Water Resources Study partners and the US Fish and Wildlife Service. The group will meet on an annual basis to discuss study progress, interim results, financial status, project modifications, impact assessment and the need for mitigation, and all other matters relating to the conduct and completion of the monitoring program. Interim meetings will be scheduled on an as-needed basis. In general, it will be the goal of the working group to achieve consensus in all decisions regarding the monitoring program and the need for follow-up mitigation.

The monitoring program will be initiated before construction of the restoration project in order to accurately characterize pre-project conditions - the basis for evaluating project related change and potential impacts. The estimated duration of the program is 5 years or until the follow-up, long term restoration program has been initiated. The need for additional monitoring will be evaluated at that time.

II. Monitoring Elements - Physical Environment

Project Evolution - Information describing change over time in the physical characteristics of the project in order to document evolution of the storm berm, berm elevation, dispersal of beach fill material within the nearshore system, rates of shoreline erosion, and cross-island movement of sediment.

Monitoring activities - Biannual (late March/early April and September) cross-island beach profile surveys along established transects (every 500 meters) extending from wading depth bayside to point-of-closure oceanside; biannual GPS surveys of shoreline position; biannual surveys of mean high water location.
Products - Annual report describing methodology and results; time series analysis of elevational and volumetric changes in beach profile along transects; GIS theme depicting and analyzing shoreline change over time.
Responsibility - COE (beach profile and MHW surveys) and NPS (GPS surveys)
Estimated 5 Year Cost - Beach and nearshore profile surveys - $300,000.; Mean high water surveys - $30,000.; GPS shoreline surveys - $5,000.
Funding Status - Partially funded (GPS surveys)

Island Topography - Information describing change over time in the topographic relief of uplands adjacent to project area to document elevational response (change in areal extent of low overwash flats) to reduced overwash and potential cross-island movement of sediments from the beach fill. Data will also contribute towards characterizing plover habitat through correlation with vegetation and plover nest site and foraging habitat location data.

Monitoring activities - Annual LIDAR surveys of northern Assateague Island; winter/summer cross-island beach profile surveys along established transects.
Products - Annual report describing methodology and results; GIS theme depicting and analyzing topographic change over time.
Responsibility - NASA (LIDAR surveys), COE (beach profile surveys), NPS (LIDAR surveys)
Estimated 5 Year Cost - $75,000. (beach profile costs included in Project Evolution component)
Funding Status - Unfunded

Physical Processes - Information describing the physical processes driving evolution of the project to assist in the interpretation of physical characterization data and to identify and describe unusual/extreme events with potential influence on vegetation community dynamics and piping plover reproductive success.

Monitoring activities - Continuous sampling of nearshore wave climate, meteorology, and ocean and bay water levels via automated data collection stations.

Products - Annual report describing methodology and results; continuous digital data sets.
Responsibility - COE (wave climate and ocean water levels) and NPS (meteorology and bay water levels)
Estimated 5 Year Cost - Wave climate - $425,000.; Meteorology - $26,000; Ocean Water Levels - $300,000.; Bay Water Levels - $30,000.
Funding Status - Partially Funded (Meteorology and Bay Water)

Overwash - Information describing the areal extent, frequency, and magnitude of overwash in the project area (and control sites) to evaluate the effectiveness of storm berm construction in limiting overwash to approximately one significant event per year. Data will also assist in the interpretation of physical characterization and vegetation cover information.

Monitoring activities - Routine surveys to visually detect overwash events; GPS mapping of overwash event location and areal extent of penetration beyond storm berm line.
Products - Annual report describing methodology and results; GIS theme depicting location and areal extent of overwash events.
Responsibility - NPS
Estimated 5 Year Cost - $10,000.
Funding Status - Unfunded

III. Monitoring Elements - Biological Resources

Piping Plover Reproductive Success - Information describing overall reproductive success and nest failures/mortality in the population utilizing northern Assateague Island for comparison to historic trends and to identify potential project-related changes.

Monitoring activities - Routine observational surveys (4-5 days/week April through August) to document the breeding population and key measures of reproductive success and failure as per existing monitoring protocols described in ASIS Piping Plover Management Plan, 1993.
Responsibility - NPS and MD DNR
Products - Annual report describing methodology, results, and comparisons to historic data.
Estimated 5 Year Cost - $400,00.
Funding Status - Partially Funded (NPS - $210,000.)

Piping Plover Distribution - Information describing the distribution and abundance of plovers along northern Assateague during the breeding season for comparison to historic data and to identify potential project-related changes. Data will also contribute towards characterizing plover habitat through correlation with vegetation and topographic data.

Monitoring activities - Routine nesting site and brood location surveys as per existing monitoring protocols described in ASIS Piping Plover Management Plan, 1993.
Products - Annual report describing methodology and results; GIS theme depicting locations of nest sites and brood foraging areas.
Responsibility - NPS and MD DNR

Estimated 5 Year Cost - Included in Piping Plover Reproductive Success monitoring component
Funding Status - Partially Funded

Vegetation Cover - Information describing landscape level changes in the distribution and abundance of primary vegetation cover alliances in the uplands adjacent to the project area for comparison to historic data and to identify potential project-related changes. Data will also contribute towards characterizing plover habitat through correlation with topographic and plover nest site and foraging habitat data.

Monitoring activities - annual (late summer/early fall) ground-based sampling at an intensity to support landscape level analysis of change in frequency of vegetation cover alliances (combined random and stratified-random sampling of vegetation cover alliance type); Aerial photography to support mapping of vegetation cover twice during life of project (Flown years 2 and 4)
Products - Annual report describing methodology and results; GIS theme depicting location of monitoring plots; time series analysis of changes in frequency of vegetation cover alliances; vegetation cover maps (years 3 and 5)
Responsibility - COE, NPS and MD DNR
Estimated 5 Year Cost - $250,000.
Funding Status - Unfunded

Fox Distribution - Information describing the number, location, and physical characteristics of fox den sites within the project area to assess potential project-related changes in habitat suitability for fox reproduction.

Monitoring activities - Biannual (late fall/early spring) surveys to locate active den sites
Products - Annual report describing methodology and results; GIS theme depicting den locations
Responsibility - NPS
Estimated 5 Year Cost - $4,000.
Funding Status - Funded

IV. Performance Indicators

The following are proposed as indicators for use in evaluating the need for mitigation to correct deficiencies in project performance relating to the protection of piping plovers and reduction in breach potential. The indicators are structured as threshold conditions, above which project performance would be considered unacceptable, and which would signal the need for mitigation. *They are not, however, intended to be "written-in-stone" action criteria, but rather guidelines to be utilized as part of an overall multi-disciplinary assessment of project performance*.

Impacts to Piping Plovers - A detrimental impact will be considered to have occurred if a significant change in either reproductive success [1] ***or*** breeding population size [2] is documented that cannot be explained by "natural" factors known to affect plovers on Assateague Island (e.g. losses to storms and predation) ***and*** significant changes are documented in key habitat characteristics [3] known to influence plover success (e.g. sparse vegetation cover and presence of low elevation, moist sand flats).

[1] A significant change in plover reproductive success is defined as two consecutive reproductive seasons with fewer than 1.25 chicks fledged per breeding pair.

[2] A significant change in plover breeding population size is defined as a cumulative decline of greater than 25% of the population at the start of the project (subject to re-evaluation based upon pre-project conditions and trends).

[3] A significant change in key habitat characteristics is defined as a cumulative reduction of greater than 25% of the area on the north end less than ***** m NGVD elevation ***or*** a cumulative decrease of greater than 25% of the area on the north end classified as unvegetated open sand habitat.

* To be defined when LIDAR data is available in useable format

Risk of breaching - An unacceptable risk of breaching will be considered to have occurred when the elevation of the constructed storm berm decreases to an average of less than 2.6m NGVD (the estimated average "natural" berm height) over a contiguous length of greater than .5km **and** the frequency of significant overwash events[4] exceeds four per year as documented by monitoring. Other situations may evolve which do not meet this criteria but which may also represent an unacceptable risk. These could include the formation of narrow, yet relatively deep overwash channels and localized areas of persistent, high frequency overwash regardless of elevation.

[4] A significant overwash event is defined as the overtopping of the constructed storm berm with evidence of water flow penetrating to at least the midpoint of the island over a cumulative lateral distance of greater than .5km ***or*** a contiguous lateral distance of .25km.

V. Mitigation Strategy

The most important element influencing success of the project is performance of the constructed storm berm in modifying the frequency and magnitude of overwash. Too great a reduction in overwash may alter existing habitat characteristics and thereby reduce the area's suitability for plovers. Conversely, too little reduction in overwash frequency indicates an unacceptable risk of island breaching. The critical role of overwash in influencing both habitat characteristics and breach susceptibility suggests that if performance problems occur, mitigation strategies should focus on the manipulation of those parameters that influence overwash as opposed to actions targeting specific conditions resulting from the process itself.

The principle, *controllable* factor influencing overwash frequency within the project area is the constructed storm berm. As such, should mitigation become necessary the preferred course of action will be to modify configuration of the storm berm. Mitigation for plover impacts (as previously defined) would seek to stimulate habitat changes by decreasing the elevation of the storm berm and promoting additional overwash. Mitigating an unacceptable risk of breaching (as previously defined) would focus on increasing the resistance of the storm berm to overwash. Potential options under both scenarios include alterations to storm berm elevation, design, or location and the manipulation of vegetative condition; all at a variety of scales ranging from small localized manipulations to project-wide changes.

VI. Funding Summary

Monitoring Component	Estimated 5 Year Cost	Funded Amount	Unfunded Amount
Physical Environment			
Project Evolution	335,000.	5,000.	330,000.
Island Topography	75,000.	0.	75,000.
Physical Processes *	781,000.	56,000.	725,000.
Overwash	10,000.	0.	10,000.
Biological Resources			
Plover Success	400,000.	210,000.	190,000.
Plover Distribution **	0.	0.	0.
Vegetation	250,000.	0.	250,000.
Fox Distribution	4,000.	4,000.	0.
TOTALS	$ 1,855,000.	$ 275,000.	$ 1,580,000.

* The estimated 5 Year Cost reflects the full cost of wave climate and ocean water level data acquisition - there may be an opportunity to cost share with the Atlantic Coast of Maryland Shoreline Protection Project.

** 5 Year Cost is included in the Plover Success component.

Figure 1

Conceptual Model of Monitoring Program

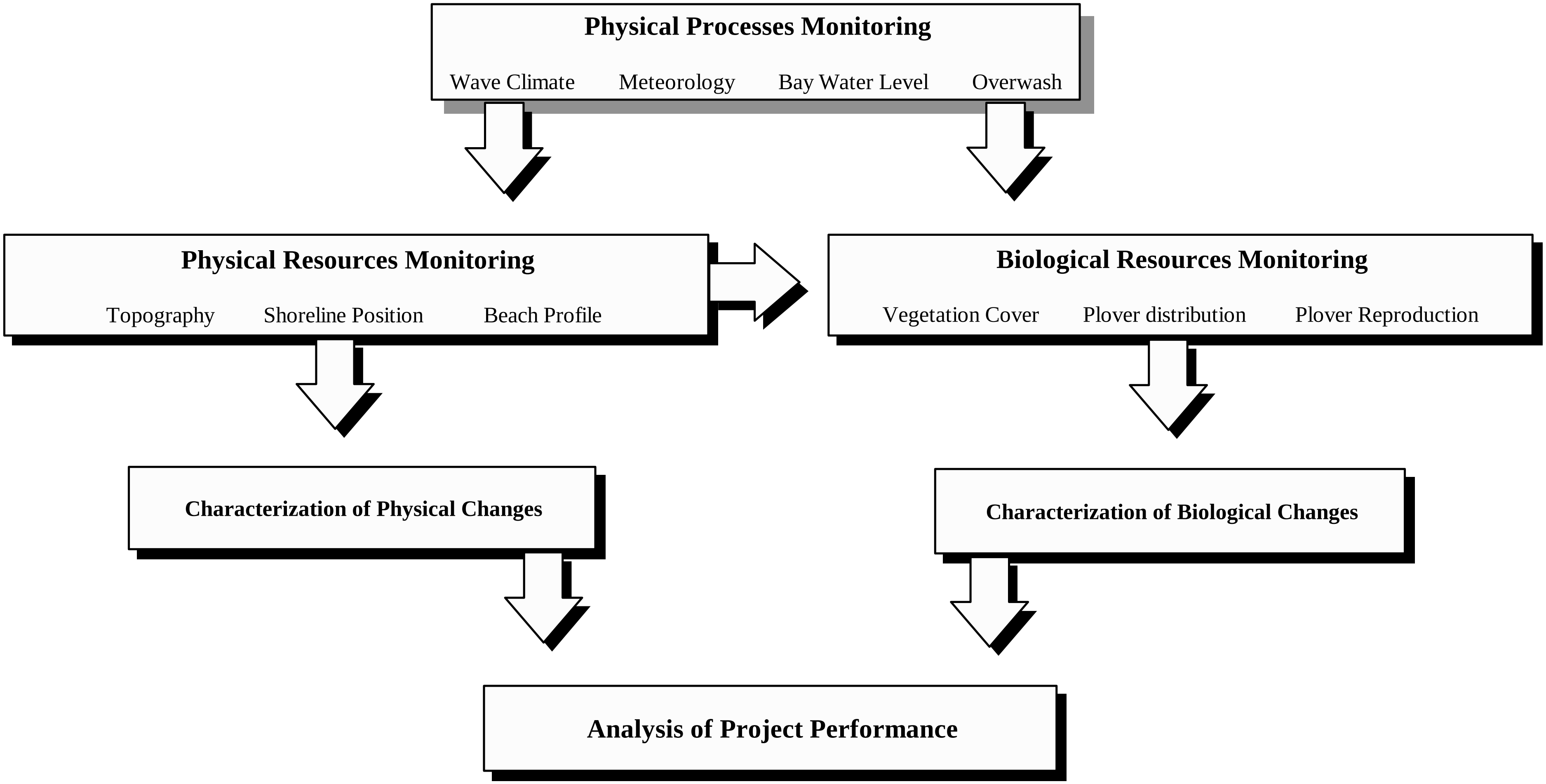


Figure 2

Conceptual Model of Key Relationships and Monitoring Opportunities

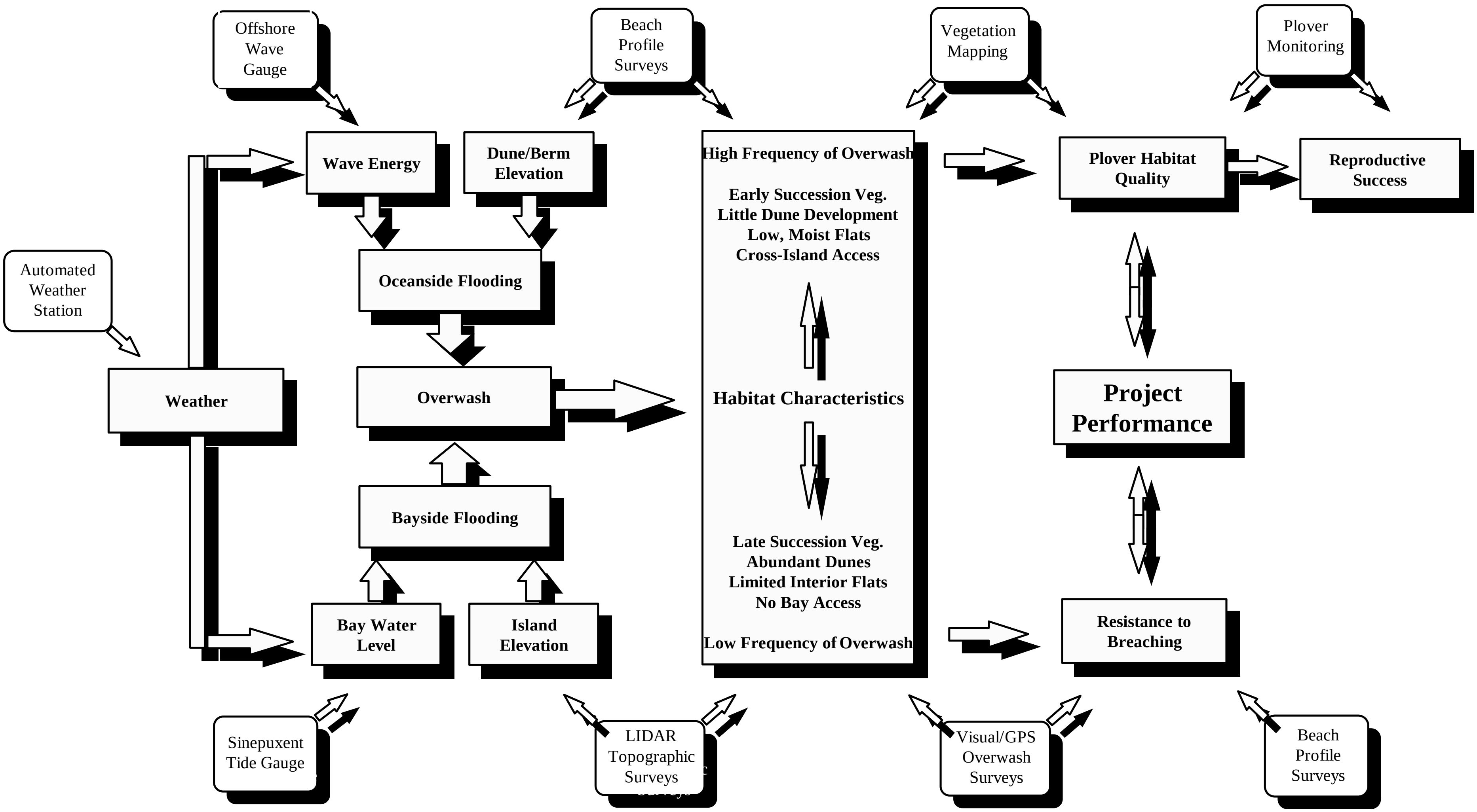
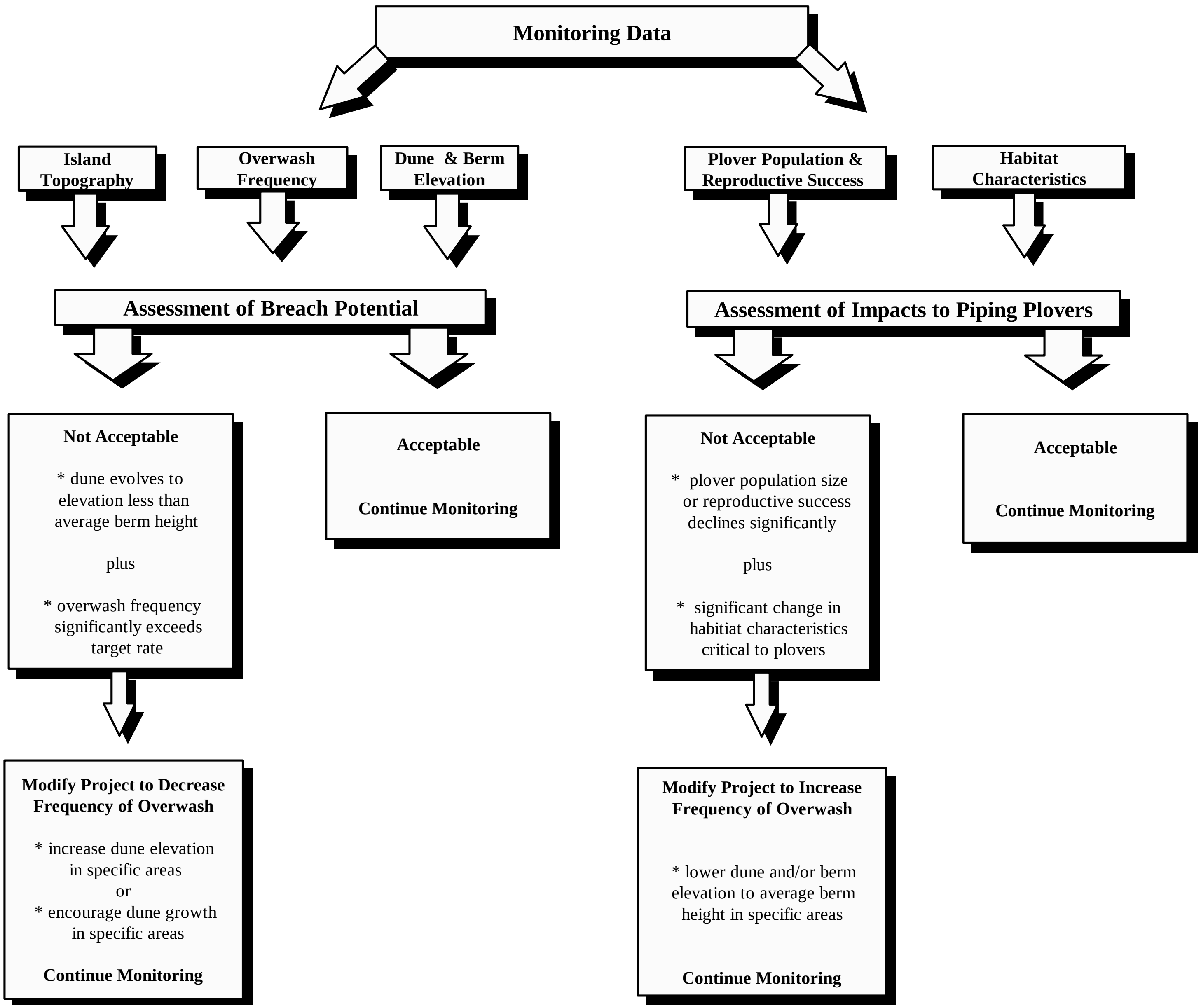


Figure 3

Conceptual Model of Mitigation Decision Tree



ANNEX F

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Ocean City, Maryland, and Vicinity Water Resources Study

Restoration of Assateague Island

Appendices

June 1998

APPENDIX A

COASTAL ENGINEERING ANALYSIS

Ocean City, Maryland, and Vicinity Water Resources Interim Report

Appendix A
Coastal Engineering Analysis

INTRODUCTION

The following sections describe in detail the technical studies that were conducted in support of the Ocean City Water Resources Study. These sections were prepared for the Baltimore District by the Waterways Experiment Station, Coastal Engineering Research Center. The first section deals with wave transformation and potential longshore sediment transport modeling. This work was conducted to support the sediment budget formulation required for the study as well as assessing the effects of mining offshore shoals on the shoreline.

The second section describes the Ocean City Inlet sediment budget. This work documents the present day sediment budget and provides information that helped address island restoration design issues. The next section documents the design of the restoration project cross-section, while the fourth section describes the numerical modeling of the tidal hydraulics and storm surge analysis. This information was useful in evaluating problems associated with potential breaching of the northern end of Assateague Island.

This interim report provides information as it pertains to the short-term restoration of Assateague Island. As other study components (i.e. long-term sand placement, navigation, etc.) progress, these sections will be updated for the second report, with the exception of section A3 (*Design of Restoration Project Cross-Section*), which will be final in the final interim report. Additional sections will also be added for the second report. Namely, these sections will be *Inlet Sand Management*, *Sediment Pathways*, and *Ebb Shoal Evolution*.

APPENDICES

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Appendix A1
Wave Transformation and Potential Longshore Sediment Transport Modeling

Introduction

Ocean City Inlet is bounded to the south by Assateague Island and to the north by Fenwick Island along the Atlantic coast of Maryland. The offshore bathymetry along this reach of shoreline is irregular with the presence of numerous shoals that affect transformation of shore-approaching waves. The influence of the offshore shoals on the nearshore wave climate and (consequently longshore sediment transport) requires wave transformation modeling to properly define longshore sediment transport trends. This chapter describes and documents methods used and results obtained from the modeling of wave transformation and potential longshore sediment transport for shorelines adjacent to Ocean City Inlet. Results from longshore sediment transport modeling are later used in developing the sediment budget.

Wave Modeling

The numerical wave model REF/DIF was chosen to model wave transformation over the offshore bathymetries near Ocean City Inlet, MD. REF/DIF was selected for its accurate wave propagation scheme and ability to simulate wave transformation over complex bathymetry. Given off-shore wave conditions and the offshore bathymetry, REF/DIF can be used to define the nearshore wave climate.

The numerical wave model, REF/DIF

The model REF/DIF is a combined refraction/diffraction model based on Booij's (1981) parabolic approximation for Berkoff's (1973) mild slope equation, in which reflected waves are neglected. Booij's model is valid for waves propagating within ±60 degrees of the input direction. The mild slope equation, in terms of the horizontal gradient operator, is given by

$$\nabla \cdot CC_g \nabla A + \sigma^2 \frac{C_g}{C} A = 0 \qquad \textbf{(A1-1)}$$

where:

C = wave celerity
C_g = group velocity
σ = angular frequency
A = wave amplitude

and the linear dispersion relationship is $\sigma^2 = gk\ tanh\ kh$, where g is the gravitational constant, k is the wave number, and h is the water depth. Kirby (1986) expanded the valid wave directions within the model to ±70° from the assumed principal wave direction by using a minimax wide angle parabolic approximation.

The model is based on Stokes perturbation expansion. In order to have a model that is valid in shallow water outside the Stokes range of validity, a dispersion relationship which accounts for the nonlinear effects of amplitude is provided. This relationship, developed by Hedges (1976), is

$$\sigma^2 = gk\ \tanh(kh(1+|A|/h)) \qquad \textbf{(A1-2)}$$

The Hedges form is fit with the Stokes relationship to form a model valid in shallow and deep water. The model can be operated in three different modes 1) linear 2) Stokes-to-Hedges nonlinear model and 3) Stokes weakly nonlinear. The model was used in the linear mode for this study.

Land boundaries such as coastlines and islands are modeled using the thin film approach in which the surface piercing feature is replaced by shoals with very shallow depth (less than 0.1 depth units). Applications of REF/DIF may be found in Kirby and Dalrymple (1986) and Dalrymple et al. (1984). Version 2.5 of REF/DIF (Kirby and Dalrymple 1994) was used in this study with some modifications required to meet the study requirements.

Grid Formulation

To represent effects of irregular offshore bathymetry on the nearshore wave climate, the offshore bathymetry must first be defined in a numerical grid. The numerical domain to be modeled should be selected such that features affecting transformation processes are included.

Offshore Bathymetry. The offshore bathymetry of the Fenwick and Assateague Island study domain is complex. Several large offshore shoals and the ebb shoal of Ocean City Inlet each influence the character of the nearshore wave climate by creating converging and diverging wave patterns. East of northern Assateague Island are two distinct features, Little Gull and Great Gull Banks

(Figure A1-1). Each shoal is approximately 8 km in length and 1 km in breadth with water depths at the crest ranging from 4.5 to 5.0 m referenced to the National Geodetic Vertical Datum (NGVD). Both shoals are oriented between 40° and 45° East of North (oriented approximately southwest to northeast).

The offshore bathymetry of southern Fenwick Island (Figure A1-1) is similar in complexity to that of Assateague Island. Several elongated shoals in the nearshore bathymetry are evident and have been associated with areas of higher erosion at Ocean City, MD (Stauble et al. 1993). Further offshore are Isle of Wight Shoal (6.0 m depth NGVD at crest) and Fenwick Shoal (4.5 m depth NGVD at crest).

The large offshore features found in the study domain are capable of causing converging and diverging wave patterns at the nearshore and therefore were included in the numerical domain. The irregular nearshore wave climate resulting from transformation over the shoals will likely produce gradients in longshore sediment transport and result in regions of erosion and accretion along the coast. Through the use of an appropriate numerical wave model, the influence of the irregular offshore bathymetry on the nearshore wave climate and longshore sediment transport can be represented.

Selection of domain. Due to the large size of the combined Assateague and Fenwick Island study domain, two separate but overlapping modeling domains were developed. Selection of the two wave modeling domains involved consideration of many competing factors. The domains were required to be large enough to include bathymetric influences affecting the nearshore wave climate and to reduce lateral boundary effects in the areas of interest. The domains were also required to be small enough to permit efficient processing of the modeled conditions with available computing resources. The selection of the numerical domain was made such that the longshore orientation of the domain corresponded to the general shoreline orientation of the study reach, 15.5° East of North.

The domain for northern Assateague Island was established as an area with a longshore dimension of 18.45 km and a cross-shore dimension of 11.55 km (extending offshore to include Little Gull and Great Gull Banks). This numerical domain was discretized as a uniform rectangular grid with horizontal resolution of 150 m and 75 m in the longshore and cross-shore directions, respectively. The northern-most lateral boundary of the Assateague Island grid is located approximately 3.6 km north-northeast of Ocean City Inlet.

The numerical domain of southern Fenwick Island was established as an area with a longshore dimension of 26.0 km and a cross-shore dimension of 15.05 km (extending offshore to include both Isle of Wight and Fenwick Shoals). This domain was discretized with horizontal resolution of 100 m and 50 m in the longshore and cross-shore directions, respectively. The bathymetric grid for the

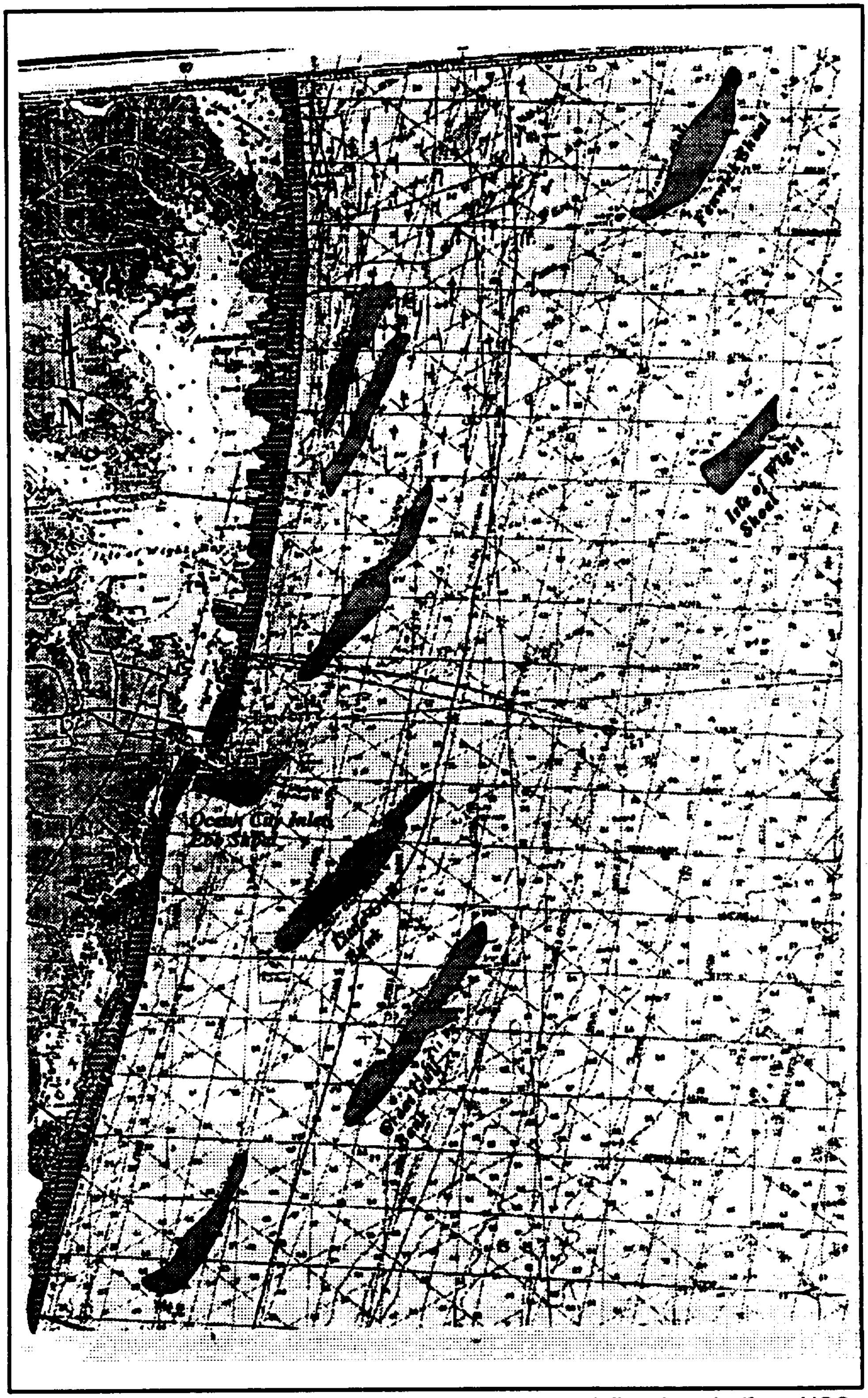

Figure A1-1. Offshore bathymetry of OCWRS wave modeling domain (from NOS chart 12211)

Fenwick Island domain was more finely discretized than the Assateague Island domain to better resolve the nearshore wave information defining the hotspot regions near Ocean City. The southern-most lateral boundary of the Fenwick Island domain is located approximately 5.8 km south-southwest of Ocean City Inlet, overlapping the northern-most portion of the Assateague Island modeling domain. The size and position of both the Fenwick Island and Assateague Island numerical wave modeling domains are presented in Figure A1-2.

Bathymetric data. Bathymetric data used to develop the numerical domain were obtained from several data sources. The primary data source was the NOS bathymetric database consisting of survey data from the years 1976-1977. Supplemental data covering the nearshore bathymetry and ebb shoal bathymetry were provided by US Army Engineer District, Baltimore (CENAB). Bathymetric data for the nearshore region were obtained from 1993 beach profile surveys, and the bathymetric data defining the ebb shoal were obtained from 1995 boat surveys.

With-project bathymetry. Beach-fill sediments for the proposed Assateague Island beach erosion and flood protection project may potentially be removed from a borrow area located on and adjacent to Great Gull Bank. The borrow area covers an estimated area of 4.8 km^2 as represented in Figure A1-3. An estimate of material required for the initial beach-fill construction is 1.4 million m^3. At the time potential transport computations were made, the estimated maximum volume to be removed from the borrow area was 10 million m^3. Since that time, a decision was made to only remove a volume of 1.4 million m^3 from the borrow area at Great Gull Bank.

For the purpose of modeling the effect of the dredged borrow area on the nearshore wave conditions and potential longshore sediment transport, the bathymetric grid was modified using a basic set of assumptions. First, the bathymetry outside of the borrow area is not allowed to adjust with removal of material from within the borrow area. In addition, a prescribed stable slope defines the maximum slope allowed within the borrow area. The maximum stable slope for the borrow area at Great Gull Bank is estimated by determining the maximum slope of the shoal (1.9 degrees or 1V:30H on the seaward edge of the shoal). Using the borrow area domain, the 1.9 degree stable slope, and the 10 million m^3 of material initially assumed to be removed from the borrow area, the bathymetry of the borrow area was modified as indicated in Figure A1-4.

WIS hindcast information

The offshore wave climate directly influences nearshore wave conditions and therefore must be characterized before the wave model is used to define the nearshore wave conditions. Characterization of the offshore wave climate requires long-term measurements or estimates of wave height, period, and direction. In the absence of long-term measured wave data near the project location, hindcast

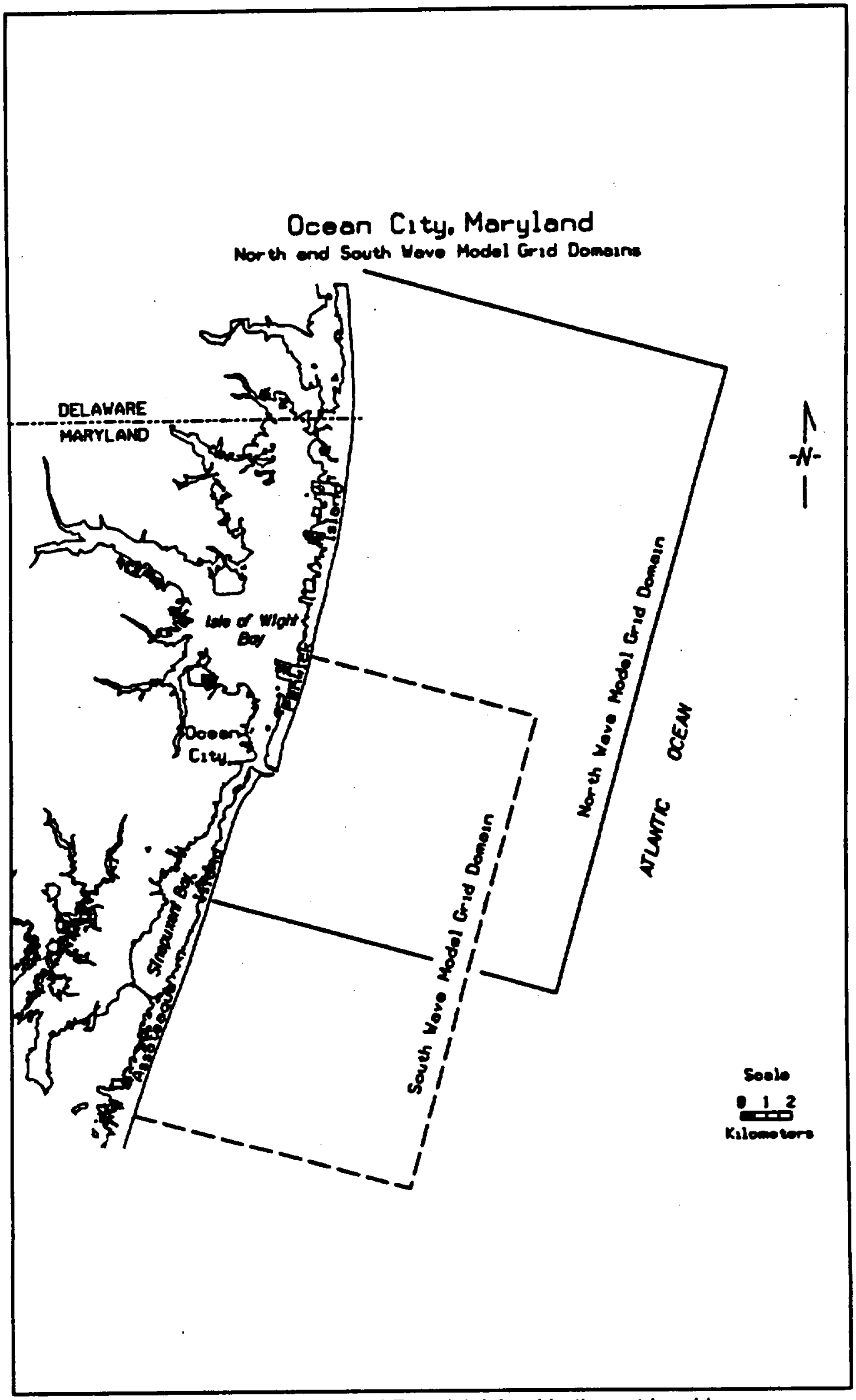

Figure A1-2. Assateague Island and Fenwick Island bathymetric grids

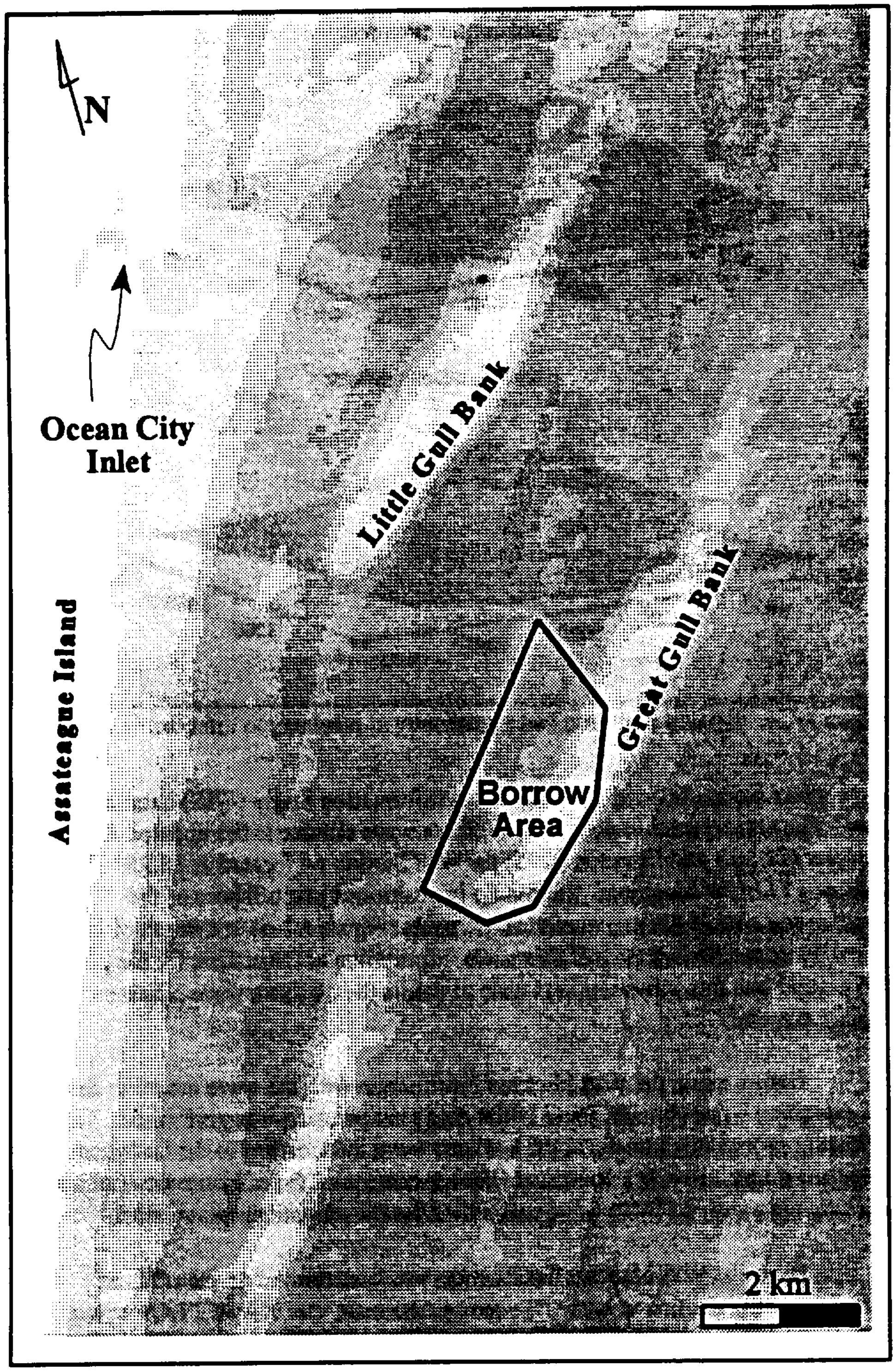

Figure A1-3. Great Gull Bank borrow area

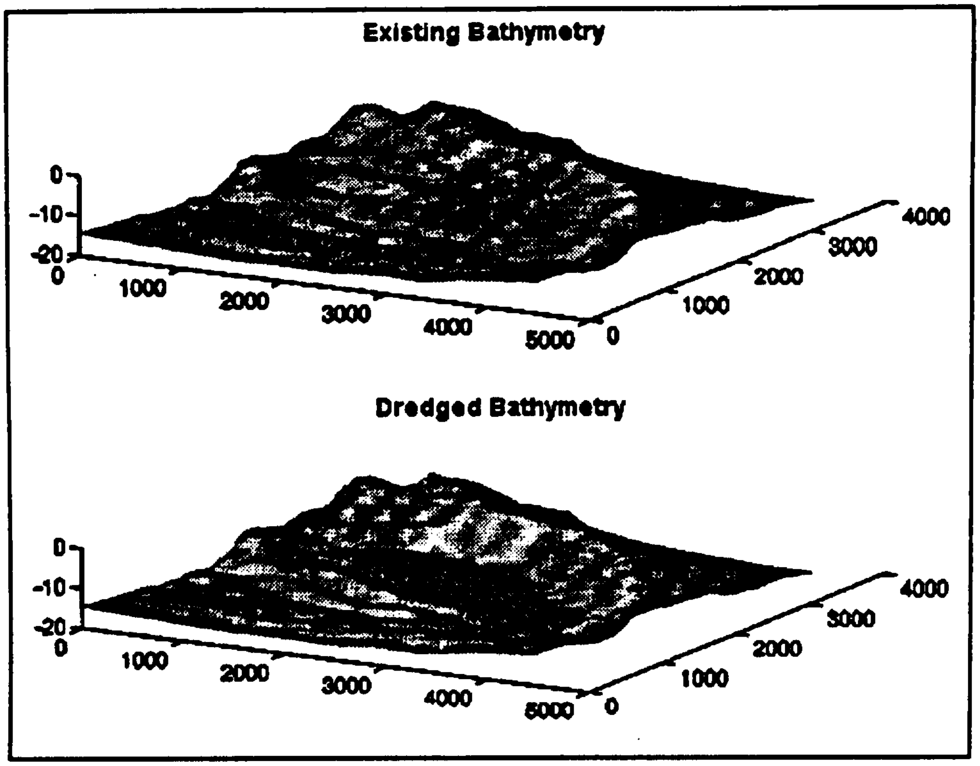

Figure A1-4. Existing and modified bathymetry in proximity to the borrow area

wave information obtained from the Wave Information Study (WIS) database was used. The dataset used to define the offshore wave climate is the updated Atlantic hindcast (Brooks and Brandon 1995) for WIS Station 64 located at 38.25° N latitude 75.00° W longitude. Station 64 is positioned just offshore of the overlapping area of the two numerical domains (Figure A1-5) at a depth of 16 m. The WIS updated hindcast includes wave information at the station for the period 1976-1993 and this information is used to define the offshore wave climate for the project domain.

Before using the WIS hindcast information with the wave model to define the nearshore wave climate, some initial data manipulation was performed. The following procedures transform the hindcast wave information to the bathymetric reference frame, provide a statistical characterization of the offshore wave climate, and provide a suite of input wave conditions for the numerical wave model.

First, the WIS hindcast information was transformed to the offshore boundary of the numerical grid. To perform this task, the WAVETRAN utility (Gravens 1992) of the Shoreline Modeling System (SMS) was used. WAVETRAN treats the hindcast waves in a spectral fashion and computes a Snell's law transformation from the depth of the WIS station to an arbitrary depth (in this case, the nominal depth of the offshore boundary of the bathymetric grid). WAVETRAN

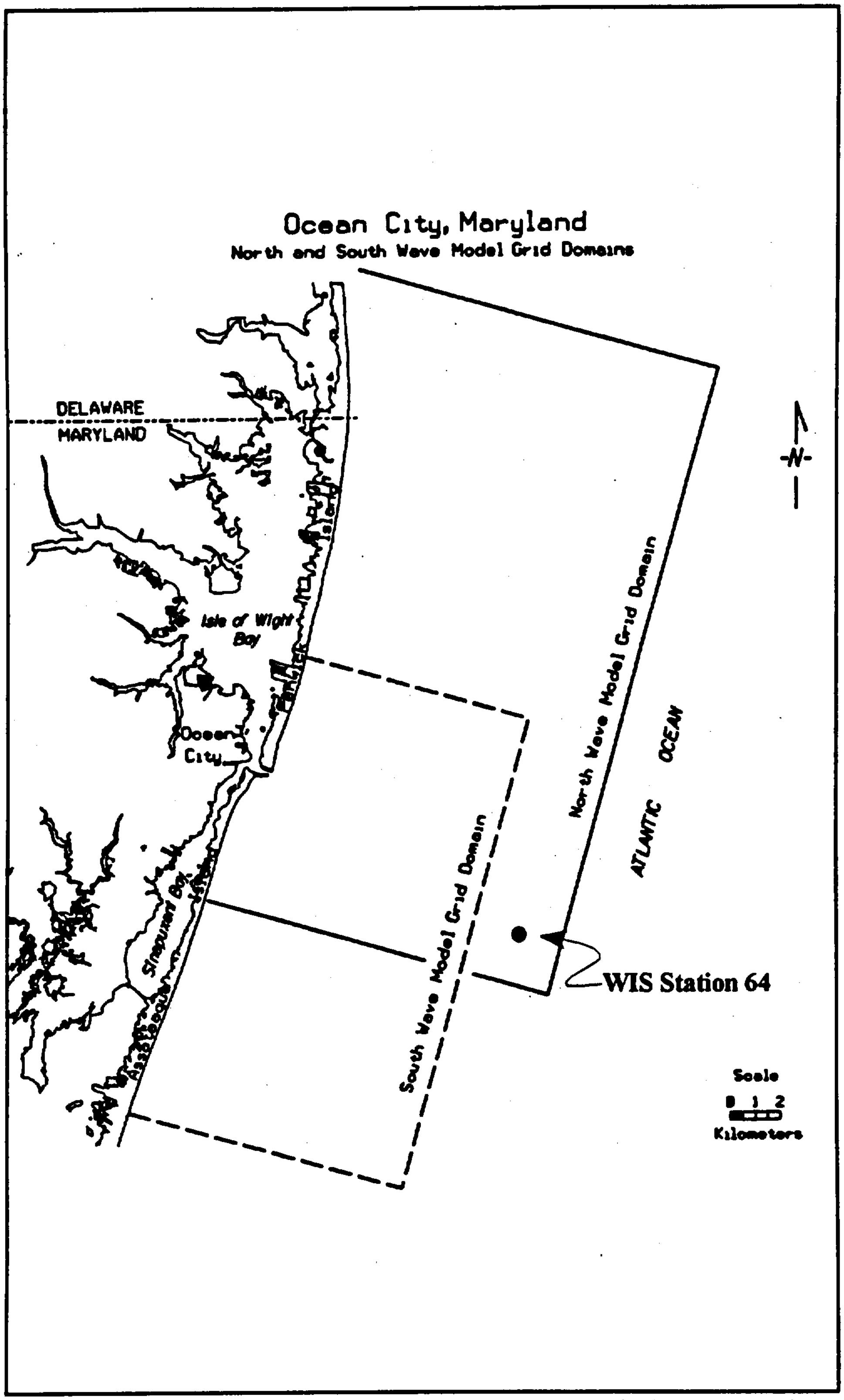

Figure A1-5. Location of WIS Station 64 in proximity to model grids and domain also converts the wave direction convention from meteorological (relative to true north) to a convention relative to shoreline orientation.

To efficiently represent all 105,200 wave events in the hindcast time series, classification of wave events was necessary. The entire time series can be represented by a much smaller number of wave cases by classifying wave events into a smaller number of similar cases. From linear wave theory, both wave refraction and shoaling are independent of wave height. Therefore, offshore waves with similar wave direction and period transform similarly and can be classified into a representative group. A procedure used to classify wave events into representative groups is outlined by Gravens, Kraus, and Hanson (1991). Definitions of angle and period bands used by this procedure to characterize offshore wave data at Station 64 are presented in Table A1-1. The Shoreline Modeling System (SMS) utility WHEREWAV (Gravens 1992) was used to characterize the offshore wave climate. WHEREWAV compiles statistics for the hindcast period using the angle and period bands defined in Table A1-1. These statistics define angle and period combinations occurring within the hindcast record. Results from WHEREWAV are used to generate a suite of wave modeling input conditions. Output from the WHEREWAV utility is presented in Figure A1-6.

With the wave climate at the offshore boundary of the modeling domain defined, preparation of the hindcast wave data for input to the numerical wave model was concluded. Combinations of angle and period bands from Table A1-1 that are populated in the WIS hindcast time series were used as input conditions for the wave model.

Table A1-1
Offshore Wave Climate Discretization

Angle Band	Angles with respect to shore normal (deg)	Period Band	Wave Period (sec)
1	$90.00 \le \theta < 71.75$	1	$5 < T$
2	$71.75 \le \theta < 49.25$	2	$5 \le T < 7$
3	$49.25 \le \theta < 26.75$	3	$7 \le T < 9$
4	$26.75 \le \theta < 4.25$	4	$9 \le T < 11$
5	$4.25 \le \theta < -18.25$	5	$11 \le T < 13$
6	$-18.25 \le \theta < -40.75$	6	$13 \le T < 15$
7	$-40.75 \le \theta < -63.25$	7	$15 \le T < 17$
8	$-63.25 \le \theta < -85.75$	8	$17 \le T < 23$
9	$-85.75 \le \theta < -90.00$	9	$23 \le T$

WAVE CLASSIFICATION & STATISTICS FOR INPUT TIME SERIES: au64p3.cts
THE FOLLOWING CLASSIFICATIONS ARE BASED ON A SHORELINE ORIENTATION OF: 15.50

NUMBER OF RECORDS PROCESSED................................	52600
NUMBER OF CALM PRIMARY COMPONENT EVENTS	10997
NUMBER OF CALM SECONDARY COMPONENT EVENTS	38025
NUMBER OF OFFSHORE TRAVELING PRIMARY COMPONENT EVENTS	0
NUMBER OF OFFSHORE TRAVELING SECONDARY COMPONENT EVENTS	0

CLASSIFICATION OF COMBINED WAVE EVENTS BY ANGLE BAND

ANGLE BAND NUMBER	NUMBER OF EVENTS	AVERAGE WAVE ANGLE (W.R.T. SHORE-NORMAL)	AVERAGE WAVE HEIGHT	PERIOD BANDS
1	1873	74.56	0.84	1 2 3 4
2	3662	62.28	1.07	1 2 3 4 5
3	6127	34.89	0.98	1 2 3 4 5 6 7
4	13572	14.63	1.02	1 2 3 4 5 6 7 8
5	11924	-7.05	0.92	1 2 3 4 5 6 7 8 9
6	7990	-27.42	0.85	1 2 3 4 5 6 7 8
7	5225	-53.30	0.95	1 2 3 4 5
8	5805	-69.61	0.80	1 2 3 4
9	0	-	-	-

CLASSIFICATION OF COMBINED WAVE EVENTS BY PERIOD BAND

PERIOD BAND NUMBER	NUMBER OF EVENTS	AVERAGE PERIOD	AVERAGE WAVE HEIGHT	ANGLE BANDS
1	6016	3.83	0.58	1 2 3 4 5 6 7 8
2	13495	5.51	0.92	1 2 3 4 5 6 7 8
3	13526	7.53	0.95	1 2 3 4 5 6 7 8
4	11690	9.47	0.92	1 2 3 4 5 6 7 8
5	6914	11.42	1.08	2 3 4 5 6 7
6	3127	13.36	1.25	3 4 5 6
7	1015	15.36	1.34	3 4 5 6
8	394	18.27	1.50	4 5 6
9	1	24.00	0.40	5

CLASSIFICATION OF PRIMARY WAVE EVENTS BY ANGLE BAND

ANGLE BAND NUMBER	NUMBER OF EVENTS	AVERAGE WAVE ANGLE (W.R.T. SHORE-NORMAL)	AVERAGE WAVE HEIGHT	PERIOD BANDS
1	1310	74.60	0.90	1 2 3 4
2	2221	62.22	1.23	1 2 3 4 5
3	4101	34.08	1.14	1 2 3 4 5 6 7
4	11008	14.45	1.11	1 2 3 4 5 6 7 8
5	9588	-6.85	1.01	1 2 3 4 5 6 7 8 9
6	6025	-27.11	0.95	1 2 3 4 5 6 7 8
7	3322	-53.33	1.13	1 2 3 4 5
8	4028	-69.54	0.88	1 2 3 4
9	0	-	-	-

CLASSIFICATION OF PRIMARY WAVE EVENTS BY PERIOD BAND

PERIOD BAND NUMBER	NUMBER OF EVENTS	AVERAGE PERIOD	AVERAGE WAVE HEIGHT	ANGLE BANDS
1	2661	3.87	0.63	1 2 3 4 5 6 7 8
2	9846	5.56	0.99	1 2 3 4 5 6 7 8
3	10444	7.53	1.04	1 2 3 4 5 6 7 8
4	9084	9.47	1.01	1 2 3 4 5 6 7 8
5	5626	11.42	1.19	2 3 4 5 6 7
6	2704	13.36	1.35	3 4 5 6
7	875	15.37	1.46	3 4 5 6
8	362	18.29	1.58	4 5 6
9	1	24.00	0.40	5

CLASSIFICATION OF SECONDARY WAVE EVENTS BY ANGLE BAND

ANGLE BAND NUMBER	NUMBER OF EVENTS	AVERAGE WAVE ANGLE (W.R.T. SHORE-NORMAL)	AVERAGE WAVE HEIGHT	PERIOD BANDS
1	563	74.47	0.71	1 2 3 4
2	1441	62.38	0.83	1 2 3 4
3	2026	36.54	0.67	1 2 3 4 5 6 7
4	2564	15.39	0.62	1 2 3 4 5 6 7 8
5	2336	-7.90	0.58	1 2 3 4 5 6 7 8
6	1965	-28.37	0.56	1 2 3 4 5 6 7
7	1903	-53.26	0.62	1 2 3 4
8	1777	-69.77	0.61	1 2 3 4
9	0	-	-	-

CLASSIFICATION OF SECONDARY WAVE EVENTS BY PERIOD BAND

PERIOD BAND NUMBER	NUMBER OF EVENTS	AVERAGE PERIOD	AVERAGE WAVE HEIGHT	ANGLE BANDS
1	3355	3.80	0.53	1 2 3 4 5 6 7 8
2	3649	5.40	0.73	1 2 3 4 5 6 7 8
3	3082	7.55	0.67	1 2 3 4 5 6 7 8
4	2606	9.45	0.61	1 2 3 4 5 6 7 8
5	1288	11.40	0.62	3 4 5 6
6	423	13.35	0.60	3 4 5 6
7	140	15.26	0.60	3 4 5 6
8	32	17.97	0.59	4 5
9	0	-	-	-

Figure A1-6. WHEREWAV output for WIS Station 64 waves at model boundary

Nearshore reference line

The concept of using 50 discrete wave cases to represent the entire time series is based on the independence of refraction and shoaling of linear waves to wave height implied by linear wave theory. Considering linear wave theory, a unit wave height may be applied to the offshore boundary of the numerical model allowing model-computed wave heights to be interpreted as wave height multipliers. The nearshore wave height for any offshore event within the bounds of the wave period and direction definition for a given model simulation is given by the product of the wave transformation multiplier at the specified nearshore location and the offshore wave height from the transformed WIS hindcast time series. This technique is valid only for events in which wave breaking does not occur seaward of the point where the wave height multiplier is obtained.

To output wave transformation height multipliers at specified nearshore locations, a nearshore reference line is established. The purpose of the nearshore reference line is to act as a location where wave height multipliers and wave directions representing the nearshore wave conditions are output. The nearshore reference line should be positioned close enough to shore to include the effects of the offshore bathymetry on the nearshore wave climate, but seaward of wave breaking. To balance these two competing objectives, a trial and error procedure was used to locate the breaker line for wave events with the largest wave heights from the WIS hindcast time series. This exercise led to the establishment of the nearshore reference line at a nominal depth of 6.0 m NGVD. By locating the nearshore reference line at this depth, 99.3 percent of wave events in the hindcast time series did not break seaward of the reference line.

Although the nominal depth of the nearshore reference line was established, one additional problem existed: How to include the effects of the Ocean City Ebb Shoal? The ebb shoal certainly exerts some influence on the local wave climate thereby influencing the shorelines adjacent to Ocean City Inlet. For extreme wave events, breaking occurs over the outer lobe of the ebb shoal, and use of the wave height multiplier shoreward of this location is not valid. However, for calmer wave events, waves do not break on the outer margins of the ebb shoal but are refracted by the shoal and break closer to shore. The problem of positioning the nearshore reference line in the vicinity of the ebb shoal was addressed by forming two nearshore reference lines: one that skirts the outer margin of the ebb shoal at a nominal depth of 6 m NGVD, and a second that crosses the ebb shoal shoreward of the outer lobe at a nominal depth of 4-5 m NGVD. These two reference lines are later used independently to compute potential longshore sediment transport rates.

Production runs

Each of the 50 input conditions were applied to the offshore boundary of the modeling domains for Assateague and Fenwick Islands. The without-project condition was modeled at both Fenwick and Assateague Islands and the with-project condition was modeled using the dredged condition of Great Gull Bank. Wave model results for each case were output at each of the two nearshore reference lines and used to develop nearshore wave databases for existing conditions at Assateague and Fenwick Islands and for the with-project condition at Assateague Island.

Existing nearshore wave climate

The results of the REF/DIF wave modeling illustrate the effects of the complex offshore bathymetry of Fenwick and Assateague Islands on the nearshore wave climate. The wave model results along the nearshore reference line for an offshore incident wave angle of -7.4 deg relative to the cross-shore axis (azimuth of 105.5° relative to true north) of the numerical wave model grid and a wave period of 9.5 seconds (Angle Band 5, Period Band 4) for the Fenwick Island domain are presented in Figure A1-7 (the thick line represents the wave height multiplier and the thin line represents the wave direction). This figure presents wave height multipliers and wave directions (relative to the 105.5° azimuth) along the nearshore reference line. The wave case presented in Figure A1-7 represents the most commonly occurring wave condition in the transformed WIS hindcast for Station 64. The nearshore wave results presented in this figure do not indicate a smoothly varying wave field alongshore due to the nature of the monochromatic model. Neglecting the "noise" of the model, variability in the model results with length scales of 0.5 km or less, areas of wave amplification and attenuation are evident. These areas of differing wave characteristics are caused by the focusing effects of the offshore shoals near Fenwick Island.

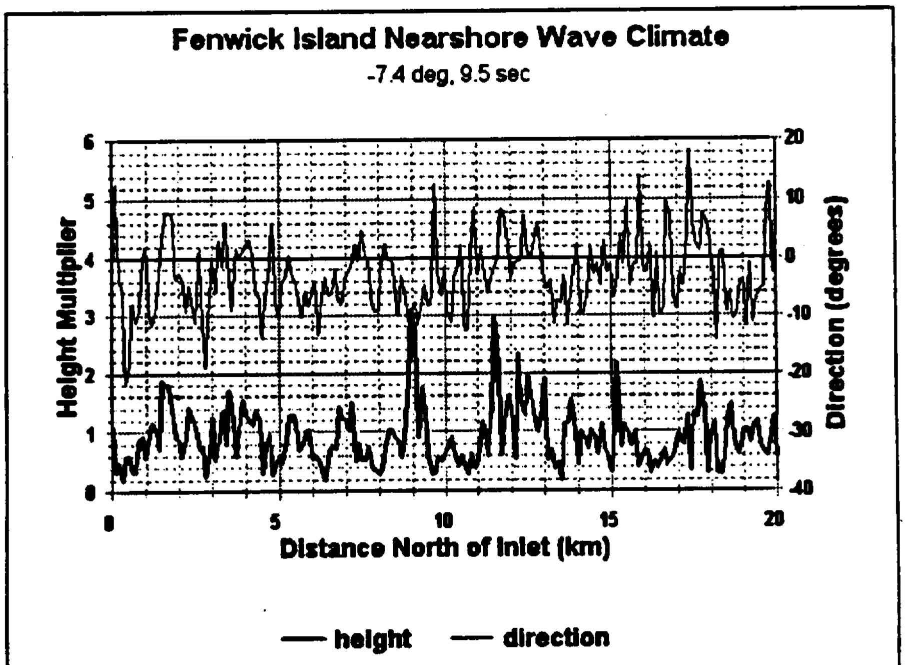

Figure A1-7. Nearshore wave properties at Assateague Island (-7.4 deg, 9.5 sec)

Wave focusing by the irregular bathymetry is sensitive to both wave direction and wave period. Change in the incident wave angle causes the effect of a particular shoal to translate alongshore. Increases and decreases in wave period cause corresponding increases and decreases in the focusing intensity of the offshore shoals. The effects of varying wave period on the intensity of wave focusing are demonstrated by comparing Figures A1-8 and A1-9 to Figure A1-7. Note that each of these figures represents the same incident wave angle with variance only in wave period. Also note that the intensity of wave focusing at 9 km, 11-13 km, and 15 km north of
Ocean City Inlet increases with an increase in wave period and decreases with a decrease in wave period. REF/DIF results representing the five most common nearshore wave conditions for Fenwick Island are presented in Figures A1-10 through A1-14. Combined, these five most frequently occurring wave events represent more than 30 percent of the entire wave record.

The nearshore wave properties for the most commonly occurring offshore wave condition (-7.4 deg, 9.5 sec) at Assateague Island are presented in Figure A1-15. In this figure, the effects of the offshore shoals at Assateague Island are seen in the nearshore wave properties, particularly at 3 km, 6.5 km, and 11.5 km south of Ocean City Inlet. These areas of focusing correspond to the effects of Little Gull Bank, Great Gull Bank, and a smaller, un-named shoal located 10-14 km south of Ocean City Inlet (offshore of the state park). The effect of the shoals within the Assateague Island domain on nearshore waves is somewhat less than the effect of the shoals within the Fenwick Island domain. The increased influence on the nearshore waves by the shoals offshore of Fenwick Island is likely related to the close proximity of several shoals to the shore. REF/DIF results representing the nearshore wave condition for the five most frequently occurring offshore wave conditions for Assateague Island are presented in Figures A1-15 through A1-19.

Project effects on nearshore wave climate

To evaluate the effects of mining Great Gull Bank on the nearshore wave climate of Assateague Island, an additional suite of wave model simulations were made using the modified bathymetry described earlier. Comparing the nearshore wave properties from these simulations to the nearshore wave properties of the existing conditions indicates the effect of the dredged borrow area on the nearshore wave climate. The typical response of waves passing over a bathymetric depression causes waves to diverge leeward of the center of the depression and to focus leeward of the flanks of the depression.

Responses of the nearshore wave properties at Assateague Island to removal of the initially assumed 10 million m^3 of material from Great Gull Bank for the five most frequent wave cases are presented in Figures A1-20 through A1-24, in terms of the change in wave height multiplier and wave direction at the nearshore reference line. Zero values indicate no effect of the shoal mining on the nearshore wave climate, whereas positive and negative changes indicate corresponding

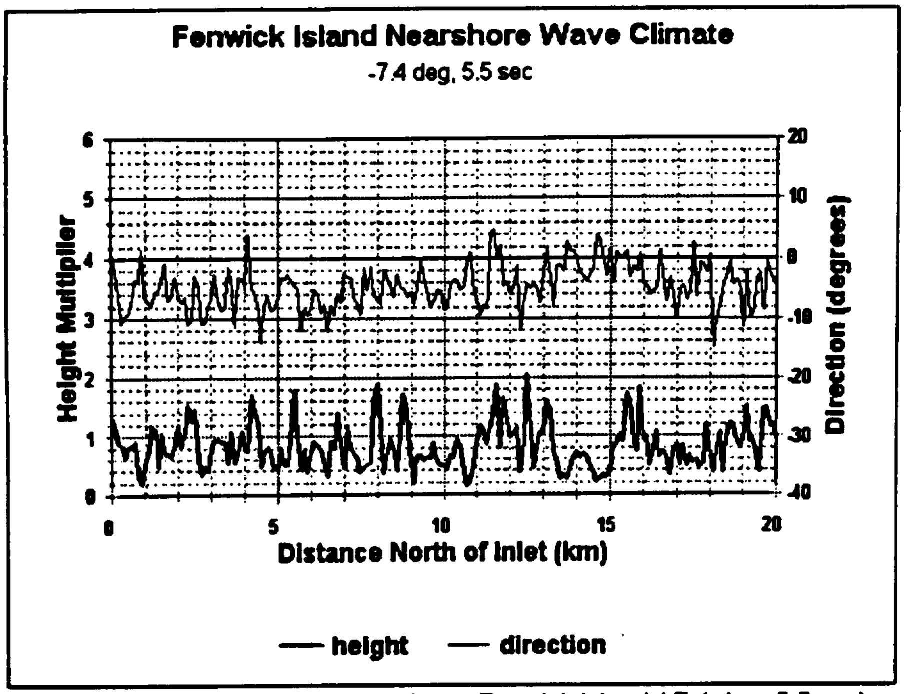

Figure A1-8. Nearshore wave properties at Fenwick Island (-7.4 deg, 5.5 sec)

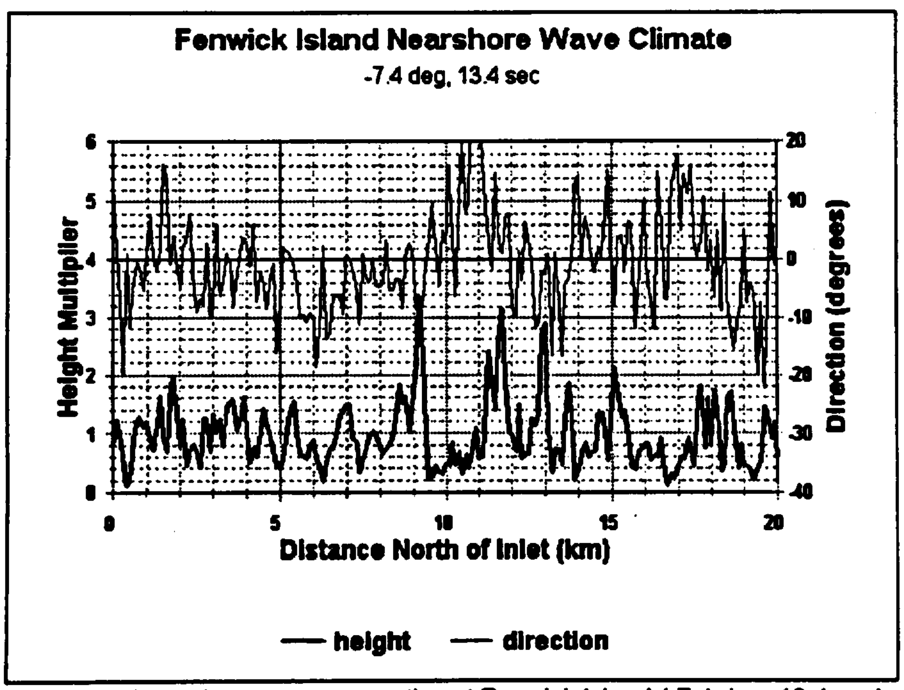

Figure A1-9. Nearshore wave properties at Fenwick Island (-7.4 deg, 13.4 sec)

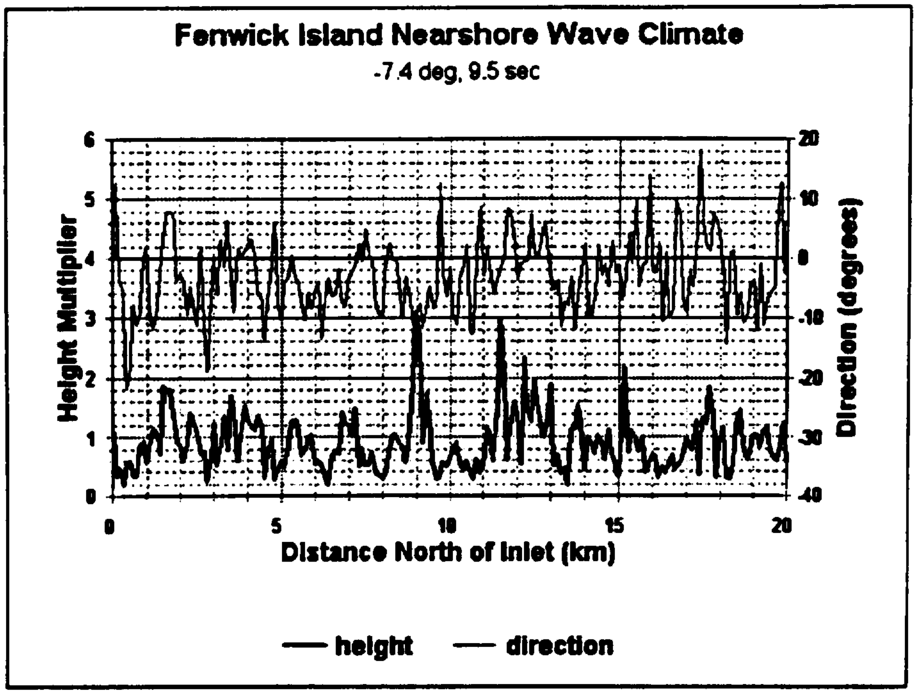

Figure A1-10. Nearshore wave properties at Fenwick Island (-7.4 deg, 9.5 sec)

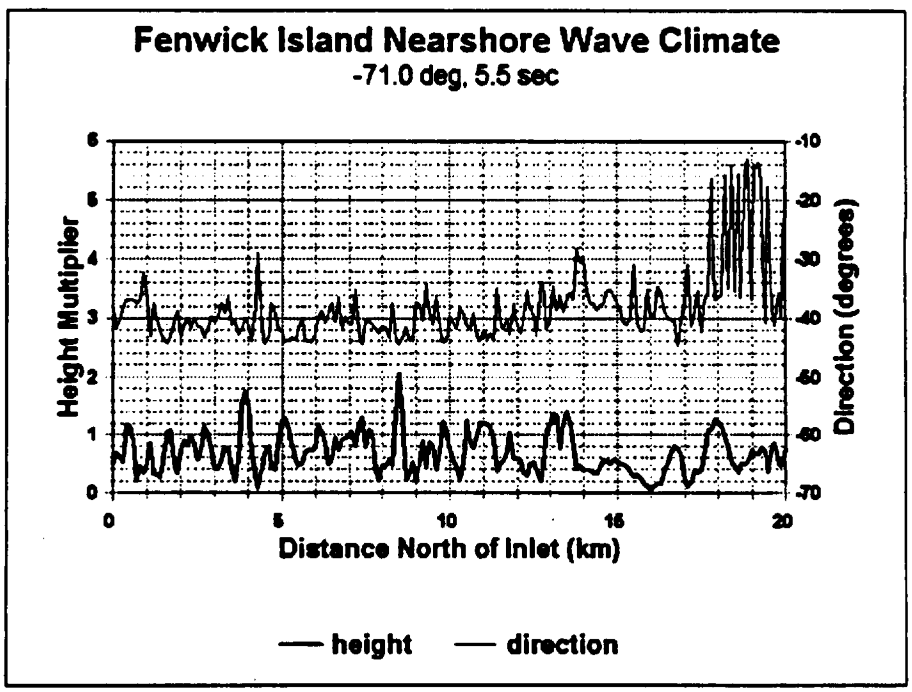

Figure A1-11. Nearshore wave properties at Fenwick Island (-71.0 deg, 5.5 sec)

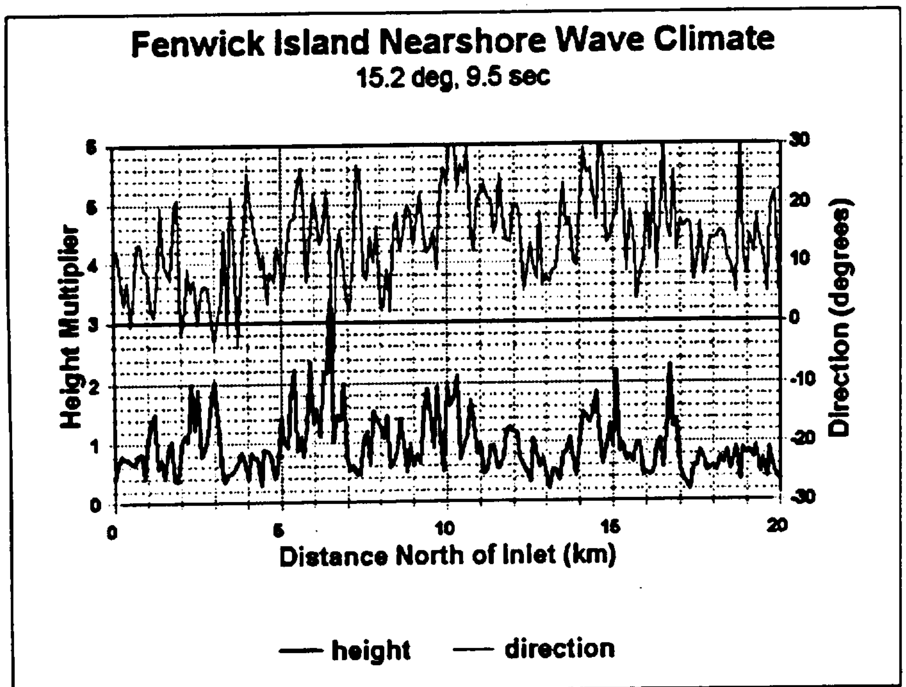

Figure A1-12. Nearshore wave properties at Fenwick Island (15.2 deg, 9.5 sec)

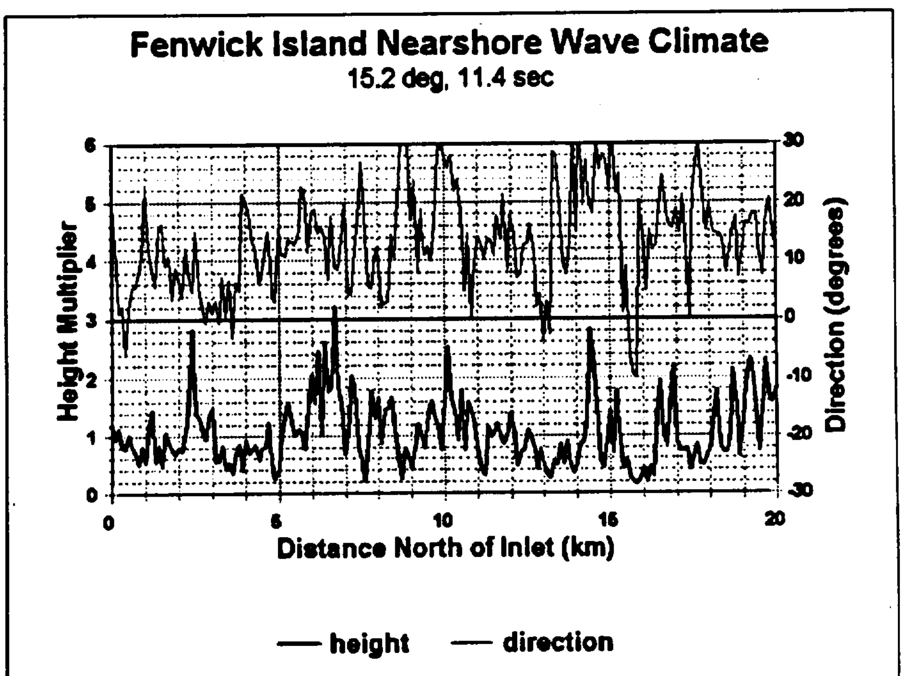

Figure A1-13. Nearshore wave properties at Fenwick Island (15.2 deg, 11.4 sec)

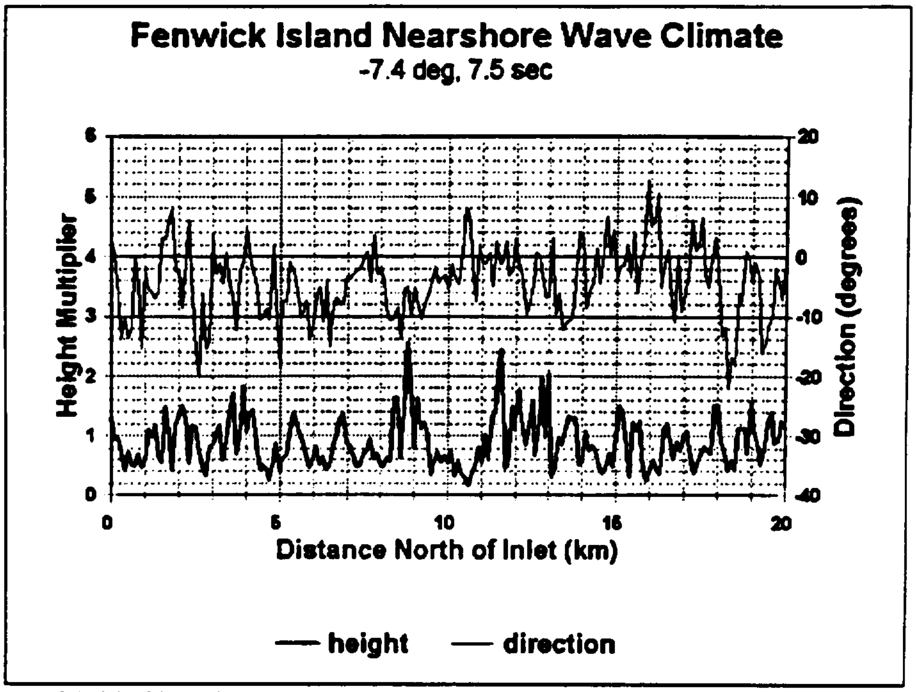

Figure A1-14. Nearshore wave properties at Fenwick Island (-7.4 deg, 7.5 sec)

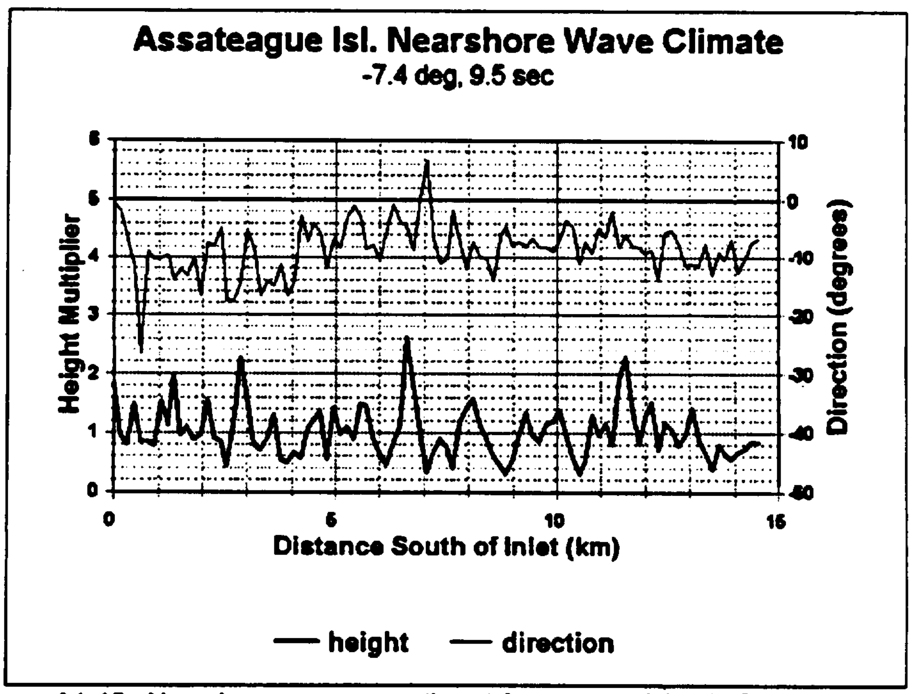

Figure A1-15. Nearshore wave properties at Assateague Island (-7.4 deg, 9.5 sec)

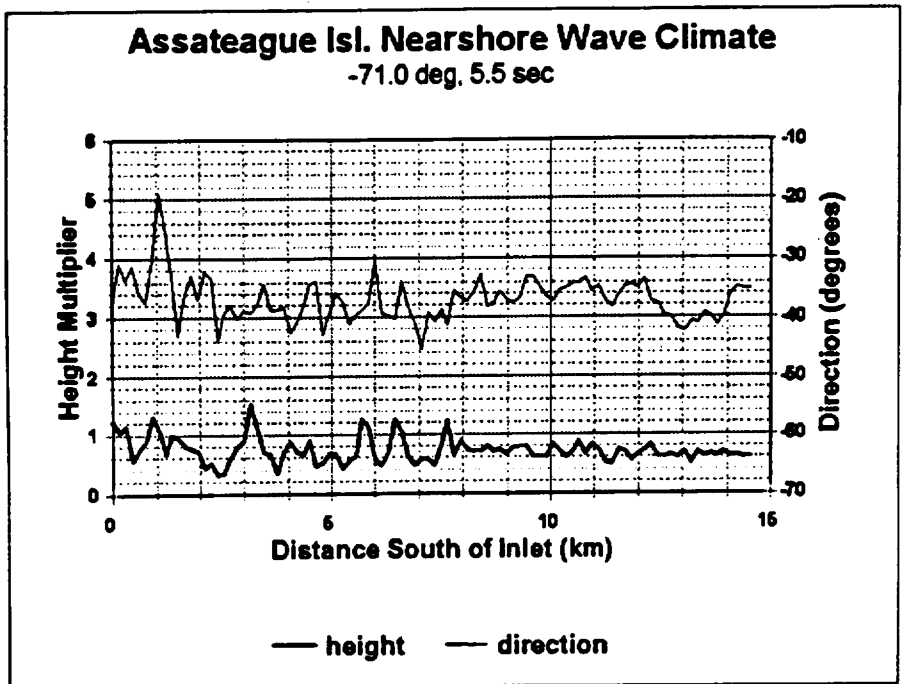

Figure A1-16. Nearshore wave properties at Assateague Island (-71.0 deg, 5.5 sec)

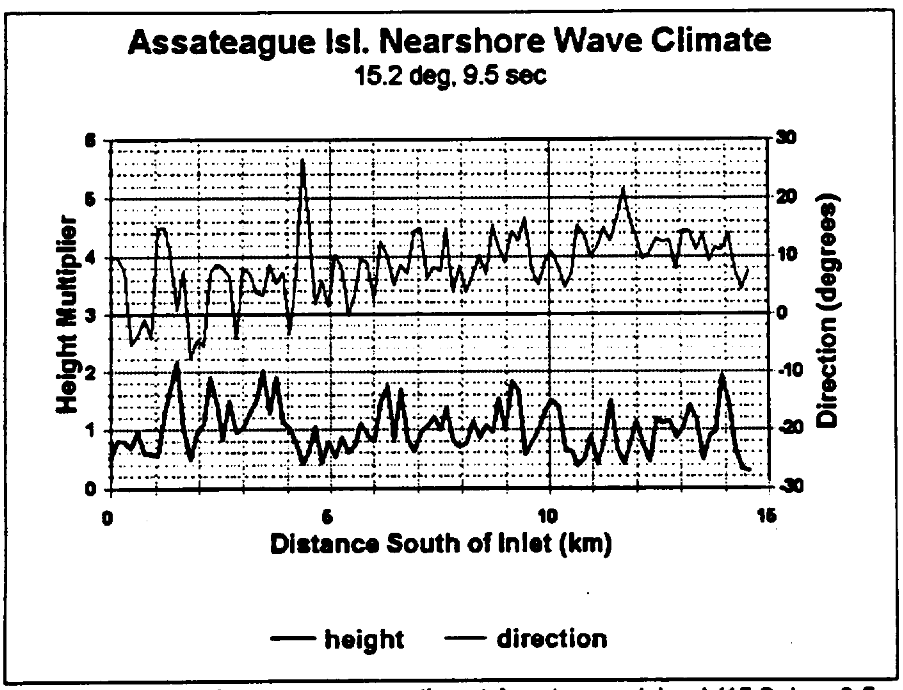

Figure A1-17. Nearshore wave properties at Assateague Island (15.2 deg, 9.5 sec)

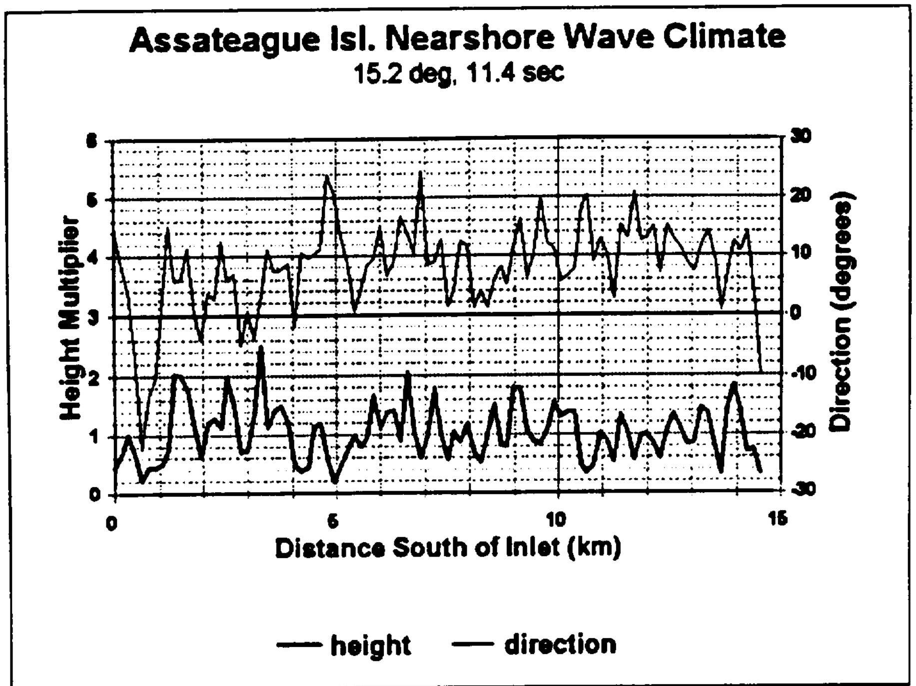

Figure A1-18. Nearshore wave properties at Assateague Island (15.2 deg, 11.4 sec)

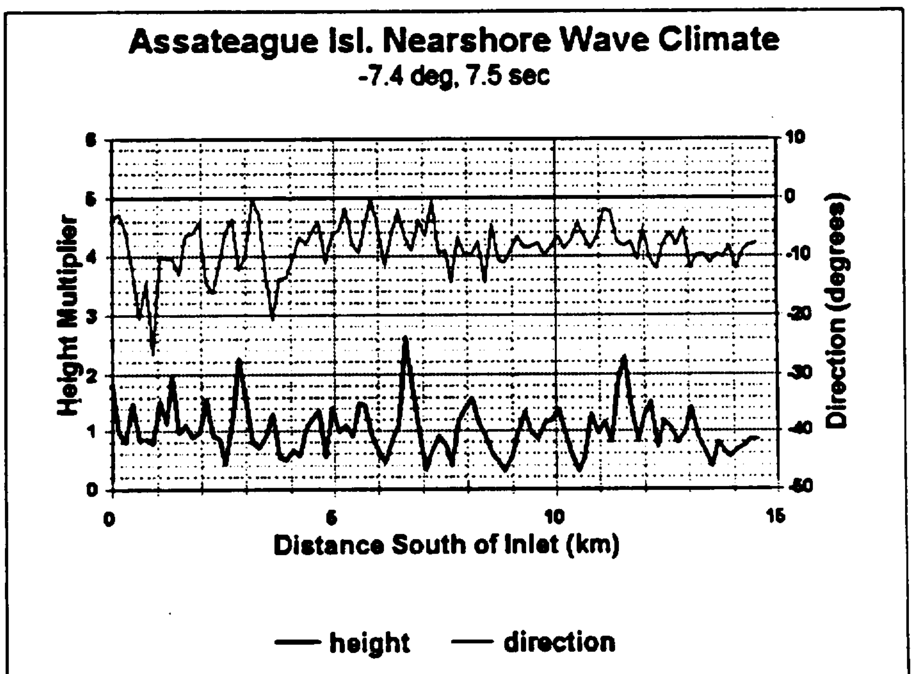

Figure A1-19. Nearshore wave properties at Assateague Island (-7.4 deg, 7.5 sec)

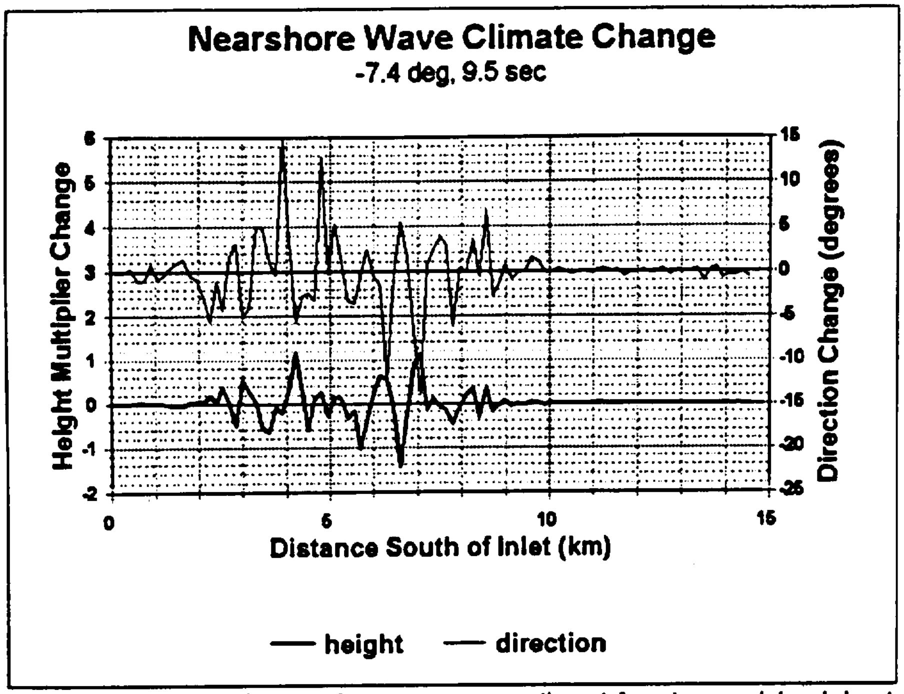

Figure A1-20. Change in nearshore wave properties at Assateague Island due to mining of Great Gull Bank (-7.4 deg, 9.5 sec)

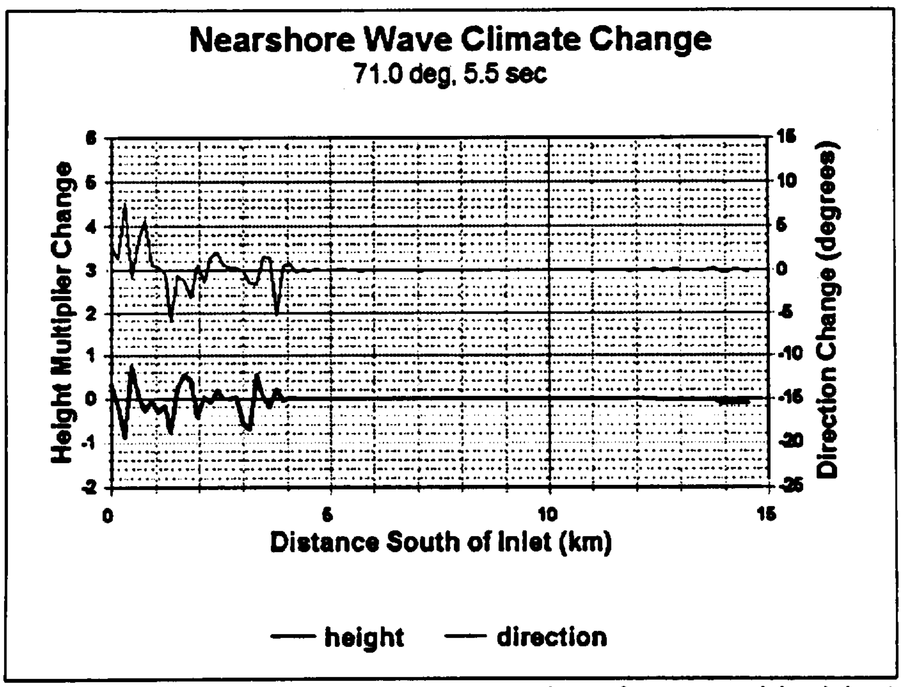

Figure A1-21. Change in nearshore wave properties at Assateague Island due to mining of Great Gull Bank (-71.0 deg, 5.5 sec)

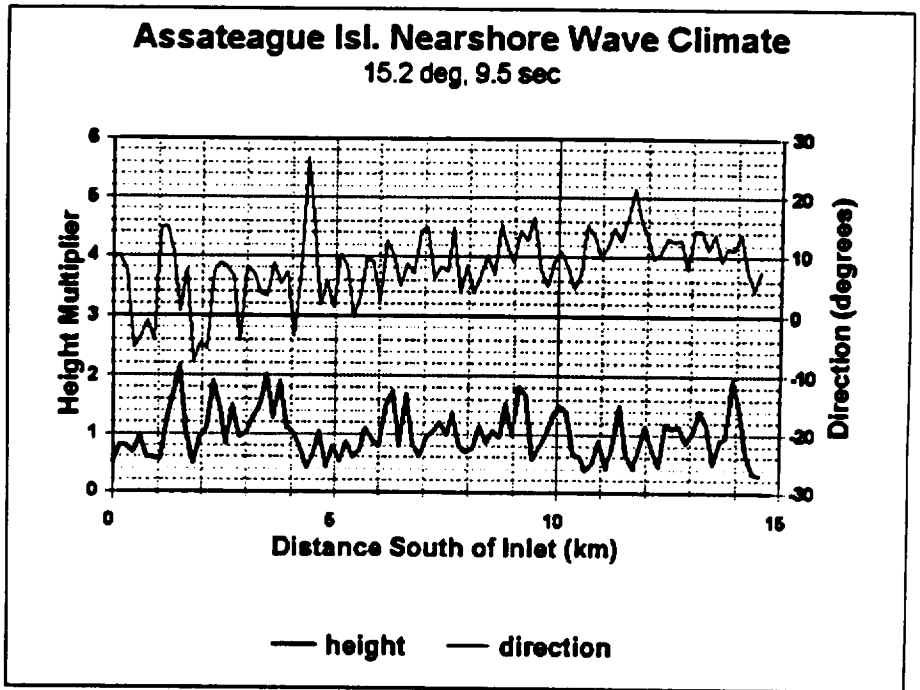

Figure A1-22. Change in nearshore wave properties at Assateague Island due to mining of Great Gull Bank (15.2 deg, 9.5 sec)

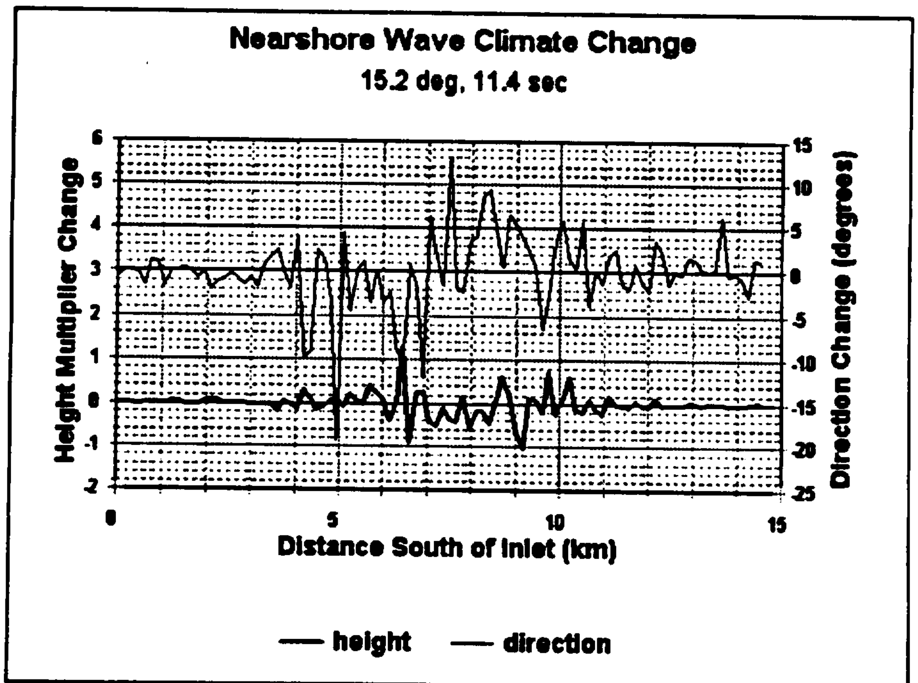

Figure A1-23. Change in nearshore wave properties at Assateague Island due to mining of Great Gull Bank (15.2 deg, 11.4 sec)

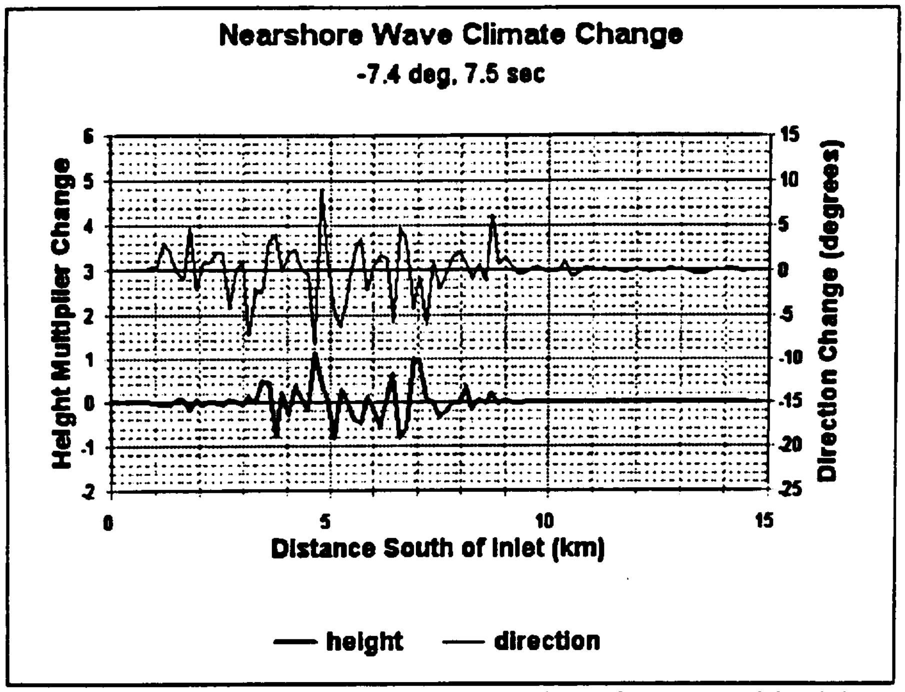

Figure A1-24. Change in nearshore wave properties at Assateague Island due to mining of Great Gull Bank (-7.4 deg, 7.5 sec)

increases and decreases in wave height and/or wave direction due to the mining of the borrow area. The wave condition presented in Figure A1-20 is the most common wave condition within the transformed WIS hindcast for Station 64. Looking at the changes in wave height multiplier and wave direction, a 5 km length of shore experiences a change in nearshore wave conditions due to the dredging of the borrow area. The complicated pattern of changed nearshore wave conditions is due to the monochromatic model's behavior over the complex offshore bathymetry. The complexity of the changes in the nearshore wave field preclude any assessment of the effect of borrow area mining on longshore sediment transport rates at this point in the study. Application of the potential longshore sand transport model is required to estimate the dredged borrow area's impacts on longshore sediment transport.

Due to the offshore distance of Great Gull Bank, the alongshore extent of affected shoreline for all wave conditions ranges from Ocean City Inlet to greater than 15 km south. However, the effect of the borrow area on nearshore wave conditions is negligible at the oblique angles necessary to affect these distant locations.

Potential Longshore Sediment Transport Rates

In support of the sediment budget formulation of the OCWRS, potential longshore sediment transport rates were computed for without-project conditions for portions of Assateague Island and Fenwick Island within the project reach. To accomplish this task, the wave modeling results were used with a modified version of the SMS utility NSTRAN (Gravens 1992) to provide estimates of average potential longshore sediment transport rates for the 18-year period of the WIS hindcast.

Potential transport model: NSTRAN

The SMS utility NSTRAN is used to estimate potential longshore sediment transport volumes and rates, given a database of nearshore wave conditions, an offshore wave time series, and location and depth of the nearshore reference line. The model performs sediment transport computations using a simple transport expression derived from the longshore wave energy flux (U.S. Army Corps of Engineers 1989) given by

$$Q = \frac{K}{16\left[\left(\rho_s/\rho\right) - 1\right] a'} \sqrt{\frac{g}{\gamma}} \frac{H_b^{5/2}}{2.386} \sin\left(2\alpha_b\right) \qquad (3)$$

where

- Q = potential longshore sand transport rate, m^3/s
- K = nondimensional empirical sand transport coefficient ($K = 0.77$)
- ρ = density of water, g/cm^3
- ρ_s = density of sediment (quartz sand, $\rho = 2.65$ g/cm^3)
- a' = volume solids/total volume (accounts for sand porosity, $a' = 0.6$)
- g = acceleration due to gravity, m/s^2
- γ = breaking wave index ($\gamma = 0.78$)
- H_b = significant wave height at breaking, m
- α_b = breaking wave angle

The calculation of longshore sediment transport using this method neglects the effects of beach slope, grain size, and availability of sediment for transport (therefore the label "potential" longshore sand transport).

NSTRAN computes potential longshore sediment transport in a straightforward manner. First, NSTRAN uses the wave direction and transformation multipliers to obtain wave height and direction at the nearshore reference line. The model assumes that the nearshore bathymetric contours (shoreward of the nearshore reference line) are straight, parallel, and of the same orientation as the wave modeling domain. Using these assumptions and the depth at the nearshore reference line, NSTRAN computes a Snell's law wave transformation from the nearshore reference line to the wave's breaking point. The resulting breaking wave height and breaking wave angle relative to the shoreline is then used to compute longshore sediment transport using Equation A1-3.

One necessary improvement to NSTRAN to allow its use in developing a sediment budget is the inclusion of local shoreline orientation. The local shoreline orientation of the OCWRS domain varies with alongshore distance. The orientation of the 1989 shorelines of Assateague and Fenwick Islands within the project reach varies by 50° from an orientation of 42° east of north to 8° west of north as seen in Figure A1-2. Since longshore sediment transport is a function of the relative orientation of the breaking wave crest to the local shoreline, a change in local shoreline orientation may cause gradients in longshore sediment transport rate (depending on the nearshore wave climate).

To include local shoreline orientation in the computed potential sediment transport rates, digitized shorelines of Assateague Island and Fenwick Island were used. These digitized shorelines were mapped to the locations of nodes within the bathymetric grid of the numerical wave model. The local shoreline orientation relative to the orientation of the wave modeling domain was computed and then used to convert wave direction at the nearshore reference line from relative to the wave model grid to relative to the local shoreline orientation. Potential transport computations proceed from this point as described earlier, following through the Snell's law wave transformation (assuming now that the nearshore bathymetry is plane and parallel to the local shoreline orientation) and computation of the potential sediment transport rate from the breaking wave height and the breaking angle relative to shore.

Modeling results

The time period used to determine average potential longshore sediment transport rates corresponds to the period of the updated WIS hindcast (1976-1993). This 18-year period is expected to capture the current climatic offshore wave condition in the vicinity of Ocean City Inlet and the study area. Therefore the potential net longshore sediment transport rates presented here are not representative of any shorter span of time within the 18-year hindcast time series, but rather a representation of the average longshore sediment transport regime given the offshore wave climate from the transformed WIS hindcast time series.

Potential sediment transport rates computed for this study are limited in several ways, and should be used within the context of these limitations. First, the relationship used to compute the potential longshore sediment transport rate does not include the effects of sediment character (size, shape, or density) or profile shape and uses an empirical coefficient derived from field studies to incorporate these two factors. The empirical coefficient, K, used to compute potential longshore sediment transport affects the magnitude of the potential net longshore sediment transport rate, but does not affect the direction of transport or trends in transport (assuming uniform character and size of the sediment distributed alongshore throughout the study area and similar characteristics of profile shape). Therefore, trends in potential longshore transport are much more reliable than magnitudes of longshore sediment transport presented here. Also, the potential sediment transport model NSTRAN assumes an unlimited supply of sediment is available for transport. This assumption is questionable in the proximity of littoral barriers or sediment sinks (such as the Ocean City Inlet Ebb Shoal). Finally, in deriving shoreline change from the potential net longshore sediment transport trends, the modeler must remember that only wave-induced sand transport is included in the potential transport trends. Shoreline change is also affected by sand sources and sinks, which are not included in the potential longshore sand transport trends.

Extracting useful information from the potential net longshore transport plots lies in the recognition of longshore sediment transport trends related to the nearshore wave climate. Visual inspection of the net longshore sediment transport rates reveals that underlying trends of sediment transport exist. Analysis of these trends yields an understanding of the physical processes at work within the study area. Existing and with-project potential net longshore sediment transport rates for Assateague Island and Fenwick Island are presented later with corresponding relationships to the physical processes at work and the implications of the transport trends in the context of shoreline change.

Assateague Island. The shoreline orientation of Assateague Island has been quite dynamic since the formation of Ocean City Inlet. Considering the dynamic nature of Assateague Island's shoreline orientation, the potential transport rates for the Assateague Island modeling domain were computed using 1933, 1976, 1989, and 1995 shoreline positions. The potential net transport rates for these three shorelines are presented in Figures A1-25 through A1-28. The sign convention for sediment transport direction in these figures is positive for southbound transport and negative for northbound transport. Figures A1-25 through A1-28 reveal that the potential sediment transport regime changes with time and the local shoreline morphology. The 1976 shoreline (Figure A1-26) is limited by available shoreline position data for that time.

It should be noted here that the bathymetry used to compute the nearshore wave climate for each shoreline is identical and includes the 1995 condition of the Ocean City Ebb Shoal. Therefore, the wave transformation results near the ebb-shoal may contain considerable error for the simulations in which the ebb shoal was significantly different from the 1995 condition. The large variability in potential net longshore sediment transport rates within these three figures is caused by the variability of the nearshore wave results from the monochromatic wave model REF/DIF and the division of the offshore wave climate into discrete directional bins. The potential longshore sediment transport plots presented in the text of this chapter are from the nearshore reference line that skirts the outer lobe of the ebb shoal, referred to as NSR2. This reference line was chosen because significant numbers of large wave events in the hindcast time series break seaward of NSR1.

Figure A1-27 presents the potential net longshore sand transport rates for Assateague Island using the 1989 shoreline orientation. Although the transport rates oscillate on a short scale (less than 1 km), larger scale trends (greater than 1 km) are evident in the potential net longshore transport rates. The overall directional trend in net longshore sediment transport is southbound from Ocean City

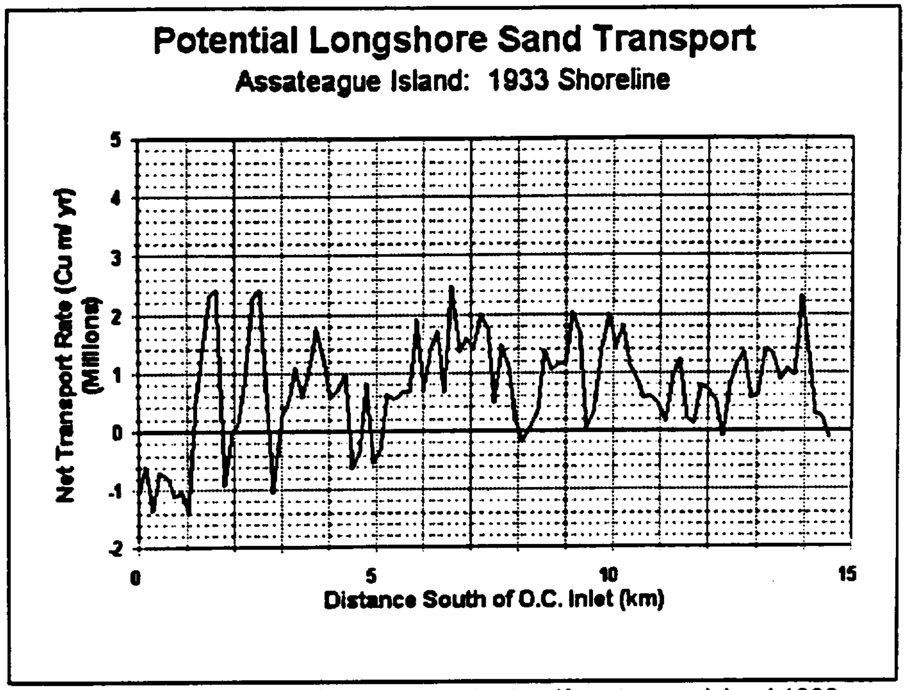

Figure A1-25. Potential longshore transport rates (Assateague Island 1933 shoreline)

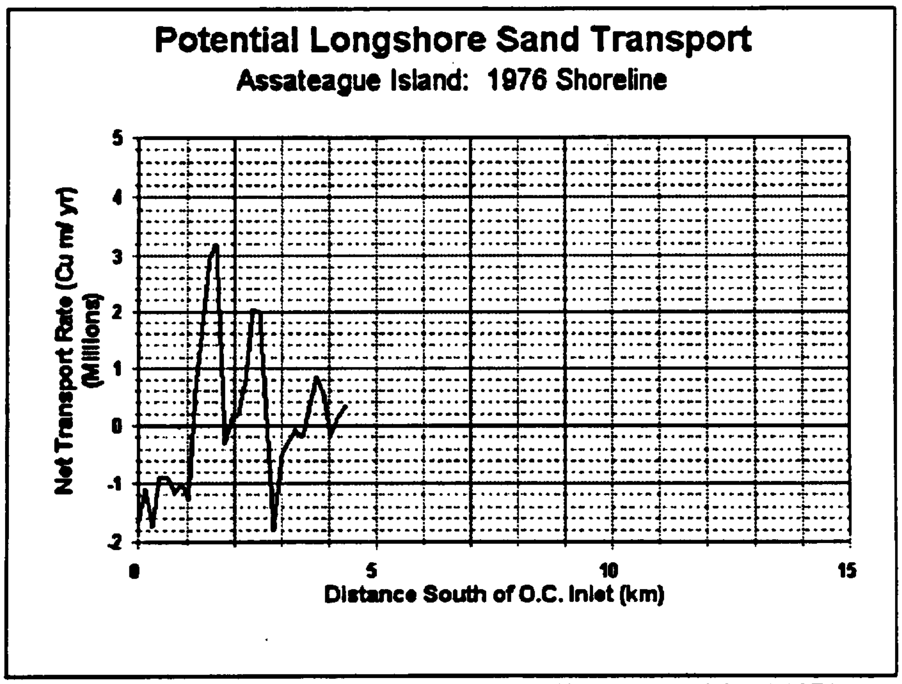

Figure A1-26. Potential longshore transport rates (Assateague Island 1976 shoreline)

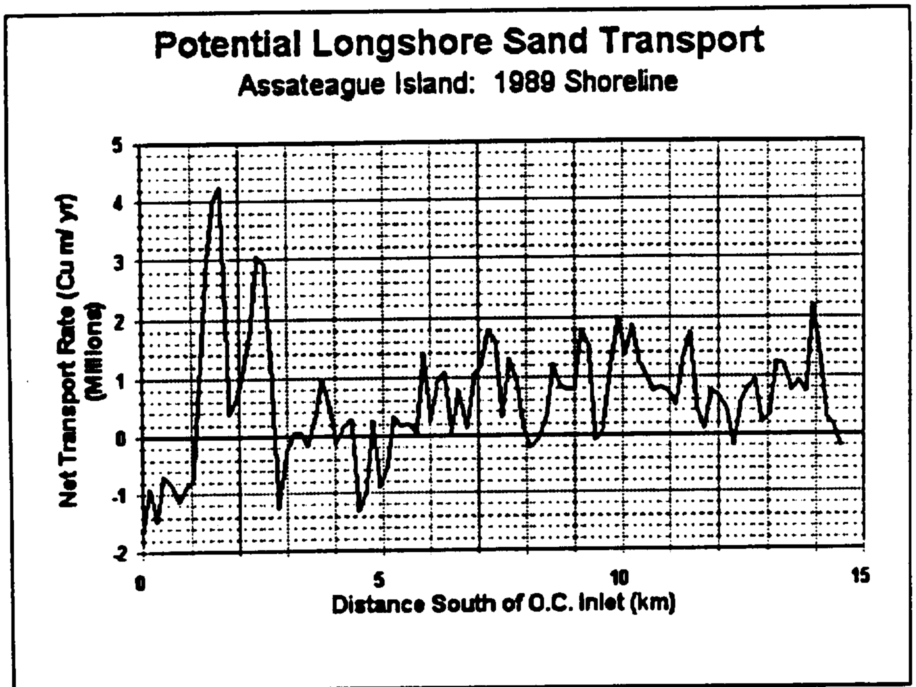

Figure A1-27. Potential longshore transport rates (Assateague Island 1989 shoreline)

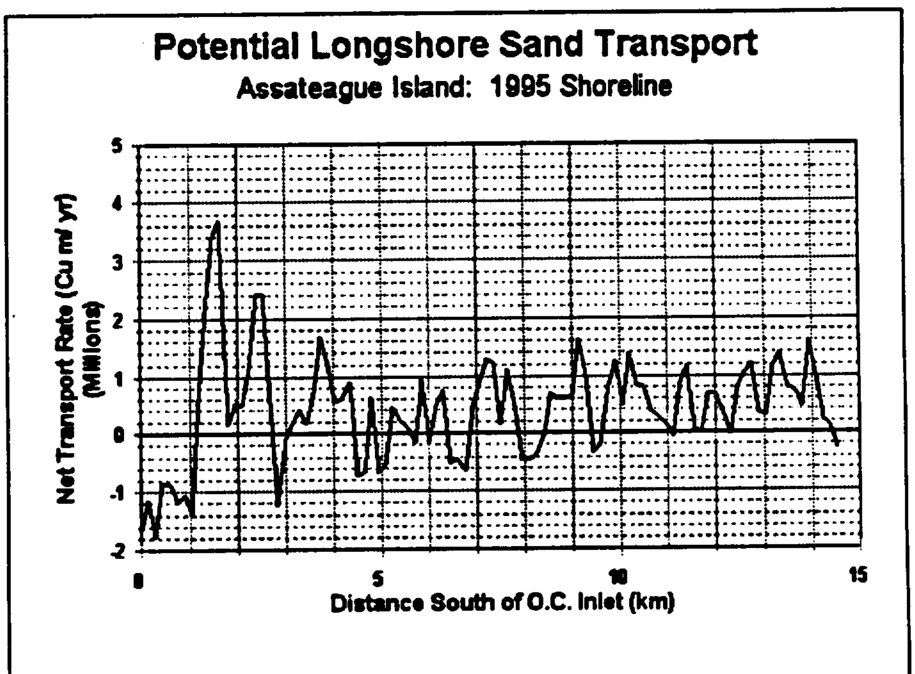

Figure A1-28. Potential longshore transport rates (Assateague Island 1995 shoreline)

Inlet to the southern boundary of the model (approximately 15 km south). Within the overall trend of southbound transport exist smaller scale trends in sediment transport rate and consequently segments of shoreline with erosional and accretional tendencies. Identifying these smaller scale trends (yet larger than 1 km), a trend of stable to erosional shoreline is indicated between 0 km and 1.5 km south of Ocean City Inlet, changing to decreasing southbound transport between 1.5 km and 3 km south of the inlet. The net transport gradient between 1.5 km and 3.0 km south of the inlet indicates an accretional tendency within this reach of shoreline. The trends for the reach of shoreline between 3 km and 5 km south of the inlet are relatively stable, but the south-directed net transport rates for the shoreline between 5 km and 10 km south of Ocean City inlet increase with distance south of the inlet, indicating an erosional trend. Further south, between 10 km and 12 km south of the inlet, the potential transport trend is accretional, changing again to erosional between 12 km and 15 km south of the inlet. The results near the 15 km mark should be considered suspect due to the close proximity to the lateral boundary of the wave model.

The potential sediment transport trends using the 1995 shoreline are presented in Figure A1-28. The large scale potential sand transport trends from this figure indicate first a stable to erosional trend between the inlet and 1.5 km south of the inlet, changing to an accretionary trend from Ocean City Inlet to approximately 5 km south of the inlet. The potential longshore transport rates remain essentially constant between 5 km and 6 km south of the inlet, indicating a stable shoreline. Further south, between 6 km and 15 km south of the inlet, the potential longshore sediment transport trends indicate erosion.

Comparing the trends in potential net longshore sediment transport to observed shoreline changes during a similar period of time allows a first order validation of the potential sediment transport model to observations. Figure A1-29 presents the observed shoreline change at Assateague Island between 1989 and 1996. Evident in this figure is a zone of stable or eroding shoreline between 0-1 km south of Ocean City Inlet changing to accretion between 1 km and 3 km south of the inlet similar to that indicated by the potential sediment transport modeling using the 1989 and 1995 shorelines. South of this point, observed shoreline change indicates a consistent and significant erosional trend. Trends derived from the potential transport model results indicate a mix of stable and accreting shoreline between 3 km and 5 km south of the inlet. From 5 km to 14.5 km south of Ocean City Inlet, the potential longshore transport model indicates primarily shoreline erosion with the exception of the 10-12 km range for the 1989 shoreline. Generally, the computed potential net longshore transport trends agree with the observed shoreline change.

To evaluate the effect of mining Great Gull Bank, potential longshore sediment transport rates were computed using with-project nearshore wave model results. Trend differences between the with-project transport rates and without-project transport rates are used as indicators of changes in the longshore transport regime. Figure A1-30 presents potential longshore sediment transport rates for both

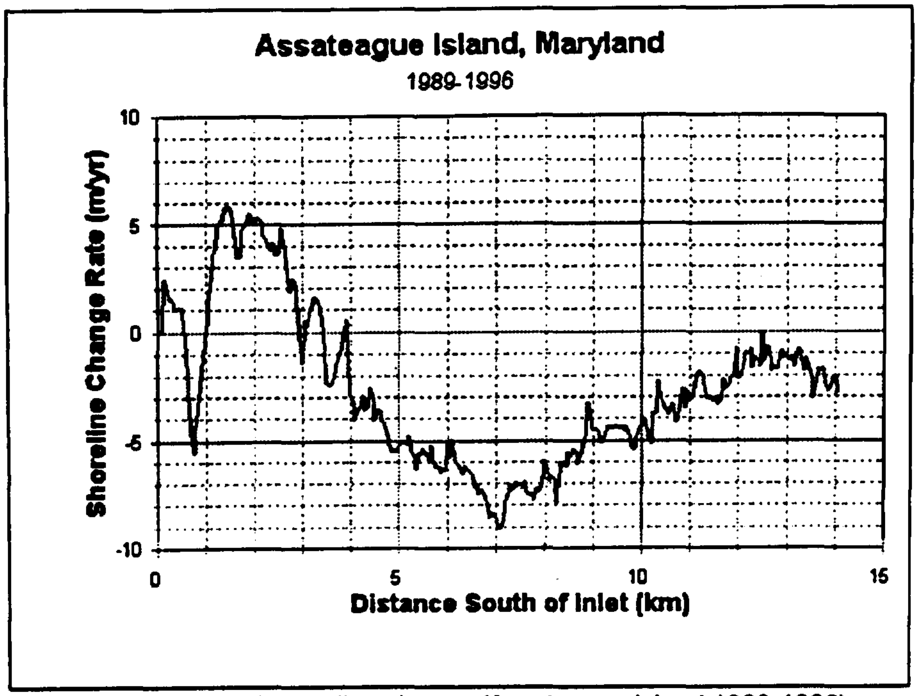

Figure A1-29. Observed shoreline change (Assateague Island 1989-1996)

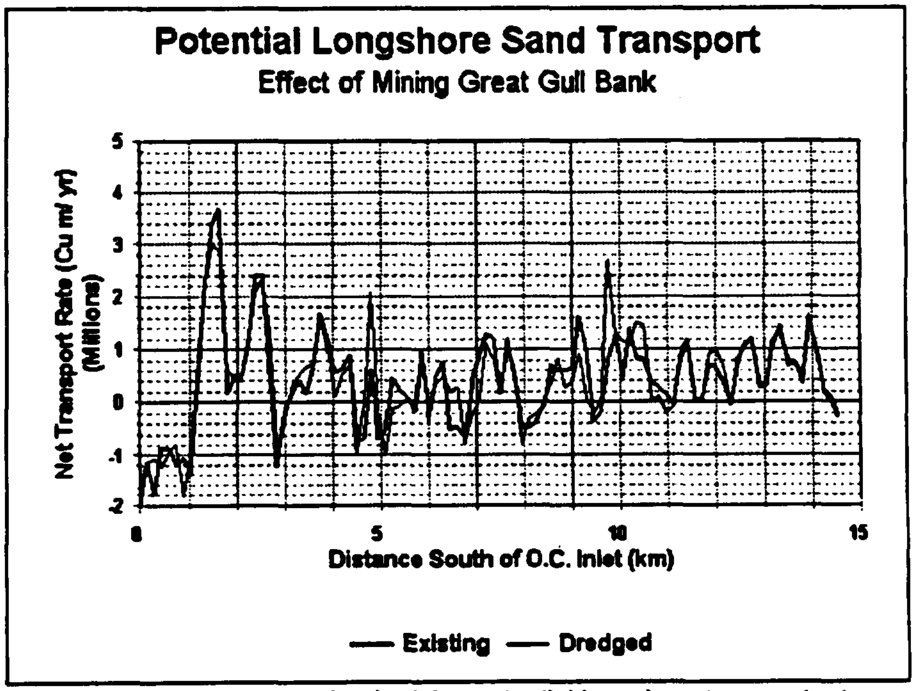

Figure A1-30. Pre- and post-shoal-mining potential longshore transport rates (Assateague Island using the 1995 shoreline) the pre- and post-shoal-mining bathymetric conditions. This figure indicates small changes in potential sediment transport, but no changes in the general sediment transport trends. The negligible changes in general sediment transport trends suggest that the mining of 10 million m^3 of material from the western portion of Great Gull Bank would not cause shoreline erosion on Assateague Island. If the significantly smaller volume of 1.4 million m^3 is removed from the borrow area, the probability of adverse effects to the shoreline due to shoal mining becomes even less.

Southern Fenwick Island. The shoreline orientation of southern Fenwick Island has not been as dynamic as that of Assateague Island since the formation of Ocean City Inlet in 1933. Since Fenwick Island's shoreline orientation has remained relatively constant with time, the 1989 shoreline was used to compute potential longshore sediment transport.

The potential net longshore sediment transport rates for southern Fenwick Island from Ocean City Inlet north to approximately 5 km north of the Maryland/Delaware state line is presented in Figure A1-31. The potential net longshore sediment transport rates for the Fenwick Island domain are affected by the wave model and wave modeling procedure in a similar fashion to the Assateague Island domain. If an underlying trend is extracted from the net transport rates, one sees a southerly transport at Ocean City Inlet decreasing in magnitude with distance north of the inlet and changing direction to predominantly north-bound transport approximately 15 km north of Ocean City Inlet.

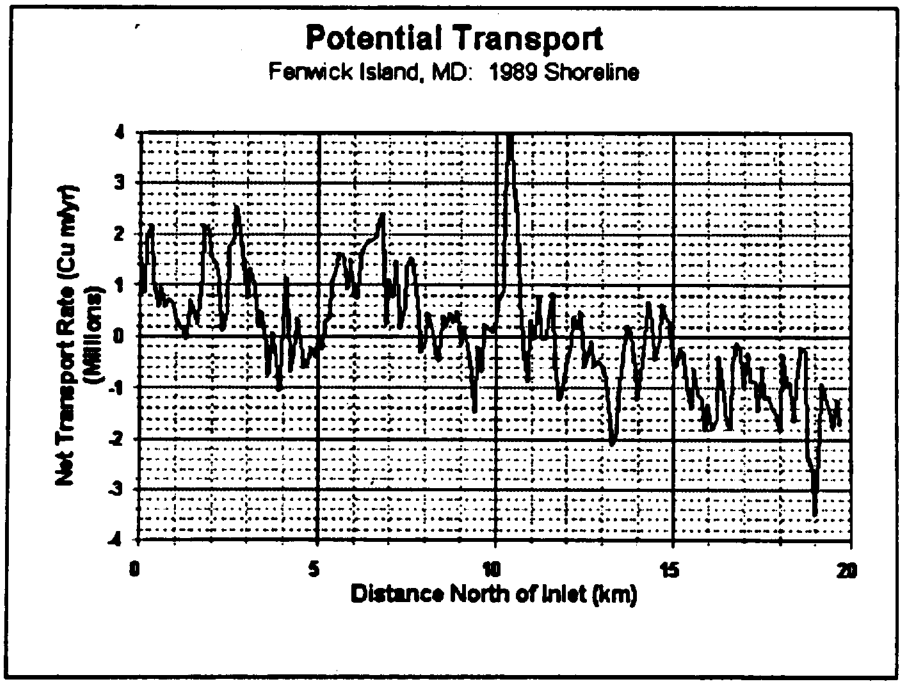

Figure A1-31. Potential longshore transport rates for Fenwick Island

The location of the nodal point presented above is in general agreement with historical data and littoral drift rose computations by Mann and Dalrymple (1986). Mann and Dalrymple computed littoral transport roses for WIS Stations along the coast between Cape Henlopen and Ocean City Inlet. From this exercise (combined with historical data), the nodal point of net littoral transport was found to occur near York Beach, Delaware. York Beach is located approximately 17.5 km north of Ocean City Inlet. The nodal point identified from the potential transport modeling of the OCWRS is located south of York Beach at approximately 15 km north of Ocean City Inlet. The agreement between the historical data, the Mann and Dalrymple study, and this study indicate a degree of confidence in the general trends of potential longshore sediment transport along Fenwick Island computed in this study.

If the trends of the potential net transport rates are examined at a finer scale (on the order of kilometers), patterns of erosion and accretion are evident. For instance, an erosional reach of shoreline (decreasing southbound transport as one travels north) is indicated from Ocean City Inlet to 1 km north of the inlet. Further north, between 1 km and 2.5 km north of the inlet, the trend changes to accretional, but the adjacent area between 2.5 km and 5 km north of the inlet indicates a trend of pronounced erosion. A similar trend of alternating accretional and erosional transport patterns is evidenced between 5 km and 9 km north of the inlet. The reach of shoreline between 7 km and 9 km (74th to 103rd streets) north of the inlet is an area of recognized erosion, as noted by Stauble et. al (1993). The location's erosional trends in the potential net transport rates correspond to the location of shoreface-attached shoals in the nearshore bathymetry. Stauble et. al (1993) identified areas of erosional "hot spots" as areas of foreshore erosion located in areas where shoals were attached to the shoreface. There appears to be a cause-effect relationship between the shoreface-attached shoals and sediment transport gradients at these locations.

Conclusions from potential longshore transport rates. The potential net longshore transport rates presented here offer a satisfying representation of expected trends in longshore transport due to the offshore wave climate and bathymetry. Limitations in the understanding of longshore sediment transport and the assumptions made in computation of potential longshore sediment transport restrict inferences from the potential longshore sand transport modeling results to transport trends and associated shoreline responses. Combined with historical sediment transport information, the usefulness of the potential sediment transport rates presented here may be extended to estimate quantitative transport rates for use in sediment budget calculations.

Evaluation of the effects of removing 10 million m^3 from the potential borrow area at Great Gull Bank indicate that no changes in the general sediment transport trends of the shoreline would be expected. Since the general transport trends remain unchanged, no adverse effects on the shoreline would be expected. Since only the initial construction volume of 1.4 million m^3 will be removed from the borrow area, the probability of adverse effects on the Assateague Island shoreline is even less.

Summary

The combined wave transformation modeling and potential longshore sediment transport modeling described within this chapter offer a representation of the effect of irregular offshore bathymetry on the nearshore wave climate and potential longshore sediment transport rates. To define the offshore wave climate, the updated WIS hindcast (1976-1993) was used. Statistics from this offshore wave time series were used to generate a suite of 50 unique wave direction and wave period combinations representative of the wave conditions of the entire 18-year hindcast. The monochromatic version of the numerical wave model REF/DIF was employed to define the effect of the offshore bathymetry on the nearshore wave climate. The wave model results from the 50 unique input conditions were then compiled into a nearshore wave database. The potential net longshore sediment transport model NSTRAN used the nearshore wave database in conjunction with the WIS hindcast time series to compute potential longshore sediment transport rates. Since the shoreline orientation of Assateague Island and Fenwick Island change significantly alongshore, NSTRAN was modified to include the effect of local shoreline orientation on longshore sediment transport. The result of the combined modeling effort is a representation of the present (18-year average) longshore sediment transport trends at northern Assateague and southern Fenwick Islands and the longshore sediment transport trends for Assateague Island as affected by the mining of the initially assumed 10 million m^3 of material from Great Gull Bank.

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Appendix A2: Ocean City Inlet Sediment Budget

Overview

Under the Ocean City Water Resources Study (OCWRS), a "present-day" sediment budget was formulated to quantify the magnitude and direction of sediment transport processes presently existing at Ocean City Inlet, Maryland and along adjacent beaches. Results from this task will assist the U.S. Army Corps of Engineers District, Baltimore (CENAB) in determining the volume and planview design of the Assateague Island beach fill, which is intended to partially mitigate impacts of the Ocean City Inlet system since the time that CENAB stabilized the inlet (1934) through the present (1996). Questions of particular interest in the design of this beach fill are as follows:

- What has been the total littoral impact of the inlet system, defined in terms of a total volume and alongshore impact distance, to Assateague Island since it was stabilized (1934) through the present (1996)?
- What has been the total littoral impact of the inlet system to Assateague Island since it became a National Park (1965) through the present (1996)?
- What is presently the most critically eroding region of Assateague Island? Given a beach fill quantity and planview design, and the present rate of inlet bypassing, how long will the beach fill provide protection to Assateague Island?

A question that needs to be addressed for the long-term sand placement plan is:

- What is the inlet bypassing rate required to restore "natural" sediment bypassing processes to Assateague Island?

Analyses to address this question have been initiated; however, a final estimate is not expected until completion of the Draft Feasibility Report II.

To support the development of a present-day sediment budget, significant engineering and coastal process events including dredging records and beach fill placement and volume information were documented. Other supporting analyses were conducted to determine:

- the variation of shoreline position with time;
- profile evolution;
- ebb shoal evolution (planview shape and volume); and
- flood shoal evolution (planview shape and volume).

The purpose of this chapter is to present results of the supporting data analysis, document the present-day sediment budget, and provide information for CENAB to address the beach fill design questions listed previously.

Results of Data Analysis

History of Significant Coastal Process and Engineering Events

To appropriately account for important alterations and impulses to the inlet system, it is necessary to consider significant coastal process and engineering events in formulation of an inlet sediment budget. Table A2-1 presents a summary listing of these events which occurred from the pre-inlet time period through the present (1996). These events were deemed of importance in formulating the sediment budget, and in understanding the coastal process setting. The following paragraphs narrate the most critical of these events.

Prior to inlet formation, a single barrier island separated the bay from the mainland. Assateague Island was inhabited in the early 1800s by English settlements, approximately 6 km south of the existing inlet. These settlements used the area for agriculture and grazing of livestock, and they established in this region of Assateague Island due to its higher ground and wider expanses of land as compared to the northern part of the island. The town of Ocean City prospered largely due to its railway system which connected the barrier to the mainland and increased the recreational popularity of Ocean City beach. By the early 1900s, hotels were constructed on Ocean City, and construction of groins to stabilize the beach began in 1922. Sinepuxent Inlet breached Assateague Island in February 1920 approximately 4.8 km south of Ocean City, and had migrated southward about 0.8 km until it was closed by another storm on May 9, 1928 (Underwood and Hiland 1995).

Ocean City Inlet was formed by a hurricane on August 23, 1933, and separated the existing barrier island into Fenwick Island to the north and Assateague Island to the south (Figure A2-1). Stabilization of the inlet with jetties commenced in

Table A2-1. Summary of Significant Engineering and Coastal Process Events, pre-inlet to 1996		
Date	**Event**	**Notes**
pre-inlet (early 1800s)	Assateague Island settled approximately 6 km south of present inlet; used for agriculture and grazing of livestock. Southern Assateague preferred because of higher ground and wider expanses of land.	Underwood and Hiland (1995)
Aug 23, 1933	Hurricane creates OC Inlet	Inlet quickly scours to 3 m depth and 76 m wide
1933-1962	Ebb shoal volume change	Accretion 151,000 m^3/yr (Underwood and Hiland 1995)
1931-1972	Flood shoal volume change	Accretion 19,600 m3/yr (Total 765,000 m3 over 39 years, Dean and Perlin 1977)
Sep 1933-Oct 1934	North jetty constructed	Elevation: 1.2 m NGVD
Oct 1934-May 1935	South jetty constructed	Elevation: 1.8 m NGVD
1935	North jetty increased in elevation	Elevation increased from 1.2 to 2.7 m NGVD
Aug 1935	First dredging of OC Inlet	no quantity available; depth 2.6 m NGVD (Dean, Perlin, and Dally 1978)
Dec 1935	Commercial Fish Harbor dredged	no quantity available (Dean, Perlin, and Dally 1978)
1937	North jetty increased in elevation	Elevation increased from 2.7 to 3.6 m NGVD
1947-1948	OC Inlet and/or bay dredged	48,200 m^3; limits of area unknown (Wicker 1974)
1948	Isle of Wight & Sinepuxent Bays dredged	267,600 m3 (CENAB 1978)
1954-1955	OC Inlet and/or bay dredged	57,300 m^3; limits of area unknown (Wicker 1974)
1955-1956	Outermost section of north jetty reconstructed; increased in elevation	Elevation increased from average elevation for outermost section of -0.4 to 2.7 m NGVD
1956	First occurrence of breach adjacent to south jetty; repaired with hydraulic dredge	Dean, Perlin, and Dally 1978

Table A2-1. Summary of Significant Engineering and Coastal Process Events, pre-inlet to 1996		
Nov 1961	Breach adjacent to south jetty	Not repaired until after March 1962 storm
Mar 6-8, 1962	"Ash Wednesday" extratropical cyclone breached AI in a second location, and FI in one location	AI breached approximately 1.6 km south of jetty FI breached near 71st street (CENAD 1963)
16 Apr-19 May 1962	Dredged material placed to repair AI	750,000 m3 dredged from OCI channel and Sinepuxent Bay used to closed jetty breach (Underwood and Hiland 1995, CENAB 1978, CENAD 1963) 400,000 m3 dredged from inlet and Sinepuxent Bay used in an attempt to close breach (at low tide) 1.6 km south of jetty (CENAB 1978, CENAD 1963)
5 Aug 1962-12 Jan 1963	Dredged material placed to repair FI	Sediment moved from foreshore to build retaining dunes which were filled with dredged material. 798,000 m3 dredged from Isle of Wight, Sinepuxent, and Assawoman Bays were placed along entire barrier to Delaware border (CENAB 1963, see p. 6-17 for borrow areas) (FI fill confirmed by p. 6-31, CENAD 1963) (total volume placed to repair AI and FI damage due to this storm confirmed by CENAD 1963, p. 6-18, although they state it was all placed in dunes).
1962-1978	Ebb shoal volume change	Accretion 101,000 m3/yr (Underwood and Hiland 1995)
1962-1963	Commercial fishing harbor dredged	29,100 m3; Sta 3+900 to 6+250 (Wicker 1974)
1963-1964	Sinepuxent to Chincoteague Bay dredged	306,000 m3 (CENAB 1978)
1963-1966	South jetty repaired	220 m of middle jetty section rehabilitated; 210 m inshore segment added
1964	Commercial Fish Harbor dredged	30,600 m3 (CENAB 1978)
1965	AI National Seashore officially authorized	
1965	Sinepuxent Bay dredged	153,000 m3 (CENAB 1978)
Jan 29, 1965	Oblique aerial shows breach 1.6 km from inlet being filled with dredged material	Dike was constructed and sediment used to fill behind dike

Table A2-1. Summary of Significant Engineering and Coastal Process Events, pre-inlet to 1996		
1967	Sinepuxent Bay (SB) dredged; Isle of Wight Bay (IWB) dredged	53,500 m3 (SB) (CENAB 1978) 42,800 m3 (IWB) (CENAB 1978)
1969	OC channel dredged (bay portion)	42,800 m3; Sta 2+530 to 3+750 (Wicker 1974)
1970	OC channel dredged (bay portion)	38,200 m3; Sta 2+450 to 3+900 (Wicker 1974, CENAB 1978)
1971	OC Inlet and/or bay dredged	84,100 m3; limits of dredging unknown (Wicker 1974, CENAB 1978)
1973	OC channel (bay) and fish harbor dredged	72,600 m3; Sta 2+300 to 5+300 (Wicker 1974, CENAB 1978)
1975	Fish harbor dredged	29,000 m3 (CENAB 1978)
1976	OC Inlet dredged	22,900 m3 (CENAB 1978)
1977	OC Inlet dredged	34,400 m3 (CENAB 1978)
1977	Sediment transport rate through/over pre-rehabilitated south jetty	39,900 m3/yr under normal wave conditions (measured by Dean and Perlin 1977)
Oct-Nov 1978	OC Inlet dredged	45,900 m3 placed on AI (Price 1992)
1978-1990	Ebb shoal volume change	Accretion 150,000 m3/yr (Underwood and Hiland 1995)
1978	Ebb shoal in equilibrium?	Yes, according to Walton & Adams (1979)
Jan-Mar 1979	Isle of Wight dredged	38,200 m3 vicinity of 30th to 50th Streets; confined disposal (Price 1992)
Aug-Sep 1979	OC Inlet dredged	38,200 m3 placed on AI (approximately at present-day Station 8+00) (Price 1992)
1980-1995	Beach fills adjacent to south jetty	228,000 m^3 (Underwood and Hiland 1995)
Jan-Mar 1982	OC Inlet dredged	26,800 m3 (Price 1992)
1984	South jetty scour hole repaired	Maximum scour depth 15.2 m (NGVD? - no datum given) prior to repair (Underwood and Hiland 1995)
Dec 1984-Dec 1985	Three headland breakwaters constructed on north AI (inside OC inlet); South jetty sand-tightened and increase in elevation	South jetty elevation increased from 1.4 m to 2.3 m NGVD
Jun-Sep 1988	FI: State beach fill	2.1 million m3 placed 3rd to 146th Streets
Jun-Sep 1990	FI: Federal beach fill	2.9 million m3 placed 3rd to 100th Streets

Table A2-1. Summary of Significant Engineering and Coastal Process Events, pre-inlet to 1996		
Nov 1990	OC Inlet dredged	37,500 m3 placed northern end of AI; beginning approximately 1.1 km south of OC Inlet and extending 3.0 km (Price 1992)
Oct 29 - Nov 1, 1991	"Halloween Storm" northeaster	
Nov 11, 1991	Northeaster	
Jan 4, 1992	Northeaster	
Jan-Feb 1992	FI: storm repair	Truck rearranged storm repair
Apr-Jun 1992	FI: beach fill	1.2 million m3 placed (assumed placement from 3rd to 146th Streets)
Dec 11, 1992	Northeaster	
Feb-Mar 1993	FI: storm repair	Truck rearranged storm repair
Apr-May and Sep-Oct 1994	FI: beach fill	1.1 million m3 placed (assumed placement from 3rd to 146th Streets)
Mar-Apr 1995	Isle of Wight Bay dredged	FI Fill: 47,500 m3 placed to repair dune line at 33rd Street (Blama 1996)

Figure A2-1. Aerial view of Ocean City Inlet on December 6, 1935

September 1933, and the inlet quickly scoured to 3 m depth and 76 m width (Underwood and Hiland 1995).

Inlet processes began forming ebb and flood shoals (note waves breaking offshore of the south jetty in Figure A2-1, indicating early formation of the ebb tidal shoal), at the expense of the adjacent beaches. Shoreline change rates for Assateague Island extending 14.2 km south of the inlet nearly doubled from a pre-inlet (1850-1929/33) erosion rate averaging -1.5 ± 1.7 m/yr to an average post-inlet (1929/33-1996) erosion rate averaging -2.9 ± 2.7 m/yr (latter rate excludes shoreline advancement due to beach fill). For the post-inlet time period, overwash processes were significant along Assateague Island, with bay shoreline change indicating accretion for all consecutive time periods. For the Fenwick shoreline extending approximately 15.1 km north of the inlet, the shoreline responded to construction of the jetties by decreasing the pre-inlet erosion trend (-0.37 ± 0.98 m/yr for the pre-inlet time period to -0.21 ± 0.91 m/yr in the post-inlet time period (latter rate excludes shoreline advancement due to beach fill)). For the post-inlet time period, the bay portion of Fenwick Island was comparably stable, experiencing only rare overwash events. Shoreline change rates are discussed in detail in the next section.

The most severe storm since inlet formation occurred during March 6-8, 1962. This Northeaster, called the "Ash Wednesday Storm," worsened an existing breach at the south jetty that had occurred in November 1961, and created two other breaches, one along Fenwick Island near 71st Street, and the other approximately 1.6 km south of the inlet on Assateague Island. The first two breaches were closed during the period April 1962 through January 1963, but the Assateague Island south breach persisted (despite closure attempts during April and May 1962) until at least January 1965. Figure A2-2 shows the Assateague Island breach.

Figure A2-2. Assateague Island breach due to 1962 Ash Wednesday storm

The establishment of Assateague Island as a National Seashore in 1965 was related to the devastation that occurred to this island during the Ash Wednesday Storm. Assateague Island had been recommended for federal protection as early as 1935, but no action was taken and private development and ownership of the Maryland portion of the island was firmly established by 1955. However, the Ash Wednesday Storm removed 32 of the 50 dwellings, and severely damaged 7 others. Requests from private interests to establish storm protection for this region had extremely high cost-to-benefit ratios, and therefore could not receive federal assistance. The rapidly expanding population along the eastern seaboard during the early 1960s created a need for more federally protected coastal recreation areas, and Assateague Island was officially authorized as a National Seashore in 1965 (Underwood and Hiland 1995).

A study of historical and existing coastal processes along northern Assateague Island was conducted by Dean, Perlin, and Dally (1978) and Dean and Perlin (1977) in an effort to understand the mechanisms and potential solutions for a persistent shoaling problem along the northeast corner of Assateague Island (Figure A2-3). These field, numerical modeling, and historical evolution studies concluded that this shoal was forming due to a reversal in net sediment transport along northernmost Assateague Island, with this sediment being transported over the south jetty into the inlet channel. The study recommended that the south jetty be raised and tightened, and that northern Assateague Island (inside channel bank) be stabilized with three detached breakwaters. The detached breakwaters and sand-tightening projects were constructed from December 1984 through December 1985. The most recent significant engineering event affecting the region's sediment budget has been the placement of approximately 7.4 million m3 of beach fill on Fenwick Island from June 1988 through April 1995, which extended from the inlet north to the Maryland-Delaware state line.

Variation of shoreline position with time

Shoreline position, orientation, and the rate of shoreline change between time periods provides information about regional coastal processes and their resulting effect on beaches. This information is critical for general understanding of the project site and for developing a quantifiable sediment budget. For most sites, a historical database of detailed topographic and bathymetric data sets from which volumetric change can be calculated are not available. Therefore, volumetric change rates are approximated by multiplying the shoreline change rates by an "active profile depth" (discussed in the next section). The volumetric change rates between time periods provide an elemental data set applied in the formulation of a sediment budget. In addition, the variation of alongshore volumetric change can be applied in determining the alongshore extent of inlet influence through time (see section, "Estimating the total littoral impact of the inlet").

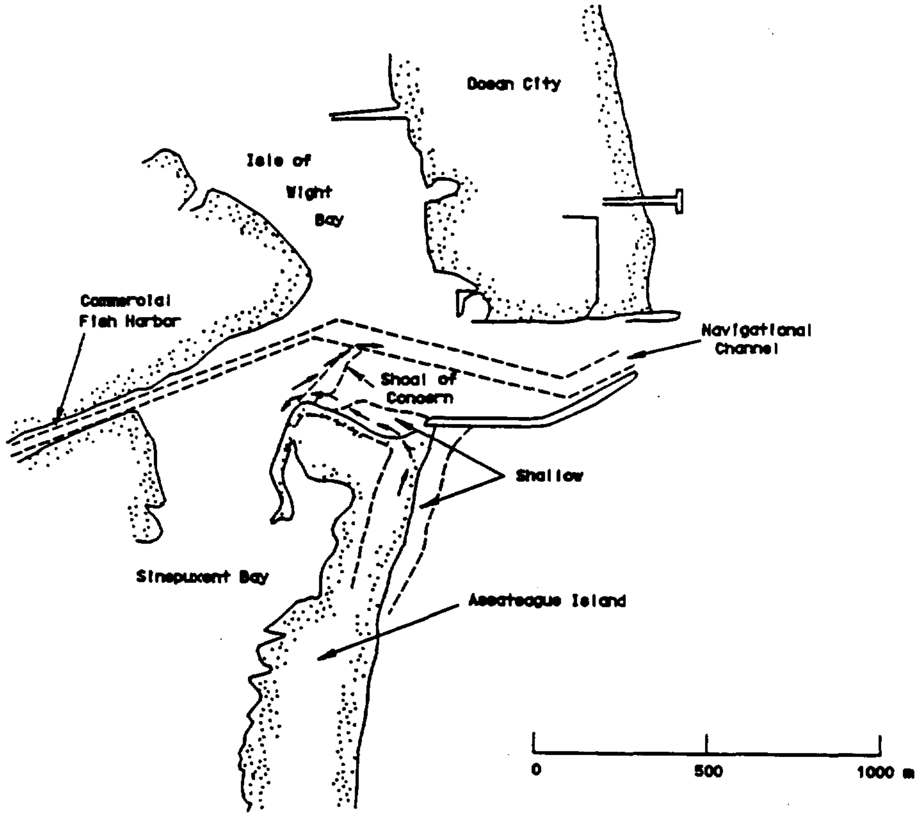


Figure A2-3. Dominant sediment transport pathways (indicated by arrows) and resulting shoaling problem on the northeast corner of Assateague Island prior to 1985 (Dean, Perlin, and Dally 1978)

Both ocean and bay shoreline position were recorded with respect to an alongshore coordinate, x, which was set to zero at the centerline of the inlet and used a right-handed coordinate convention (i.e., negative x indicates north; positive x indicates south). Shoreline position for each time period was calculated as a distance from an arbitrary baseline at a 50-m alongshore cell spacing. Shoreline change rates and associated standard deviations were calculated in meters per year by subtracting shoreline position data and dividing by the number of years represented by the time period. Negative values indicate erosion and positive values indicate accretion. Average shoreline change rates and the standard deviation associated with these values were calculated in meters/year. Results of the shoreline change analysis used in the sediment budget are presented in Table A2-2, and shoreline position for these time periods is shown in Figure A2-4.

Table A2-2. Summary of Shoreline Change Analysis: Average Rates and Associated Standard Deviation (m/yr)

Time Period	Alongshore Extent: Ocean (km)	Alongshore Extent: Bay (km)	Fenwick Island		Assateague Island	
			Ocean	Bay	Ocean	Bay
1850-1929/33	-19.35 to 23.50	-13.7 to 3.25	-0.42 ± 0.88	-0.37 ± 1.7	-0.87 ± 1.5	2.8 ± 1.8
1929/33-1962	-19.45 to 23.50	-13.5 to 3.25	-0.48 ± 1.6	0.77 ± 5.0	-2.5 ± 3.7^{1}	8.1 ± 2.8^{1}
1962-1980	-19.45 to 23.50	-13.25 to 7.00	-0.98 ± 1.4^{2} -1.2 ± 1.3^{3}	3.1 ± 11.2	$-2.1 \pm 2.9^{1,2}$ $-2.2 \pm 3.2^{1,3}$	6.9 ± 8.5^{1}
1980-1989	-19.45 to 16.25	-13.15 to 16.55	5.1 ± 2.3^{2} 3.8 ± 2.4^{3}	3.2 ± 7.5	2.9 ± 2.9^{2} 2.9 ± 2.7^{3}	1.6 ± 3.9
1989-1995/96	-15.05 to 14.15	-13.15 to 16.55	0.16 ± 2.0^{2} -5.2 ± 2.4^{3}	-[4]	-2.6 ± 3.6^{2} -2.7 ± 3.5^{3}	4.9 ± 10.4
1929/33-1995/96	-15.05 to 14.15	Not analyzed	0.44 ± 0.80^{2} -0.21 ± 0.91^{3}	Not analyzed	-2.9 ± 2.2^{2} -2.9 ± 2.7^{3}	Not analyzed

[1] Excludes region of 1962 breach.
[2] Shoreline change rate reflects advancement due to beach fill.
[3] Adjusted shoreline change rate to remove advancement due to beach fill.
[4] 1980-1989 rate assumed.

Profile Data

Information about the profile shape was applied in the sediment budget to estimate: (1) the depth of closure at the site, which was used to set the offshore boundary of the sediment budget, and also was used in estimating the active profile depth; (2) the active berm, which is used with the depth of closure and shoreline change data to calculate volumetric change rates; and (3) the percentage of the Fenwick Island beach fill remaining in 1996, which was required in the sediment budget to correctly account for alongshore movement of this material from Fenwick Island into other regions of the project.

Depth of Closure. In a report evaluating the initial performance of the Fenwick Island beach fill, Stauble et al (1993) estimated the depth of closure for Fenwick Island using profile data measured from the spring of 1988 through the winter of 1992. This data set encompassed higher wave energy events as well as typical waves. Depth of closure was defined as the minimum depth at which the standard deviation in depth changes decreased to a near-constant value, and was estimated to

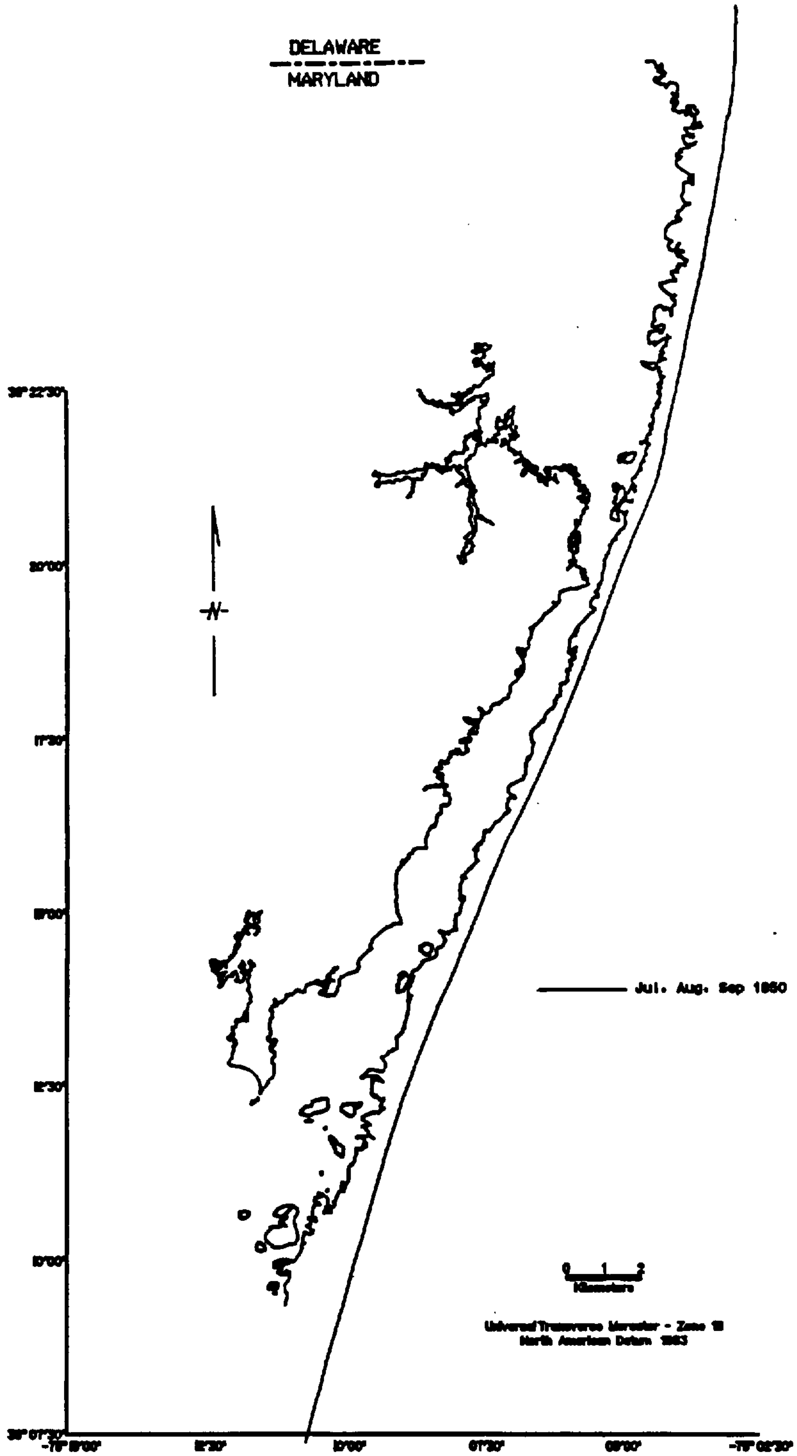


Figure A2-4 (a). 1850 shoreline position

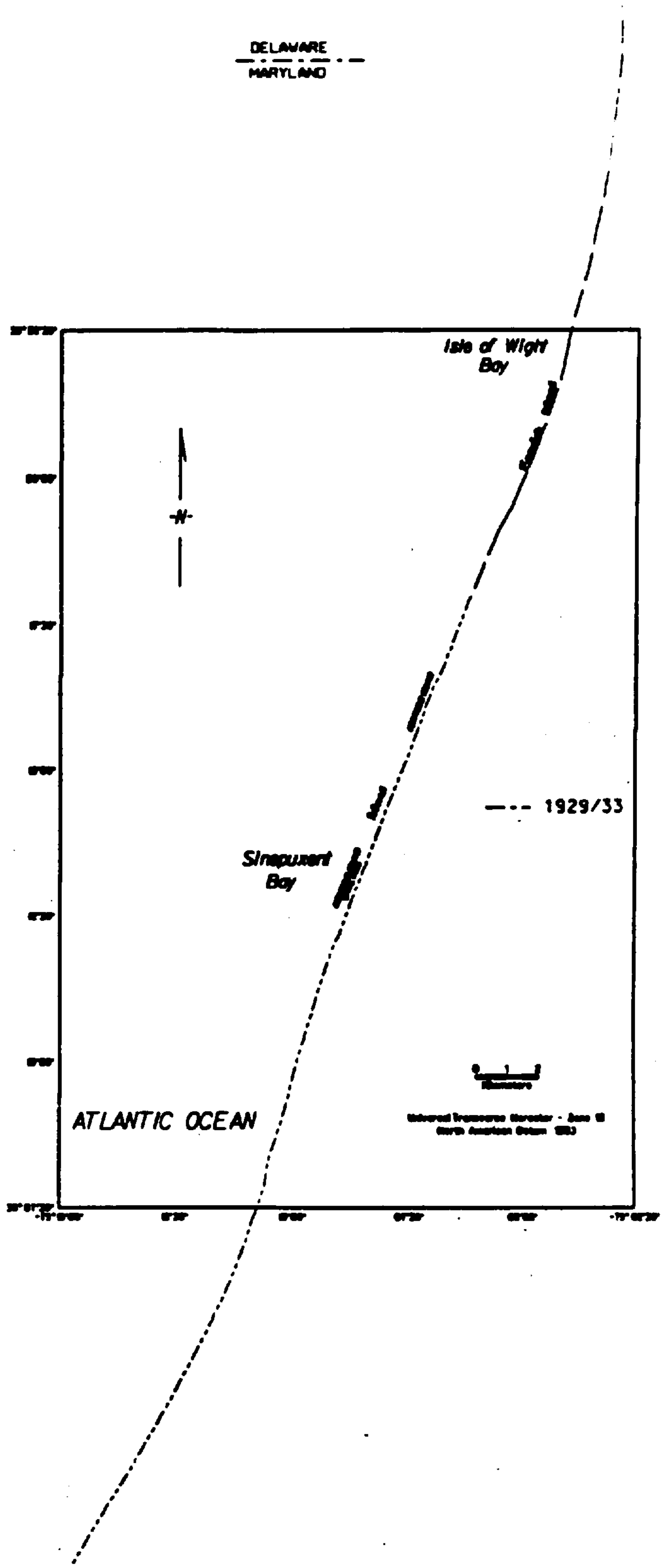


Figure A2-4 (b). 1929/33 shoreline position

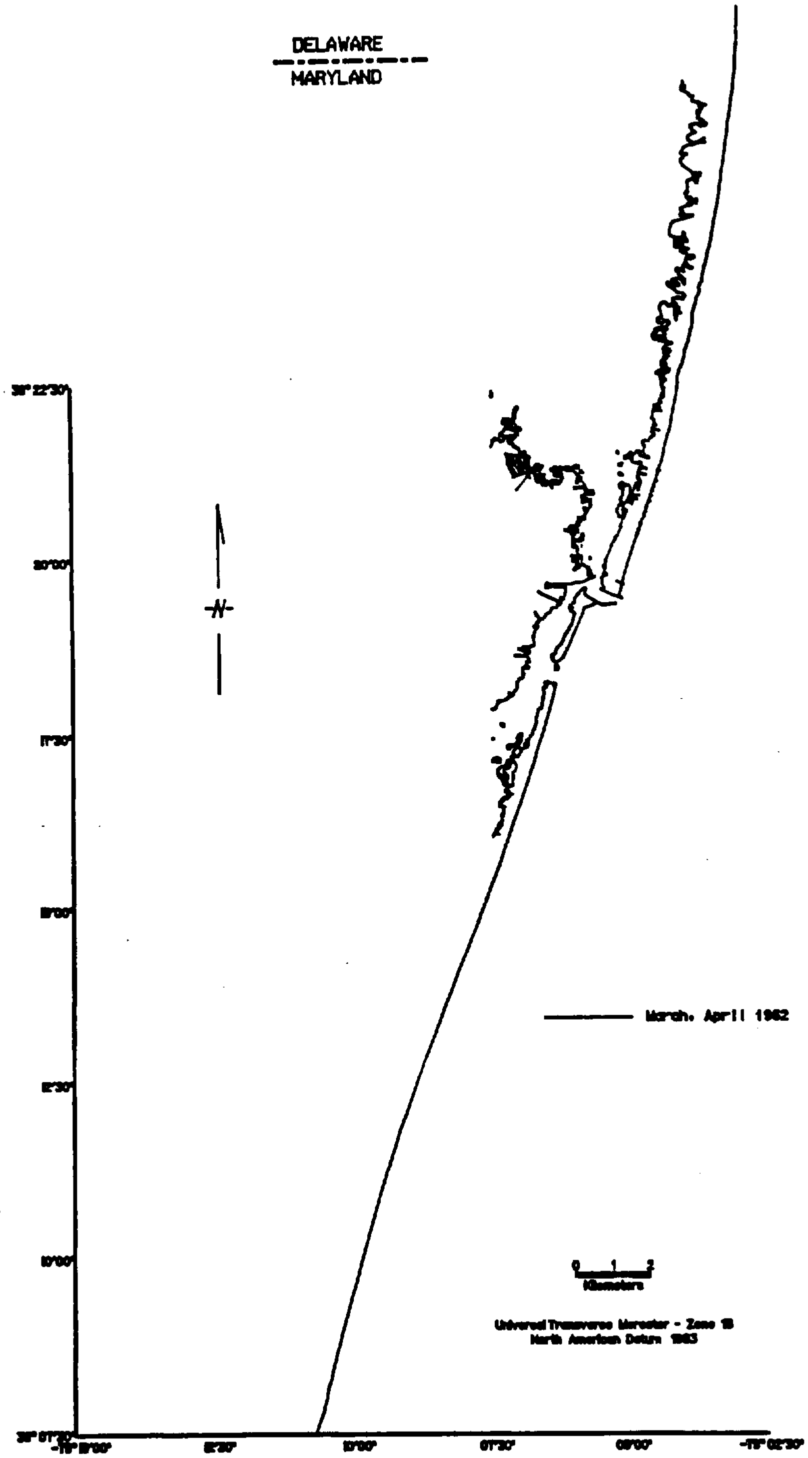


Figure A2-4 (c). 1962 shoreline position

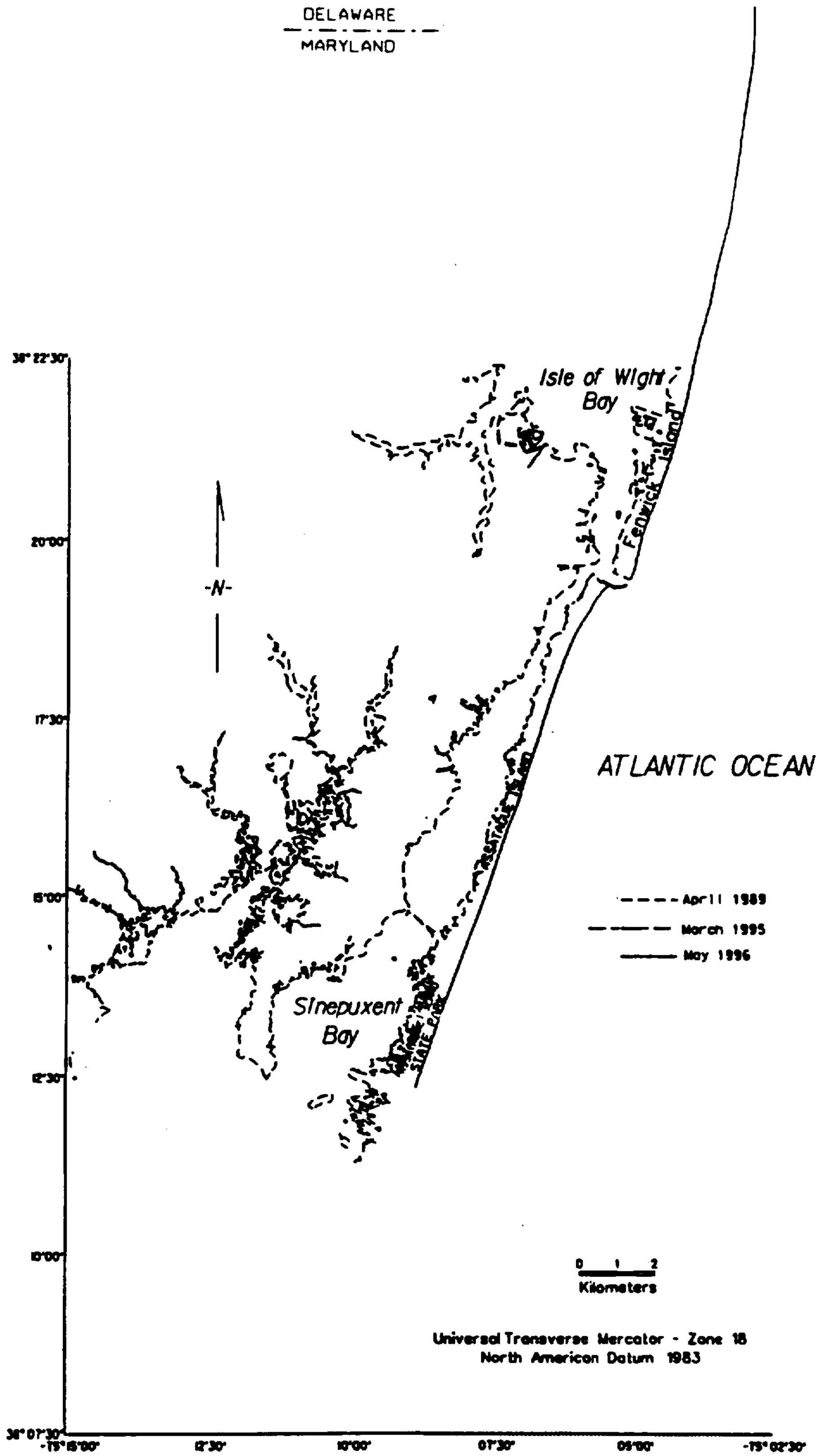


Figure A2-4 (d). 1989/95/96 shoreline position range from 4.8 to 6.7 m relative to National Geodetic Vertical Datum (NGVD), with 6.1 m NGVD being a representative value (Stauble et al 1993).

Because coastal processes at this depth are most likely similar offshore of Fenwick and Assateague Islands, this depth was also assumed to be representative of Assateague Island in formulation of the sediment budget. An exception was the northern region of Assateague Island for which sediment transport processes most likely would be influenced by the ebb shoal. For this northern portion of Assateague Island, which for the present-day sediment budget extended approximately 2.5 km south of the centerline of the inlet, the depth at the shoreward edge of the ebb shoal was used in active depth calculations. For the present-day sediment budget, the depth at the shoreward edge of the ebb shoal was a minimum of 2.5 m NGVD at 0.9 km south of the centerline of the inlet. Volume change within the ebb shoal was accounted for separately. For the southern region of Fenwick Island landward of the ebb shoal, the depth at the shoreward edge of the ebb shoal was approximately equal to the active depth; therefore, a 6.1-m NGVD active depth was assumed to represent the entire ocean shoreline of Fenwick Island.

Profile data for the bay shoreline were not available. After discussions with CENAB personnel and others who have studied processes at Ocean City Inlet (personal communication, Ebersole and Dean), it was judged that a reasonable estimate for the bay depth of closure would be 1 m NGVD.

Active Berm Elevation. Shoreline change, dy, within a given alongshore cell, dx, is estimated to represent a horizontal translation of the profile that occurs uniformly between the berm elevation Db and the closure depth Dc (Figure A2-5). The absolute sum of Db and Dc is the active profile depth. The change in volume, dV, for this section is given as

$$dV = dx\,dy(Db + Dc) \qquad \text{(A2-1)}$$

Using the Fenwick Island profile data discussed previously, Stauble et al (1993) estimated the active berm elevation, Db, for Fenwick Island as 3.0 m NGVD, resulting in a total active depth for Fenwick Island equal to 3.0 + 6.1 = 9.1 m. This active depth was assumed to be representative of Fenwick Island from 1933 through 1996. However, for the pre-inlet time period (1850-1933), in the absence of ocean profile data representative of this time period, the Fenwick Island active berm was reduced slightly within 1 km of the eventual inlet location to create a smooth transition in active berm crest from Fenwick to Assateague Islands.

The active berm crest for Assateague Island was determined to vary alongshore and with time. Although no profile information is available for the pre-inlet time period, alongshore variation of the active berm is suggested by the land use history

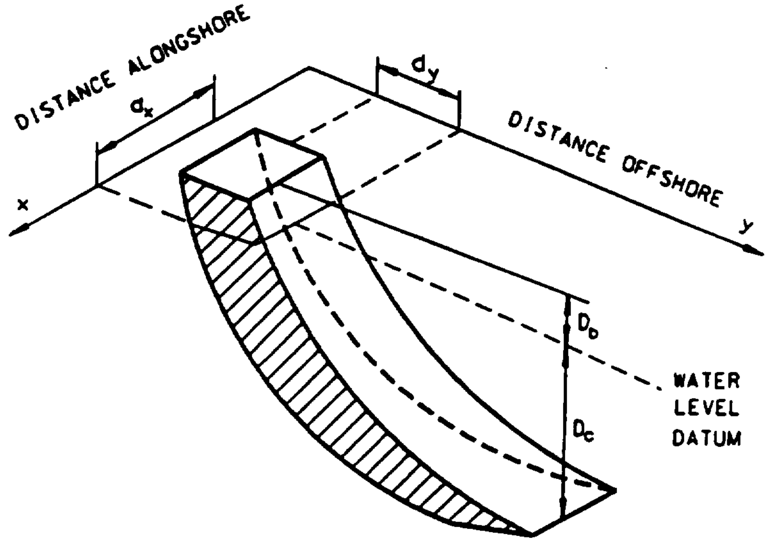


Figure A2-5. Definition of terms for active berm, closure depth, and shoreline change (modified from Hanson and Kraus 1989)

of Assateague Island (refer to "Summary of significant engineering and coastal process events" section). Active berm elevations for the pre-inlet time period were assumed using this anecdotal information together with analysis of pre-jetty rehabilitation profile information, and are presented in the second column of Table A2-3.

From 1933 to 1985 (pre-jetty tightening time period), the active berm on northern Assateague Island was most likely influenced by the elevation and porosity of the south jetty. Dean, Perlin, and Dally (1978) measured up to four sets of profiles for northern Assateague Island during the time period September 1976 through June 1977. Results from their analysis indicated that the low elevation of the south jetty was affecting the active berm elevation (Figure A2-6). For formulation of the sediment budget, this information was merged with active berm elevations as indicated by analysis of 1965, 1979, and 1984 profile data which extended further south on Assateague Island. Pre-jetty rehabilitation active berms are shown in the third column of Table A2-3.

Table A2-3. Active Berm Elevations, Assateague Island (Ocean)			
Distance South from South Jetty (km)	Active Berm Elevation (m NGVD)		
	Pre-Inlet (1850-1933)	Pre-South Jetty Rehabilitation (1933-1985)	Post-South Jetty Rehabilitation (1986-1996)
0.1	2.0	1.4	2.3
0.15	2.0	1.6	2.3
0.2	2.0	1.9	2.3
0.25-0.35	2.1	2.1	2.3
0.4-0.45	2.1	2.1	2.4
0.5-0.9	2.2	2.2	2.4
0.95-1.75	2.3	2.3	2.4
1.8-5.2	2.4	2.4	2.4
5.25-14.1	2.5	2.5	2.5

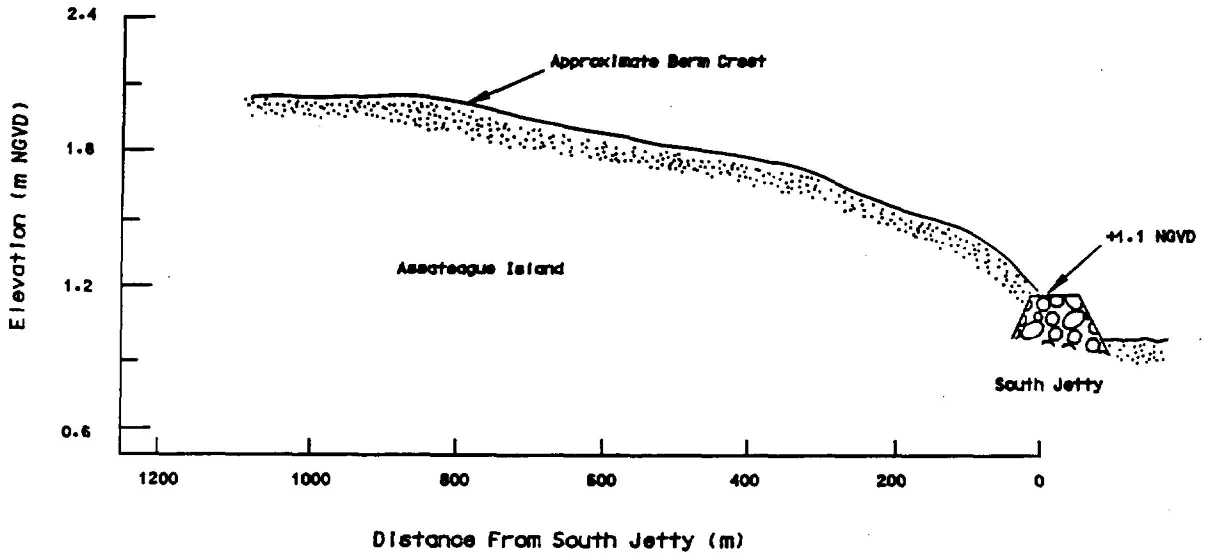


Figure A2-6. Active berm crest determined from pre-jetty rehabilitation profile data (modified from Dean, Perlin, and Dally 1978)

Analysis of profile data measured after jetty tightening and raising was completed in 1985 indicate that the active berm increased in elevation for the northern-most portion of Assateague Island. Bass et al (1994) evaluated four sets of profile data measured from June 1986 through January 1989 and concluded that profiles near the jetty accreted, with profile change further away from the jetty not as significant. Profiles from 1986 and 1995 were evaluated and indicated that the active berm for northern Assateague Island increased for the post-rehabilitation time period (1986-1996), as indicated by the fourth column in Table A2-3.

Because of the absence of bay profile data, a value for the active bay berm elevation was assumed based on discussions with CENAB personnel and others to be 1 m NGVD, for an active bay profile elevation of $Db + Dc = 1\ m + 1\ m = 2\ m$.

Percentage of Fenwick Island Beach Fill Remaining in 1996. Seven profiles from June 1988 (immediately pre-fill) and May 1996 (present-day condition) were analyzed to determine the volume of beach fill remaining on Fenwick Island. Volume change for each profile was multiplied by an alongshore distance represented by that profile to properly "weight" results at each profile location. Results from this analysis indicated that, on average, approximately 17 percent of the placed material was lost from the profile between the active berm crest elevation (3.0 m NGVD) to the active depth (-6.1 m NGVD). An additional 10 percent of material was originally placed in a dune feature (above 3.0 m NGVD), and this entire volume remained on the profile. Because the fill material was similar to or coarser than the native sediments, it was assumed that any fill losses would have moved alongshore rather than offshore. Using these results, calculations in the sediment budget assumed that 17 percent of the placed beach fill moved alongshore. Because 10 percent of the fill had been placed above the active profile elevation, this quantity was excluded in calculations of volumetric change from shoreline change data.

Ebb Shoal Evolution

Bathymetric data from 1933, 1962, 1976, 1986, and 1995 were utilized to define the ebb shoal planview "footprint," depth at the seaward edge of the footprint, and volume. Results of this analysis were used in formulation of the sediment budget to identify regions of Fenwick and Assateague Islands that are influenced by the ebb tidal shoal, and to calculate ebb shoal volume change rates for each time period.

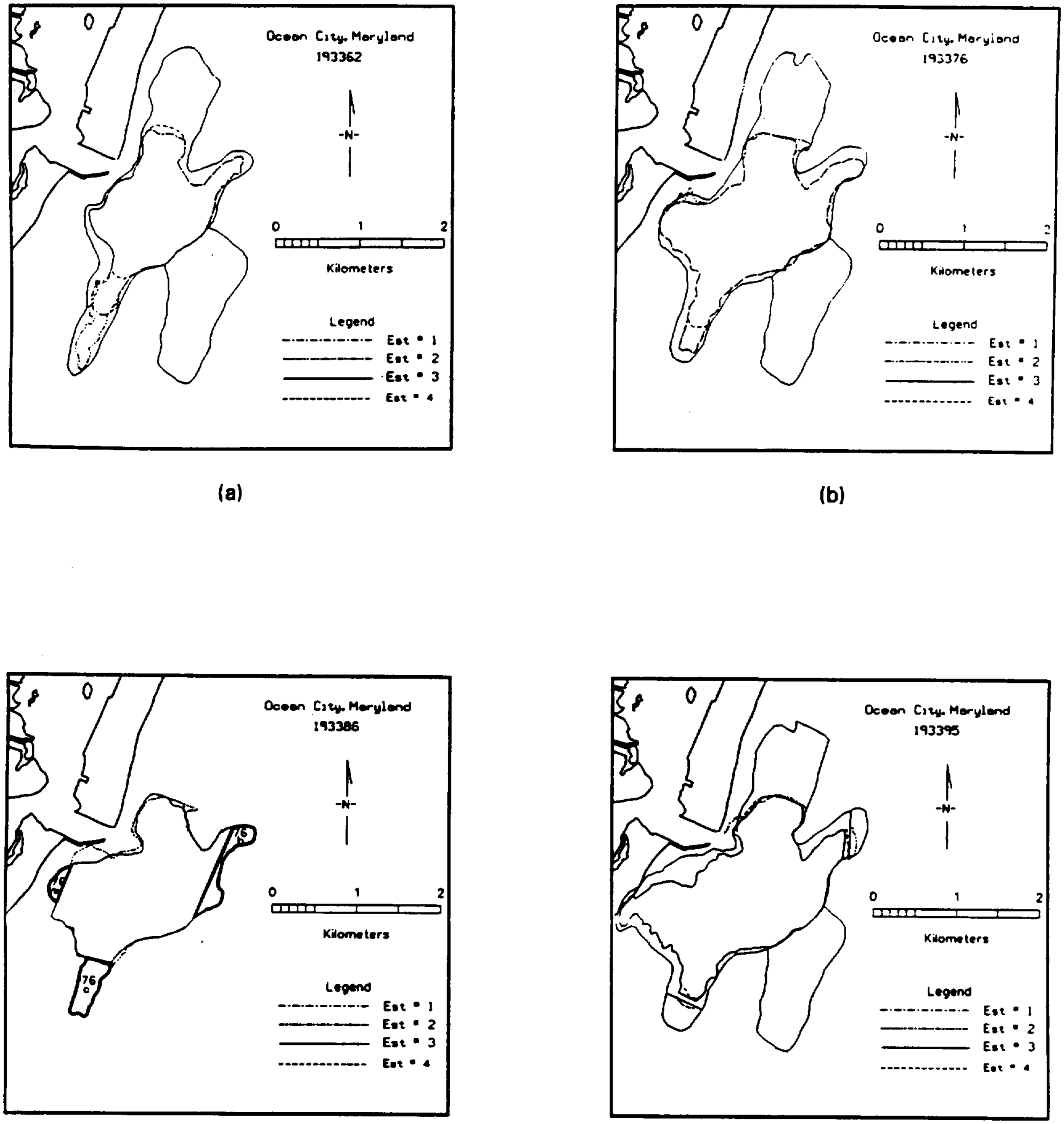
Visual inspection of a bathymetric data set or a bathymetric contour plot to delineate an ebb shoal is rather subjective. For the OCWRS, the availability of a pre-inlet (1933) bathymetry enabled application of a more objective procedure, as modified from that discussed by Hicks and Hume (1996). First, an idealized "non-inlet" bathymetry was created by using the 1933 bathymetric data set, but replacing the 1933 shoreline along the northern region of Assateague Island with the present-day shoreline position, and replacing the 1933 bathymetry in the region between the 1933 and present shorelines with present-day bathymetry which was typical of that found outside the influence of the ebb tidal shoal. To accomplish this, the 1995 shoreline was used to define the shoreward extent of the data set, and a 1995 profile which did not reflect the presence of the ebb tidal shoal was duplicated along the northern Assateague region. Using this idealized non-inlet bathymetry, "residual" bathymetries were created by subtracting it from the subsequent time periods. The residual bathymetries for each time period are shown in Figures A2-7a through A2-7d.

Next, the ebb tidal shoal footprint for each residual bathymetry was estimated by four different individuals, and residual ebb shoal volumes were calculated. Four independent estimates of the ebb shoal footprint were made to give an indication of the error associated with personal subjectivity. Results of this analysis are shown in Table A2-4.

Table A2-4. Residual Volume (Million m3) and Planview Area (Million m2) of the Ebb Tidal Shoal

Residual Bathymetry	Estimate Number							
	1		2		3		4	
	Vol	Area	Vol	Area	Vol	Area	Vol	Area
1933-1962	5.2	1.7	5.3	1.8	7.2	2.9	5.0	1.6
1933-1976	7.9	2.5	8.0	2.5	10.4	3.6	7.8	2.4
1933-1986	9.0	2.2	9.2	2.3	-	-	9.0	2.3
1933-1995	9.8	3.0	9.9	3.0	12.9	4.2	9.9	3.0

Estimates 1, 2, and 4 applied similar methods of using the 1-m residual contour to delineate the ebb shoal footprint. This contour appeared to provide a planform shape of the ebb tidal shoal that reflected onshore and alongshore evolutionary trends of the shoal as evidenced from bathymetric data. Estimate 3 used the 0-m residual contour to delineate the shoal, and therefore these estimates are higher. Estimate 3 chose the 0-m residual contour to fully capture bathymetric regions which may have accreted. These regions resulted in footprints which included more of the areas reflecting growth and lengthening of finger shoals, and deposition in troughs, which are probably only partly represented by Estimates 1, 2, and 4. All residual volumes were calculated by using the selected footprint and determining the volume above a 0-m residual contour within this polygon. Bathymetric data from 1986 and 1995 did not fully cover the ebb tidal shoal. Therefore, 1933-1976



(a) (b)

(c) (d)

Figure A-7. Residual ebb shoal bathymetries: (a) 1933-1962; (b) 1933-1978; (c) 1933-1986; (d) 1933-1995 residual ebb shoal data were used to complete coverage on the outer edges of the ebb tidal shoal for the 1933-1986 and 1933-1995 residual bathymetries.

Ebb shoal volumetric change rates using each estimate are presented in Table A2-5. For initial development of the sediment budget, volumetric change rates using Estimate 1 were utilized. For final budget calculations, sensitivity analyses are envisioned using a range of ebb shoal volume change rates.

Table A2-5. Ebb Shoal Volume Change Rates (m^3/yr)

Time Period	Estimate Number			
	1	2	3	4
1933-1962	178,000	183,000	250,000	173,000
1962-1976	196,000	190,000	223,000	201,000
1976-1986	104,000	126,000	-	122,000
1986-1995	92,100	74,000	-	84,300
1933-1995	158,000	159,000	207,000	158,000

Flood Shoal Evolution

Information about deposition in the bay is necessary in formulation of the inlet sediment budget to account for losses to the littoral system. Unfortunately, detailed bathymetric data providing full coverage of the region are not available for Isle of Wight and Sinepuxent Bays. However, bathymetric data providing partial coverage of the flood tidal shoal are available from 1934/35, 1962, 1977/78, 1981, 1991/92, and 1995. In addition, aerial photography showing partial or full coverage of the flood tidal shoal are available from Jan-Dec 1935, Jun 1952, Feb 1960, May 1964, Jun 1986, Jun 1990, and Sep 1995. By combining the partial bathymetric data sets and aerial photography, we envision that information about volumetric change in the flood tidal shoal can be estimated. This work is only partially completed at this time, as described below.

First, bathymetric data sets were digitized and aerial photographs scanned into a Geographic Information System (GIS) database. Using the aerial photographs, the footprint of the flood tidal shoal was visually interpreted and the area calculated. Digital bathymetry and photographs from the same time period were overlain with the flood shoal footprint. Our goal is to estimate the volume represented by the entire footprint by using data from the regions for which there is overlapping aerial photograph and bathymetric coverage.

For initial development of the sediment budget, the flood shoal accretion rate calculated by Dean and Perlin (1977) and Dean, Perlin, and Dally (1978) using 1931 to 1972 bathymetry was used, 19,600 m^3/yr. The sensitivity of the present-day sediment budget was evaluated by reducing this rate by half, due to the belief that flood shoal accretion would probably be greatest during the initial years after inlet formation, and would decrease with time.

Total Littoral Impact of Ocean City Inlet

CENAB required information about the total littoral impact of Ocean City Inlet on the adjacent beaches so that the impacts to Assateague Island could be mitigated. In particular, estimates of volume of littoral sediment which has not been provided to Assateague Island, and the alongshore distance which has been impacted by the inlet were applied in design of the Assateague Island beach fill.

Alongshore Impact. To estimate the alongshore distance of inlet impact, a simple analytical procedure, the even/odd method, was applied to the shoreline change data sets. This method is discussed and applied by Berek and Dean (1982), Dean and Pope (1987), Work and Dean (1990), and Dean and Work (1993), and can be solved from the linearized treatment of shoreline evolution (Pelnard-Considere 1956). The method decomposes shoreline change (or, as applied in this case, volume change) data into their symmetric (even) and anti-symmetric (odd) components about a point of significance. For application at Ocean City Inlet, the center of the inlet was chosen as the point about which data were decomposed into even and odd components. Volumetric change data were used so that the effects of beach fill could be removed, and so that the alongshore variation in active depth could be incorporated.

Volume change between two time periods at some alongshore position x, $dV(x)$, can be represented by even (symmetric) $dVe(x)$ and odd (anti-symmetric) components $dVo(x)$,

$$dV(x) = dVe(x) + dVo(x) \qquad \text{(A2-2)}$$

The even component is defined as

$$dVe(x) = \frac{dV(x) + dV(-x)}{2} \qquad \text{(A2-3)}$$

And the odd component is given by

$$dVo(x)=\frac{dV(x)-dV(-x)}{2} \qquad \text{(A2-4)}$$

The even and odd functions are indicators of those shoreline or volumetric changes which have been symmetric or anti-symmetric, respectively, about the point of significance. For an inlet with the centerline chosen as the point of significance, the even function reflects changes in shoreline position (or volume change rate) which have occurred symmetrically about the inlet. Examples of symmetric changes that might occur at an inlet are: shoreline retreat or advance due to cross-shore transport (due to storms or relative sea level change), and symmetric shoreline retreat due to sediment feeding the ebb and flood tidal shoals. An example of an anti-symmetric change common to stabilized inlets, which is reflected by the odd function, is impoundment on the updrift beach at the expense of the downdrift beach. The alongshore point at which the odd function returns to a zero value is an indicator of the alongshore distance influenced by the anti-symmetric effects, such as impoundment, which is a project-induced impact. The alongshore point at which the even function approaches a constant value is an indication of the alongshore distance influenced by symmetric inlet-induced effects such as shoreline retreat due to feeding the ebb and flood tidal shoals. For the region of shoreline for which the even function approaches a constant value, the sum of the even and odd functions can be thought to represent the "background" shoreline (or volumetric) change rate (e.g., sea level rise, influence of storms, etc.).

For analysis at Ocean City, the even/odd method was applied to four ocean shoreline change data sets: 1929/33-1962, 1929/33-1980, 1929/33-1989, and 1929/33-1996. These data were converted to volume change rates by multiplying by the active depth and the alongshore cell width (see Equation A2-1). The effects of beach fill (which are reflected in the shoreline position) were removed from the signal by subtracting an estimate of the beach fill volume remaining from the volume in each cell. If measurements indicating the volume of remaining beach fill were not available, then an estimate of beach fill reflected in the shoreline position was estimated by assuming a beach fill "loss" (or alongshore movement) rate of approximately 2-percent per year. This estimate was based on the volume of beach fill remaining as of May 1996 for the Fenwick Island profiles (see "Percentage of Fenwick Island Beach Fill Remaining in 1996" section). Figure A2-8 shows an example result for the 1929/33-1996 data set, for which the odd function returns to a zero value approximately 10 km from the centerline of the inlet, and the even function approaches a constant value at approximately 12.5 km from the centerline of the inlet. The even-odd method was applied to data sets for each of the time periods listed above, and the alongshore impact distances for the even and odd functions were determined. Figure A2-9 shows the variation of alongshore impact distance with time.

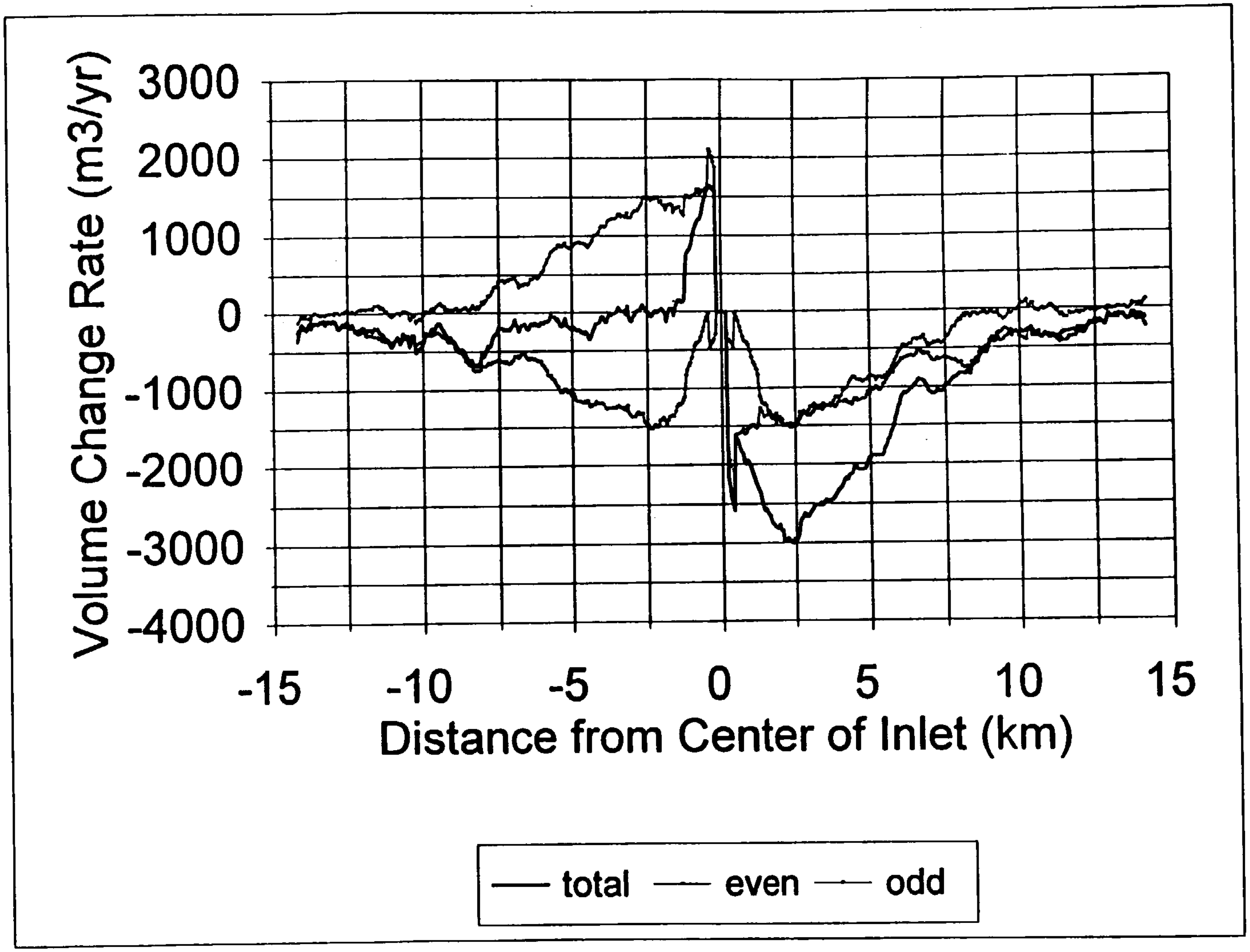


Figure A2-8. Total volumetric change, even, and odd functions for the time period 1929/33-1996 (beach fill effects have been removed from the signal)

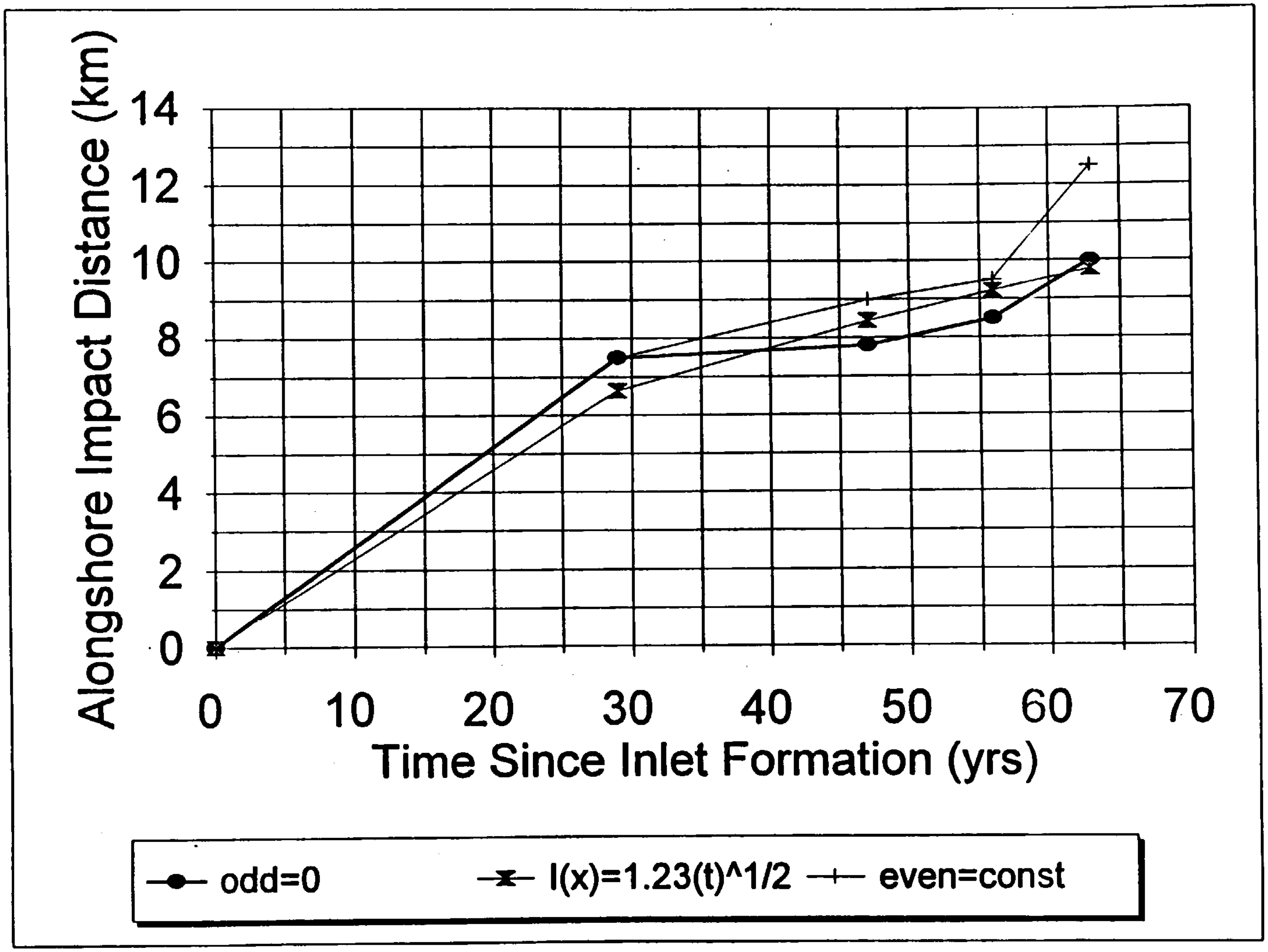


Figure A2-9. Variation of alongshore impact distance with time, and comparison with theory

The increase in the odd component's alongshore impact distance with time as shown in Figure A2-9 agrees well with an analytical solution of the one-line model of shoreline change (Dean and Grant 1989) for the case of a total littoral barrier (e.g., a long groin or jetty). This solution expresses the alongshore impact distance $I(x)$ as a function of the square root of time, t,

$$I(x) = 1.23\sqrt{t} \qquad \text{(A2-5)}$$

in which the coefficient has been empirically determined as a best-fit average from this data set.

Volumetric Impact. To estimate the total volumetric impact, volumetric change rates were calculated for the pre-inlet (1850-1933) and post-inlet (1933-1996) time periods. The control volume for the calculations extends offshore to the depth of closure (6.1 m NGVD), includes the bay shoreline changes and assumptions about the flood shoal accretion rate, and extends alongshore through the region influenced by the inlet. For preliminary estimates, the minimum alongshore impact distance, ± 10 km from the centerline of the inlet, was used in calculations. We plan to also evaluate the maximum impact distance, ± 12.5 km and include these results in the Final Feasibility Report. The volumetric impact was defined as the increase in Assateague Island's volume change losses in the post-inlet time period over those that occurred in the pre-inlet condition.

Figure A2-10 shows idealized shoreline positions with calculation results for the pre-inlet time period. Both ocean and bay volumetric change rates are reflected in the results, as calculated from shoreline change data. The portion of the pre-inlet barrier from 0 to -10 km (Fenwick Island) had a net change of -61,500 m3/yr over the 83-year time period. The southern 10 km (Assateague Island) lost more than double this rate, or -136,000 m3/yr. The higher volumetric erosion for what would become Assateague Island most likely reflects, in part, effects of the groins constructed on Fenwick Island (initiated in 1922), and the fact that northern Assateague was of lower elevation and therefore could have been experienced more overwash than Fenwick Island. This material could have been transported over the island and deposited in the bay (i.e., sediment losses to the island which would not be reflected by the bay shoreline position).

For the post-inlet time period, several data sets were utilized: ocean and bay shoreline change rates (used to calculate volume change rates), dredging and beach fill placement records (presented in Table A2-1), the ebb shoal volume change rate from 1933-1995 (estimate 1 presented in Table A2-5), and flood shoal growth rate as estimated by Dean and Perlin (1977). The initial loss of material due to the island breach in 1933 was estimated using typical ocean and bay profile shapes, and amortized over the 63-year post-inlet time period. The calculations for the post-

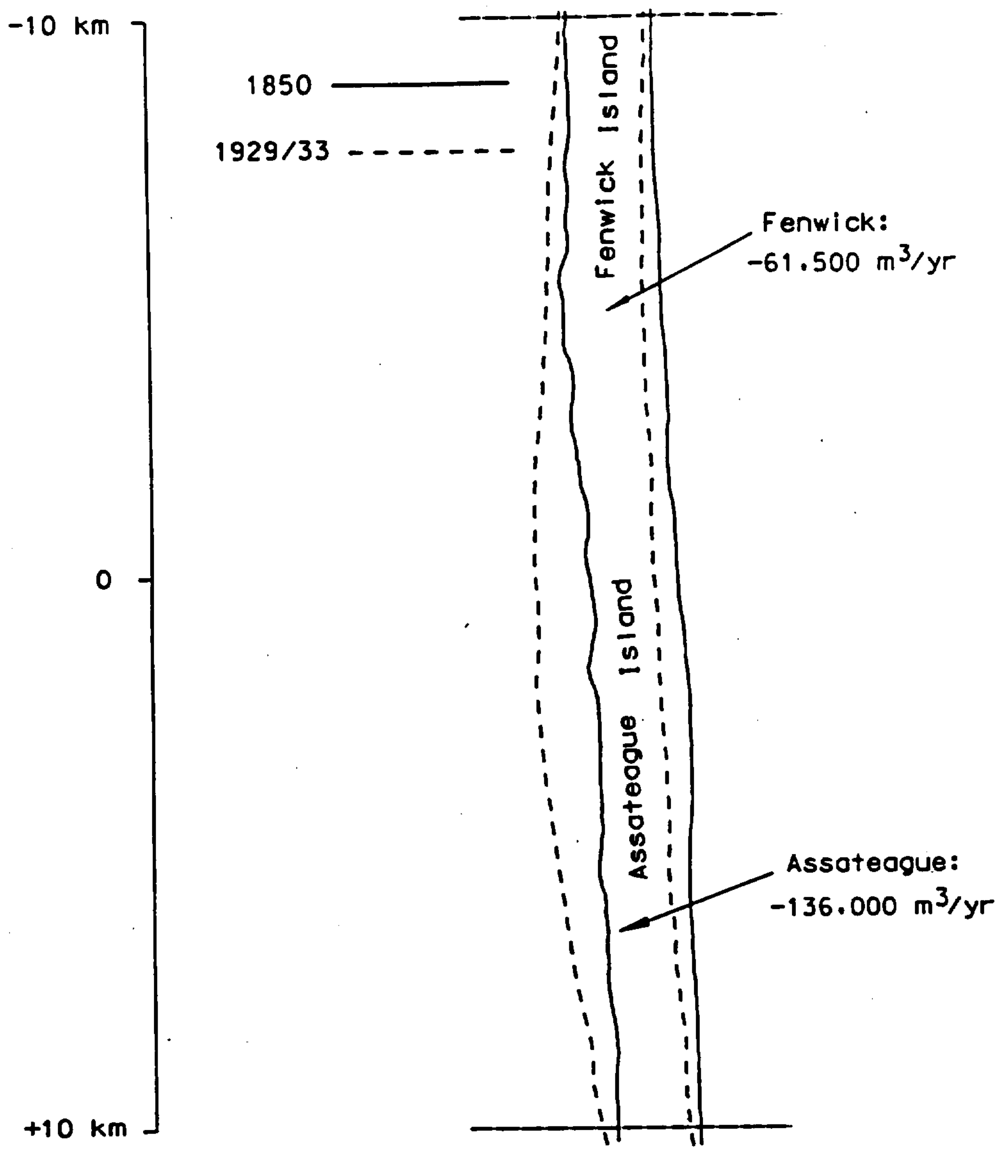


Figure A2-10. Pre-inlet (1850-1933) volumetric change rates inlet time period are presented in Figure A2-11. These volume change rates have been corrected to account for fill placement.

Since inlet creation, Fenwick Island has been relatively stable with a net accretion of 1,500 m^3/yr. However, Assateague Island has lost a net -242,000 m^3/yr. Dredging of the channel and bay accounts for approximately 56,000 m^3/yr of sediment, and Estimate 1 indicates that the ebb shoal has accreted at approximately 158,000 m^3/yr. Estimates for the initial breach loss, amortized over the 63-year post-inlet time period indicate 8,500 m^3/yr loss.

To calculate the total volumetric impact to Assateague Island, the pre-inlet volumetric erosion rate was subtracted from the post-inlet rate to result in an increase in the loss rate during the post-inlet time period of -106,000 m^3/yr from 1933-1996. CENAB requested an estimate of the volumetric impact since Assateague Island became a National Park in 1965 through the present (1996), or over 31 years. Using the increased volumetric erosion rate of -106,000 m^3/yr times 31 years results in a volumetric loss to Assateague Island since 1965 of **3.3 million m3**. Since 1934, Assateague Island has lost approximately **6.6 million m3**. These volume loss estimates represent an approximation of the impact due to natural processes (creation and evolution of Ocean City Inlet and its ebb and flood shoals) and human-induced changes to the inlet system (maintenance of a federal navigational channel and stabilization of the inlet with jetties). It must be recognized that this entire volumetric impact cannot be solely attributed to the Federal project. It is possible that, if the inlet were not stabilized and maintained, that the inlet would have closed with time (as occurred with Sinepuxent Inlet from 1920 to 1928), and the adjacent beaches would have lost material that was used to form the ebb and flood tidal shoals. It is likely that most of the ebb tidal shoal material would have eventually returned to the littoral system; however, losses to the bay would have been permanent. However, if natural processes alone (no human intervention) had kept the inlet open, there would also have been a significant volumetric impact to Assateague Island.

Present-day Shoreline Change Trends along Assateague Island

Present-day (April 1989-May 1996) trends along the ocean shoreline are presented in Figure A2-12. These data indicate that the present-day erosion rate is a maximum of approximately -9 m/yr and occurs approximately 7 km south of the inlet. However, the strong erosional zone (rates ranging from -1 to -9 m/yr) extends from approximately 3 to 12.5 km from the inlet.

CENAB designed the Assateague Island beach fill to mitigate slightly less than half the estimated volumetric loss since 1965, or 1.4 million m^3. The beach fill extends from 3 to 11.3 km along Assateague Island. The northern bound of the

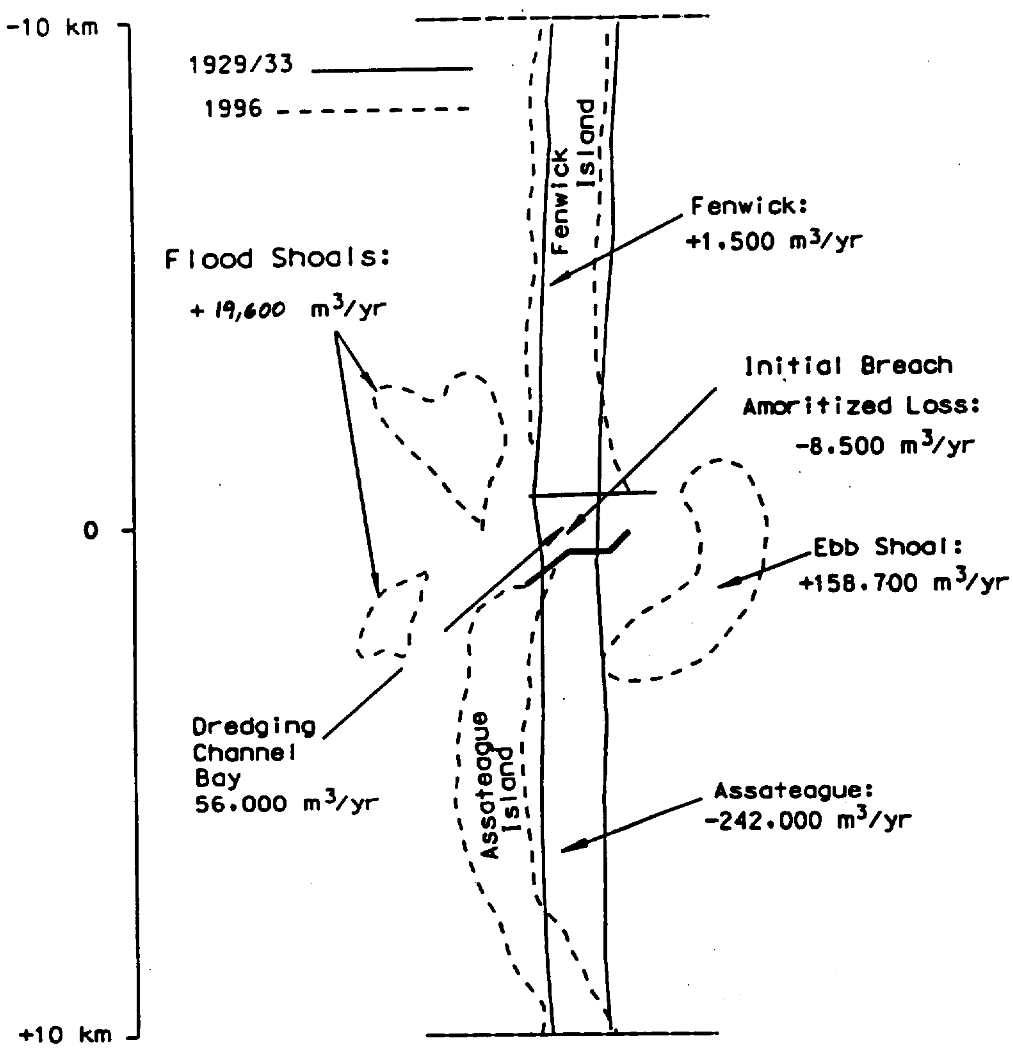


Figure A2-11. Post-inlet (1933-1996) volumetric change rates

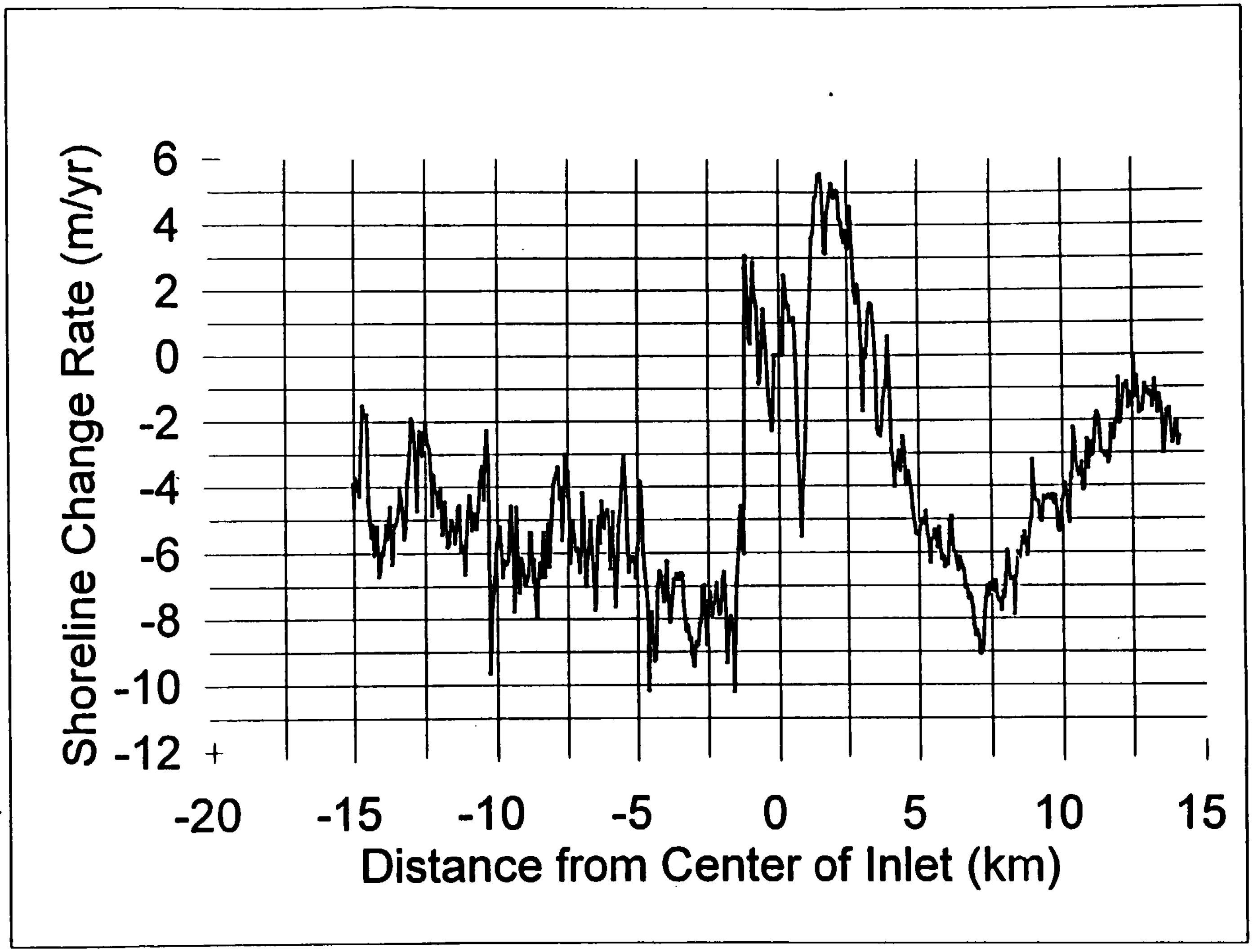


Figure A2-12. Present-day (1989-1996) ocean shoreline change rates beach fill (3 km south of the inlet) was chosen to mitigate the present-day "strong" erosional zone, as discussed previously. The southern bound of the beach fill (11.3 km) was chosen as the average of the alongshore impact distance indicated by the odd (10 km) and even (12.5 km) functions (see Figure A2-8). It is expected that the beach fill will be transported past 11.3 km by the net southerly transport direction. Present-day erosion rates have been factored into the design of the storm berm (its position on the existing and construction profile).

Present-Day Sediment Budget and Bypassing Rate Required to Restore "Natural Processes" along Assateague Island

A present-day sediment budget reflecting the post-jetty tightening time period, 1986 through the present 1996, was formulated using volume change calculations for cells within the project reach. The purpose of the present-day sediment budget was to define a range of bypassing rates that would be required to restore "natural bypassing processes" to Assateague Island. "Natural bypassing" was interpreted as the net longshore sediment transport rate that presently occurs on south Fenwick Island and would reach Assateague Island if Ocean City Inlet did not exist. Under present-day conditions, it is speculated that only a portion of this transported material reaches Assateague Island, but that the rate of material reaching Assateague Island will increase with time.

Sediment budget cells representing regions of the shoreline were delineated based on observed trends in shoreline change rates during the present-day time period. Other sediment budget cells represent the ebb shoal footprint, the flood shoal and bay, and the channel region. Figure A2-13 shows cells for the present-day sediment budget. Volume change rates within each sediment budget cell were calculated using the data sets discussed previously: volume change associated with shoreline retreat/advance; volume change within the ebb tidal shoal; dredging records; beach fill placement records; and an estimate of the flood shoal accretion rate from Dean and Perlin (1977).

The concept of a sediment budget is simply that sediment continuity is maintained within each cell; that is, the volume change rate within a cell is reflected by the difference between the rate of sediment entering and leaving the cell. For this study, the greatest unknown in formulation of the budget was the magnitude of the net and gross longshore sediment transport rates. For a shoreward-looking observer, the net longshore sediment transport rate, Q_{net}, is defined as the sum of sediment moving to the right, which is to the south at Ocean City, Q_{south}, and sediment moving to the left, which is to the north at Ocean City, Q_{north}, for which right-directed transport is positive, and left-directed transport is negative,

$$Q_{net}=Q_{south}+Q_{north} \qquad \text{(A2-6)}$$

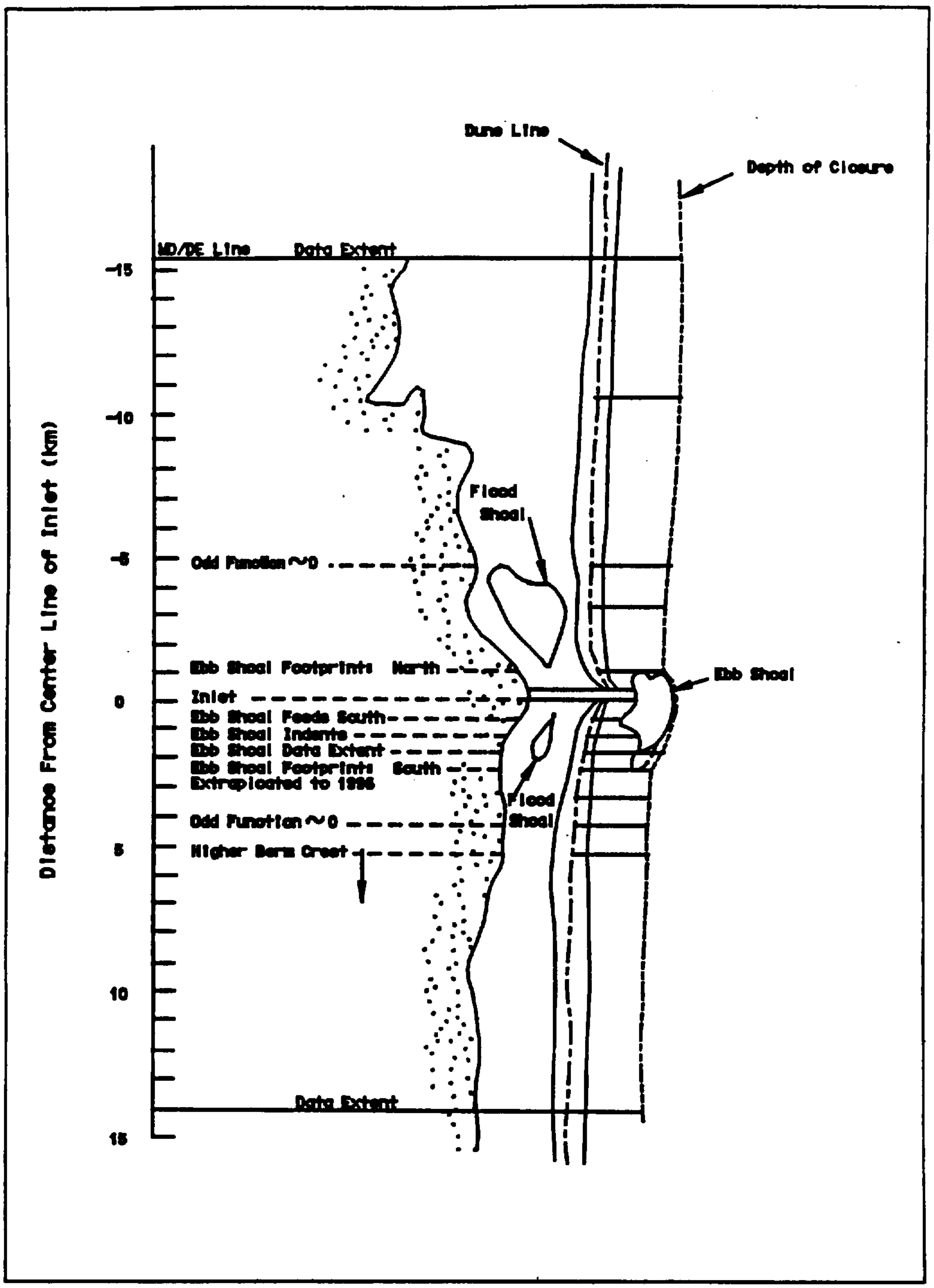


Figure A2-13. Present-day (1989-1996) sediment budget cells

The gross longshore sediment transport rate, Q_{gross}, is defined as the absolute sum of these two quantities,

$$Q_{gross}=|Q_{south}|+|Q_{north}| \tag{A2-7}$$

Net and gross potential longshore sediment transport rate calculations presented in Appendix A1 give an indication of alongshore sediment transport *trends*; however, the *magnitude* of these values are a function of sediment availability, sediment grain size and distribution, and other factors (including deficiencies in the predictive formulae). Ideally, these magnitudes can be calibrated to reflect the calculated volume change within each cell.

Use of accepted longshore sediment transport rates in the project region is another method of calibrating the potential longshore sediment transport rates. Several researchers have estimated values for Ocean City from various data sets. Dean and Perlin (1977) estimated that the north jetty was fully impounded by 1972, with an impoundment rate from 1933 to 1972 ranging from 115,000 to 153,000 m^3/yr. This impoundment rate can be thought to represent the southerly-directed Q_{south} , and probably represents a lower estimate due to the fact that the north jetty was most likely not a total littoral barrier for all conditions during this time period. Dean and Perlin also analyzed Littoral Environment Observation (LEO) data which was measured approximately 12.9 km south of the inlet on Assateague Island in 1973. These data indicated an average Q_{net} to the south equal to 795,000 m3/yr, with Q_{gross}=1,892,000 m3/yr, Q_{south}=1,344,000 m3/yr, and Q_{north}= 549,000 m3/yr. Although the magnitude of the values most likely is too high, the relative proportion of Q_{south}/Q_{north}=2.5 might be reasonable for this location on Assateague Island. This ratio varies alongshore; as mentioned in the previous chapter, there is a generally-accepted nodal point in Q_{net} which is approximately located at the Maryland-Delaware state line. This nodal point can vary annually from Indian River Inlet, Delaware to as far south as the northern sections of Ocean City (Mann and Dalrymple 1986; Underwood and Hiland 1995). Therefore, at the state line, on average the ratio Q_{south}/Q_{north}~1. Douglass (1985) estimated an average Q_{net} to the south of 214,000 m^3/yr based on Wave Information Study (WIS) hindcast data from 1956-1975. Based on Douglass' work and growth rates of the ebb and flood tidal shoals, Underwood and Hiland (1995) adopted southerly-directed Q_{net} equal to 212,800 m^3/yr.

Within this study task, two other methods to estimate longshore sediment transport rates were applied. Using the concept of continuity and an assumption that Ocean City inlet represents a total sink for littoral material, the total volume of the ebb and flood tidal shoals, plus maintenance dredging volume divided by the number of years since inlet creation can be thought to represent Q_{gross} at the inlet, or approximately 14.8 million m^3/63 years = 234,000 m^3/yr. A second method used the rate of alongshore movement of the Fenwick Island beach fill. The rate of Fenwick Island beach fill alongshore movement, which was determined to be approximately 17 percent of the total volume placed, can be thought to represent the net longshore sediment transport rate. Seventeen-percent of the total fill volume, 0.17 * 7.4 million m^3 divided by the time period in which the loss was estimated (1988 to 1996, or 8 years) results in Q_{net}~156,000 m^3/yr. Table A2-6 summarizes these results.

Table A2-6. Summary of Longshore Sediment Transport Estimates

Study	Longshore Sediment Transport Estimate (m^3/yr)
Dean and Perlin 1977; Dean, Perlin, and Dally 1978	Q_{south}~115,000-153,000 Q_{south}/Q_{north} at 12.9 km ~ 2.5
Mann and Dalrymple 1986; Underwood and Hiland 1995	Q_{south}/Q_{north} at -14 km ~ 1.0
Douglass 1985	Q_{net}~214,000
Underwood and Hiland 1995	Q_{net}~212,800
This Study: Method #1	Q_{gross}~234,000
This Study: Method #2	Q_{net}~156,000

A preliminary sediment budget was formulated using three magnitudes of Q_{net} at the southern-most end of Fenwick Island: 115,000, 153,000, and 212,800 m^3/yr. These Q_{net} values were selected as being a representative range of reasonable low, mid, and high magnitudes based on the estimates presented in Table A2-6. For each of these values, longshore sediment transport magnitudes for all other cells were calculated using the known volume change rates within each cell. Also, the sensitivity of the preliminary budget to the flood shoal volumetric accretion rate was evaluated by using half the value cited by Dean and Perlin (1977). Preliminary sediment budget results are presented in Table A2-7. Subtracting the quantity that is estimated to reach Assateague Island (see net longshore sediment transport values at 0.9 km) from the quantity that enters the ebb shoal (see net longshore sediment transport values at the north jetty, -0.2 km) gives the bypassing quantity necessary to restore natural processes to Assateague Island. The preliminary sediment budget indicates that this quantity ranges from 118,000 (using Dean and Perlin's (1977) flood shoal/bay accretion rate) to 107,000 m^3/yr. The lower range of flood shoal/bay accretion rate is probably more reasonable for present-day estimates. Therefore, guidance from this preliminary present-day sediment budget is that approximately 110,000 m^3/yr must be mechanically bypassed to Assateague Island to restore natural processes. This estimate will be revised as the preliminary sediment budget is refined, and will be presented in the Final Feasibility Report.

Table A2-7. Preliminary Sediment Budget Results						
Distance from Center of Inlet (km)	Net Longshore Sediment Transport Rates (m^3/yr) *(positive values indicate transport to the south)*					
	Flood Shoal/Bay Accretion = 19,600 m^3/yr			Flood Shoal/Bay Accretion = 9,800 m^3/yr		
	115,000	153,000	212,800	115,000	153,000	212,800
-15.1	-405,000	-349,000	-289,000	-405,000	-349,000	-289,000
-10.5	-193,000	-137,000	-77,000	-193,000	-137,000	-77,000
-4.5	-42,000	-3,600	56,000	-42,000	-3,600	56,000
-3	14,000	52,000	112,000	14,000	52,000	112,000
-0.85	92,000	130,000	190,000	92,000	130,000	190,000
-0.2	115,000	153,000	212,800	115,000	153,000	212,800
0.2	0	0	0	0	0	0
0.9	-2,800	35,000	95,000	8,200	46,000	106,000
1.3	-6,600	31,000	91,000	4,000	42,000	102,000
2.05	-32,000	5,600	65,000	-21,000	17,000	76,000
2.6	-51,000	-13,000	47,000	-40,000	-1,500	58,000
3.5	-60,000	-22,000	38,000	-49,000	-11,000	49,000
4.5	-56,000	-18,100	42,000	-45,000	-7,100	53,000
5.6	-9,100	29,000	89,000	2,000	40,000	100,000
14.2	187,000	225,000	285,000	198,000	236,000	296,000

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Appendix A3
Design of the Restoration Project Cross-Section

Introduction

One critical design parameter for the restoration of north Assateague Island is the elevation to be created during the process of restoring sand to the island. The restoration is justified, in part, as a means for reducing the potential for breaching along the island's severely eroded north end. Some of the economic benefits associated with the project stem from the breach protection that it provides. Much of north Assateague Island is void of any relief above the natural berm height, and overwash is a regular occurrence. There are several areas that are particularly low in elevation and show evidence of well-defined overwash channels. The low relief and the presence of these channels make the island susceptible to breaching, as has happened in the past. The most cost-effective means for reducing the potential for breaching is to provide additional elevation to the island, in the form of a dune or storm berm feature. Creating and maintaining a well-designed elevation feature would provide the greatest protection against a breach.

However, environmental factors and desires of the local cost-sharing partners pose constraints on the design, and must be considered. The restoration must be done in such a way as to avoid any significant adverse impact on the piping plover habitat that presently exists on the north end of the island. Design of the elevation feature basically involves conflicting goals: a desire to increase the elevation of the island to reduce the likelihood of a breach and a desire to minimize the increase in elevation to avoid alterations to the existing plover habitat. This chapter describes the process of designing the cross-sectional shape of the project in a way that balances engineering and environmental concerns.

The primary tool used in the design process was the Storm-induced BEAch CHange Model (SBEACH) (Larson and Kraus, 1989, 1990), (Wise et al, 1996). The model was applied to compute wave run-up, overwash, and storm-induced beach erosion for without- and with-project conditions. The following overview summarizes the work that will be discussed in this chapter.

First, existing beach conditions along the northern end of Assateague Island are characterized in terms of vegetation cover, beach profile shape, maximum profile elevations, and risk of breaching. Next, observations of current run-up and overwash conditions are presented, along with discussion of the estimated minimum frequency of overwash that is needed to retain acceptable plover habitat. An analysis was then done using the SBEACH model to assess the typical tide and storm conditions which now produce the frequent overwash, and this work included qualitative validation of the model. Next, a process for selecting storm events that overwash with the desired frequency is outlined. Lastly, application of the SBEACH model to predict run-up, overwash, and erosion for several design alternatives is presented, along with the rationale for deciding on a preferred cross-sectional shape.

Beach Conditions Along North Assateague Island

Figure A3-1 is a composite aerial photo of the northernmost 4.5 km of north Assateague Island taken in September of 1995. The area most susceptible to overwash and breaching extends from a distance of about 1.5 km south of the inlet to a point about 9 km south of the inlet. The southern portion of the photo is typical of the beach in the critical area. The photo shows a beach and barrier island nearly void of vegetation as a result of the frequent overwash events. Only near the back side if the island does significant vegetation remain, and only in isolated areas. At locations about 1 and 4-4.5 km south of the inlet, well-defined overwash channels are identifiable (darker lines running across the island). Overwash deposits are visible on the bay side of the island in the vicinity of these overwash channels. The larger morphologic features on the bay side of the island are remnant overwash fans from historic episodic overwash events. The two vegetated overwash fans in the center of the photo are in the vicinity of the 1962 breach, the last major breach that occurred along this part of the island.

Beach profile surveys were done on north Assateague in September of 1995. Existing National Park Service (NPS) monumentation was re-occupied to establish the survey lines and reference the data to known geographic positions. Twenty-six profile lines were surveyed. Figures A3-2 through A3-8 show the profiles, in groups of three or four, starting with profile AI-1 which is closest to the inlet and ending with AI-26 which is in the State Park. Profile AI-2 is located about 0.5 km south of the inlet. Profiles to the south of AI-2 are spaced at approximately 0.5-km intervals. In the original data files, profile elevations are given in feet NGVD and horizontal cross-shore distances are given in ft relative to the NPS baseline monuments. However in the figures, profiles are horizontally aligned, or shifted, so that the zero elevation point on the profiles match. This was done to study the relative shapes and similarities of adjacent profiles.

The influence of the Ocean City Inlet ebb tidal shoal is seen in profiles AI-1 through AI-3. Note the high degree of similarity in the above-NGVD portions of profiles AI-4 through AI-18, which represent a stretch of some 7 km. The profile steadily increases from an elevation of about 2 ft (0.6 m) NGVD on the bay side to the ocean-side berm crest at an elevation of about 8.5 ft (2.6 m) NGVD. The slope of the subaerial portion of the island also is very similar for all these profiles. The beach berm crest is the highest part of the island over a substantial length of shoreline. These are the areas most prone to overwash and breaching.

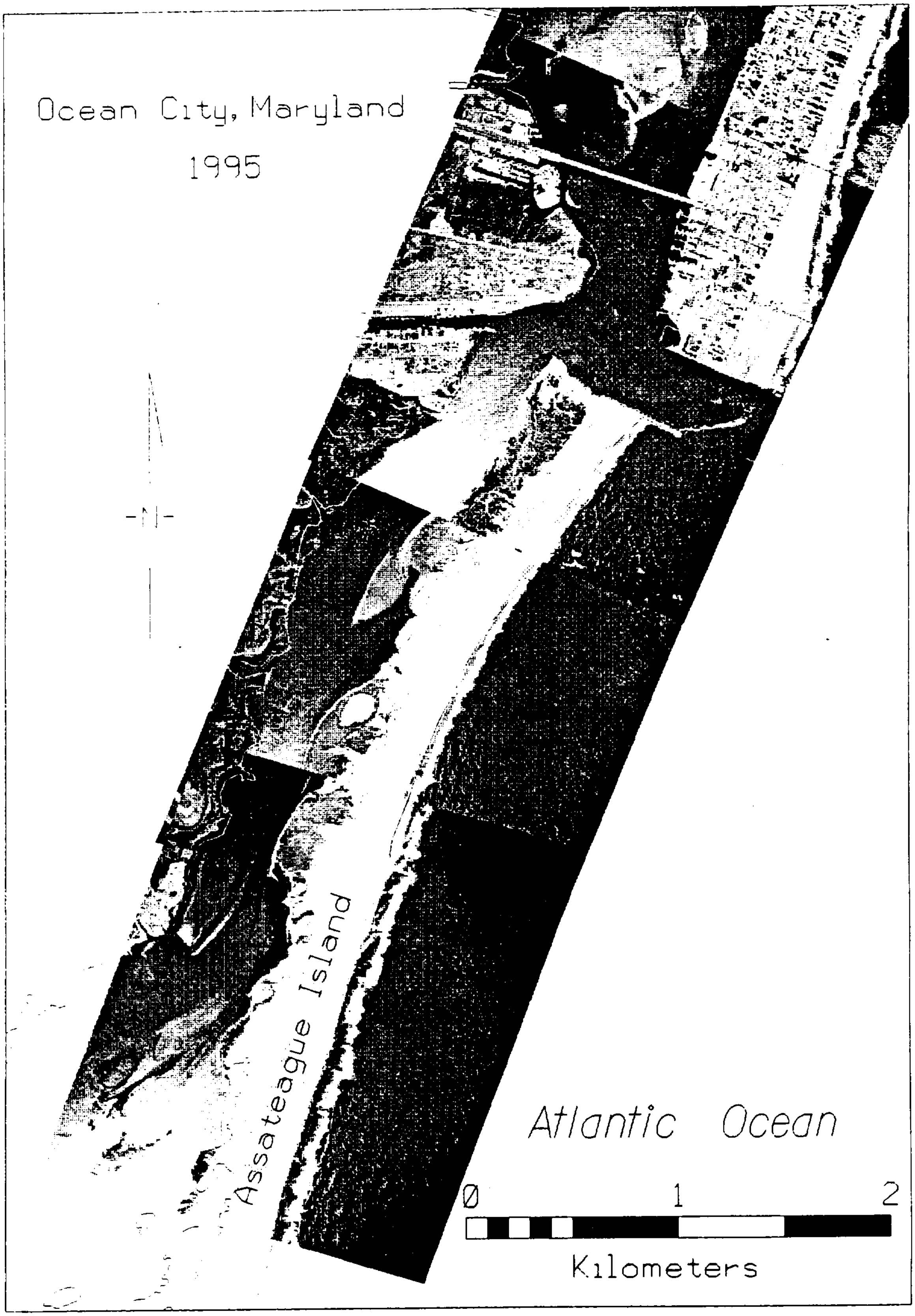

Figure A3-1. Composite aerial photograph of Ocen City Inlet, MD and Northern Assateague Island

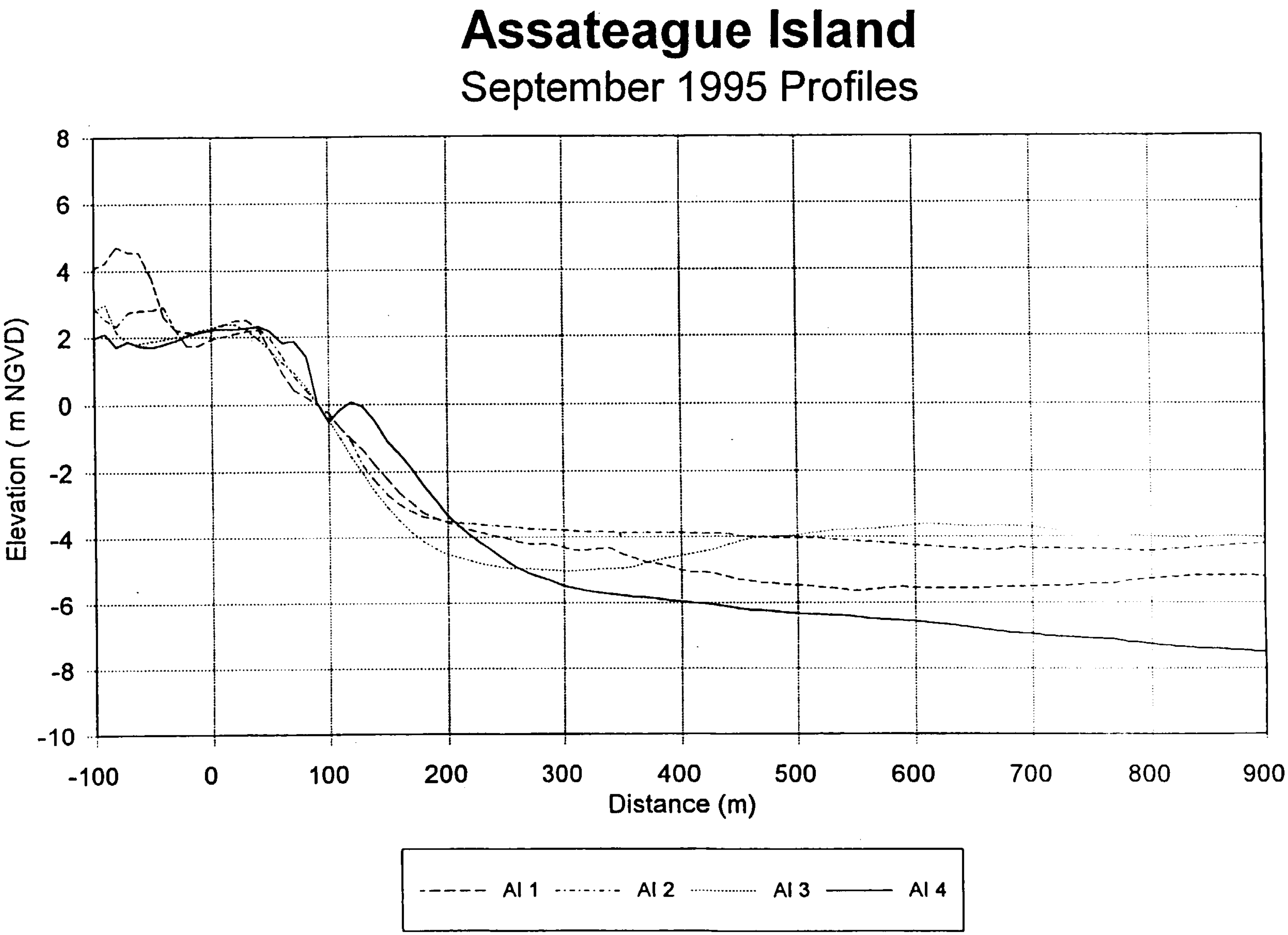

Figure A3-2. Assateague Island Profiles, Lines AI 1 through AI 4

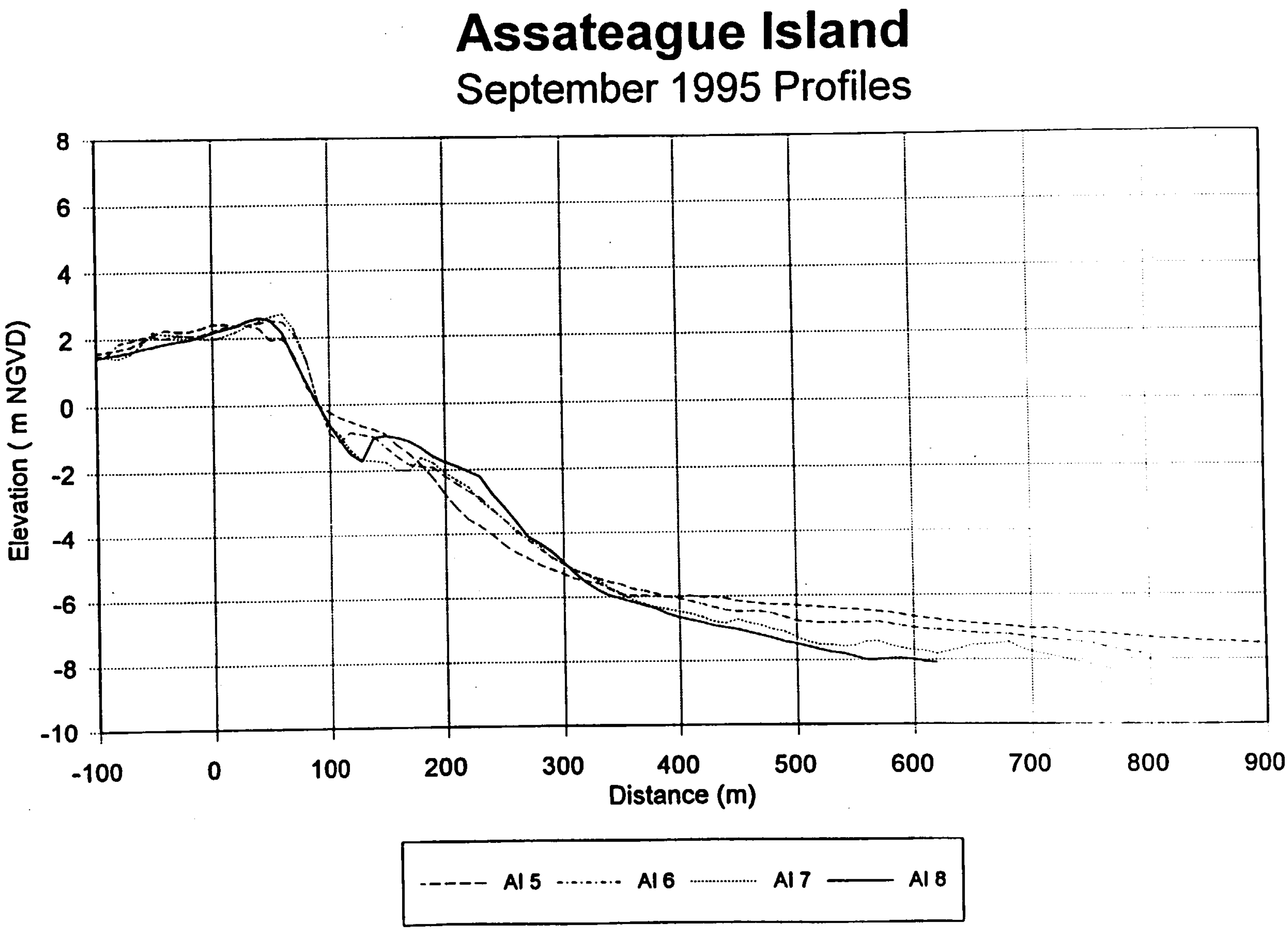

Figure A3-3. Assateague Island Profiles, Lines AI 5 through AI 8

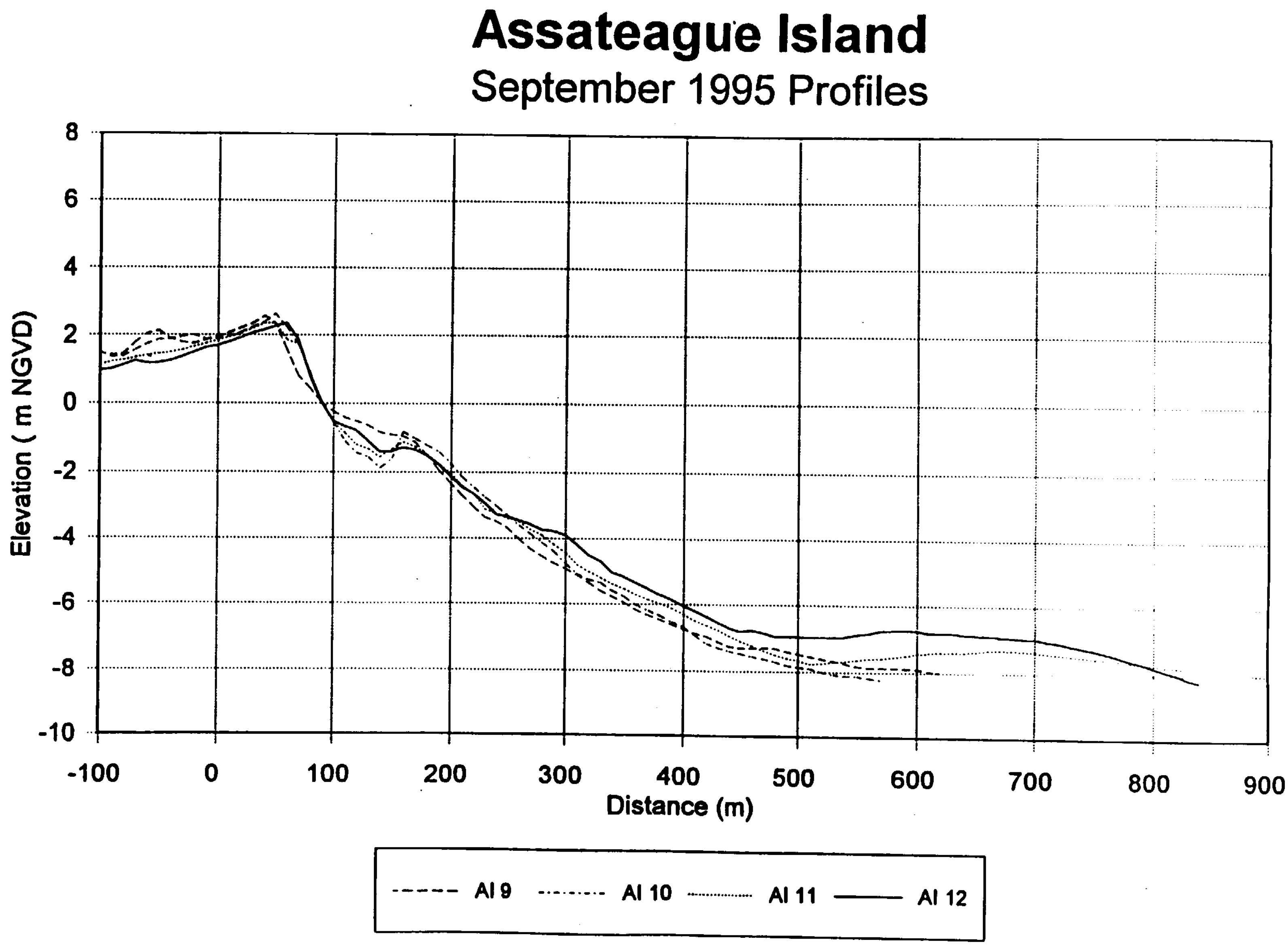

Figure A3-4. Assateague Island Profiles, Lines AI 9 through AI 12

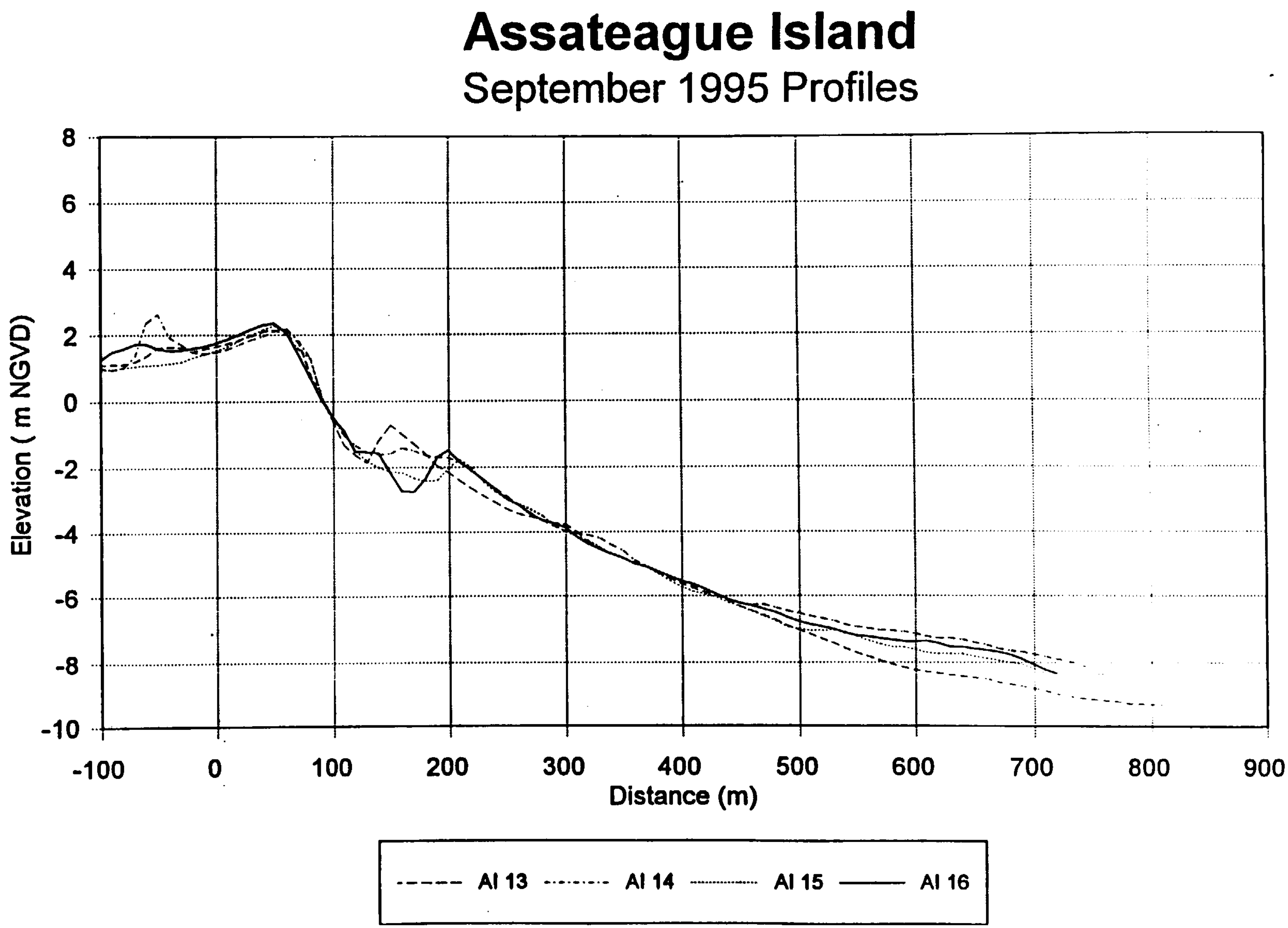

Figure A3-5. Assateague Island Profiles, Lines AI 13 through AI 16

Assateague Island
September 1995 Profiles

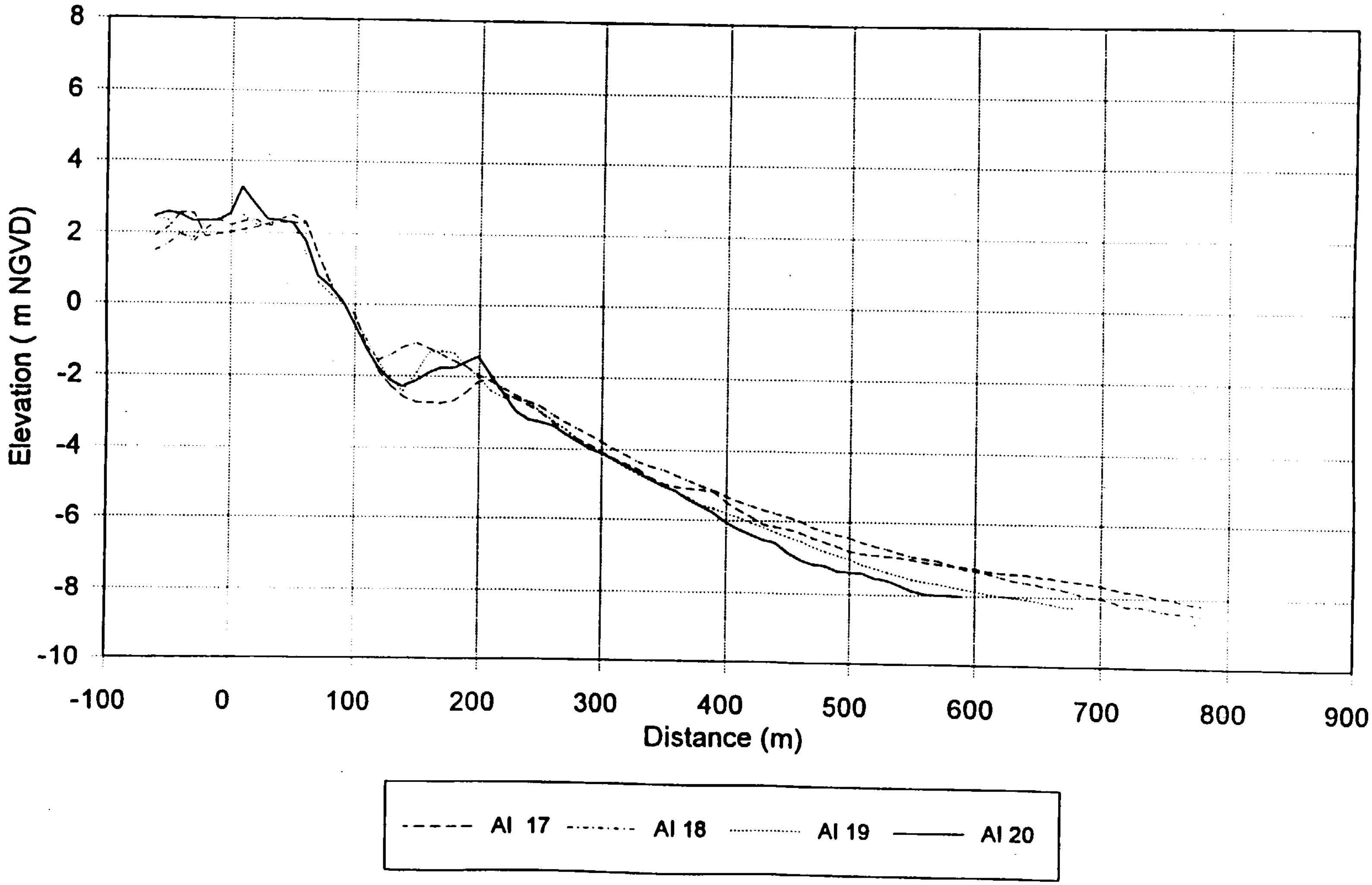

Figure A3-6. Assateague Island Profiles, Lines AI 17 through AI 20

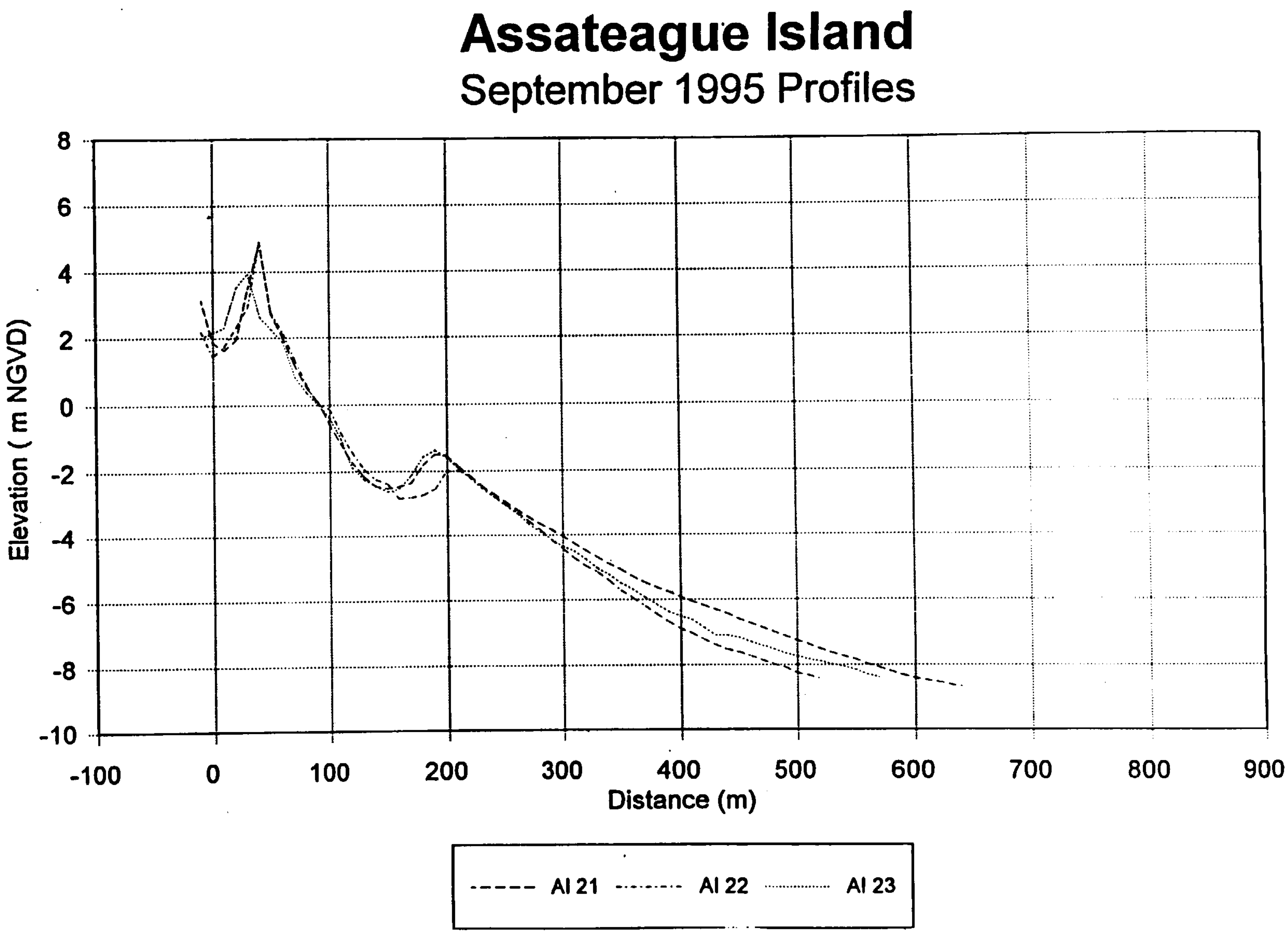

Figure A3-7. Assateague Island Profiles, Lines AI 21 through AI 23

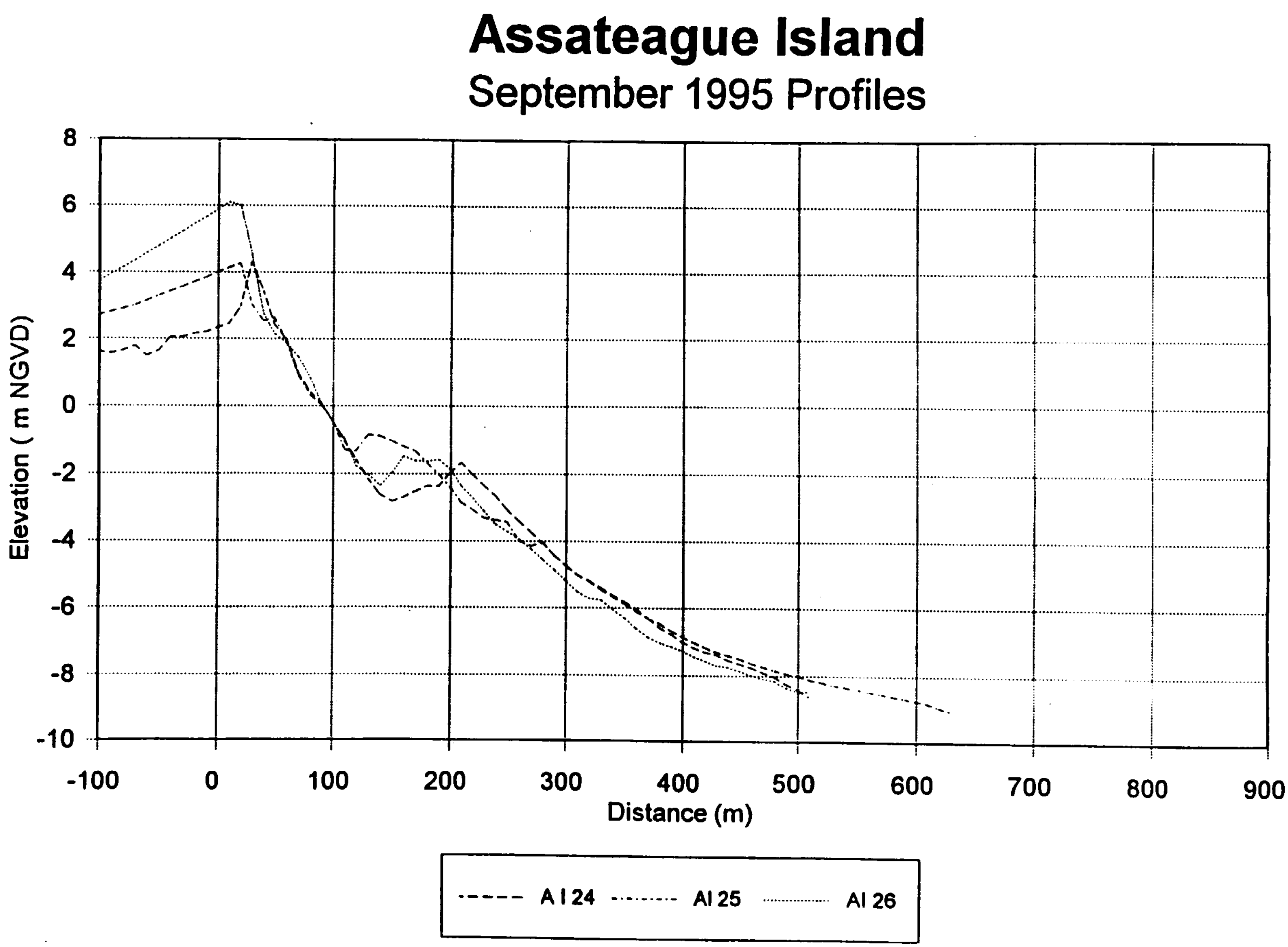

Figure A3-8. Assateague Island Profiles, Lines AI 24 through AI 26

Profiles AI-17 through AI-20 are similar except that backshore elevations are beginning to increase. Profiles AI-21 through AI-26 are characterized by very high dunes, some of which have been constructed in the State Park and some of which have developed naturally.

Offshore, profile shapes are similar for profiles south of AI-4. Profile shape and slopes are very similar for the portions of the profile at elevations less than about -20 ft NGVD (-6.1 m). It is interesting that this elevation is about the "depth of significant movement" that has been observed during monitoring of the Ocean City beach fill. It is intuitively reasonable that the profiles have a similar shape in the wave-process-driven portion of the profile. However, away from the immediate vicinity of the inlet, there is a general tendency for the offshore portion of the profile, elevations between -20 ft (-6.1m) and -30 ft (-9.1m) NGVD, to steepen with increasing distance away from the inlet.

This can be explained as a result of profile flattening in these depths as the shoreline of north Assateague has receded. Analysis of historic bathymetric data indicates that the -9 m NGVD contour off Assateague Island has changed position very little since formation of the inlet. However as the shoreline on north Assateague retreated, the beach profile was "dragged" along with it, flattening the portion of the profile between elevations of -9 m and -6 m NGVD. In this elevation range, this process creating gentler slopes closer to the inlet where the shoreline retreat has been greatest. Cumulative recession decreases with distance south of the inlet, and therefore the degree of profile flattening follows the same trend. Profiles at the State Park are relatively unaffected by this "dragging" process. The inner portion of the profile is very much wave-driven and retains a very similar shape irrespective of distance south of the inlet.

Figure A3-9 shows the alongshore variation of maximum profile elevation. The maximum profile elevation is plotted for each of the twenty-six profile lines. The solid line connects the maximum profile elevations at each profile. From AI-4 through AI-19 the maximum elevation corresponds the natural berm crest elevation. The average elevation is about 2.5 m NGVD; and maxima range from 2.2 to 2.7 m, a difference of only 0.5 m over about 7 km of shoreline. The lowest berm elevations, 2.2 and 2.3 m NGVD, are at profiles AI-13 and AI-15, respectively. This is an especially critical area in terms of breach potential. The locations of the high dune fields are also evident, immediately adjacent to the south jetty of Ocean City Inlet and in the State Park.

Based on an inspection of aerial photos and the beach profile data, there are two areas that seem to be the most critical, in terms of breach potential. One is located in the vicinity of the 1962 breach, near profile AI-5. At the present time, the shoreline in the vicinity of the 1962 breach appears to be accreting at a small rate and there seems to be more vegetation on the back bay side. One would expect these factors to slightly reduce the breach potential here. The other critical area is located in the region from profiles AI-11 to AI-18. This southernmost area is of particular concern because of its greater distance from the existing inlet and proximity to Sinepuxent Bay (i.e. higher potential to capture more tidal prism in the event of a breach) and because the present rates of shoreline erosion are

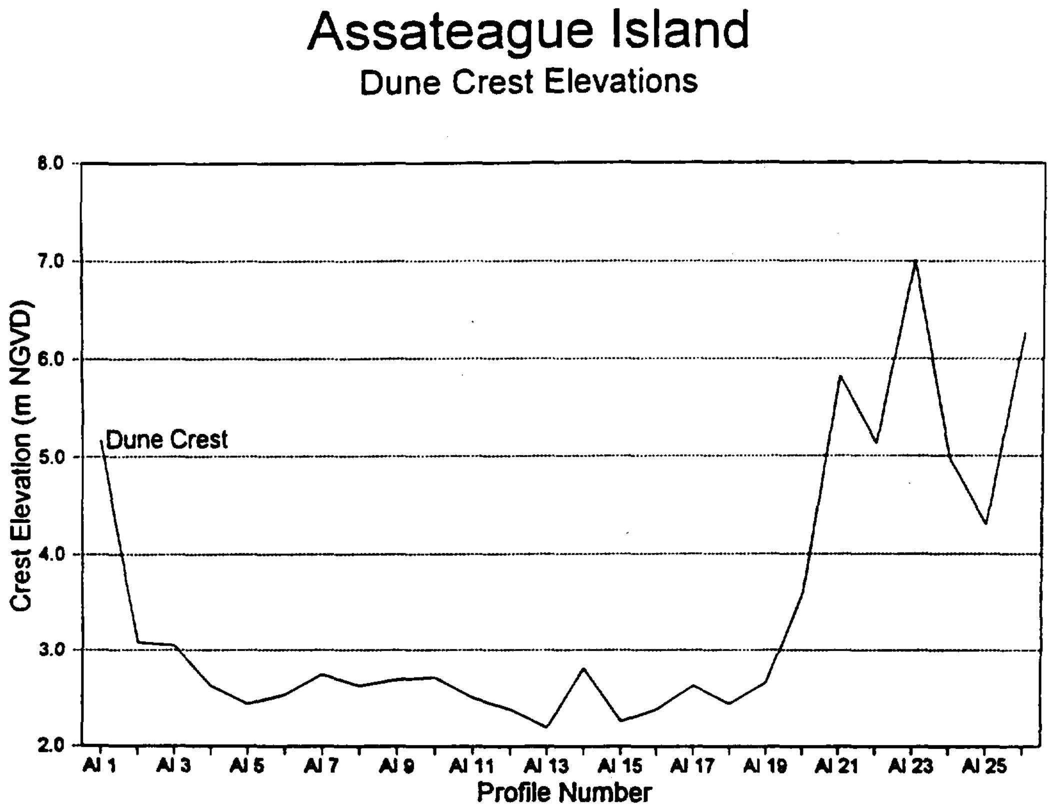

Figure A3-9. Alongshore Variation of Dune Crest Elevations

greatest in this area. It is likely that the high erosion rates in this area have contributed to the low berm crest elevations.

Observed Overwash Processes

Observations by NPS personnel indicate that much of the northern island overwashes frequently. Nearly all spring tide conditions produce some overwash, and many storms produce substantial overwash. Of particular relevance to the assessment of SBEACH, as an accurate predictor of storm erosion, run-up, and overwash, was information provided by the NPS about the response of north Assateague to two storms, the "Halloween Storm" in October 1991, and the January 1992 storm. The storms where characterized by different wave and water level conditions and produced distinctly different overwash patterns and changes to the beach. The following were comments made by NPS staff regarding the Halloween Storm:

a. More intense than most northeasters, lasted two to three high tide cycles

b. At the McCabe tract, 8.5 km south of inlet, dunes before storm were 9-11 feet above beach berm. The storm caused failure of half the dunes.

c. No evidence of flooding like January 1992 storm

d. Overwash pushed sand landward. Deposition occurred in a new "wedge-shaped" berm characterized by a deposit 2-4 ft thick. The new berm was moved about 30 m to the west of the old berm, and had a gradual slope to the west. In some places the new berm was 1 ft thick and displaced 80-90 m west of the old berm.

e. Sand was exposed between overwash bores, not submerged continuously.

f. Western parts of the island were submerged.

The following comments were made describing the January 1992 storm:

g. The storm lasted only a few hours and was a wave of water moving onshore.

h. Foam and debris line remaining on wooden matter indicated a surge over the island of 4-6 ft. Everything was submerged by a few feet.

i. Beach was flattened, no distinct berm formed like in the Halloween storm. Sand overburden existed across entire island on lower 4 km of north end of the island. Significant deposition in the bay on the west side of the island.

j. Berm was displaced westward by 20-30 m.

k. Severe cuts in some dunes. Took out all dunes at McCabe house area

l. Dunes to the south of the State Park that had withstood numerous northeasters were 80% damaged during the storm. These dunes were 10.5-22.5 mi south of the inlet. Dune elevations before the storm were 6-10 ft (8 ft average) above the berm elevation.

From the descriptions provided, it is clear that storms can produce a range of responses on north Assateague from distinct overwash occurrences with sand visible between overwash events to overwash and inundation that completely overwhelms the northern part of the island. In both cases, the storms caused significant sand movement as a result of the overwash; however the storms produced distinctly different overwash deposits. Later, these qualitative observations will be compared to predictions made using the SBEACH model for the same two storms.

Environmental Perspective on Overwash

Based on conversations with NAB staff, their contractors, and others representing environmental interests, it was determined that an overwash frequency of once every one to two years was the minimum that is believed to be required to maintain suitable piping plover habitat. A decision was made to raise the island elevation in critical areas to an elevation that would increase protection from breaching and limit overwash to this minimum frequency. The increased elevation would prevent overwash associated with typical spring tide conditions, and restrict overwash to storm events that are expected to occur every year or two, on average. An analysis was undertaken to determine the hydrodynamic characteristics of typical tides and storms, and to assess their potential for run-up and overwash.

Defining Typical Tide and Storm Characteristics

One hydrodynamic parameter that influences wave run-up and overwash is wave height. The Wave Information Study (WIS) hindcast wave data base (Hubertz et al, 1993 and Brooks and Brandon, 1995) was queried, and hindcast wave data for the WIS site nearest north Assateague Island, WIS station 64, was used to determine the maximum wave height associated with a recurrence interval of one and two years. WIS wave data for this site are computed for a water depth of 16 m. Only extratropical storms were considered here because they are the events of interest at frequencies of once every one to two years. Average annual maximum wave heights for the entire available hindcast period, 1956 to 1994, were extracted from the data base, ranked, and plotted following standard probability procedures. The average annual maximum energy-based significant wave heights are approximately 3.6 m and 5.1 m for return intervals of one and two years, respectively.

Storm water level, the combination of storm surge and astronomical tide, are also important in determining run-up and overwash conditions. Pressure data are measured by the wave gages off Ocean City, MD that have been operational since about 1990, and these data provide a means for assessing the water level climate (both tides and typical storms). The submerged pressure sensor records the pressure of the overlaying water and air. A rigorous analysis to convert the measured pressure fluctuations to a geodetically referenced water level had not been completed at the time of analysis, so the following approximate procedure was used to estimate water levels. The measured pressure data were adjusted to account for the column of air above the water. Atmospheric pressure varies; and to correct for the variations, measured barometric pressure data for the period of record were obtained from the airport at Salisbury, MD and used to correct for the actual barometric pressure at the times of wave gage measurements. This correction resulted in a depth correction of +/- 0.3 m to the computed water depth. The corrected water depth data were then averaged for the entire time period of data availability, and the average was assumed to correspond to mean sea level (MSL). This value was subtracted from all water depth data to compute water surface fluctuations above/below MSL. Published corrections (from MSL to NGVD) were used to relate the water level data to NGVD.

The pressure data recorded by the wave gage are also processed to compute wave height, period, and wave direction. For the period January 1991 through January 1996, fairly continuous synoptic measured wave and water level data from the Ocean City gage are available. Wave and water level data were extracted for all storm events that were identified during a visual inspection of the data. Data for randomly selected spring and mean tide conditions were also extracted.

Table A3-1 lists wave and water level characteristics for all the "events" that were extracted from the database. The first column in the table lists the date of a particular event and whether it was a storm, spring tide, or mean tide event. The next three columns list the significant wave height, H_{mo}, and peak spectral wave period, T_p , at the time of maximum still water level (SWL). Results listed in the last four columns characterize nearshore water levels and wave run-up and will be discussed in the next section.

Simulation of Run-up and Beach Response

The SBEACH model has been successfully applied to predict storm-induced beach change observed at Ocean City, MD (Kraus and Wise, 1993). A comprehensive evaluation using other field and large-scale laboratory data sets is documented in Wise et al (1996). The same calibrated model used for the Ocean City simulations was used to simulate processes on north Assateague Island.

Input to the SBEACH model is the initial profile shape, information to characterize the wave and water level conditions (time series of wave height period, and water level), and the median diameter of the sand. The time series of synoptic wave and water level data extracted from the Ocean City wave and water level database were used as hydrodynamic input. Profile AI-6 was determined to be representative of nearly all profiles in the critical overwash region, and was used as the input beach profile. Based on an analysis of sediment samples taken during the beach surveying in September 1995, a median diameter, $D_{50,}$ of 0.30 mm was chosen to represent the size characteristics of the foreshore sediments.

The model was applied for each of the events listed in Table A3-1. Two versions of the model were applied, one using the root-mean-squared wave height,H_{rms}, to compute run-up elevation, and the other using the average of the highest one-tenth of the waves, $H_{1/10}$, to compute run-up. In engineering practice, the SBEACH model is applied using H_{rms} to compute run-up. Better predictions of beach erosion have been achieved when using this run-up measure, and this is the standard model. The $H_{1/10}$ version was only used here to examine the elevation reached by a smaller percentage of the waves during an event, recognizing the fact that a number of waves during any interval of time on the order of an hour exceed the H_{rms} value.

Figure A3-10 is a schematic of the beach profile and various measures of elevation and water level that will be discussed in the following sections. The astronomical tide is the periodically varying water level driven by gravitational effects of the sun and moon (12-hr periodicity along this part of the Atlantic coast). The storm surge is the additional increase in water level caused by

Table A3-1 Wave and Water Level Characteristics for Tides and Storms

Date	Event	At Max SWL H_{mo} (m)	T_p (sec)	SWL (m)	Using H_{rms} SWL+Setup (m)	Run-up Elv (m)	Using $H_{1/10}$ SWL+Setup (m)	Run-up Elv (m)
10791	Storm	2.5	9	0.9	1.5	2.3	1.5	3.0
103191	Storm	3.1	15	1.6	2.2	3.2	2.2	3.6
110891	Storm	3.0	10	1.5	1.8	2.5	1.8	3.0
10492	Storm	4.4	15	2.0	2.8	3.7	2.8	4.2
92392	Storm	3.5	9	1.5	2.3	3.0	2.3	3.4
100492	Storm	2.3	8	1	1.5	2.3	1.5	2.8
102693	Storm	3	12	1	1.7	2.5	1.7	3.1
112593	Storm	3.4	11	0.8	1.6	2.3	1.6	3.0
121593	Storm	2.5	11	1.4	2.1	2.9	2.0	3.5
30294	Storm	3.9	12	1.6	2.5	3.2	2.5	3.7
101494	Storm	2	12	1	1.6	2.7	1.6	3.2
111694	Storm	3.3	13	0.9	1.9	2.6	1.9	3.2
122394	Storm	3.1	14	0.8	1.6	2.7	1.6	3.4
50295	Storm	2.0	7	0.9	1.3	2.4	1.4	2.9
62895	Storm	1.5	6	0.9	1.4	2.3	1.4	2.7
80795	Storm	1.7	10	1.2	1.7	2.7	1.7	3.1
81595	Hurr Felix	2.0	13	0.9	1.4	3.0	1.4	4.0
90895	Hurr Luis	1.6	16	0.8	1.4	3.7	1.5	4.0
10796	Storm	3.6	11	1.2	2.1	2.8	2.0	3.3
61295	Spring Tide	0.8	8	1.1	1.3	2.6	1.5	2.8
10296	Spring Tide	1.3	7	0.9	1.2	2.3	1.3	2.9
51895	Spring Tide	0.7	5	0.8	1.1	2.0	1.1	2.5
90695	Spring Tide	1.0	13	0.8	1.2	2.6	1.2	3.0
82895	Spring Tide	1.5	6	0.8	1.2	1.9	1.1	2.5
50895	Mean Tide	0.8	12	0.6	0.9	2.4	0.9	2.9
112895	Mean Tide	1.1	6	0.5	0.8	1.8	0.8	2.3
52695	Mean Tide	0.9	5	0.7	0.8	2.0	0.8	2.3
60895	Mean Tide	0.6	8	0.5	0.8	1.8	0.8	2.3
62395	Mean Tide	1.0	6	0.6	0.9	2.1	0.9	2.5

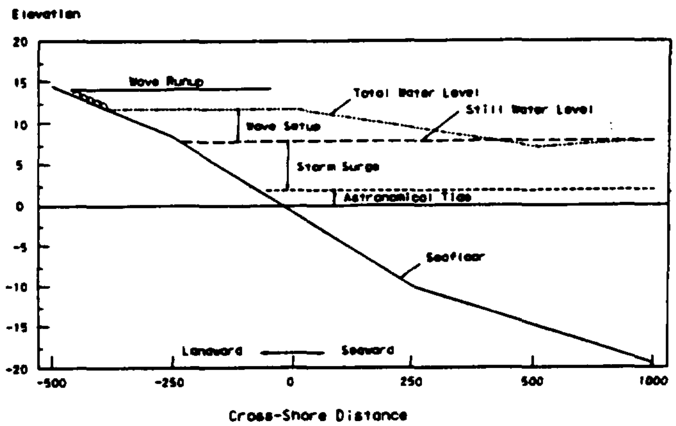

Figure A3-10. Definitions of Water Level and Elevation Parameters

atmospheric pressure gradients and wind associated with a storm. Both forces can act to "pile" water against the shoreline for a several-day duration. The still water level, SWL, is assumed to consist of both tide and surge contributions. Wave set-up is the increase in water level across the surf zone caused by the shore-directed excess momentum flux associated with the surface wind waves. Total water level, TWL, is assumed to consist of the SWL plus wave set-up. The run-up elevation is the elevation reached by broken waves as they advance up the beach face. In this study, if the run-up elevation exceeds the maximum profile elevation, overwash is assumed to take place. SBEACH predictions for run-up and beach change for various hydrodynamic conditions are discussed in the following sections.

Mean Tide Conditions

Five mean tide events were simulated. The duration of each simulation was several days. The maximum SWL for these events ranged from 0.5 to 0.7 m, and the average maximum significant wave height for these events is about 0.9 m, ranging from 0.6 to 1.1 m. These events represent typical mean tide and wave conditions. Wave periods are fairly short except for one 12-sec case. The maximum run-up values computed using H_{rms} are less than or equal to 2.1 m for four of the cases, and 2.4 m for the 12-sec wave case. Run-up results from the $H_{1/10}$ model runs show run-up exceeding 2.5 m only for the 12-sec wave case. Observations by NPS personnel indicate that the berm rarely overwashes during typical tide conditions. Run-up values computed using SBEACH are consistent with these observations.

Intuitively it also seems reasonable that nature would build the berm crest to an elevation that exceeds the normal run-up limit under typical tide and wave conditions. Predicted run-up levels are consistent with the average natural berm crest elevation of 2.5 to 2.6 m that characterizes this stretch of coast.

Spring Tide Conditions

Five spring tide events were simulated. Maximum SWL ranged from 0.8 to 1.1 m for the events considered. Waves heights are generally higher than for the mean tide events, about 1.1 m on average, ranging from 0.7 to 1.5 m. One spring tide event is also characterized by long wave periods, 13 sec. The run-up elevations computed using the H_{rms} model reach 2.6 m for two of the cases, the one with the long wave periods, and the one with the highest SWL. Results using the $H_{1/10}$ model show three events reach an elevation of 2.8 to 3.0 m and the other two reach an elevation of 2.5 m. This indicates that for berms with maximum elevations of 2.5 to 2.6 m or less, overwash will occur for many spring tide conditions. This predicted response is also consistent with observations by the NPS staff.

It is possible that the natural berm crest elevation is influenced by the typical spring tide and average wave conditions, which are periodic and occur every few weeks. The run-up results using H_{rms} also are consistent with the natural berm elevation of 2.5 to 2.6 m NGVD. Based on the typical tide simulations, the SBEACH model seems to provide reasonable estimates of run-up. Predictions are consistent with NPS observations and intuitively consistent with the natural berm elevations.

Storm Conditions

Nineteen storm events were extracted from the period January 1991 through January 1996. These events included both tropical and extratropical storms, or "northeasters." The Halloween storm of October 1991 and the January 1992 storm are included in this set. All storms were simulated with the SBEACH model. As shown in Table A3-1, run-up results for the H_{rms} model indicated that at least half of these events (those producing run-up elevations exceeding 2.6 m NGVD) would produce substantial overwash along most of the north Assateague Island shoreline. This is consistent with observations made by the NPS staff. SBEACH predictions for two of the storms, the Halloween storm and the January 1992 storm are discussed next in more detail.

Simulations made for the tidal events seem to confirm the suitability of the SBEACH model to calculate run-up and overwash. As another step to evaluate the accuracy of the SBEACH model, the predicted beach response for both the Halloween storm and the January 1992 storm were compared to anecdotal evidence provided by NPS staff who observed the aftermath of these storms. The computed profile response for the Halloween and January 1992 storms is shown in Figures A3-11 and A3-12, respectively.

Initial and final calculated profiles for the Halloween storm are shown in Figure A3-11. Model results indicate substantial erosion of the beach berm, the occurrence of substantial overwash and formation of a berm landward of the pre-storm berm. The computed amount of berm retreat (measured as the displacement of the berm crest is about 35-40 m, and the computed beach face recession is about 30 m. The model predicts a distinct localized overwash deposit. The exact shape and dimensions of the overwash deposit are probably not correctly predicted by the model. The overwash algorithm used in the model was developed using data from Ocean City beach fill response to the January 1992 storm, in addition to laboratory data from large-scale wave tank experiments. Qualitatively, the model yields reasonable estimates; however, it is beyond the capability of the model to predict the details of the overwash process. But, even in light of the crudeness of the overwash model and the limited data used to develop it, the computed results are consistent with the qualitative observations made by NPS staff that were presented earlier for this storm.

Figure A3-12 shows computed beach response for the January 1992 storm. The beach face, at an elevation of 2 m NGVD, was computed to by displaced landward by a distance of about 30 m. From the beach face seaward, profile response is similar to that for the Halloween Storm. However, the overwash response is quite different. Instead of a well-defined berm created landward of the original berm, the post-storm profile indicates substantial overwash and deposition of sand over a much larger extent (across much of the island), but in a thinner deposit with flattening of the berm crest. This post-storm profile reflects complete inundation of the profile, as calculated by the model. The computed maximum value of SWL-plus-setup (total water level) is 2.8 m which exceeds the maximum berm crest elevation. Again, the erosion results are consistent with observations. The SBEACH model qualitatively reproduced the very different overwash characteristics of the two storms.

Selecting the Degree of Elevation Needed

Wave and water level characteristics at the height of the storm influence run-up and overwash experienced during the storm. Returning to results shown in Table A3-1, in terms of wave height, the September 1992 (3.5 m), March 1994 (3.9 m), and January 1996 (3.6 m) storms appear to be similar to what one might consider to be a one-year event.

Wave period also influences run-up. Wave periods for the same three storms are 9, 12, and 11 sec, respectively. The average period for these events is about 11 sec, which is about the average for all the extratropical events. The Halloween Storm, October 1991, was characterized by waves with lower wave height than the one-year value, but with very long periods. The wave period at the time of maximum SWL for the Halloween storm was 15 sec, but wave periods reached 20 sec during the storm just before the time of greatest storm surge. Wave period for the January 1992 storm, 15 sec, was also greater than the average.

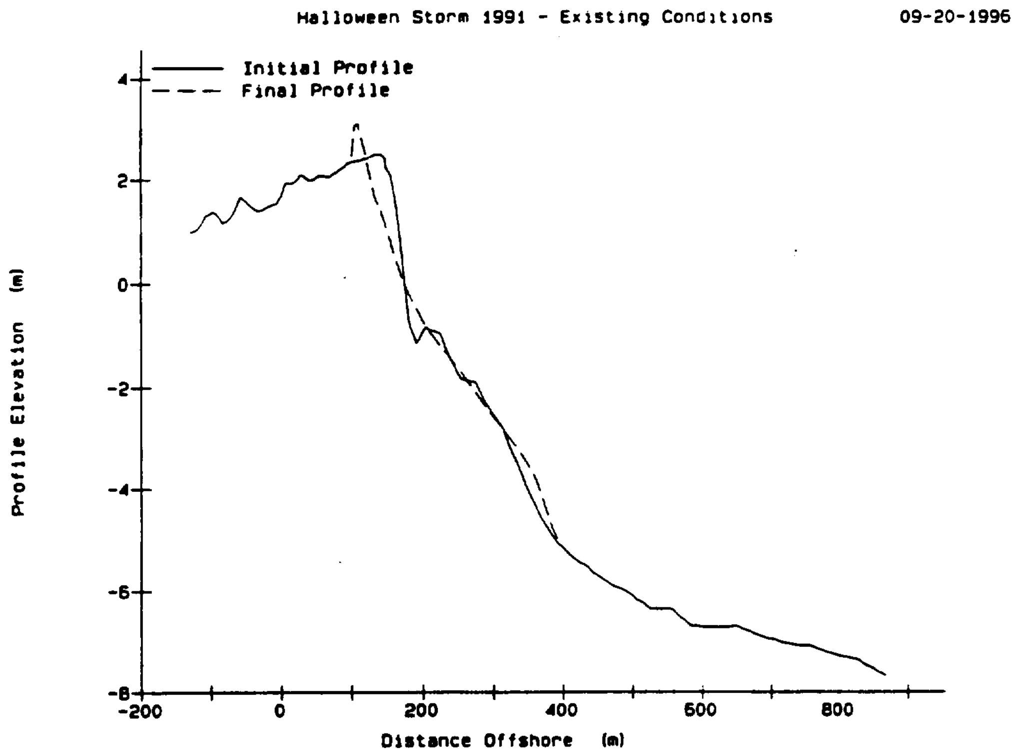

Figure A3-11. Computed Beach Profile Response, Halloween 1991 Storm

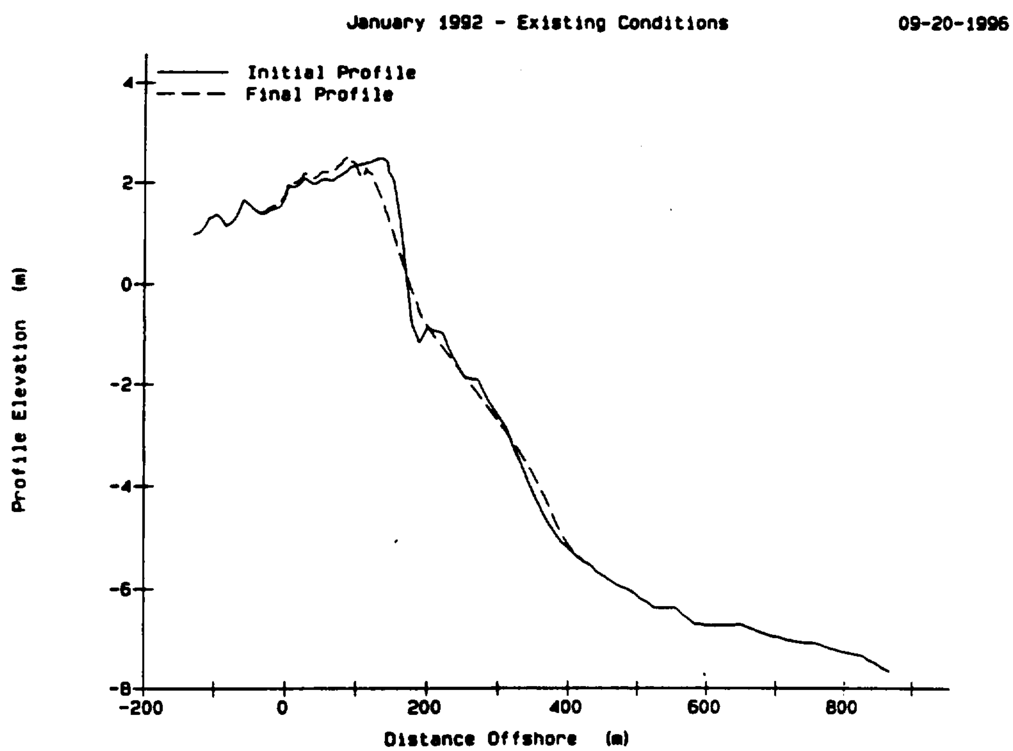

Figure A3-12. Computed Beach Profile Response, January 1992 Storm

In terms of maximum SWL, the Halloween Storm, the November 1991, September 1992, and March 1994 storms appear to represent the type of event that can be expected about every year (1.5 to 1.6 m NGVD). There were four occurrences of this water level during the five-year period. The January 1992 storm had the highest SWL, 2.0 m NGVD.

Considering both wave and water level conditions at the height of the storm, the March 1994 and September 1992 storms seem to best represent events that can be expected on average once each year. The Halloween storm, seems to represent a less frequent event, not in terms of wave height and maximum SWL, but because of the unusually long wave periods. The SWL of the January 1992 storm was the highest measured during the five-year period, and the wave period was unusually large; therefore, it was not considered to be a one to two-year event in terms of water level and wave parameters.

Run-up elevations for the March 1994 and September 1992 events, predicted with the H_{rms} model, were 3.2 m and 3.0 m, respectively. Run-up computed using $H_{1/10}$ was 3.7 m and 3.4 m for the same two storms. Run-up calculations for the Halloween storm are 3.2 and 3.6m. It seems reasonable to estimate the one-to two-year run-up level at about 3.2 m NGVD (using H_{rms}) and 3.6 m NGVD (using $H_{1/10}$). A design elevation of 3.3 m NGVD was selected as the elevation needed to limit substantial overwash to a frequency of about once every one to two years. It should be noted that a few other storms during this period would probably produce sporadic overwash over a berm with a crest of 3.3 m NGVD, as indicated by the $H_{1/10}$ run-up results. Also, an unusually severe northeaster, such as the January 1992 storm, or tropical storm has a chance of occurring at any time and can produce significant overwash as indicated by the results in Table A3-1.

Based on this run-up analysis, an elevation feature with a crest elevation of 3.3 m NGVD, a top berm crest width of 5 m and side slopes of 1:20 was defined as the engineered feature for providing some breach protection, albeit at a reduced level. Side slopes were chosen to be typical of those that would be created during a hydraulic pump-out operation used to construct the project. The cross-shore "footprint" of this feature is approximately 45 m. The feature will be called a storm berm, rather than a dune, because of its low relief. An analogous feature is the relief created on a well-drained football field, which is about 40 yd across with a crown at mid-field of about 2 to 3 ft. This storm berm would not be very visible on the natural beach because of its gentle slope and low relief (as compared to a dune).

Survivability of the Storm Berm

Another engineering issue considered in the design of the project cross-section is the location of the storm berm. Several locations were considered, but the most natural location is just landward of the crest of the natural "tidal" berm, where storm berms and dunes are typically located. An important consideration in locating the exact position of the storm berm on the existing beach profile is its survivability. Added elevation that is removed by the first typical winter storm does not provide the desired protection. Also, survivability must consider the present longer-term "background" erosion rates which vary along the shoreline that is to be protected. The design goal is to create an elevation feature that will survive on its own until the natural supply of sand can be restored to Assateague Island.

To evaluate survivability, beach erosion caused by frequent and infrequent storms was investigated to determine what additional beach width should initially be created seaward of the storm berm. The added beach width would serve as a buffer to absorb the erosive impact of a storm and protect the berm. The frequent storms considered in the analysis are included in Table A3-1; the infrequent storms are shown in Table A3-2. These historical storms were hindcast by a contractor working for NAB using computer wave and hydrodynamic circulation models. The hindcast produced time series of wave and water level conditions, that were in turn used as input to the SBEACH model. The first column in Table A3-2 shows the date of the storm in month-day-year format. Other columns contain the following: maximum significant wave height, peak spectral wave period, maximum still water level, maximum total water level (SWL plus set-up), and the maximum run-up computed by the SBEACH model (using H_{rms} to estimate run-up). Note that wave and water level parameters for the January 1992 storm are from the measured, not the hindcast, data.

Table A3-2 Maximum Wave and Water Level Characteristics for Infrequent Storms

Date	Wave Height (m)	Wave Period (sec)	SWL (m)	SWL+ Setup (m)	Run-up (m)
330914	3.8	11	1.7	2.5	3.3
440914	2.9	9	2.1	2.7	3.5
560316	2.3	6	1.3	1.8	2.7
560411	5.5	11	1.4	2.5	3.2
560925	3.9	10	1.6	2.6	3.1
600912	3.3	9	1.4	2.1	2.9
620305	5.9	17	2.2	2.7	3.8
621102	4	9	1.6	2.4	3.0
640112	5.2	13	1.6	2.7	3.4
710406	3	9	1.4	2.2	2.9
741201	3.4	13	1.2	2.1	2.8
760409	3.7	8	1.1	1.8	2.5
780206	3.3	10	1.3	1.9	2.9
811111	5.7	10	1.5	2.7	3.2
830211	3.5	9	1.5	2.3	3.1
850926	3	9	1.8	2.5	3.1
920102	4.1	17	2.0	2.8	3.7
921210	4.4	13	1.9	2.8	3.4

It is interesting to note that several storms have computed total water levels that exceed the present maximum berm elevation that exists along much of the north end of the island. These are probably the kinds of storms that have the greatest potential to cause a breach from the ocean side. Beaching can also occur from the bay side, but that is not considered here. If maintained, the increase in island elevation to 3.3 m NGVD would provide limited protection for these infrequent storms. However, many of these storms would produce substantial overwash, and the effect of overwash on maximum elevation is uncertain. If the storm berm does not increase in elevation through natural "dune" building processes, with time storm overwash may begin to decrease the storm berm elevation back to its current elevation.

Without-Project Storm-Induced Erosion

To assess response of the existing beach to storms, the SBEACH model was applied using time series data for the storms identified in Table A3-1 along with the input beach profile, AI-6 measured in September 1995. Figure A3-13 shows the initial and final profiles for the March 1994 storm simulation. Recall that the March 1994 and September 1992 storms are representative of the most severe storm that is expected each year. The March 1994 storm produced about 20-25 m of berm recession. Sand was removed from the berm, deposited in deeper water (seaward to about the -5.5 m NGVD elevation), and pushed landward over the existing berm to form an overwash deposit. The occurrence of overwash is computed with more certainty than the exact shape and limits of the overwash deposit. Calculated beach response for the September 1992 storm was nearly identical to that for the March 1994 storm.

Results for the Halloween Storm were presented in Figure A3-11. They show greater berm recession, about 30 m. The more severe erosion is believed to be associated with the longer duration of this storm. More severe storms were found to produce even greater erosion. Results for the worst case simulated, the March 1962 storm that actually caused a breach, indicted that the island would be completely overwhelmed, with extensive landward overwash, and computed berm recession was about 40-45 m.

Based on the results of the without-project erosion simulations, a buffer of about 25 m (added beach width at the natural tidal berm elevation) would provide satisfactory protection against erosion for storms with a frequency of occurrence of once every year or two. However, a berm of 40-50 m would be required to provide protection from the most severe of the historical storms.

Evaluation of the Protective Buffer

Testing of several berm design concepts was also done using the SBEACH model. One design alternative involved placement of only the 3.3 m NGVD storm berm, with the seaward toe of the storm berm placed at the existing berm crest (i.e. no protective buffer). The other two alternatives involved placement of the same storm berm at the same location , but with an additional buffer, or "sacrificial berm" with a berm crest elevation of 2.5 m NGVD (the natural tidal berm elevation). Two added berm widths were considered, 25 and 50 m. The two widths were selected based on erosion results for the without-project runs and initial estimates of the volume of sand to be placed as part of the restoration project.

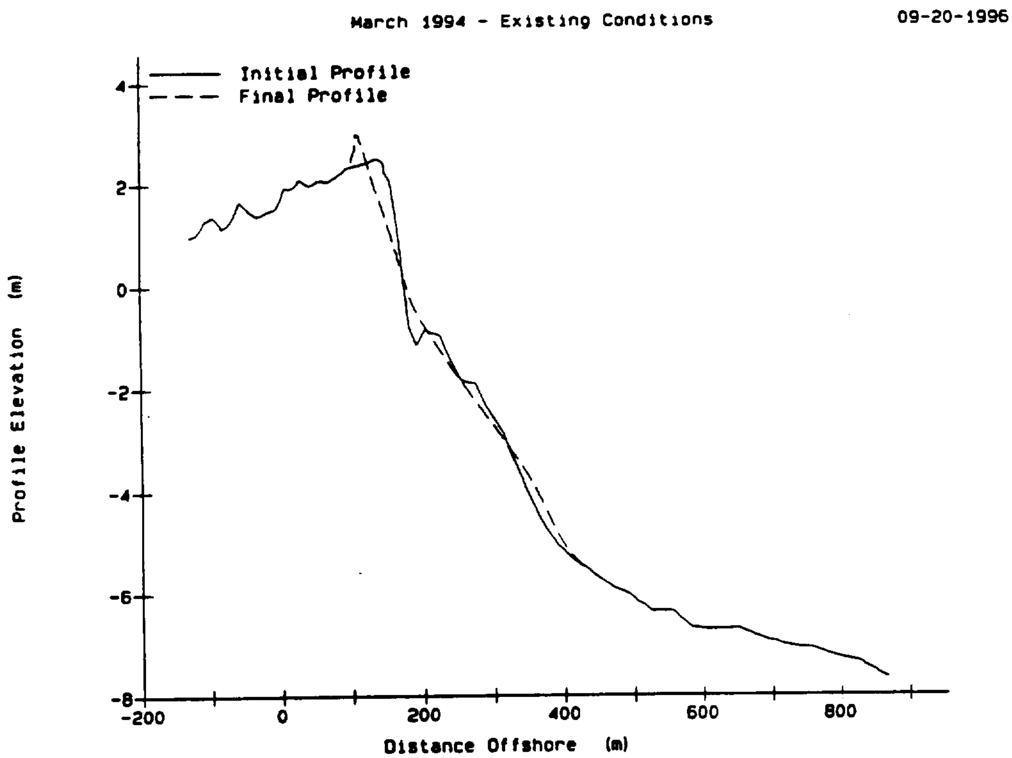

Figure A3-13. Computed Beach Profile Response, March 2, 1994 Storm, With-out Project Conditions

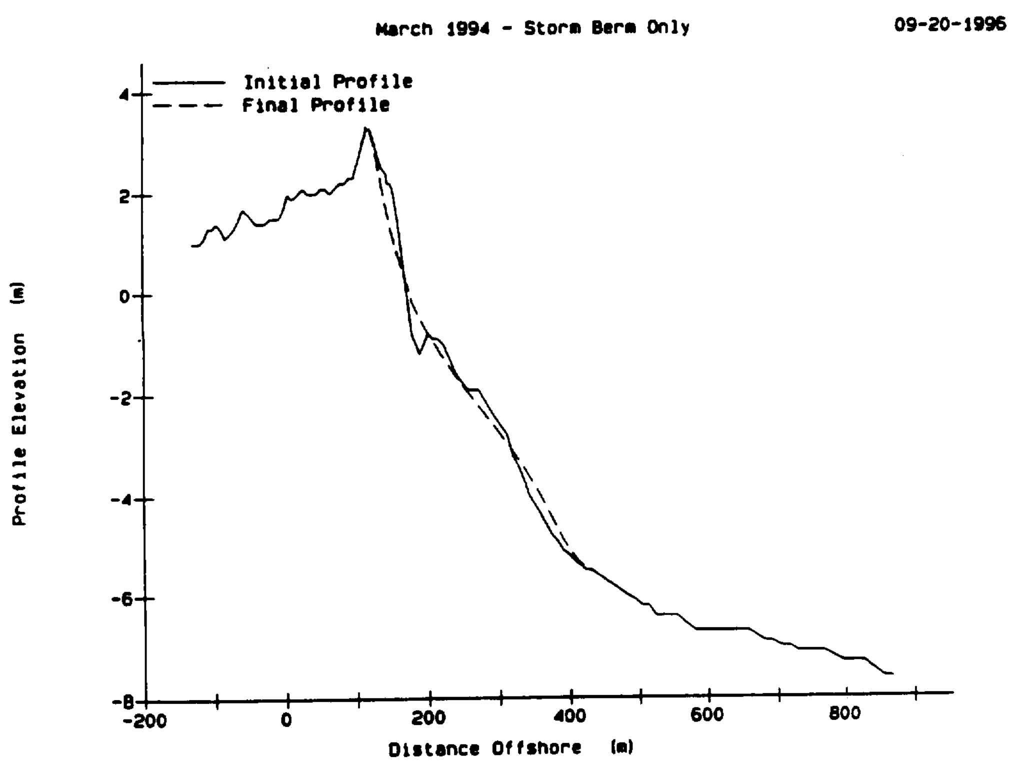

Figure A3-14. Computed Beach Profile Response, March 2, 1994 Storm With Storm Berm Only

Calculations were made to examine the response of each of the three alternatives to several frequent storms and several of the most severe infrequent storms. Results for the March 1994 storm and the storm berm-only case are shown in Figure A3-14. They show that the storm berm is slightly eroded and sand overwash occurs, along with the possibility of elevation loss. Note that the distorted scale used in the figures gives the impression that the elevation feature is more like a "dune." Other more severe storms produced greater erosion of the storm berm. Figure A3-15 shows results for the January 1992 storm. This type of storm completely erodes the storm berm.

Figures A3-16 and A3-17 show predicted beach responses for the March 1994 and January 1992 storms, respectively, for the second design alternative, the storm berm plus a 25-m buffer. The 25-m buffer protects the storm berm from erosion losses for the one-year event, March 1994. The entire buffer is eroded for the January 1992 storm and the storm berm is impacted slightly. Recall that the Halloween Storm has nearly identical erosion characteristics as the January 1992 storm. The January 1992 storm had higher wave heights and higher water levels but had a short duration. The Halloween Storm had lower wave heights but was of much greater duration. The erosion characteristics of both storms are very similar; and in terms of foreshore erosion, both are considered to be relatively frequent events. The 25-m buffer provided adequate protection from all other frequent storm events. Figure A3-18 shows the response of the 25-m buffer and storm berm to the March 1962 storm. The 25-m buffer is inadequate for providing erosion protection for this level of storm.

Results for the 50-m buffer case indicated that this added beach width successfully provided protection from nearly all storms, except perhaps the March 1962 storm. In this case the storm buffer was completely eroded, but the storm berm remained relatively intact.

Concern was expressed over the added width associated with the buffer, its impact on run-up elevation and overwash, and the capability of the SBEACH model to simulate the sensitivity of run-up to profile shape. It was agreed that a 50-m buffer in front of the storm berm would probably limit run-up and overwash for lesser storm conditions. The SBEACH model is not able to adequately assess the impact of added buffer width and foreshore profile shape on run-up elevation, because of limitations in the run-up algorithms used in the model. A decision was made to adopt the 25-m buffer to provide erosion protection from storms. For the 25-m buffer, and for the one- to two-year events which are the ones that will produce the overwash, much of the buffer would be eroded and deposited offshore during the storm. Therefore it was reasoned that any remaining buffer width would have a much smaller influence on run-up and overwash.

The Design Cross-Section

The adopted design cross-section includes the 3.3 m NGVD storm berm and a 25-m natural berm (at elevation 2.5 m NGVD) that acts as a storm erosion buffer, plus an additional buffer to account for background erosion rates. This design

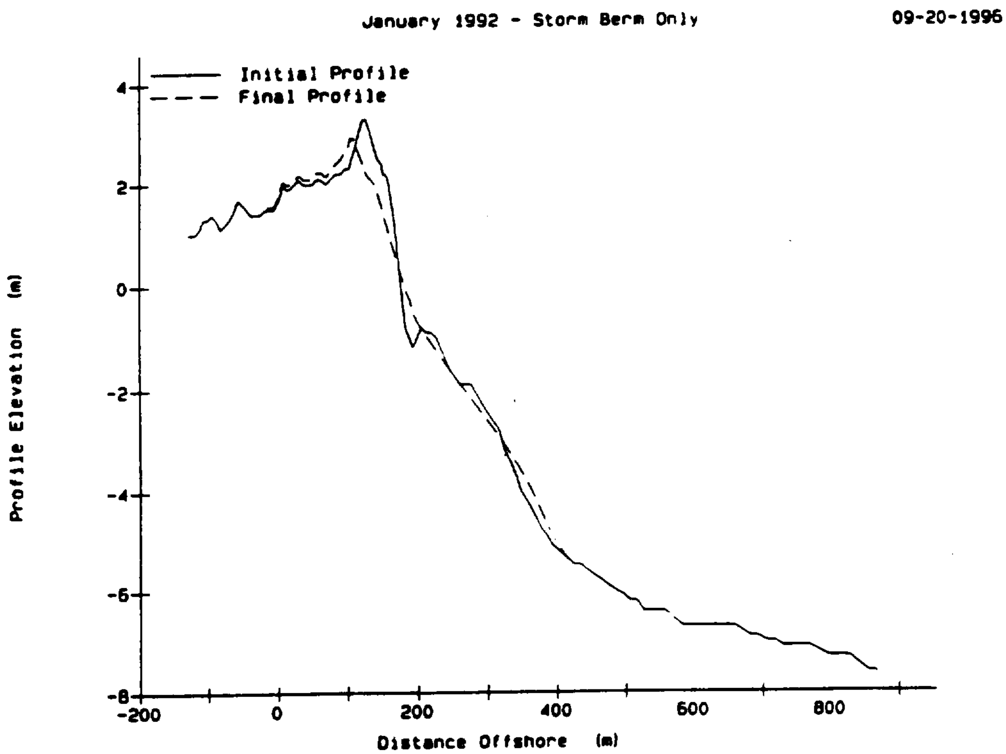

Figure A3-15. Computed Beach Profile Response, January 1992 Storm, With Storm Berm Only

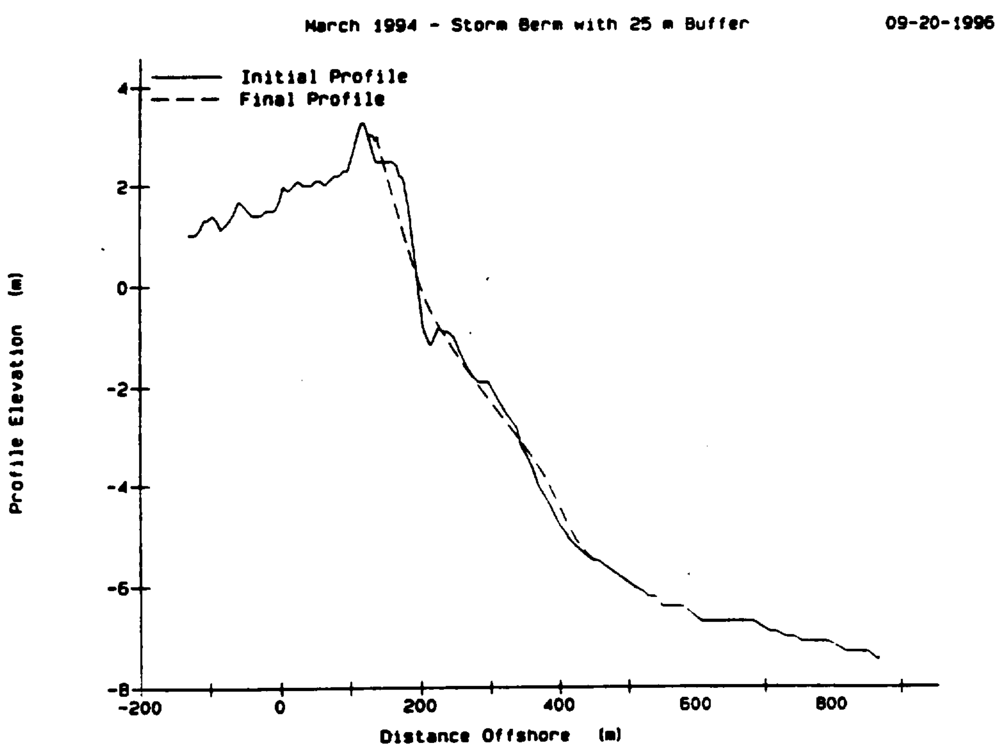

Figure A3-16. Computed Beach Profile Response, March 2, 1994 Storm With Storm Berm Plus 25-m Buffer

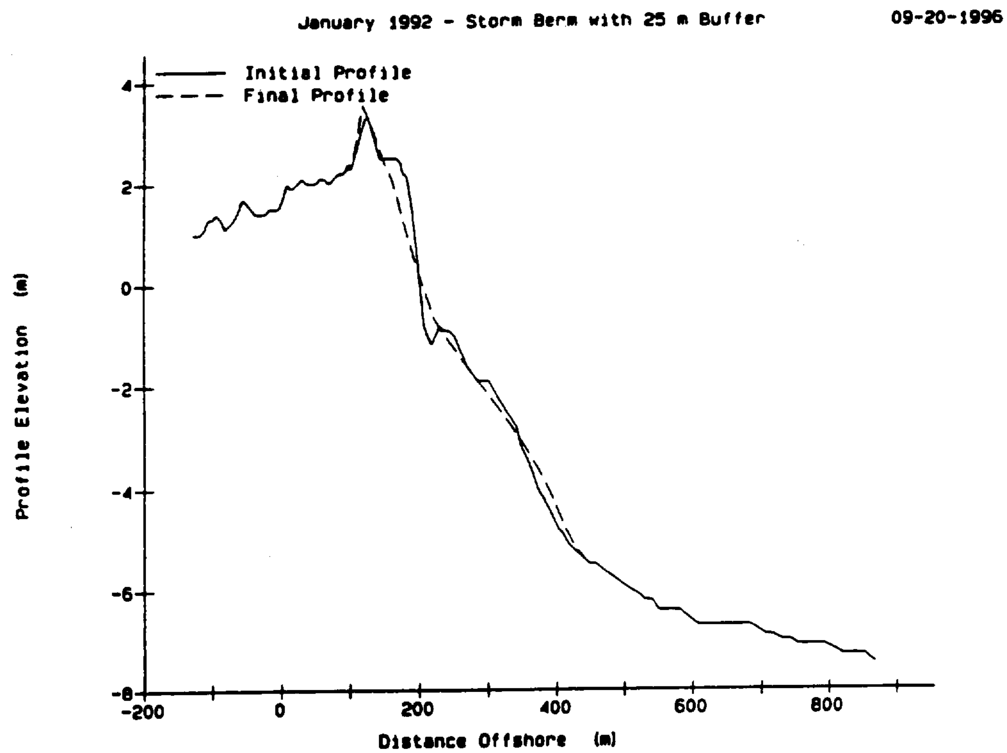

Figure A3-17. Computed Beach Profile Response, January 1992 Storm, With Storm Berm Plus 25-m Buffer

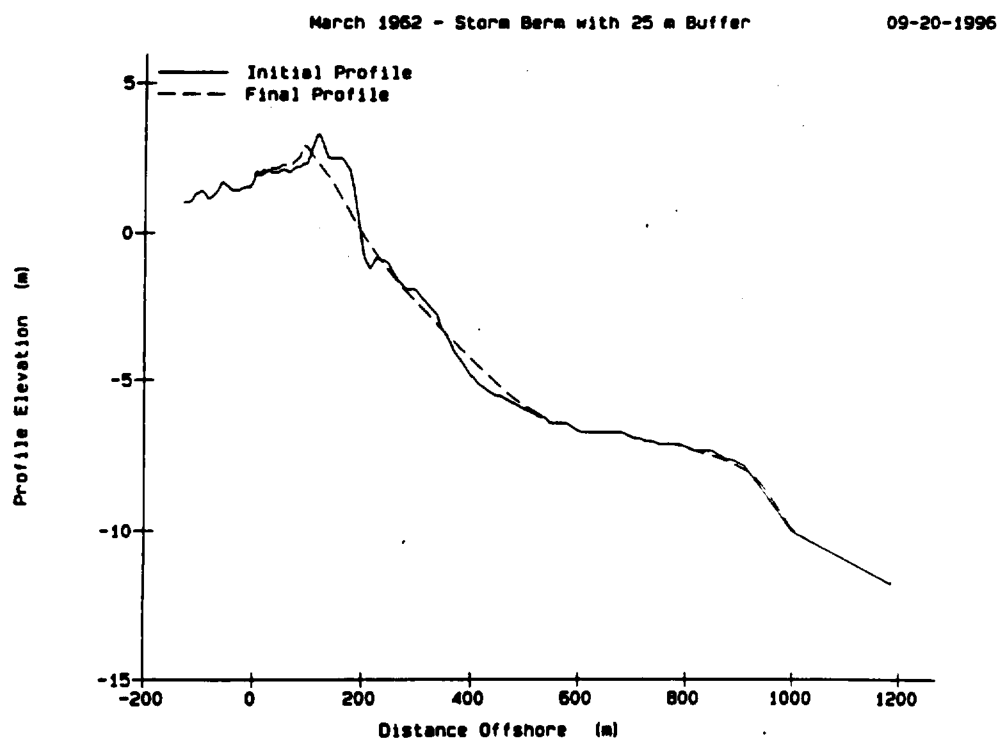

Figure A3-18. Computed Beach Profile Response, March 3, 1962 Storm With Storm Berm Plus 25-m Buffer

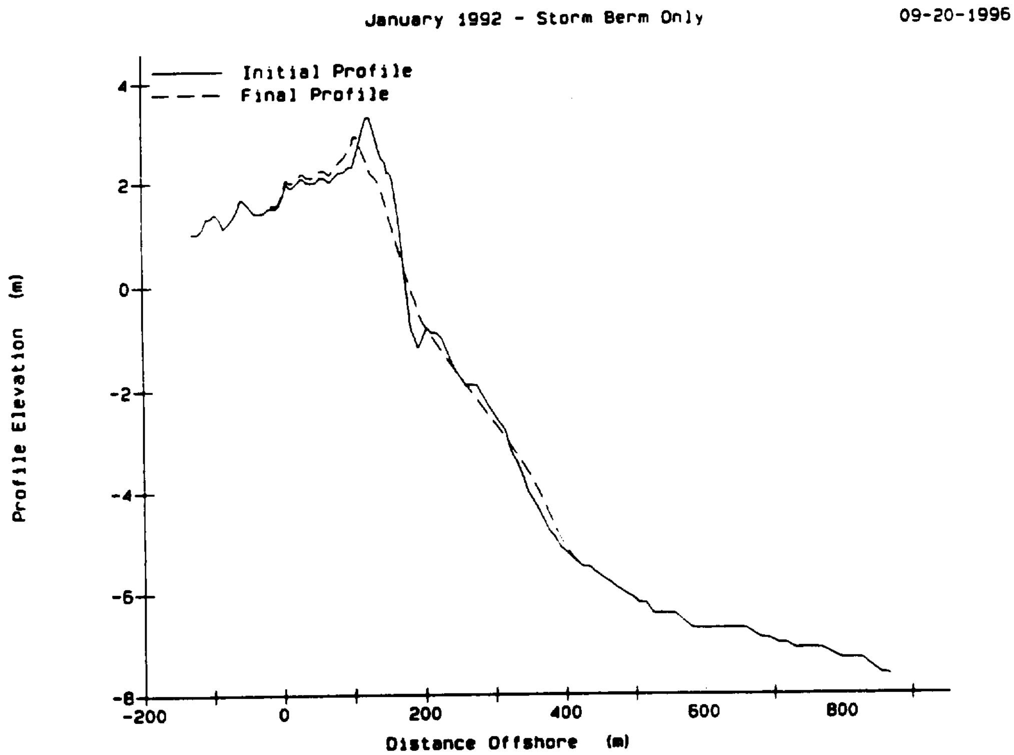

Figure A3-15. Computed Beach Profile Response, January 1992 Storm, With Storm Berm Only

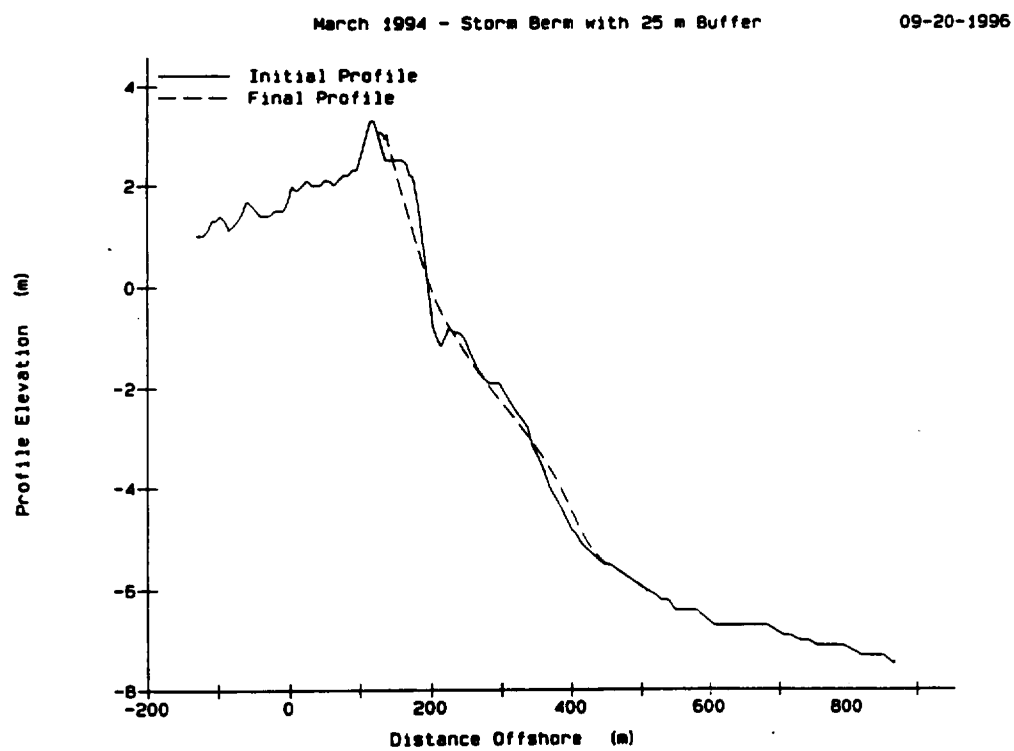

Figure A3-16. Computed Beach Profile Response, March 2, 1994 Storm With Storm Berm Plus 25-m Buffer

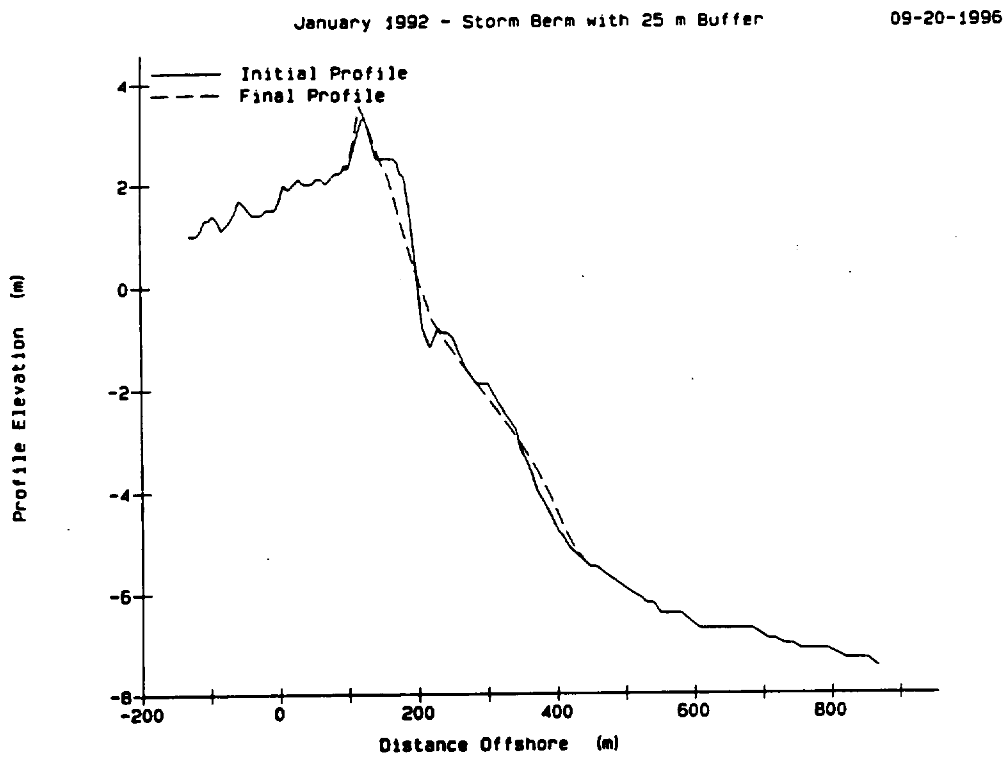

Figure A3-17. Computed Beach Profile Response, January 1992 Storm, With Storm Berm Plus 25-m Buffer

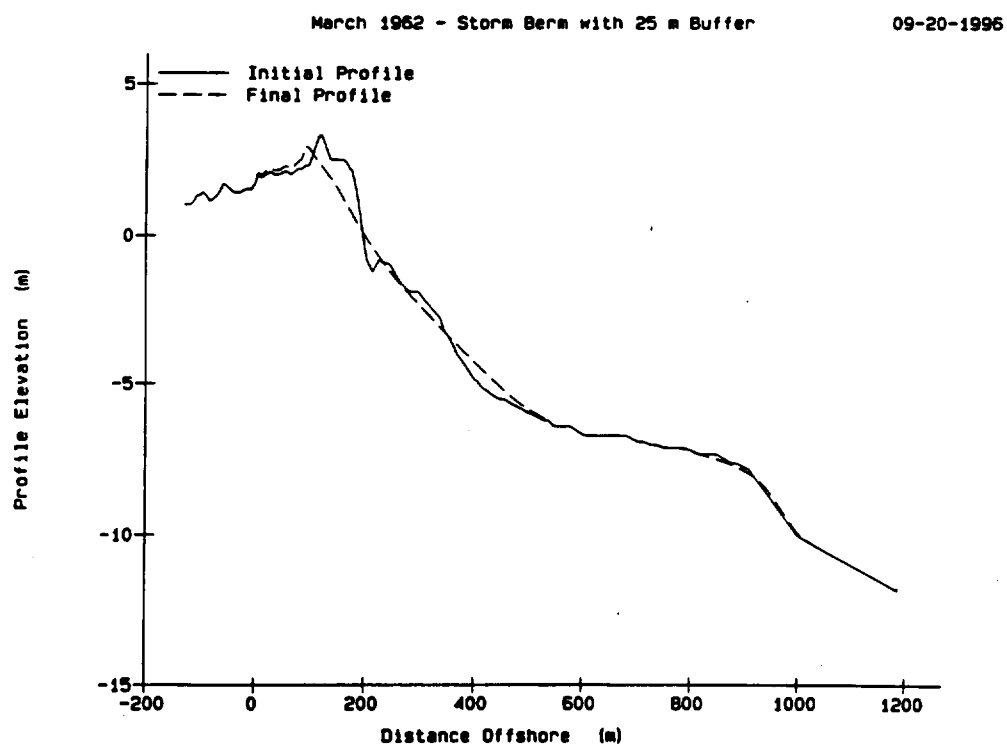

Figure A3-18. Computed Beach Profile Response, March 3, 1962 Storm With Storm Berm Plus 25-m Buffer considers the elevation needed to reduce the frequency of overwash to a one- to two-year frequency, and the need to protect the storm berm from erosion associated with frequent storms.

Background, or long-term, erosion trends associated with longshore sand transport processes must also be considered in the design. The same wave forces and limitations in sand supply that are presently producing high erosion rates along certain portions of north Assateague Island will immediately begin to work on the constructed storm berm and buffer. During the lag in time between construction of the storm berm and restoration of a continuous supply of sand to the island, the losses associated with longshore processes must be factored into the design. An additional buffer was recommended, with the added width to be determined based on the rate of shoreline recession presently being experienced locally. The actual position of the constructed berm on the existing beach profile will depend on the amount of fill to be placed locally to construct the storm berm and erosion buffer.

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Appendix A4
Beachfill Design and Quantity Analysis

The following paragraphs describe the method used to determine the placement configuration within the beach system and the expected shape of the fill after reaching an equilibrium with the local wave climate.

Construction of the beach and storm berm will involve the placement of approximately 1.4 million cubic meters (1.8 million cubic yards) of beachfill oceanward of a construction baseline. The construction template (Plate 6-5) defines the shape of the fill profile at the time of fill placement. The construction berm height should be the same or slightly less than the natural berm crest elevation. This will help to prevent scarping of the fill material as it undergoes readjustment. As discussed in Appendix A2, the average height of the natural berm was determined to be approximately 2.5 m (8.2 ft) NGVD. Consequently, this was chosen as the construction berm height. This construction berm will erode, distributing the material throughout the entire profile, resulting in a naturally shaped profile.

The offshore slope of the construction profile from the horizontal berm will be 1:20 to -.5 m (-1.5 ft) NGVD, hence 1:12 to its intersection with the existing bottom. These slopes should closely conform to the natural configuration of the pumped sand on the beach. During placement, the fill will be continually monitored to determine actual foreshore slopes. Adjustments can be made to the construction berm width to allow for differences that occur between assumed and actual slopes, although every effort will be made to achieve these slopes during construction.

The determination of the construction berm widths was performed by an iterative process. Since the point of maximum erosion is currently about 7 km south of the inlet, the largest unit volume of material will be placed there and will be gradually decreased alongshore in both directions. An initial estimate of the required width at each profile line was made and quantities computed using the Interactive Survey Reduction Program (ISRP) and the average-end-area method. The total quantity was compared to the allowable fill quantity of 1.4 million cubic meters (1.8 million cubic yards), minus an estimated amount required for the storm berm, and adjustments in the berm widths were made as necessary. This process was continued until the computed fill quantity closely matched the quantity allowed for the beachfill. The final construction berm widths for each reach are shown in Table A4-1 and the corresponding calculated unit volumes and cumulative volumes for the beachfill are shown in Table A4-2. The final construction template calculations are contained in Section 1 of this Appendix.

Construction profiles are out of equilibrium with the prevailing coastal processes and are expected to be reshaped, starting almost immediately after placement. The design profile or equilibrium profile is the shape the fill material is expected to achieve after being worked by waves over the first 2 to 6 months after fill placement. Assuming that the fill material will be similar to the original native beach material, the equilibrium profile may be based on the pre-fill profile shape. Consequently, the beach profile after nourishment should be the same as before nourishment, except translated seaward.

An iterative process was used by translating each existing profile seaward starting from the natural berm and calculating the unit volume from the berm to the depth of closure (-21.6 ft (6.6 m) NGVD). The estimated depth of closure was based on analysis of profile data collected for the Fenwick Island beachfill project since 1988. The unit volume was compared to that calculated using the construction template. The profile was consequently adjusted until close agreement was reached between the construction template unit volume and the equilibrium profile unit volume. The resulting translated profile is thus the expected equilibrium profile. The resulting equilibrium width, or movement of the shoreline seaward after adjustment, for each profile is shown in Table A4-1. The profile translation method assumes that the profile will be reshaped by the prevailing coastal processes and form the fill material into the existing equilibrium profile shape out to the depth of closure with conservation of volume. The final equilibrium quantity calculations are shown in Section 2 of this Appendix.

The final consideration in the design of the project was the location of the storm berm on the equilibrated profile. An important consideration in determining its location is survivability. As discussed in Appendix A3, a 25 m (82 ft) wide buffer in front of the storm berm was adopted to act as a storm erosion buffer. Background, or long-term, erosion trends associated with longshore sand transport processes must also be considered. As discussed in the main report, it was decided to allow for two years of local shoreline recession. Consequently, the ocean toe of the storm berm at the point of maximum erosion (7 km south of the inlet) will be set back from the location of the natural berm on the estimated equilibrated profile a distance of 25 m (82 ft) plus two times the present local shoreline recession rate (9 m/yr (29.5 ft/yr)). This equates to 43 m (141 ft). As proposed, the setback distances were then linearly interpolated alongshore in each direction to the minimum of 25 m (82 ft) at 2.5 km and 10 km south of the inlet where the storm berm terminates. Table A4-1 shows the setback distances at each profile location. The exact location of the storm berm may be modified slightly during preparation of the plans & specs to account for localized shoreline recession rates. Any modifications will be coordinated with the participating agencies.

Once the location of the storm berm was established, the quantity of material required to construct the feature was determined. Unit volumes at each section were calculated using ISRP and total volumes were determined using the average end area method. Table A4-2 shows the unit volumes and cumulative volumes for the storm berm. Section 3 of this Appendix contains the quantity calculations for the storm berm. Section 4 of this Appendix contains a listing of the profile data of September 1995 which was used as the base condition. Station zero corresponds to the established control point for that profile location. Section 5 of this Appendix contains plots of each location showing the existing profile (September 1995), construction template, equilibrated profile, and the location of the storm berm. The final design may be adjusted slightly since current and more extensive beach profile information will be gathered during preparation of the plans & specs.

TABLE A4-1
PROPOSED ASSATEAGUE ISLAND RESTORATION
BERM WIDTH AND SETBACK DISTANCES

LINE NO.	STATION (feet)	STATION (kilometers)	CONSTRUCTION BERM WIDTH Y m (ft)	EQUILIBRIUM BERM WIDTH X m (ft)	STORM BERM SETBACK Z m (ft)
1	500				
2	1700	0.518			
3	3300	1.006			
4	4950	1.509			
5	6600	2.012			
6	8250	2.515			25.0 (82)
7	9900	3.018	0		27.1 (89)
8	11550	3.520	1.5 (5)	4 (13)	29.0 (95)
9	13200	4.023	7.6 (25)	4 (13)	31.1 (102)
10	14850	4.526	7.6 (25)	8.2 (27)	32.9 (108)
11	16800	5.121	19.8 (65)	7.3 (24)	35.0 (115)
12	18450	5.624	19.8 (65)	14.3 (47)	36.9 (121)
13	20100	6.127	39.6 (130)	18.6 (61)	39.0 (128)
14	21750	6.629	39.6 (130)	25.3 (83)	41.1 (135)
15	23550	7.178	48.8 (160)	29.3 (96)	43.0 (141)
16	25200	7.681	48.8 (160)	28.7 (94)	39.3 (129)
17	26850	8.184	36.6 (120)	27.7 (91)	35.7 (117)
18	28500	8.687	36.6 (120)	19.5 (64)	32.3 (106)
19	30150	9.190	30.5 (100)	16.8 (55)	28.7 (94)
20 *	31800	9.693	21.3 (70)	13.7 (45)	25.0 (82)
21	33450	10.196	12.2 (40)	11.0 (36)	
22	35100	10.699	9.1 (30)	8.2 (27)	
23	36630	11.165	9.1 (30)	5.5 (18)	
24	38280	11.668	0		
25	39930	12.171			
26	41580	12.674			

* approximate limit of State park

TABLE A4-2
QUANTITY ESTIMATES FOR ASSATEAGUE ISLAND BEACHFILL

LINE NO.	STATION (kilometers)	STATION (feet)	STORM BERM QUANTITIES UNIT VOLUME yd3/ft	STORM BERM QUANTITIES VOLUME yd3	STORM BERM QUANTITIES CUM. VOL. yd3	BEACHFILL QUANTITES UNIT VOLUME yd3/ft	BEACHFILL QUANTITES VOLUME yd3	BEACHFILL QUANTITES CUM. VOL. yd3	TOTAL QUANTITIES yd3
1		500	0	0	0	0	0		0
2	0.518	1700	0	0	0	0	0		0
3	1.006	3300	0	0	0	0	0		0
4	1.509	4950	0	0	0	0	0		0
5	2.012	6600	0	0	0	0	0		0
6	2.515	8250	9.1	9.1	9.1	0	0		9
7	3.018	9900	11.2	16747.5	16756.6	0	0	0	16757
8	3.520	11550	11	18315	35071.6	15.5	12788	12788	47859
9	4.023	13200	17.2	23265	58336.6	15.1	25245	38033	96369
10	4.526	14850	15.1	26647.5	84984.1	29.3	36630	74663	159647
11	5.121	16800	22.7	36855	121839.1	26.7	54600	129263	251102
12	5.624	18450	18.7	34155	155994.1	51.2	64268	193530	349524
13	6.127	20100	23.5	34815	190809.1	64.7	95618	289148	479957
14	6.629	21750	22.3	37785	228594.1	88.8	126638	415785	644379
15	7.178	23550	22.1	39960	268554.1	103.3	172890	588675	857229
16	7.681	25200	16.1	31515	300069.1	102.9	170115	758790	1058859
17	8.184	26850	10.1	21615	321684.1	99.7	167145	925935	1247619
18	8.687	28500	9.9	16500	338184.1	69.5	139590	1065525	1403709
19	9.190	30150	7.8	14602.5	352786.6	60	106838	1172363	1525149
20 *	9.693	31800	2.1	8167.5	360954.1	49.5	90338	1262700	1623654
21	10.196	33450	0	0	360954.1	40.2	74003	1336703	1697657
22	10.699	35100	0	0	360954.1	30.3	58163	1394865	1755819
23	11.165	36630	0	0	360954.1	20.2	38633	1433498	1794452
24	11.668	38280	0	0	360954.1	0	16665	1450163	1811117
25	12.171	39930	0	0	360954.1	0	0	1450163	1811117
26	12.674	41580	0	0	360954.1	0	0		1811117

* approximmate limit of State park

SECTION 1

CONSTRUCTION TEMPLATE

QUANTITY ESTIMATE

CALCULATIONS

Analysis of Profile Changes between:

Profile 8 Survey 11(950928) and Profile 8 Survey 1(961010)
Start Distance = 502.00 FT, Ending Distance = 821.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	752.96	-5.83	15.45	1.66	15.45	15.45
END	821.00	-7.34	-11.80	-4.68	3.65	27.24

construction berm = 5 ft

Volume Change: Above Datum= 7.40 YD3/FT , Below Datum= -3.74 YD3/FT
The Shoreline changed 45.20 FT , from 625.80 FT to 671.00 FT

Analysis of Profile Changes between:

Profile 9 Survey 11(950928) and Profile 9 Survey 1(961010)
Start Distance = 510.00 FT, Ending Distance = 849.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	728.31	-1.47	15.07	1.86	15.07	15.07
END	849.00	-7.26	-18.26	-4.08	-3.19	33.33

Volume Change: Above Datum= 13.49 YD3/FT , Below Datum= -16.68 YD3/FT
The Shoreline changed 44.50 FT , from 654.50 FT to 699.00 FT

construction berm = 25 ft.

Analysis of Profile Changes between:

Profile 10 Survey 11(950928) and Profile 10 Survey 1(961010)
Start Distance = 382.00 FT, Ending Distance = 721.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	657.01	-6.17	29.33	2.88	29.33	29.33
END	721.00	-7.13	-9.50	-4.01	19.83	38.83

construction berm = 25 ft.

Volume Change: Above Datum= 14.81 YD3/FT , Below Datum= 5.02 YD3/FT
The Shoreline changed 77.37 FT , from 493.63 FT to 571.00 FT

Analysis of Profile Changes between:

Profile 11 Survey 11(950928) and Profile 11 Survey 1(961010)
Start Dist ·e = 623.00 FT, Ending Distance = 1012.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	938.98	-5.41	26.68	2.33	26.68	26.68
END	1012.00	-7.58	-10.29	-3.80	16.39	36.96

construction berm = 65ft.

Volume Change: Above Datum= 15.92 YD3/FT , Below Datum= .47 YD3/FT
The Shoreline changed 73.50 FT , from 788.50 FT to 862.00 FT

Analysis of Profile Changes between:

Profile 12 Survey 11(950928) and Profile 12 Survey 1(961010)
Start Distance = 430.00 FT, Ending Distance = 817.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	731.57	-4.38	51.18	4.58	51.18	51.18
END	817.00	-8.27	-10.84	-3.42	40.34	62.01

construction berm = 65ft

Volume Change: Above Datum= 32.82 YD3/FT , Below Datum= 7.52 YD3/FT
The Shoreline changed 143.00 FT , from 524.00 FT to 667.00 FT

Analysis of Profile Changes between:

Profile 13 Survey 11(950927) and Profile 13 Survey 1(961010)
Start Distance = 287.00 FT, Ending Distance = 761.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	651.91	-2.41	64.70	4.84	64.70	64.70
END	761.00	-8.48	-12.29	-3.04	52.41	77.00

construction berm = 130ft.

Volume Change: Above Datum= 38.67 YD3/FT , Below Datum= 13.74 YD3/FT
The Shoreline changed 147.44 FT , from 463.56 FT to 611.00 FT

Analysis of Profile Changes between:
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Profile 14 Survey 11(950927) and Profile 14 Survey 1(961010)
Start Distance = 352.00 FT, Ending Distance = 816.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	741.10	-5.26	88.78	6.16	88.78	88.78
END	816.00	-8.56	-7.46	-2.69	81.32	96.24

construction berm = 130 ft.

Volume Change: Above Datum= 51.65 YD3/FT , Below Datum= 29.67 YD3/FT
The Shoreline changed 204.13 FT , from 461.87 FT to 666.00 FT

Analysis of Profile Changes between:
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Profile 15 Survey 11(950927) and Profile 15 Survey 1(961010)
Start Distance = 527.00 FT, Ending Distance = 1015.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	972.08	-7.92	103.27	6.26	103.27	103.27
END	1015.00	-9.10	-3.10	-1.95	100.17	106.37

construction berm = 160 ft

Volume Change: Above Datum= 53.00 YD3/FT , Below Datum= 47.17 YD3/FT
The Shoreline changed 202.86 FT , from 662.14 FT to 865.00 FT

Analysis of Profile Changes between:
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Profile 16 Survey 11(950927) and Profile 16 Survey 1(961010)
Start Distance = 412.00 FT, Ending Distance = 894.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	844.45	-7.37	102.85	6.42	102.85	102.85
END	894.00	-8.33	-6.09	-3.32	96.76	108.95

construction berm = 160 ft

Volume Change: Above Datum= 53.76 YD3/FT , Below Datum= 43.00 YD3/FT
The Shoreline changed 196.33 FT , from 547.67 FT to 744.00 FT

Analysis of Profile Changes between:

Profile 17 Survey 11(950927) and Profile 17 Survey 1(961010)
Start Distance = 188.00 FT, Ending Distance = 622.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	590.15	-8.85	99.70	6.69	99.70	99.70
END	622.00	-9.83	-1.62	-1.37	98.08	101.32

construction berm = 120 ft.

Volume Change: Above Datum= 46.61 YD3/FT , Below Datum= 51.47 YD3/FT
The Shoreline changed 172.40 FT , from 299.60 FT to 472.00 FT

Analysis of Profile Changes between:

Profile 18 Survey 11(950927) and Profile 18 Survey 1(961010)
Start Distance = 296.00 FT, Ending Distance = 742.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	650.93	-3.91	69.54	5.29	69.54	69.54
END	742.00	-8.51	-9.54	-2.83	60.00	79.08

construction berm = 120ft

Volume Change: Above Datum= 43.40 YD3/FT , Below Datum= 16.60 YD3/FT
The Shoreline changed 166.46 FT , from 425.54 FT to 592.00 FT

Analysis of Profile Changes between:

Profile 19 Survey 11(950926) and Profile 19 Survey 1(961010)
Start Distance = 351.00 FT, Ending Distance = 775.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	711.84	-6.24	60.04	4.49	60.04	60.04
END	775.00	-7.87	-9.18	-3.92	50.86	69.22

construction berm = 100ft.

Volume Change: Above Datum= 35.16 YD3/FT , Below Datum= 15.70 YD3/FT
The Shoreline changed 107.00 FT , from 518.00 FT to 625.00 FT

Analysis of Profile Changes between:

Profile 20 Survey 11(950926) and Profile 20 Survey 1(961010)
Start Distance = 265.00 FT, Ending Distance = 657.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	605.25	-7.19	49.46	3.94	49.46	49.46
END	657.00	-8.73	-5.11	-2.67	44.35	54.57

construction berm = 70 ft.

Volume Change: Above Datum= 26.24 YD3/FT , Below Datum= 18.11 YD3/FT
The Shoreline changed 88.38 FT , from 418.62 FT to 507.00 FT

Analysis of Profile Changes between:

Profile 21 Survey 11(950926) and Profile 21 Survey 1(961010)
Start Distance = 570.00 FT, Ending Distance = 924.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	885.41	-8.28	40.16	3.44	40.16	40.16
END	924.00	-9.80	-2.25	-1.57	37.91	42.40

construction berm = 40 ft.

Volume Change: Above Datum= 19.67 YD3/FT , Below Datum= 18.23 YD3/FT
The Shoreline changed 75.60 FT , from 698.40 FT to 774.00 FT

Analysis of Profile Changes between:

Profile 22 Survey 11(950926) and Profile 22 Survey 1(961010)
Start Distance = 235.00 FT, Ending Distance = 579.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	532.54	-7.63	30.32	2.75	30.32	30.32
END	579.00	-10.40	-1.93	-1.12	28.39	32.26

construction berm = 30 ft

Volume Change: Above Datum= 16.94 YD3/FT , Below Datum= 11.44 YD3/FT
The Shoreline changed 74.00 FT , from 355.00 FT to 429.00 FT

Analysis of Profile Changes between:
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Profile 23 Survey 11(950926) and Profile 23 Survey 1(961010)
Start Distance = 770.00 FT, Ending Distance = 1114.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	1068.97	-7.75	20.21	1.82	20.21	20.21
END	1114.00	-10.02	-2.35	-1.41	17.86	22.55

construction berm = 30 ft.

Volume Change: Above Datum= 11.26 YD3/FT , Below Datum= 6.60 YD3/FT
The Shoreline changed 39.80 FT , from 924.20 FT to 964.00 FT

SECTION 2

EQUILIBRIUM PROFILE

QUANTITY ESTIMATE

CALCULATIONS

Analysis of Profile Changes between:

Profile 8 Survey 11(950928) and Profile 8 Survey 12(950928)
Start Distance = 502.00 FT, Ending Distance = 2365.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	755.93	15.99	6.71	.71	6.71	6.71
2	804.00	18.55	-1.33	-.75	5.38	8.04
3	2183.98	-4.74	11.26	.22	16.64	19.30
4	2257.20	-4.43	-.16	-.06	16.47	19.47
END	2365.00	-4.97	.24	.06	16.72	19.71

Volume Change: Above Datum= 14.35 YD3/FT , Below Datum= 2.37 YD3/FT
The Shoreline changed 13.00 FT , from 1619.67 FT to 1632.67 FT

Analysis of Profile Changes between:

Profile 9 Survey 11(950928) and Profile 9 Survey 12(950928)
Start Distance = 510.00 FT, Ending Distance = 2401.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	1823.84	-2.37	15.49	.32	15.49	15.49
END	2401.00	-4.68	1.17	.07	16.66	16.66

Volume Change: Above Datum= 14.34 YD3/FT , Below Datum= 2.32 YD3/FT
The Shoreline changed 13.00 FT , from 1629.00 FT to 1642.00 FT

Analysis of Profile Changes between:

Profile 10 Survey 11(950928) and Profile 10 Survey 12(950928)
Start Distance = 382.00 FT, Ending Distance = 2068.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	672.56	15.49	14.36	1.33	14.36	14.36
2	734.65	18.58	-3.33	-1.45	11.02	17.69
END	2068.00	-5.34	24.10	.49	35.12	41.79

Volume Change: Above Datum= 29.81 YD3/FT , Below Datum= 5.32 YD3/FT
The Shoreline changed 27.00 FT , from 1486.25 FT to 1513.25 FT

Analysis of Profile Changes between:

Profile 11 Survey 11(950928) and Profile 11 Survey 12(950928)
Start Distance = 633.00 FT, Ending Distance = 3783.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	947.05	16.44	12.04	1.04	12.04	12.04
2	1033.84	17.89	-1.69	-.53	10.35	13.74
3	2183.43	-3.81	19.46	.46	29.81	33.20
4	2535.60	-2.60	-1.12	-.09	28.70	34.32
5	2701.39	-2.31	-.26	-.06	28.43	34.58
END	3783.00	-5.70	3.02	.08	31.46	37.60

Volume Change: Above Datum= 26.39 YD3/FT , Below Datum= 5.07 YD3/FT
The Shoreline changed 24.00 FT , from 1860.00 FT to 1884.00 FT

Analysis of Profile Changes between:

Profile 12 Survey 11(950928) and Profile 12 Survey 12(950928)
Start Distance = 438.00 FT, Ending Distance = 2984.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	728.60	17.18	21.67	2.01	21.67	21.67
2	780.65	17.25	-.74	-.39	20.93	22.41
3	1736.33	-.60	31.40	.89	52.33	53.81
4	1843.83	-1.12	.92	.30	53.25	54.74
5	1985.97	-1.20	.13	.03	53.38	54.87
6	2169.29	-.50	-1.22	-.18	52.16	56.09
END	2984.00	-5.15	7.92	.26	60.09	64.01

Volume Change: Above Datum= 51.17 YD3/FT , Below Datum= 8.92 YD3/FT
The Shoreline changed 47.00 FT , from 1645.67 FT to 1692.67 FT

Analysis of Profile Changes between:

Profile 13 Survey 11(950927) and Profile 13 Survey 12(950927)
Start Distance = 317.00 FT, Ending Distance = 2830.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	605.07	16.54	28.86	2.70	28.86	28.86
2	693.11	18.16	-6.10	-1.87	22.76	34.95
END	2830.00	-9.04	62.68	.79	85.44	97.63

Volume Change: Above Datum= 65.07 YD3/FT , Below Datum= 20.38 YD3/FT
The Shoreline changed 61.00 FT , from 1707.00 FT to 1768.00 FT

Analysis of Profile Changes between:

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Profile 14 Survey 11(950927) and Profile 14 Survey 12(950927)
Start Distance = 372.00 FT, Ending Distance = 2749.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	664.20	16.71	38.24	3.53	38.24	38.24
2	736.85	16.40	-1.08	-.40	37.16	39.32
END	2749.00	-5.86	69.39	.93	106.55	108.71

Volume Change: Above Datum= 88.57 YD3/FT , Below Datum= 17.98 YD3/FT
The Shoreline changed 83.00 FT , from 1824.00 FT to 1907.00 FT

Analysis of Profile Changes between:

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Profile 15 Survey 11(950927) and Profile 15 Survey 12(950927)
Start Distance = 541.00 FT, Ending Distance = 3201.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	1000.25	14.16	54.39	3.20	54.39	54.39
2	1097.64	14.23	-5.20	-1.44	49.18	59.59
3	2110.69	-1.42	59.55	1.59	108.73	119.14
4	2999.02	-6.90	19.38	.60	128.11	138.51
5	3088.94	-6.92	-.32	-.10	127.78	138.84
END	3201.00	-7.20	1.13	.27	128.91	139.96

Volume Change: Above Datum= 103.45 YD3/FT , Below Datum= 25.47 YD3/FT
The Shoreline changed 96.00 FT , from 1898.75 FT to 1994.75 FT

Analysis of Profile Changes between:

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Profile 16 Survey 11(950927) and Profile 16 Survey 12(950927)
Start Distance = 420.00 FT, Ending Distance = 2611.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	841.72	13.99	57.65	3.69	57.65	57.65
2	950.01	15.26	-11.22	-2.80	46.43	68.87
END	2611.00	-5.08	73.37	1.19	119.80	142.24

Volume Change: Above Datum= 102.36 YD3/FT , Below Datum= 17.45 YD3/FT
The Shoreline changed 94.00 FT , from 1838.25 FT to 1932.25 FT

Analysis of Profile Changes between:

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Profile 17 Survey 11(950927) and Profile 17 Survey 12(950927)
Start Distance = 188.00 FT, Ending Distance = 2563.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	582.05	12.69	58.00	3.97	58.00	58.00
2	718.98	13.66	-5.94	-1.17	52.06	63.94
END	2563.00	-4.98	65.07	.95	117.13	129.01

Volume Change: Above Datum= 100.43 YD3/FT , Below Datum= 16.69 YD3/FT
The Shoreline changed 91.00 FT , from 1578.00 FT to 1669.00 FT

Analysis of Profile Changes between:

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Profile 18 Survey 11(950927) and Profile 18 Survey 12(950927)
Start Distance = 308.00 FT, Ending Distance = 2701.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	564.54	17.21	29.51	3.11	29.51	29.51
2	648.80	17.72	-2.77	-.89	26.74	32.28
END	2701.00	-6.14	57.09	.75	83.83	89.37

Volume Change: Above Datum= 69.38 YD3/FT , Below Datum= 14.45 YD3/FT
The Shoreline changed 64.00 FT , from 1810.50 FT to 1874.50 FT

Analysis of Profile Changes between:

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Profile 19 Survey 11(950926) and Profile 19 Survey 12(950926)
Start Distance = 361.00 FT, Ending Distance = 2478.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	701.20	14.68	31.30	2.48	31.30	31.30
2	799.53	17.25	-6.79	-1.87	24.51	38.10
END	2478.00	-5.59	46.70	.75	71.21	84.80

Volume Change: Above Datum= 59.89 YD3/FT , Below Datum= 11.32 YD3/FT
The Shoreline changed 55.00 FT , from 1736.33 FT to 1791.33 FT

Analysis of Profile Changes between:

Profile 20 Survey 11(950926) and Profile 20 Survey 12(950926)
Start Distance = 273.00 FT, Ending Distance = 2068.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	604.25	14.36	25.70	2.10	25.70	25.70
2	712.40	15.82	-2.86	-.71	22.85	28.56
3	784.45	16.34	-1.63	-.67	21.22	30.19
END	2068.00	-4.65	35.69	.75	56.92	65.88

Volume Change: Above Datum= 49.17 YD3/FT , Below Datum= 7.75 YD3/FT
The Shoreline changed 45.00 FT , from 1544.00 FT to 1589.00 FT

Analysis of Profile Changes between:

Profile 21 Survey 11(950926) and Profile 21 Survey 12(950926)
Start Distance = 570.00 FT, Ending Distance = 2523.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	905.76	13.41	21.93	1.76	21.93	21.93
2	1042.18	16.56	-4.36	-.86	17.56	26.29
END	2523.00	-6.90	31.31	.57	48.87	57.60

Volume Change: Above Datum= 39.73 YD3/FT , Below Datum= 9.14 YD3/FT
The Shoreline changed 36.00 FT, from 1871.25 FT to 1907.25 FT

Analysis of Profile Changes between:

Profile 22 Survey 11(950926) and Profile 22 Survey 12(950926)
Start Distance = 235.00 FT, Ending Distance = 1788.00 FT
Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	601.39	12.31	17.50	1.29	17.50	17.50
2	759.44	15.00	-2.74	-.47	14.76	20.24
END	1788.00	-6.16	21.14	.55	35.90	41.38

Volume Change: Above Datum= 29.80 YD3/FT , Below Datum= 6.10 YD3/FT
The Shoreline changed 27.00 FT , from 1323.67 FT to 1350.67 FT

Analysis of Profile Changes between:

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Profile 23 Survey 11(950926) and Profile 23 Survey 12(950926)

Start Distance = -170.00 FT, Ending Distance = 2523.00 FT

Datum shifted to -21.60 FT (doc)

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	1129.31	13.11	11.15	.84	11.15	11.15
2	1261.57	16.98	-2.69	-.55	8.46	13.84
3	2059.36	-1.73	12.57	.43	21.03	26.41
END	2523.00	-6.12	2.94	.18	23.98	29.35

Volume Change: Above Datum= -19.86 YD3/FT , Below Datum= 4.12 YD3/FT

The Shoreline changed -18.00 FT , from 1963.33 FT to 1981.33 FT

SECTION 3

STORM BERM

QUANTITY ESTIMATE

CALCULATIONS

Analysis of Profile Changes between:

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Profile 6 Survey 2(961004) and Profile 6 Survey 11(950928)
Start Distance = 238.00 FT, Ending Distance = 383.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
END	383.00	8.00	-9.05	-1.69	-9.05	9.05

Analysis of Profile Changes between:

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Profile 7 Survey 2(961004) and Profile 7 Survey 11(950928)
Start Distance = 203.00 FT, Ending Distance = 357.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	355.93	8.25	-11.20	-1.98	-11.20	11.20
END	357.00	8.23	.00	.01	-11.20	11.20

Analysis of Profile Changes between:

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Profile 8 Survey 2(961004) and Profile 8 Survey 11(950928)
Start Distance = 260.00 FT, Ending Distance = 420.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
END	420.00	8.09	-10.96	-1.88	-10.96	10.96

Analysis of Profile Changes between:

Profile 9 Survey 2(961004) and Profile 9 Survey 11(950928)
Start Distance = 239.00 FT, Ending Distance = 421.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
END	421.00	7.30	-17.16	-2.55	-17.16	17.16

Analysis of Profile Changes between:

Profile 10 Survey 2(961004) and Profile 10 Survey 11(950928)
Start Distance = 133.00 FT, Ending Distance = 301.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
END	301.00	7.52	-15.12	-2.44	-15.12	15.12

Analysis of Profile Changes between:

Profile 11 Survey 2(961004) and Profile 11 Survey 11(950928)
Start Distance = 322.00 FT, Ending Distance = 542.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
END	542.00	6.61	-22.65	-2.78	-22.65	22.65

Analysis of Profile Changes between:

Profile 12 Survey 2(961004) and Profile 12 Survey 11(950928)
Start Distance = 156.00 FT, Ending Distance = 364.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
END	364.00	7.20	-18.70	-2.44	-18.70	18.70

Analysis of Profile Changes between:

Profile 13 Survey 2(961004) and Profile 13 Survey 11(950927)
Start Distance = 36.00 FT, Ending Distance = 250.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
END	250.00	6.31	-23.54	-2.98	-23.54	23.54

Analysis of Profile Changes between:

Profile 14 Survey 2(961004) and Profile 14 Survey 11(950927)
Start Distance = 104.00 FT, Ending Distance = 320.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
END	320.00	6.92	-22.33	-2.85	-22.33	22.33

Analysis of Profile Changes between:

Profile 15 Survey 2(961004) and Profile 15 Survey 11(950927)
Start Distance = 272.00 FT, Ending Distance = 496.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
END	496.00	7.18	-22.05	-2.69	-22.05	22.05

Analysis of Profile Changes between:

Profile 16 Survey 2(961004) and Profile 16 Survey 11(950927)
Start Distance = 199.00 FT, Ending Distance = 385.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
END	385.00	7.69	-16.05	-2.33	-16.05	16.05

Analysis of Profile Changes between:

Profile 17 Survey 2(961004) and Profile 17 Survey 11(950927)
Start Distance = 14.00 FT, Ending Distance = 162.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
END	162.00	8.19	-10.09	-1.84	-10.09	10.09

Analysis of Profile Changes between:

Profile 18 Survey 2(961004) and Profile 18 Survey 11(950927)
Start Distance = 116.00 FT, Ending Distance = 266.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
END	266.00	7.60	-9.86	-1.84	-9.86	9.86

Analysis of Profile Changes between:

Profile 19 Survey 2(961004) and Profile 19 Survey 11(950926)
Start Distance = 182.00 FT, Ending Distance = 322.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
END	322.00	7.48	-7.84	-1.51	-7.84	7.84

Analysis of Profile Changes between:

Profile 20 Survey 2(961004) and Profile 20 Survey 11(950926)
Start Distance = 162.00 FT, Ending Distance = 236.00 FT

Cut/ Fill Cell	Distance to end FT	Elevation of end pt FT	Cell Volume YD3/FT	Cell Thickness FT	Profile Cum.Vol. YD3/FT	Profile Gross Vol. YD3/FT
1	171.77	10.80	.16	.45	.16	.16
END	236.00	7.88	-2.11	-.89	-1.94	2.27

SECTION 4

PROFILE DATA

SEPTEMBER 1995

Local	Profile	Survey	Date	Time	Points	Units
AI	6	11	950928	1800	125	FT

Label = LINE175

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	-434.00	3.20	43	404.00	8.10	85	1485.00	-19.10
2	-414.00	3.30	44	419.00	8.20	86	1519.00	-19.40
3	-395.00	3.40	45	432.00	8.30	87	1552.00	-19.70
4	-374.00	3.80	46	445.00	8.30	88	1590.00	-19.90
5	-355.00	4.30	47	457.00	8.30	89	1630.00	-20.20
6	-337.00	4.40	48	474.00	8.10	90	1658.00	-20.60
7	-320.00	4.60	49	480.00	7.40	91	1690.00	-20.80
8	-297.00	4.30	50	492.00	7.20	92	1724.00	-21.20
9	-276.00	3.80	51	503.00	6.90	93	1755.00	-21.20
10	-253.00	4.00	52	525.00	5.10	94	1790.00	-21.20
11	-233.00	4.30	53	546.00	2.80	95	1827.00	-21.20
12	-212.00	4.90	54	589.00	-2.60	96	1853.00	-21.60
13	-194.00	5.60	55	624.00	-3.90	97	1883.00	-21.90
14	-172.00	5.30	56	664.00	-2.80	98	1915.00	-22.30
15	-152.00	5.00	57	684.00	-3.00	99	1944.00	-22.30
16	-130.00	4.80	58	708.00	-3.10	100	1977.00	-22.40
17	-111.00	4.60	59	733.00	-3.20	101	2011.00	-22.40
18	-88.00	4.70	60	762.00	-4.30	102	2048.00	-22.40
19	-67.00	4.90	61	795.00	-5.20	103	2090.00	-22.40
20	-44.00	5.00	62	829.00	-6.10	104	2134.00	-22.30
21	-24.00	5.10	63	850.00	-6.20	105	2165.00	-22.50
22	-2.00	5.70	64	873.00	-6.30	106	2201.00	-22.70
3	16.00	6.50	65	897.00	-6.30	107	2239.00	-22.90
[illegible]	31.00	6.40	66	936.00	-7.50	108	2274.00	-23.10
25	44.00	6.40	67	981.00	-8.50	109	2316.00	-23.20
26	67.00	6.60	68	1028.00	-9.50	110	2358.00	-23.40
27	88.00	7.00	69	1052.00	-10.50	111	2396.00	-23.50
28	110.00	6.80	70	1080.00	-11.40	112	2440.00	-23.60
29	130.00	6.60	71	1109.00	-12.30	113	2485.00	-23.60
30	152.00	6.70	72	1133.00	-13.20	114	2524.00	-23.80
31	172.00	6.90	73	1161.00	-14.00	115	2568.00	-24.00
32	195.00	6.90	74	1189.00	-14.80	116	2614.00	-24.20
33	215.00	6.80	75	1210.00	-15.40	117	2646.00	-24.30
34	238.00	7.00	76	1234.00	-15.90	118	2683.00	-24.40
35	259.00	7.20	77	1258.00	-16.40	119	2720.00	-24.50
36	282.00	7.40	78	1282.00	-16.90	120	2748.00	-24.80
37	302.00	7.70	79	1309.00	-17.20	121	2781.00	-25.00
38	326.00	7.80	80	1337.00	-17.60	122	2814.00	-25.30
39	347.00	7.90	81	1363.00	-17.90	123	2843.00	-25.50
40	363.00	7.90	82	1392.00	-18.20	124	2877.00	-25.70
41	377.00	8.00	83	1422.00	-18.40	125	2913.00	-25.90
42	391.00	8.00	84	1451.00	-18.80			

Local	Profile	Survey	Date	Time	Points	Units
AI	7	11	950928	1600	122	FT

Label = LINE200

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	-244.00	3.10	42	515.00	1.40	83	1629.00	-22.20
2	-221.00	3.90	43	533.00	-1.10	84	1667.00	-22.40
3	-200.00	4.90	44	577.00	-2.90	85	1703.00	-22.00
4	-175.00	4.70	45	604.00	-3.30	86	1727.00	-22.30
5	[illegible]53.00	4.50	46	638.00	-5.70	87	1755.00	-22.50
6	[illegible]9.00	4.80	47	665.00	-5.40	88	1784.00	-22.80
7	-108.00	5.00	48	696.00	-5.70	89	1799.00	-23.00
8	-83.00	4.90	49	724.00	-5.80	90	1817.00	-23.20
9	-61.00	4.70	50	739.00	-6.30	91	1835.00	-23.30
10	-38.00	4.70	51	757.00	-6.70	92	1860.00	-23.80
11	-18.00	4.80	52	775.00	-7.20	93	1889.00	-24.20
12	2.00	5.20	53	798.00	-5.70	94	1919.00	-24.60
13	21.00	5.60	54	824.00	-5.20	95	1960.00	-24.60
14	40.00	6.40	55	848.00	-5.80	96	1979.00	-24.70
15	57.00	7.30	56	876.00	-6.70	97	2000.00	-24.80
16	81.00	7.20	57	894.00	-7.00	98	2022.00	-24.90
17	103.00	7.00	58	915.00	-7.60	99	2039.00	-24.70
18	125.00	7.00	59	932.00	-7.90	100	2060.00	-24.40
19	145.00	7.00	60	950.00	-8.40	101	2081.00	-24.20
20	167.00	6.80	61	955.00	-8.60	102	2125.00	-24.70
21	187.00	6.60	62	966.00	-9.00	103	2174.00	-25.20
22	208.00	6.50	63	989.00	-10.00	104	2190.00	-25.20
23	228.00	6.50	64	1017.00	-10.80	105	2208.00	-25.30
24	249.00	6.70	65	1045.00	-11.70	106	2227.00	-25.30
25	268.00	6.90	66	1084.00	-13.20	107	2264.00	-25.70
26	291.00	7.20	67	1121.00	-13.90	108	2293.00	-25.40
27	311.00	7.70	68	1147.00	-14.50	109	2327.00	-25.10
28	331.00	7.90	69	1181.00	-15.80	110	2362.00	-24.70
29	349.00	8.20	70	1228.00	-16.50	111	2391.00	-24.70
30	362.00	8.30	71	1253.00	-17.10	112	2425.00	-24.60
31	374.00	8.50	72	1281.00	-17.50	113	2460.00	-24.50
32	394.00	8.80	73	1311.00	-18.00	114	2475.00	-24.80
33	404.00	8.90	74	1342.00	-18.70	115	2493.00	-25.10
34	414.00	9.00	75	1378.00	-19.40	116	2511.00	-25.40
35	[illegible]26.00	9.00	76	1415.00	-20.00	117	2537.00	-25.60
36	437.00	9.00	77	1447.00	-20.40	118	2567.00	-25.80
37	452.00	7.70	78	1485.00	-20.80	119	2598.00	-26.00
38	468.00	6.60	79	1524.00	-21.10	120	2648.00	-26.50
39	481.00	5.40	80	1543.00	-21.20	121	2706.00	-26.90
40	493.00	3.90	81	1564.00	-21.40	122	2766.00	-27.40
41	504.00	2.80	82	1586.00	-21.50			

Local	Profile	Survey	Date	Time	Points	Units
AI	8	11	950928	1400	133	FT

Label = LINE225

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	-618.00	2.00	46	443.00	8.40	91	1403.00	-18.80
2	-590.00	2.10	47	457.00	8.60	92	1426.00	-19.20
3	-565.00	2.30	48	469.00	8.60	93	1449.00	-19.60
4	-540.00	2.40	49	479.00	8.60	94	1469.00	-19.80
5	-517.00	2.60	50	491.00	8.40	95	1492.00	-20.00
6	-491.00	2.70	51	502.00	8.20	96	1516.00	-20.20
7	-468.00	2.80	52	522.00	7.30	97	1532.00	-20.40
8	-443.00	2.90	53	534.00	6.50	98	1551.00	-20.60
9	-420.00	3.00	54	546.00	5.60	99	1571.00	-20.80
10	-396.00	3.10	55	573.00	3.20	100	1587.00	-21.10
11	-373.00	3.10	56	606.00	1.20	101	1607.00	-21.40
12	-350.00	3.10	57	639.00	-.80	102	1626.00	-21.70
13	-328.00	3.20	58	661.00	-2.20	103	1669.00	-22.00
14	-304.00	3.30	59	685.00	-3.40	104	1696.00	-22.20
15	-283.00	3.50	60	711.00	-4.60	105	1723.00	-22.50
16	-258.00	3.50	61	752.00	-5.90	106	1756.00	-22.80
17	-234.00	3.60	62	793.00	-2.90	107	1787.00	-22.90
18	-211.00	3.70	63	808.00	-3.10	108	1831.00	-23.30
19	-189.00	3.80	64	826.00	-3.20	109	1850.00	-23.50
20	-163.00	3.90	65	843.00	-3.30	110	1872.00	-23.70
21	-139.00	4.10	66	858.00	-3.40	111	1895.00	-23.90
22	-114.00	4.20	67	876.00	-3.60	112	1912.00	-24.10
[illegible]	-90.00	4.30	68	894.00	-3.70	113	1932.00	-24.30
[illegible]	-68.00	4.40	69	911.00	-4.20	114	1953.00	-24.50
25	-48.00	4.60	70	932.00	-4.70	115	1999.00	-24.80
26	-24.00	4.60	71	953.00	-5.20	116	2019.00	-25.00
27	-1.00	4.70	72	974.00	-5.60	117	2042.00	-25.20
28	20.00	4.90	73	998.00	-6.00	118	2065.00	-25.40
29	41.00	5.00	74	1023.00	-6.30	119	2083.00	-25.50
30	65.00	5.10	75	1040.00	-6.60	120	2103.00	-25.60
31	87.00	5.20	76	1058.00	-6.90	121	2124.00	-25.80
32	113.00	5.40	77	1078.00	-7.10	122	2140.00	-26.00
33	135.00	5.60	78	1102.00	-8.50	123	2158.00	-26.20
34	162.00	5.80	79	1129.00	-9.60	124	2177.00	-26.40
35	186.00	6.00	80	1158.00	-10.80	125	2199.00	-26.20
36	210.00	6.10	81	1204.00	-13.20	126	2225.00	-26.10
37	231.00	6.30	82	1224.00	-13.70	127	2252.00	-26.00
38	258.00	6.40	83	1246.00	-14.20	128	2270.00	-26.10
39	282.00	6.60	84	1270.00	-14.70	129	2291.00	-26.20
40	308.00	6.90	85	1287.00	-15.30	130	2313.00	-26.30
41	333.00	7.20	86	1306.00	-15.90	131	2328.00	-26.40
42	359.00	7.40	87	1327.00	-16.50	132	2346.00	-26.50
43	384.00	7.70	88	1344.00	-17.20	133	2365.00	-26.60
44	407.00	7.90	89	1363.00	-17.70			
45	428.00	8.20	90	1383.00	-18.30			

Local	Profile	Survey	Date	Time	Points	Units
AI	9	11	950928	1200	117	FT

Label = LINE250

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	-437.00	2.20	40	482.00	8.40	79	1502.00	-19.50
2	-414.00	2.30	41	495.00	8.70	80	1524.00	-20.00
3	-393.00	2.40	42	510.00	8.20	81	1548.00	-20.40
4	-370.00	2.40	43	523.00	7.60	82	1564.00	-20.70
5	-349.00	2.50	44	527.00	7.40	83	1583.00	-21.00
6	-325.00	2.60	45	528.00	7.40	84	1603.00	-21.20
7	-304.00	2.70	46	540.00	6.40	85	1622.00	-21.50
8	-280.00	2.80	47	551.00	5.20	86	1643.00	-21.80
9	-258.00	2.90	48	565.00	4.20	87	1666.00	-22.10
10	-233.00	3.00	49	578.00	3.00	88	1688.00	-22.40
11	-210.00	3.10	50	609.00	1.90	89	1714.00	-22.60
12	-186.00	3.20	51	637.00	.50	90	1740.00	-22.90
13	-164.00	3.20	52	665.00	-.30	91	1762.00	-23.30
14	-140.00	3.50	53	692.00	-1.00	92	1787.00	-23.60
15	-118.00	3.80	54	722.00	-1.40	93	1813.00	-24.00
16	-92.00	3.70	55	770.00	-1.90	94	1844.00	-23.90
17	-68.00	3.60	56	819.00	-2.90	95	1880.00	-23.90
18	-43.00	3.80	57	843.00	-3.00	96	1917.00	-23.80
19	-20.00	4.10	58	871.00	-3.10	97	1936.00	-24.00
20	5.00	4.50	59	900.00	-3.20	98	1959.00	-24.20
21	29.00	4.90	60	941.00	-4.80	99	1982.00	-24.40
22	56.00	4.70	61	970.00	-6.20	100	2002.00	-24.50
23	80.00	4.50	62	1004.00	-7.40	101	2025.00	-24.70
24	105.00	5.10	63	1038.00	-8.60	102	2048.00	-24.80
25	128.00	6.00	64	1061.00	-9.60	103	2072.00	-25.00
26	153.00	6.60	65	1086.00	-10.40	104	2099.00	-25.20
27	176.00	7.30	66	1113.00	-11.20	105	2127.00	-25.40
28	203.00	6.80	67	1160.00	-11.70	106	2144.00	-25.60
29	227.00	6.10	68	1181.00	-12.40	107	2164.00	-25.70
30	254.00	5.90	69	1204.00	-13.10	108	2184.00	-25.80
31	278.00	5.70	70	1228.00	-13.80	109	2207.00	-25.80
32	301.00	5.90	71	1263.00	-14.70	110	2233.00	-25.80
33	323.00	6.10	72	1304.00	-15.50	111	2260.00	-25.80
34	366.00	6.60	73	1346.00	-16.30	112	2276.00	-25.80
35	405.00	7.10	74	1381.00	-16.90	113	2296.00	-25.90
36	421.00	7.30	75	1428.00	-18.20	114	2315.00	-25.90
37	436.00	7.70	76	1444.00	-18.50	115	2341.00	-26.00
38	453.00	7.80	77	1463.00	-18.80	116	2370.00	-26.20
39	468.00	8.10	78	1483.00	-19.10	117	2401.00	-26.30

Local	Profile	Survey	Date	Time	Points	Units
AI	10	11	950928	1000	115	FT

Label = LINE275

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	-537.00	5.40	40	285.00	7.30	79	1173.00	-15.50
2	-513.00	4.30	41	305.00	7.60	80	1199.00	-16.30
3	-492.00	2.90	42	324.00	7.90	81	1227.00	-17.10
4	-468.00	3.00	43	336.00	8.20	82	1273.00	-17.50
5	-446.00	3.20	44	346.00	8.60	83	1292.00	-18.00
6	-424.00	2.80	45	359.00	8.70	84	1315.00	-18.40
7	-404.00	2.20	46	370.00	9.00	85	1338.00	-18.80
8	-379.00	2.40	47	383.00	8.10	86	1355.00	-19.30
9	-357.00	2.50	48	395.00	7.00	87	1374.00	-19.70
10	-333.00	2.90	49	410.00	6.40	88	1394.00	-20.10
11	-312.00	3.40	50	423.00	5.70	89	1437.00	-20.70
12	-290.00	3.70	51	437.00	4.70	90	1463.00	-21.30
13	-270.00	4.10	52	449.00	3.50	91	1494.00	-21.70
14	-245.00	3.80	53	460.00	2.80	92	1526.00	-22.20
15	-223.00	3.50	54	469.00	1.80	93	1541.00	-22.80
16	-202.00	4.10	55	495.00	-.10	94	1559.00	-23.20
17	-184.00	5.00	56	519.00	-1.70	95	1578.00	-23.70
18	-183.00	4.60	57	542.00	-2.80	96	1621.00	-24.10
19	-162.00	4.80	58	560.00	-4.00	97	1643.00	-24.30
20	-143.00	5.10	59	581.00	-4.70	98	1668.00	-24.40
21	-120.00	4.80	60	609.00	-4.80	99	1694.00	-24.60
22	-99.00	4.40	61	648.00	-6.20	100	1714.00	-24.80
[illegible]	-77.00	4.50	62	676.00	-6.10	101	1738.00	-25.00
	-57.00	4.60	63	678.00	-5.90	102	1763.00	-25.20
25	-38.00	5.10	64	681.00	-5.60	103	1808.00	-25.70
26	-21.00	5.60	65	712.00	-2.60	104	1826.00	-25.80
27	2.00	5.80	66	755.00	-3.40	105	1847.00	-25.90
28	23.00	6.10	67	781.00	-3.90	106	1869.00	-25.90
29	46.00	6.20	68	821.00	-4.70	107	1892.00	-26.20
30	66.00	6.20	69	866.00	-6.20	108	1917.00	-26.40
31	91.00	6.40	70	887.00	-7.20	109	1944.00	-26.60
32	114.00	6.70	71	911.00	-8.00	110	1961.00	-26.60
33	137.00	6.50	72	937.00	-8.80	111	1980.00	-26.70
34	157.00	6.20	73	979.00	-9.90	112	1999.00	-26.70
35	180.00	6.20	74	1026.00	-11.20	113	2020.00	-26.80
36	200.00	6.30	75	1050.00	-12.00	114	2044.00	-26.90
37	222.00	6.50	76	1077.00	-12.60	115	2068.00	-27.00
38	243.00	6.70	77	1106.00	-13.30			
39	265.00	7.00	78	1150.00	-14.60			

Local	Profile	Survey	Date	Time	Points	Units
AI	11	11	950928	800	146	FT

Label = LINE300

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	-75.00	3.80	50	918.00	-4.40	99	2383.00	-24.70
2	-56.00	4.10	51	927.00	-5.80	100	2402.00	-24.60
3	-38.00	4.50	52	955.00	-4.90	101	2421.00	-24.60
4	-18.00	4.30	53	989.00	-4.20	102	2446.00	-24.40
5	.00	4.20	54	1023.00	-3.40	103	2474.00	-24.30
6	24.00	4.10	55	1044.00	-4.00	104	2503.00	-24.20
7	46.00	4.00	56	1068.00	-4.60	105	2530.00	-24.20
8	69.00	3.70	57	1092.00	-5.10	106	2561.00	-24.20
9	90.00	3.30	58	1108.00	-5.70	107	2593.00	-24.20
10	115.00	3.40	59	1125.00	-6.20	108	2618.00	-24.10
11	138.00	3.50	60	1144.00	-6.70	109	2648.00	-24.00
12	163.00	3.70	61	1164.00	-7.50	110	2678.00	-23.90
13	185.00	4.00	62	1187.00	-8.10	111	2700.00	-23.90
14	209.00	4.10	63	1211.00	-8.80	112	2726.00	-24.00
15	231.00	4.20	64	1239.00	-10.20	113	2752.00	-24.00
16	255.00	4.40	65	1278.00	-10.80	114	2770.00	-24.10
17	278.00	4.60	66	1298.00	-11.10	115	2790.00	-24.10
18	302.00	4.70	67	1321.00	-11.30	116	2811.00	-24.20
19	325.00	4.80	68	1344.00	-11.50	117	2839.00	-24.30
20	350.00	4.90	69	1368.00	-12.10	118	2871.00	-24.40
21	372.00	5.00	70	1395.00	-12.60	119	2905.00	-24.50
22	398.00	5.20	71	1424.00	-13.10	120	2933.00	-24.60
23	422.00	5.50	72	1443.00	-13.80	121	2967.00	-24.70
24	446.00	5.70	73	1466.00	-14.40	122	3001.00	-24.80
25	469.00	5.90	74	1490.00	-15.10	123	3065.00	-25.10
26	493.00	6.10	75	1523.00	-16.30	124	3139.00	-25.40
27	516.00	6.30	76	1525.00	-16.30	125	3216.00	-25.60
28	540.00	6.60	77	1546.00	-16.50	126	3242.00	-25.70
29	562.00	6.90	78	1578.00	-17.20	127	3272.00	-25.80
30	585.00	7.20	79	1616.00	-17.80	128	3302.00	-25.90
31	606.00	7.60	80	1655.00	-18.40	129	3323.00	-25.90
32	62[illegible].00	7.80	81	1692.00	-19.10	130	3347.00	-26.00
33	633.00	8.10	82	1736.00	-19.60	131	3373.00	-26.00
34	652.00	7.80	83	1781.00	-20.20	132	3398.00	-26.10
35	664.00	7.10	84	1831.00	-21.20	133	3428.00	-26.20
36	676.00	6.20	85	1889.00	-22.00	134	3459.00	-26.30
37	688.00	6.10	86	1949.00	-22.90	135	3480.00	-26.40
38	698.00	5.90	87	1981.00	-23.50	136	3504.00	-26.50
39	711.00	5.80	88	2018.00	-24.00	137	3529.00	-26.50
40	722.00	5.70	89	2057.00	-24.50	138	3558.00	-26.70
41	735.00	4.70	90	2090.00	-24.80	139	3592.00	-26.80
42	748.00	3.50	91	2128.00	-25.10	140	3627.00	-27.00
43	748.00	3.40	92	2168.00	-25.50	141	3655.00	-27.10
44	766.00	1.50	93	2204.00	-25.30	142	3687.00	-27.10
45	790.00	-.10	94	2246.00	-25.20	143	3721.00	-27.20
46	818.00	-1.80	95	2289.00	-25.00	144	3739.00	-27.30
47	843.00	-2.60	96	2312.00	-24.90	145	3761.00	-27.30
48	873.00	-3.80	97	2339.00	-24.80	146	3783.00	-27.30
49	897.00	-4.10	98	2366.00	-24.80			

Local	Profile	Survey	Date	Time	Points	Units
AI	12	11	950928	600	141	FT

Label = LINE325

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	-612.00	1.70	48	409.00	7.80	95	1697.00	-22.30
2	-588.00	1.80	49	424.00	7.80	96	1714.00	-22.30
3	-567.00	1.80	50	438.00	7.80	97	1733.00	-22.20
4	-542.00	1.80	51	450.00	6.80	98	1753.00	-22.20
5	-519.00	1.90	52	462.00	5.60	99	1768.00	-22.40
6	-490.00	2.00	53	473.00	4.60	100	1786.00	-22.60
7	-464.00	2.10	54	483.00	3.30	101	1804.00	-22.80
8	-439.00	2.20	55	499.00	1.80	102	1854.00	-22.70
9	-417.00	2.30	56	524.00	.00	103	1902.00	-22.80
10	-392.00	2.40	57	546.00	-1.30	104	1934.00	-22.80
11	-368.00	2.40	58	566.00	-2.30	105	1965.00	-22.80
12	-344.00	2.50	59	585.00	-2.20	106	1995.00	-22.80
13	-322.00	2.50	60	612.00	-2.30	107	2039.00	-22.50
14	-301.00	3.10	61	640.00	-3.30	108	2063.00	-22.40
15	-282.00	3.80	62	667.00	-3.80	109	2090.00	-22.20
16	-276.00	2.70	63	693.00	-4.90	110	2118.00	-22.10
17	-252.00	2.70	64	714.00	-4.60	111	2143.00	-22.10
18	-230.00	2.80	65	738.00	-4.30	112	2171.00	-22.10
19	-207.00	2.80	66	762.00	-4.10	113	2201.00	-22.10
20	-185.00	2.90	67	806.00	-4.70	114	2216.00	-22.20
21	-161.00	3.00	68	826.00	-5.30	115	2234.00	-22.30
22	-140.00	3.00	69	848.00	-5.80	116	2252.00	-22.30
[illegible]	-115.00	3.10	70	871.00	-6.40	117	2299.00	-22.30
	-94.00	3.20	71	906.00	-7.90	118	2340.00	-22.50
25	-71.00	3.30	72	932.00	-8.40	119	2386.00	-22.50
26	-50.00	3.50	73	957.00	-8.90	120	2414.00	-22.60
27	-27.00	3.80	74	988.00	-9.90	121	2446.00	-22.70
28	-6.00	4.10	75	1013.00	-10.80	122	2479.00	-22.70
29	15.00	3.90	76	1048.00	-11.00	123	2498.00	-22.80
30	36.00	3.80	77	1066.00	-11.20	124	2519.00	-22.80
31	61.00	3.90	78	1086.00	-11.40	125	2541.00	-22.90
32	84.00	4.00	79	1107.00	-11.60	126	2589.00	-23.20
33	108.00	4.20	80	1149.00	-12.30	127	2626.00	-23.50
34	129.00	4.50	81	1194.00	-12.50	128	2644.00	-23.60
35	155.00	4.80	82	1229.00	-13.30	129	2664.00	-23.80
36	179.00	5.30	83	1272.00	-14.70	130	2685.00	-23.90
37	204.00	5.40	84	1306.00	-15.30	131	2710.00	-24.10
38	227.00	5.60	85	1341.00	-16.50	132	2749.00	-24.50
39	253.00	5.80	86	1377.00	-17.00	133	2776.00	-24.80
40	275.00	6.20	87	1420.00	-17.70	134	2806.00	-25.00
41	301.00	6.40	88	1460.00	-18.50	135	2838.00	-25.30
42	324.00	6.80	89	1500.00	-19.10	136	2865.00	-25.70
43	336.00	6.90	90	1549.00	-20.00	137	2895.00	-26.00
44	347.00	7.00	91	1589.00	-20.50	138	2926.00	-26.30
45	364.00	7.20	92	1633.00	-21.40	139	2943.00	-26.60
46	378.00	7.30	93	1652.00	-21.70	140	2963.00	-26.80
47	394.00	7.50	94	1674.00	-22.00	141	2984.00	-27.00

Local	Profile	Survey	Date	Time	Points	Units
AI	13	11	950927	1600	115	FT

Label = LINE350

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	-434.00	2.10	40	418.00	3.40	79	1494.00	-18.60
2	-407.00	2.20	41	429.00	2.60	80	1525.00	-19.10
3	-383.00	2.30	42	439.00	1.70	81	1562.00	-19.50
4	-358.00	2.30	43	465.00	-.10	82	1600.00	-20.00
5	-335.00	2.40	44	488.00	-1.80	83	1639.00	-20.70
6	-313.00	3.10	45	510.00	-3.70	84	1684.00	-21.30
7	-293.00	4.00	46	531.00	-4.70	85	1730.00	-21.90
8	-269.00	3.80	47	549.00	-5.20	86	1759.00	-22.40
9	-246.00	3.70	48	570.00	-5.60	87	1792.00	-22.90
10	-222.00	3.60	49	591.00	-6.10	88	1827.00	-23.30
11	-199.00	3.60	50	610.00	-4.70	89	1853.00	-23.70
12	-171.00	3.60	51	631.00	-3.50	90	1883.00	-24.10
13	-145.00	3.70	52	654.00	-2.30	91	1914.00	-24.50
14	-121.00	3.70	53	695.00	-3.50	92	1941.00	-24.90
15	-98.00	3.70	54	743.00	-4.80	93	1972.00	-25.30
16	-73.00	3.90	55	792.00	-6.60	94	2003.00	-25.70
17	-50.00	4.20	56	836.00	-7.40	95	2045.00	-26.20
18	-22.00	4.70	57	858.00	-8.10	96	2092.00	-26.70
19	1.00	5.30	58	883.00	-8.70	97	2142.00	-27.10
20	26.00	5.40	59	910.00	-9.20	98	2169.00	-27.20
21	49.00	5.50	60	945.00	-10.00	99	2201.00	-27.40
22	74.00	5.30	61	983.00	-10.80	100	2234.00	-27.50
23	97.00	5.00	62	1016.00	-11.30	101	2262.00	-27.70
24	122.00	5.20	63	1054.00	-11.60	102	2294.00	-27.80
25	146.00	5.40	64	1092.00	-12.00	103	2327.00	-27.90
26	170.00	5.50	65	1114.00	-12.20	104	2365.00	-28.30
27	191.00	5.70	66	1139.00	-12.30	105	2409.00	-28.60
28	215.00	5.90	67	1165.00	-12.50	106	2455.00	-28.90
29	236.00	6.20	68	1181.00	-13.10	107	2485.00	-29.20
30	258.00	6.40	69	1199.00	-13.70	108	2519.00	-29.50
31	278.00	6.70	70	1218.00	-14.20	109	2555.00	-29.80
32	299.00	7.00	71	1244.00	-14.80	110	2595.00	-30.00
33	317.00	7.20	72	1274.00	-15.20	111	2641.00	-30.10
34	332.00	7.10	73	1305.00	-15.70	112	2689.00	-30.30
35	345.00	6.90	74	1323.00	-16.00	113	2731.00	-30.50
36	365.00	6.60	75	1344.00	-16.30	114	2780.00	-30.60
37	379.00	6.40	76	1366.00	-16.50	115	2830.00	-30.70
38	391.00	6.10	77	1404.00	-17.30			
39	406.00	4.90	78	1448.00	-17.90			

Local	Profile	Survey	Date	Time	Points	Units
AI	14	11	950927	1400	151	FT

Label = LINE375

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	-647.00	1.60	52	420.00	4.80	103	1655.00	-20.50
2	-624.00	1.70	53	420.00	4.80	104	1673.00	-20.50
3	-604.00	1.90	54	439.00	2.10	105	1694.00	-20.50
4	-579.00	1.90	55	450.00	.80	106	1715.00	-20.50
5	-556.00	2.00	56	496.00	-2.30	107	1733.00	-20.80
6	-531.00	2.00	57	507.00	-3.20	108	1754.00	-21.00
7	-507.00	2.10	58	516.00	-3.20	109	1776.00	-21.20
8	-483.00	2.10	59	544.00	-4.20	110	1798.00	-21.40
9	-461.00	2.10	60	545.00	-4.40	111	1824.00	-21.60
10	-435.00	2.20	61	567.00	-4.40	112	1851.00	-21.80
11	-411.00	2.40	62	590.00	-5.20	113	1867.00	-21.90
12	-387.00	2.40	63	607.00	-5.00	114	1886.00	-22.10
13	-366.00	2.40	64	632.00	-5.60	115	1906.00	-22.20
14	-342.00	2.40	65	654.00	-5.20	116	1941.00	-22.60
15	-321.00	2.50	66	674.00	-4.60	117	1961.00	-22.70
16	-296.00	2.50	67	723.00	-5.00	118	1984.00	-22.80
17	-274.00	2.50	68	765.00	-5.60	119	2007.00	-22.90
18	-249.00	2.80	69	788.00	-5.60	120	2053.00	-23.10
19	-225.00	3.10	70	813.00	-5.60	121	2072.00	-23.10
20	-200.00	3.20	71	840.00	-5.70	122	2093.00	-23.20
21	-177.00	3.40	72	878.00	-6.90	123	2115.00	-23.20
22	-149.00	3.30	73	922.00	-8.00	124	2133.00	-23.40
[illegible]	-123.00	3.10	74	967.00	-9.10	125	2153.00	-23.60
	-98.00	3.50	75	990.00	-9.90	126	2173.00	-23.70
25	-74.00	4.10	76	1017.00	-10.50	127	2195.00	-23.80
26	-56.00	5.60	77	1045.00	-11.20	128	2220.00	-23.80
27	-40.00	7.60	78	1067.00	-11.80	129	2246.00	-23.90
28	-26.00	8.30	79	1093.00	-12.20	130	2264.00	-24.00
29	-12.00	9.20	80	1119.00	-12.70	131	2285.00	-24.20
30	9.00	8.00	81	1140.00	-13.00	132	2306.00	-24.30
31	30.00	6.40	82	1164.00	-13.20	133	2325.00	-24.50
32	60.00	5.80	83	1188.00	-13.40	134	2346.00	-24.70
33	87.00	5.00	84	1232.00	-13.50	135	2368.00	-24.90
34	113.00	4.90	85	1255.00	-14.10	136	2386.00	-25.00
35	137.00	4.70	86	1282.00	-14.60	137	2407.00	-25.10
36	161.00	4.90	87	1310.00	-15.10	138	2428.00	-25.20
37	183.00	5.10	88	1355.00	-16.40	139	2448.00	-25.40
38	210.00	5.40	89	1375.00	-16.70	140	2471.00	-25.50
39	235.00	5.80	90	1398.00	-17.00	141	2494.00	-25.70
40	254.00	6.00	91	1422.00	-17.40	142	2541.00	-26.00
41	272.00	6.30	92	1442.00	-17.80	143	2561.00	-26.20
42	291.00	6.50	93	1466.00	-18.10	144	2583.00	-26.50
43	308.00	6.80	94	1490.00	-18.50	145	2606.00	-26.70
44	326.00	7.00	95	1505.00	-18.70	146	2627.00	-26.90
45	342.00	7.20	96	1523.00	-18.90	147	2652.00	-27.10
46	358.00	7.20	97	1541.00	-19.00	148	2677.00	-27.30
47	372.00	7.20	98	1559.00	-19.40	149	2698.00	-27.50
48	385.00	6.50	99	1581.00	-19.70	150	2723.00	-27.60
	397.00	5.60	100	1603.00	-20.00	151	2749.00	-27.70
50	416.00	3.70	101	1618.00	-20.20			
51	419.00	4.80	102	1636.00	-20.40			

Local	Profile	Survey	Date	Time	Points	Units
AI	15	11	950927	1200	146	FT

Label = LINE400

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	-572.00	1.60	50	482.00	6.90	99	1707.00	-19.20
2	-548.00	1.60	51	492.00	7.10	100	1733.00	-19.40
3	-527.00	1.60	52	505.00	7.30	101	1760.00	-19.70
4	-503.00	1.70	53	516.00	7.50	102	1781.00	-20.00
5	-482.00	1.80	54	529.00	7.50	103	1804.00	-20.30
6	-457.00	1.80	55	541.00	7.50	104	1829.00	-20.60
7	-434.00	1.80	56	554.00	7.00	105	1848.00	-20.90
8	-407.00	1.80	57	565.00	6.30	106	1870.00	-21.20
9	-383.00	1.70	58	579.00	5.80	107	1894.00	-21.50
10	-355.00	1.80	59	592.00	5.20	108	1913.00	-21.90
11	-331.00	1.90	60	604.00	5.10	109	1936.00	-22.20
12	-301.00	2.00	61	616.00	5.00	110	1960.00	-22.60
13	-274.00	2.10	62	616.00	5.00	111	1979.00	-22.80
14	-246.00	2.20	63	616.00	4.70	112	2001.00	-22.90
15	-220.00	2.30	64	635.00	2.80	113	2023.00	-23.10
16	-195.00	2.40	65	648.00	1.70	114	2052.00	-23.10
17	-173.00	2.60	66	660.00	.20	115	2085.00	-23.10
18	-146.00	2.60	67	675.00	-1.20	116	2119.00	-23.00
19	-123.00	2.60	68	707.00	-2.30	117	2157.00	-23.60
20	-97.00	2.60	69	757.00	-5.10	118	2201.00	-24.10
21	-74.00	2.70	70	782.00	-5.80	119	2246.00	-24.60
22	-50.00	2.80	71	812.00	-6.40	120	2265.00	-24.70
23	-28.00	2.90	72	843.00	-7.10	121	2288.00	-24.70
24	-2.00	3.00	73	878.00	-7.00	122	2312.00	-24.70
25	20.00	3.20	74	920.00	-7.70	123	2333.00	-25.00
26	46.00	3.20	75	959.00	-8.00	124	2356.00	-25.20
27	69.00	3.30	76	993.00	-7.80	125	2381.00	-25.40
28	93.00	3.40	77	1037.00	-5.60	126	2406.00	-25.40
29	114.00	3.50	78	1077.00	-6.30	127	2435.00	-25.40
30	139.00	3.50	79	1106.00	-7.80	128	2465.00	-25.40
31	161.00	3.60	80	1134.00	-8.70	129	2515.00	-25.80
32	186.00	3.60	81	1165.00	-9.50	130	2572.00	-26.10
33	209.00	3.70	82	1198.00	-10.20	131	2632.00	-26.50
34	234.00	3.80	83	1231.00	-10.50	132	2669.00	-27.10
35	256.00	3.90	84	1273.00	-11.30	133	2712.00	-27.60
36	281.00	4.20	85	1297.00	-12.10	134	2756.00	-28.10
37	304.00	4.50	86	1326.00	-12.70	135	2793.00	-28.20
38	326.00	4.70	87	1356.00	-13.40	136	2836.00	-28.30
39	346.00	5.00	88	1401.00	-13.80	137	2881.00	-28.50
40	366.00	5.10	89	1438.00	-14.60	138	2908.00	-28.50
41	383.00	5.40	90	1463.00	-15.10	139	2939.00	-28.50
42	395.00	5.50	91	1491.00	-15.60	140	2971.00	-28.60
43	406.00	5.80	92	1521.00	-16.10	141	2999.00	-28.50
44	417.00	5.90	93	1541.00	-16.40	142	3031.00	-28.40
45	427.00	6.00	94	1564.00	-16.70	143	3064.00	-28.40
46	438.00	6.20	95	1587.00	-16.90	144	3105.00	-28.60
47	448.00	6.40	96	1616.00	-17.70	145	3152.00	-28.80
48	460.00	6.60	97	1649.00	-18.30	146	3201.00	-29.00
49	470.00	6.70	98	1684.00	-18.90			

Local	Profile	Survey	Date	Time	Points	Units
AI	16	11	950927	1000	158	FT

Label = LINE425

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	-483.00	1.80	54	230.00	5.60	107	1295.00	-14.30
2	-483.00	1.80	55	245.00	5.80	108	1313.00	-14.70
3	-470.00	2.10	56	259.00	6.00	109	1334.00	-15.00
4	-458.00	2.40	57	274.00	6.10	110	1355.00	-15.30
5	-443.00	2.30	58	288.00	6.20	111	1389.00	-15.60
6	-429.00	2.10	59	304.00	6.40	112	1419.00	-16.20
7	-415.00	2.10	60	318.00	6.70	113	1438.00	-16.50
8	-402.00	2.20	61	332.00	6.80	114	1459.00	-16.70
9	-387.00	2.10	62	345.00	7.10	115	1482.00	-17.00
10	-374.00	2.10	63	360.00	7.30	116	1498.00	-17.30
11	-359.00	2.20	64	373.00	7.50	117	1518.00	-17.50
12	-346.00	2.20	65	386.00	7.70	118	1537.00	-17.80
13	-331.00	2.30	66	396.00	7.80	119	1559.00	-18.10
14	-317.00	2.30	67	409.00	7.80	120	1583.00	-18.30
15	-303.00	2.30	68	420.00	7.80	121	1609.00	-18.60
16	-290.00	2.40	69	431.00	7.50	122	1648.00	-19.30
17	-275.00	2.50	70	442.00	7.00	123	1700.00	-20.10
18	-262.00	2.60	71	461.00	6.20	124	1761.00	-20.70
19	-248.00	2.60	72	481.00	4.40	125	1824.00	-21.30
20	-235.00	2.70	73	481.00	4.80	126	1843.00	-21.70
21	-222.00	3.10	74	481.00	4.40	127	1864.00	-21.90
22	-209.00	3.70	75	500.00	3.10	128	1885.00	-22.20
[illegible]	-195.00	3.70	76	511.00	2.40	129	1906.00	-22.40
[illegible]	-181.00	3.60	77	521.00	1.40	130	1930.00	-22.50
25	-166.00	3.40	78	561.00	-.70	131	1955.00	-22.70
26	-152.00	3.10	79	576.00	-1.60	132	2003.00	-23.10
27	-138.00	3.30	80	594.00	-2.30	133	2019.00	-23.30
28	-125.00	3.70	81	612.00	-3.10	134	2037.00	-23.40
29	-109.00	3.70	82	637.00	-5.00	135	2056.00	-23.60
30	-95.00	3.60	83	673.00	-5.10	136	2077.00	-23.70
31	-81.00	4.00	84	715.00	-5.20	137	2103.00	-23.80
32	-68.00	4.50	85	731.00	-6.50	138	2129.00	-23.90
33	-54.00	4.70	86	749.00	-7.70	139	2150.00	-24.00
34	-42.00	5.10	87	768.00	-8.90	140	2174.00	-24.10
35	-28.00	5.10	88	785.00	-9.00	141	2200.00	-24.20
36	-16.00	5.20	89	804.00	-9.10	142	2217.00	-24.20
37	-2.00	5.40	90	824.00	-9.20	143	2238.00	-24.10
38	10.00	5.70	91	862.00	-5.80	144	2259.00	-24.10
39	24.00	5.70	92	907.00	-4.90	145	2277.00	-24.30
40	38.00	5.70	93	935.00	-5.90	146	2298.00	-24.50
41	50.00	5.70	94	966.00	-6.80	147	2321.00	-24.70
42	61.00	5.60	95	999.00	-7.60	148	2363.00	-24.70
43	76.00	5.50	96	1049.00	-9.20	149	2389.00	-24.90
44	89.00	5.20	97	1076.00	-10.00	150	2419.00	-25.00
45	104.00	5.20	98	1105.00	-10.50	151	2449.00	-25.20
46	118.00	5.10	99	1121.00	-11.00	152	2465.00	-25.30
47	132.00	5.10	100	1139.00	-11.40	153	2483.00	-25.50
48	146.00	5.10	101	1159.00	-11.80	154	2502.00	-25.60
[illegible]	160.00	5.10	102	1180.00	-12.10	155	2523.00	-26.10
[illegible]	173.00	5.20	103	1205.00	-12.30	156	2546.00	-26.50
51	188.00	5.30	104	1231.00	-12.60	157	2571.00	-26.90
52	201.00	5.40	105	1250.00	-13.20	158	2611.00	-27.40
53	216.00	5.50	106	1272.00	-13.80			

Local	Profile	Survey	Date	Time	Points	Units
AI	17	11	950927	800	123	FT

Label = LINE450

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	-312.00	4.50	42	229.00	4.70	83	1362.00	-19.00
2	-300.00	4.50	43	230.00	4.40	84	1407.00	-19.90
3	-289.00	4.50	44	243.00	3.30	85	1430.00	-20.10
4	-276.00	4.80	45	256.00	2.00	86	1457.00	-20.20
5	-263.00	5.20	46	269.00	1.50	87	1484.00	-20.40
6	-2[illegible].00	5.60	47	281.00	.80	88	1518.00	-20.90
7	-239.00	6.20	48	296.00	.10	89	1558.00	-21.40
8	-224.00	6.30	49	314.00	-.40	90	1598.00	-21.80
9	-211.00	6.40	50	333.00	-1.00	91	1623.00	-22.10
10	-196.00	6.30	51	376.00	-5.40	92	1652.00	-22.40
11	-182.00	6.20	52	407.00	-6.70	93	1682.00	-22.60
12	-168.00	6.90	53	447.00	-8.30	94	1706.00	-22.60
13	-155.00	7.70	54	470.00	-8.60	95	1734.00	-22.70
14	-142.00	8.10	55	497.00	-9.00	96	1762.00	-22.70
15	-129.00	8.60	56	516.00	-9.00	97	1795.00	-22.90
16	-115.00	8.60	57	537.00	-9.00	98	1833.00	-23.20
17	-101.00	8.60	58	559.00	-9.10	99	1872.00	-23.40
18	-86.00	7.60	59	608.00	-8.70	100	1890.00	-23.50
19	-72.00	6.20	60	650.00	-7.10	101	1912.00	-23.50
20	-58.00	6.30	61	693.00	-6.90	102	1934.00	-23.60
21	-46.00	6.50	62	723.00	-8.10	103	1955.00	-23.70
22	-33.00	6.50	63	743.00	-8.30	104	1980.00	-23.80
23	-21.00	6.50	64	764.00	-8.80	105	2006.00	-24.00
24	-9.00	6.60	65	800.00	-9.40	106	2036.00	-24.10
25	1.00	6.70	66	830.00	-10.10	107	2070.00	-24.20
26	13.00	6.80	67	867.00	-11.10	108	2105.00	-24.30
27	23.00	6.90	68	881.00	-11.70	109	2130.00	-24.40
28	38.00	6.90	69	925.00	-12.30	110	2160.00	-24.50
29	57.00	7.10	70	948.00	-12.70	111	2191.00	-24.70
30	76.00	7.20	71	974.00	-13.10	112	2210.00	-24.70
31	96.00	7.40	72	1002.00	-13.60	113	2232.00	-24.80
32	115.00	7.70	73	1028.00	-14.10	114	2255.00	-24.90
33	125.00	7.80	74	1059.00	-14.60	115	2288.00	-25.10
34	135.00	8.00	75	1091.00	-15.10	116	2327.00	-25.40
35	146.00	8.10	76	1112.00	-15.60	117	2366.00	-25.70
36	156.00	8.10	77	1136.00	-16.10	118	2392.00	-25.80
37	176.00	8.40	78	1160.00	-16.50	119	2423.00	-26.00
38	179.00	8.50	79	1196.00	-16.70	120	2454.00	-26.10
39	194.00	8.00	80	1237.00	-16.80	121	2487.00	-26.40
40	206.00	6.50	81	1280.00	-17.00	122	2524.00	-26.70
41	211.00	6.20	82	1318.00	-18.10	123	2563.00	-26.90

Local	Profile	Survey	Date	Time	Points	Units
AI	18	11	950927	600	160	FT

Label = LINE475

ax	Y	Z	Index	Y	Z	Index	Y	Z
1	-494.00	2.10	55	275.00	7.60	109	1445.00	-17.50
2	-479.00	2.10	56	286.00	7.60	110	1484.00	-17.90
3	-465.00	2.10	57	298.00	7.60	111	1500.00	-18.20
4	-450.00	2.20	58	308.00	7.70	112	1518.00	-18.40
5	-436.00	2.30	59	321.00	7.60	113	1537.00	-18.60
6	-421.00	2.30	60	331.00	7.40	114	1555.00	-18.80
7	-406.00	2.30	61	348.00	5.50	115	1575.00	-19.00
8	-391.00	2.40	62	348.00	6.00	116	1596.00	-19.20
9	-378.00	2.50	63	348.00	6.10	117	1643.00	-19.80
10	-360.00	2.60	64	348.00	6.10	118	1662.00	-20.10
11	-344.00	2.70	65	367.00	3.80	119	1684.00	-20.30
12	-328.00	2.80	66	380.00	3.00	120	1707.00	-20.60
13	-314.00	3.00	67	391.00	2.00	121	1743.00	-20.90
14	-298.00	3.70	68	406.00	1.30	122	1784.00	-21.30
15	-284.00	4.70	69	419.00	.50	123	1801.00	-21.50
16	-270.00	4.40	70	436.00	-.80	124	1820.00	-21.70
17	-256.00	4.00	71	456.00	-2.00	125	1840.00	-21.90
18	-241.00	4.10	72	476.00	-3.30	126	1880.00	-22.20
19	-227.00	4.30	73	483.00	-3.40	127	1900.00	-22.40
20	-220.00	4.20	74	515.00	-5.20	128	1923.00	-22.60
21	-206.00	4.30	75	528.00	-4.90	129	1946.00	-22.80
22	-193.00	4.30	76	556.00	-4.60	130	1967.00	-22.90
3	-176.00	4.50	77	596.00	-3.60	131	1990.00	-23.00
	-160.00	4.70	78	616.00	-3.40	132	2015.00	-23.20
25	-146.00	4.70	79	657.00	-4.00	133	2033.00	-23.40
26	-132.00	4.50	80	675.00	-4.40	134	2055.00	-23.70
27	-116.00	4.60	81	695.00	-4.80	135	2077.00	-23.90
28	-101.00	4.70	82	716.00	-5.10	136	2127.00	-24.10
29	-85.00	4.80	83	747.00	-5.60	137	2145.00	-24.30
30	-71.00	4.90	84	779.00	-6.30	138	2166.00	-24.50
31	-55.00	5.10	85	816.00	-7.00	139	2188.00	-24.70
32	-41.00	5.40	86	854.00	-7.70	140	2212.00	-24.90
33	-27.00	6.20	87	900.00	-8.60	141	2240.00	-25.00
34	-15.00	7.10	88	949.00	-9.30	142	2268.00	-25.20
35	.00	6.40	89	970.00	-9.90	143	2289.00	-25.30
36	15.00	5.40	90	994.00	-10.40	144	2313.00	-25.50
37	32.00	5.90	91	1020.00	-10.80	145	2338.00	-25.60
38	46.00	6.40	92	1036.00	-11.20	146	2381.00	-26.20
39	62.00	6.90	93	1055.00	-11.40	147	2425.00	-26.30
40	75.00	7.50	94	1074.00	-11.70	148	2443.00	-26.50
41	90.00	7.70	95	1090.00	-12.10	149	2465.00	-26.70
42	104.00	8.00	96	1107.00	-12.40	150	2488.00	-27.00
43	117.00	7.70	97	1126.00	-12.70	151	2503.00	-27.00
44	128.00	7.30	98	1168.00	-13.40	152	2520.00	-27.00
45	142.00	7.50	99	1215.00	-14.30	153	2539.00	-27.10
46	155.00	7.70	100	1237.00	-14.60	154	2556.00	-27.20
47	169.00	7.60	101	1263.00	-14.90	155	2576.00	-27.40
48	182.00	7.50	102	1290.00	-15.10	156	2596.00	-27.50
	200.00	8.00	103	1306.00	-15.40	157	2643.00	-27.60
	220.00	7.20	104	1325.00	-15.70	158	2660.00	-27.70
51	232.00	7.30	105	1344.00	-16.00	159	2680.00	-27.80
52	242.00	7.40	106	1362.00	-16.30	160	2701.00	-27.90
53	253.00	7.50	107	1382.00	-16.50			

54	264.00	7.60	108	1404.00	-16.80

Local	Profile	Survey	Date	Time	Points	Units
AI	19	11	950926	1800	124	FT

Label = LINE500

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	.00	6.40	43	503.00	.50	85	1535.00	-19.00
2	12.00	7.10	44	518.00	.00	86	1551.00	-19.20
3	22.00	8.00	45	562.00	-1.90	87	1569.00	-19.40
4	34.00	8.30	46	601.00	-4.50	88	1588.00	-19.70
5	45.00	8.70	47	632.00	-6.30	89	1611.00	-20.00
6	56.00	7.80	48	648.00	-7.00	90	1638.00	-20.30
7	67.00	6.80	49	666.00	-7.60	91	1665.00	-20.70
8	79.00	6.60	50	685.00	-8.20	92	1682.00	-20.90
9	89.00	6.40	51	704.00	-6.70	93	1702.00	-21.20
10	102.00	6.20	52	726.00	-5.40	94	1723.00	-21.40
11	113.00	6.00	53	749.00	-4.10	95	1743.00	-21.70
12	125.00	6.20	54	767.00	-4.20	96	1767.00	-22.00
13	136.00	6.50	55	788.00	-4.30	97	1791.00	-22.30
14	148.00	7.20	56	810.00	-4.40	98	1814.00	-22.60
15	159.00	7.90	57	828.00	-5.10	99	1840.00	-22.80
16	172.00	7.90	58	848.00	-5.70	100	1866.00	-23.10
17	183.00	7.90	59	870.00	-6.40	101	1883.00	-23.40
18	196.00	8.00	60	885.00	-7.00	102	1903.00	-23.60
19	207.00	8.30	61	902.00	-7.60	103	1924.00	-23.80
20	218.00	8.40	62	920.00	-8.20	104	1944.00	-24.10
21	228.00	8.60	63	941.00	-8.50	105	1967.00	-24.30
22	240.00	8.40	64	977.00	-8.40	106	1990.00	-24.50
23	251.00	8.30	65	1025.00	-9.30	107	2009.00	-24.70
	262.00	7.90	66	1042.00	-9.80	108	2032.00	-24.80
25	273.00	7.50	67	1061.00	-10.30	109	2055.00	-25.00
26	284.00	7.40	68	1082.00	-10.80	110	2076.00	-25.10
27	295.00	7.30	69	1121.00	-11.70	111	2101.00	-25.20
28	314.00	7.40	70	1142.00	-12.30	112	2127.00	-25.40
29	328.00	7.50	71	1167.00	-12.90	113	2153.00	-25.60
30	340.00	7.70	72	1193.00	-13.40	114	2184.00	-25.80
31	351.00	7.70	73	1221.00	-13.80	115	2217.00	-26.00
32	361.00	7.80	74	1235.00	-14.10	116	2234.00	-26.10
33	373.00	7.60	75	1256.00	-14.60	117	2255.00	-26.20
34	384.00	7.30	76	1281.00	-15.00	118	2276.00	-26.30
35	397.00	6.50	77	1307.00	-15.50	119	2295.00	-26.40
36	408.00	5.40	78	1357.00	-16.20	120	2316.00	-26.50
37	419.00	4.50	79	1380.00	-16.70	121	2339.00	-26.60
38	429.00	3.40	80	1407.00	-17.10	122	2380.00	-26.90
39	442.00	2.60	81	1435.00	-17.60	123	2428.00	-27.10
40	455.00	1.60	82	1450.00	-17.90	124	2478.00	-27.30
41	471.00	1.30	83	1468.00	-18.20			
42	486.00	.90	84	1487.00	-18.40			

Local	Profile	Survey	Date	Time	Points	Units
AI	20	11	950926	1600	116	FT

Label = LINE525

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	-285.00	5.80	40	230.00	7.90	79	1102.00	-13.50
2	-270.00	6.10	41	243.00	7.80	80	1129.00	-13.80
3	-255.00	6.30	42	259.00	7.80	81	1148.00	-14.30
4	-242.00	6.50	43	273.00	7.90	82	1170.00	-14.70
5	-229.00	6.70	44	291.00	7.30	83	1193.00	-15.10
6	-217.00	7.00	45	307.00	6.60	84	1242.00	-16.10
7	-201.00	6.70	46	308.00	6.60	85	1257.00	-16.40
8	-187.00	6.30	47	319.00	5.60	86	1275.00	-16.60
9	-172.00	6.50	48	329.00	4.40	87	1294.00	-16.80
10	-158.00	6.80	49	340.00	3.50	88	1313.00	-17.30
11	-144.00	6.90	50	350.00	2.30	89	1335.00	-17.80
12	-131.00	7.10	51	352.00	2.40	90	1357.00	-18.20
13	-117.00	7.50	52	355.00	2.10	91	1406.00	-19.20
14	-104.00	8.10	53	373.00	1.80	92	1425.00	-19.70
15	-90.00	8.10	54	390.00	1.30	93	1446.00	-20.10
16	-78.00	8.10	55	406.00	.80	94	1469.00	-20.50
17	-65.00	8.40	56	447.00	-1.80	95	1511.00	-21.20
18	-53.00	8.70	57	462.00	-3.00	96	1526.00	-21.40
19	-40.00	8.30	58	480.00	-4.00	97	1544.00	-21.60
20	-29.00	7.80	59	499.00	-5.00	98	1563.00	-21.70
21	-18.00	8.10	60	528.00	-6.80	99	1587.00	-22.40
22	-8.00	8.50	61	557.00	-7.20	100	1615.00	-23.00
23	6.00	8.10	62	593.00	-7.80	101	1643.00	-23.50
24	20.00	7.70	63	607.00	-7.10	102	1689.00	-23.70
25	34.00	7.70	64	626.00	-6.60	103	1730.00	-24.20
26	47.00	7.80	65	649.00	-6.10	104	1748.00	-24.20
27	62.00	7.70	66	672.00	-5.70	105	1768.00	-24.30
28	76.00	7.60	67	702.00	-5.90	106	1790.00	-24.30
29	91.00	7.80	68	728.00	-5.60	107	1831.00	-24.80
30	106.00	7.90	69	768.00	-4.40	108	1874.00	-25.00
31	120.00	8.50	70	816.00	-6.90	109	1892.00	-25.40
32	133.00	9.30	71	857.00	-9.00	110	1913.00	-25.70
33	148.00	10.40	72	890.00	-10.40	111	1934.00	-26.00
34	161.00	11.80	73	939.00	-10.70	112	1973.00	-26.20
35	161.00	11.80	74	978.00	-11.10	113	2014.00	-26.20
36	175.00	10.50	75	1000.00	-11.70	114	2030.00	-26.20
37	188.00	8.80	76	1027.00	-12.30	115	2049.00	-26.30
38	203.00	8.40	77	1054.00	-12.80	116	2068.00	-26.30
39	216.00	7.90	78	1076.00	-13.20			

Local	Profile	Survey	Date	Time	Points	Units
AI	21	11	950926	1400	119	FT

Label = LINE550

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	.00	7.20	41	599.00	6.30	81	1573.00	-17.20
2	16.00	6.50	42	616.00	4.70	82	1592.00	-17.60
3	30.00	5.50	43	630.00	3.70	83	1612.00	-17.90
4	44.00	5.10	44	642.00	2.40	84	1657.00	-18.60
5	56.00	4.70	45	656.00	1.90	85	1675.00	-18.90
6	72.00	4.60	46	669.00	1.20	86	1696.00	-19.20
7	86.00	4.50	47	682.00	.90	87	1718.00	-19.50
8	105.00	4.50	48	693.00	.40	88	1737.00	-19.80
9	122.00	4.60	49	720.00	-1.60	89	1760.00	-20.00
10	139.00	4.80	50	752.00	-3.40	90	1783.00	-20.30
11	154.00	5.00	51	784.00	-5.30	91	1798.00	-20.50
12	170.00	4.80	52	822.00	-7.10	92	1816.00	-20.80
13	184.00	4.50	53	848.00	-8.00	93	1835.00	-21.00
14	202.00	4.60	54	882.00	-8.30	94	1854.00	-21.30
15	218.00	4.70	55	926.00	-8.10	95	1877.00	-21.70
16	237.00	4.80	56	958.00	-7.70	96	1900.00	-22.00
17	254.00	5.00	57	973.00	-6.60	97	1921.00	-22.30
18	269.00	5.10	58	991.00	-5.80	98	1945.00	-22.60
19	283.00	5.30	59	1009.00	-4.90	99	1970.00	-22.90
20	297.00	5.80	60	1056.00	-5.10	100	1991.00	-23.20
21	310.00	6.60	61	1086.00	-6.10	101	2015.00	-23.50
22	329.00	9.50	62	1116.00	-7.00	102	2039.00	-23.80
[illegible]	347.00	13.10	63	1143.00	-7.80	103	2058.00	-24.10
[illegible]	363.00	10.40	64	1157.00	-8.20	104	2080.00	-24.30
25	377.00	7.00	65	1198.00	-9.20	105	2103.00	-24.60
26	394.00	6.30	66	1244.00	-10.40	106	2129.00	-25.00
27	409.00	5.50	67	1260.00	-10.80	107	2159.00	-25.30
28	424.00	5.40	68	1278.00	-11.20	108	2191.00	-25.60
29	437.00	5.30	69	1297.00	-11.50	109	2210.00	-25.80
30	452.00	5.90	70	1316.00	-12.00	110	2232.00	-26.10
31	465.00	6.60	71	1339.00	-12.40	111	2255.00	-26.30
32	479.00	8.30	72	1362.00	-12.90	112	2278.00	-26.70
33	492.00	10.50	73	1408.00	-13.80	113	2305.00	-27.00
34	506.00	14.30	74	1440.00	-14.60	114	2332.00	-27.30
35	518.00	19.10	75	1459.00	-15.00	115	2376.00	-27.70
36	535.00	14.00	76	1480.00	-15.40	116	2422.00	-27.90
37	554.00	9.60	77	1502.00	-15.80	117	2452.00	-28.20
38	565.00	8.70	78	1518.00	-16.20	118	2487.00	-28.40
39	576.00	7.60	79	1537.00	-16.50	119	2523.00	-28.60
40	588.00	7.00	80	1557.00	-16.90			

Local	Profile	Survey	Date	Time	Points	Units
AI	22	11	950926	1200	82	FT

Label = LINE575

Index	Y	Z	Index	Y	Z	Index	Y	Z
1	.00	16.40	29	351.00	.10	57	1053.00	-14.90
2	2.00	15.60	30	375.00	-.50	58	1074.00	-15.50
3	19.00	7.60	31	381.00	-.10	59	1098.00	-16.10
4	38.00	5.70	32	408.00	-2.20	60	1124.00	-16.70
5	58.00	4.60	33	438.00	-4.00	61	1157.00	-17.30
6	68.00	4.80	34	470.00	-5.80	62	1193.00	-18.50
7	78.00	5.00	35	505.00	-7.20	63	1231.00	-19.30
8	96.00	6.30	36	550.00	-7.90	64	1268.00	-20.20
9	114.00	7.80	37	573.00	-9.30	65	1299.00	-21.00
10	133.00	7.40	38	600.00	-9.30	66	1336.00	-21.90
11	143.00	8.40	39	644.00	-9.00	67	1356.00	-22.30
12	153.00	9.60	40	671.00	-8.80	68	1380.00	-22.70
13	168.00	12.00	41	704.00	-6.70	69	1404.00	-23.10
14	174.00	15.90	42	720.00	-6.60	70	1450.00	-24.00
15	185.00	16.80	43	738.00	-6.60	71	1485.00	-24.50
16	203.00	12.90	44	756.00	-6.50	72	1500.00	-24.70
17	221.00	9.20	45	787.00	-7.40	73	1518.00	-24.90
18	232.00	8.50	46	803.00	-8.00	74	1536.00	-25.00
19	241.00	7.60	47	820.00	-8.40	75	1574.00	-25.50
20	252.00	7.10	48	838.00	-8.90	76	1612.00	-26.00
21	262.00	6.40	49	855.00	-9.50	77	1656.00	-26.40
22	278.00	5.00	50	874.00	-9.90	78	1698.00	-27.10
23	278.00	5.00	51	894.00	-10.40	79	1713.00	-27.20
24	289.00	4.20	52	928.00	-11.30	80	1730.00	-27.30
25	299.00	3.30	53	963.00	-12.30	81	1748.00	-27.50
26	313.00	2.50	54	997.00	-13.30	82	1788.00	-27.90
27	326.00	1.40	55	1014.00	-13.90			
28	339.00	.80	56	1033.00	-14.40			

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3	530.00	11.00	33	998.00	-4.50	63	1788.00	-18.30
4	548.00	8.30	34	1014.00	-5.80	64	1811.00	-18.70
5	566.00	6.60	35	1044.00	-7.20	65	1826.00	-19.20
6	584.00	6.50	36	1066.00	-7.70	66	1844.00	-19.50
7	602.00	6.80	37	1091.00	-8.10	67	1862.00	-19.90
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9	638.00	6.80	39	1162.00	-8.20	69	1922.00	-21.20
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14	710.00	14.10	44	1373.00	-8.10	74	2045.00	-23.40
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16	736.00	11.70	46	1380.00	-8.30	76	2117.00	-23.80
17	747.00	10.40	47	1389.00	-8.60	77	2146.00	-24.10
18	758.00	8.70	48	1410.00	-9.20	78	2190.00	-24.60
19	770.00	8.20	49	1437.00	-9.80	79	2235.00	-25.10
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	830.00	5.10	54	1562.00	-13.40	84	2370.00	-26.30
25	843.00	4.20	55	1594.00	-13.90	85	2389.00	-26.40
26	854.00	2.90	56	1606.00	-14.30	86	2408.00	-26.50
27	868.00	2.30	57	1653.00	-15.00	87	2454.00	-27.10
28	880.00	1.40	58	1686.00	-15.90	88	2501.00	-27.60
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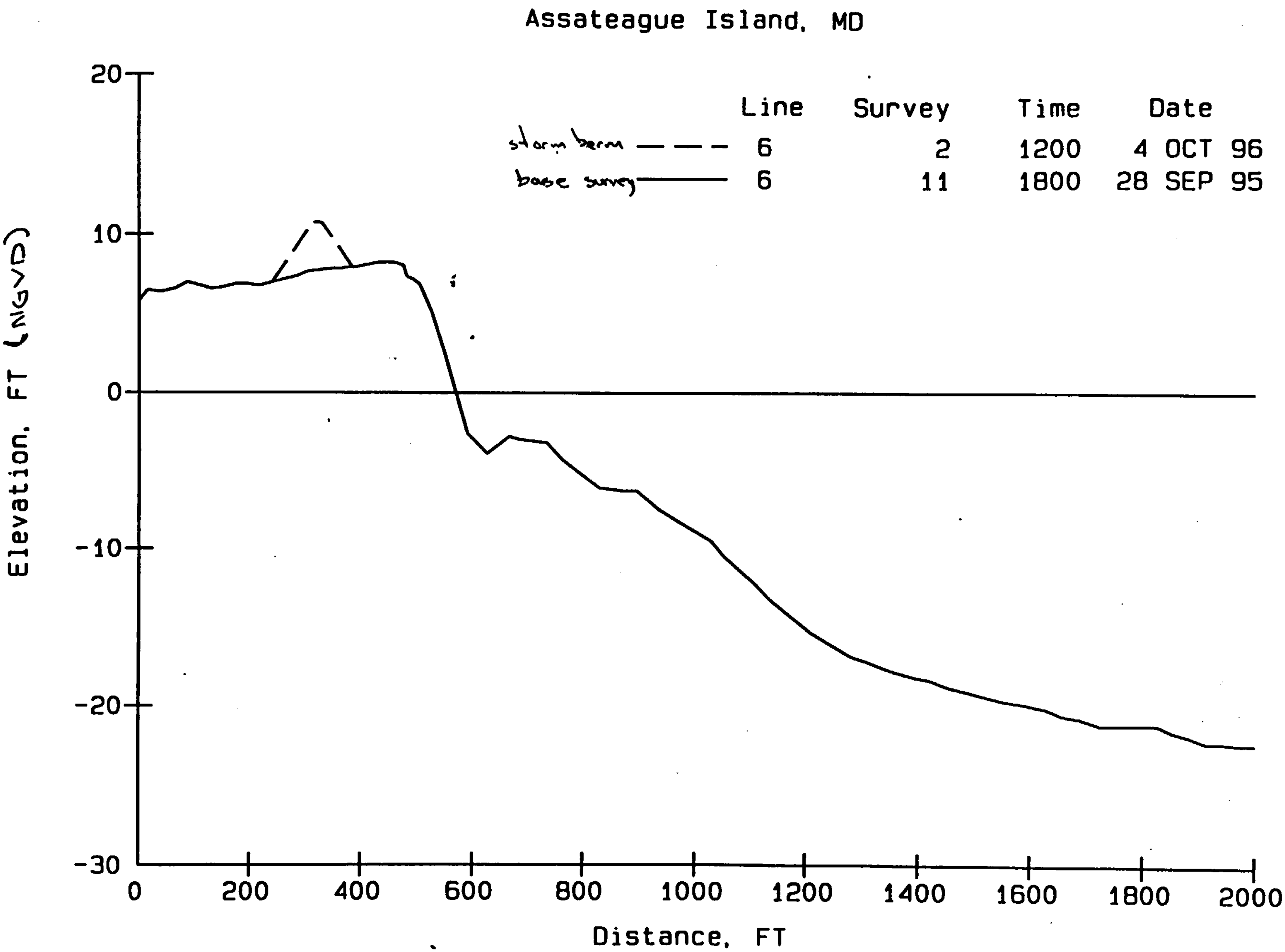
SECTION 5

PROFILE PLOTS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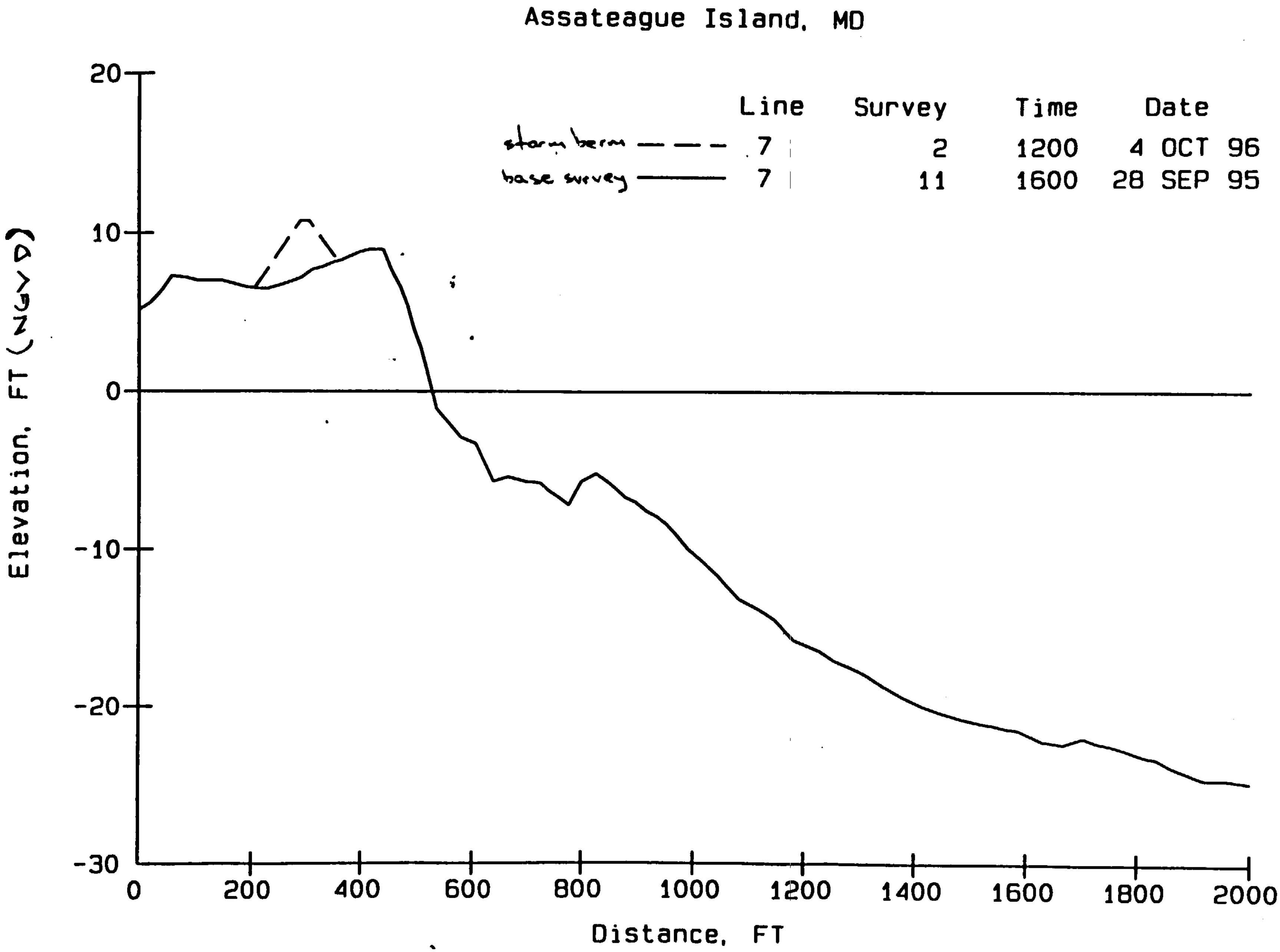

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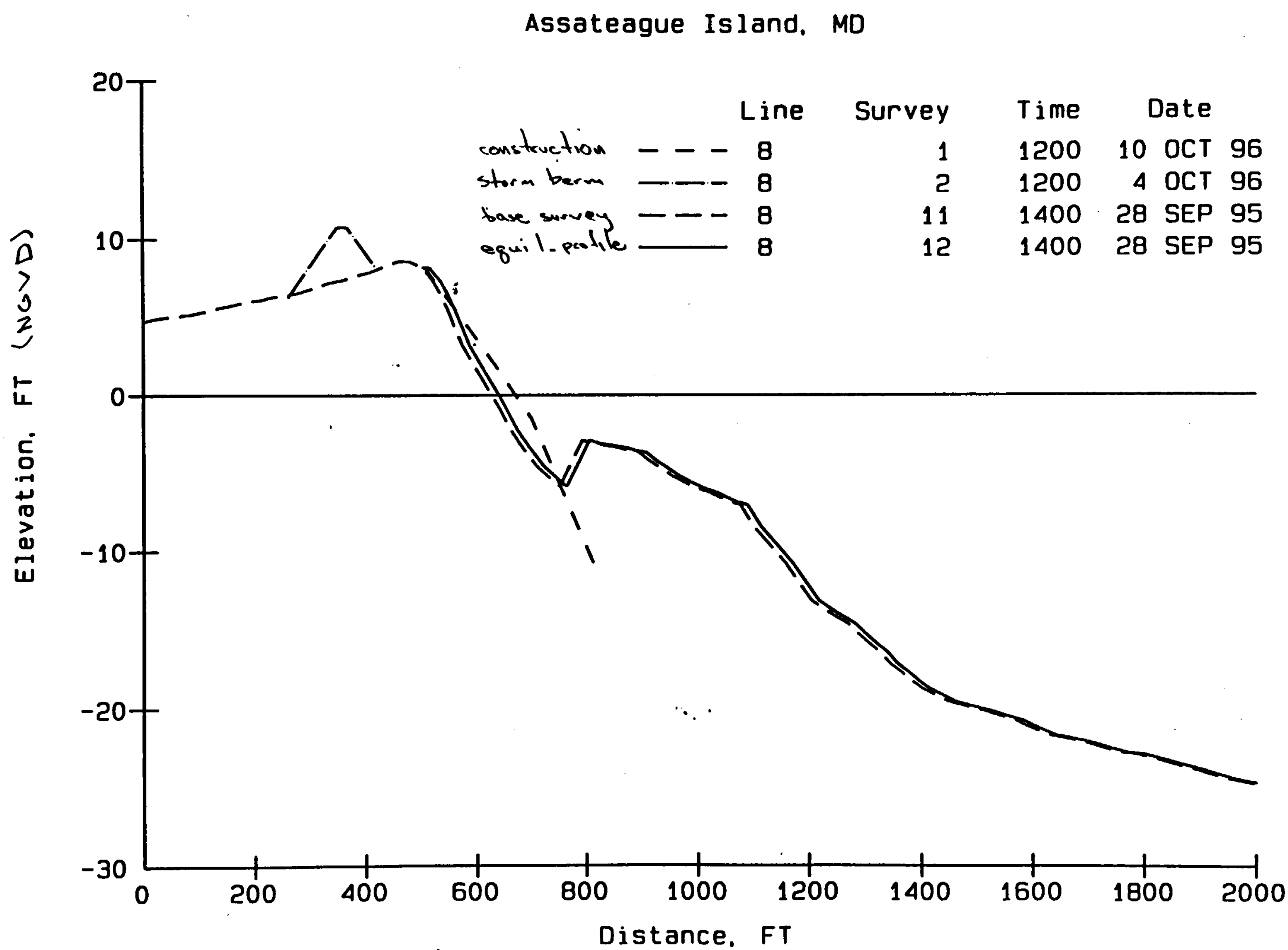

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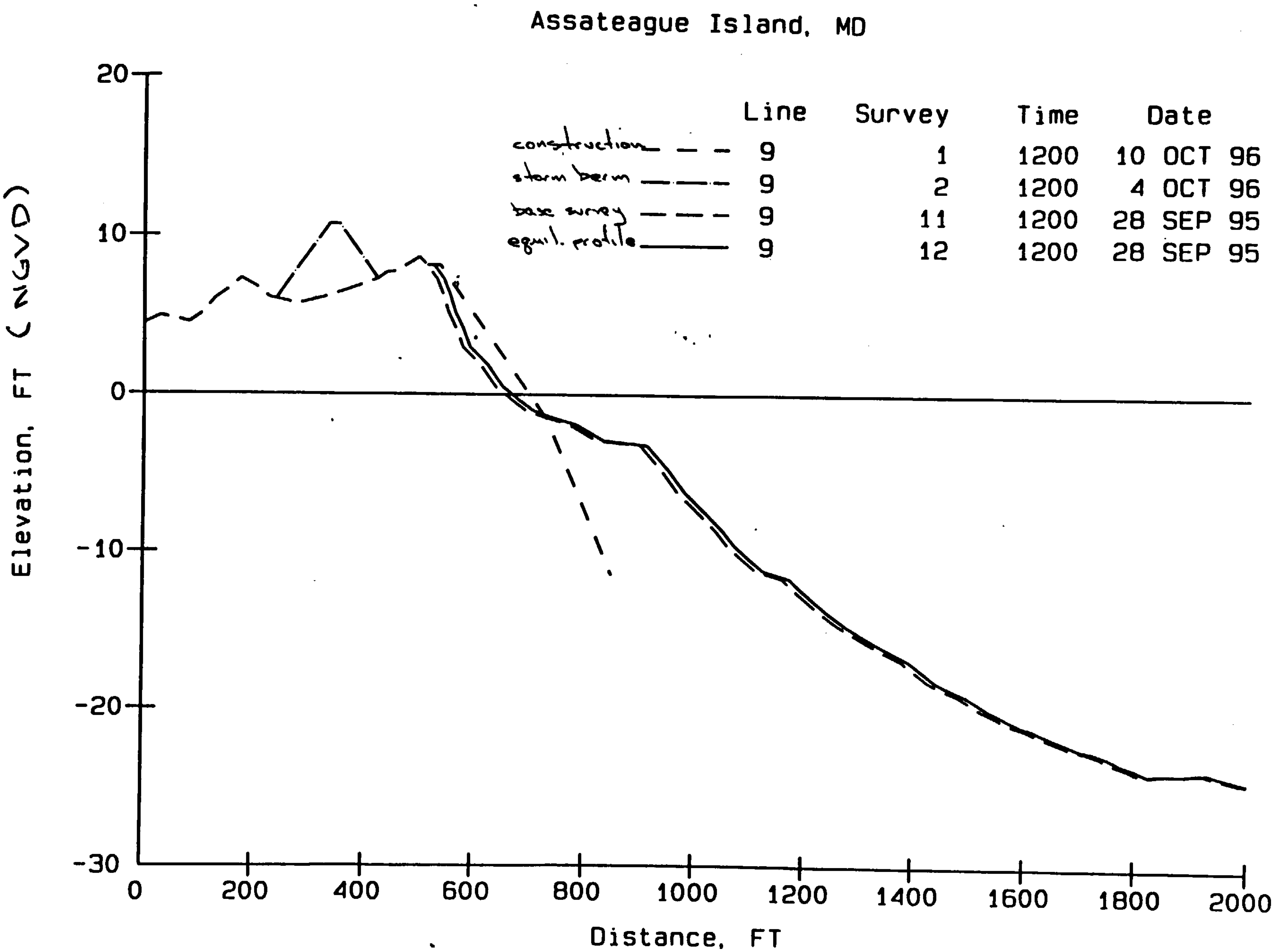

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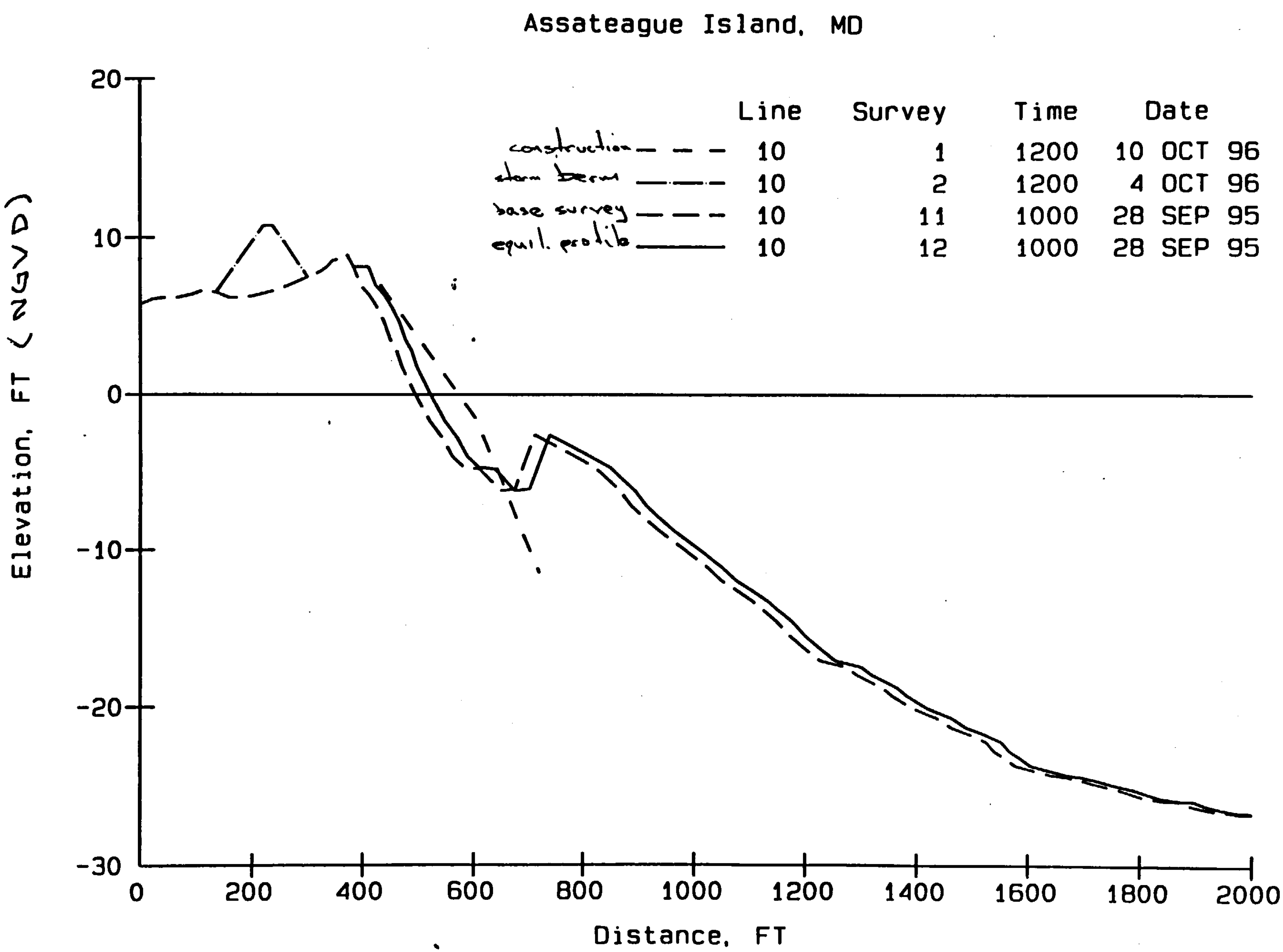
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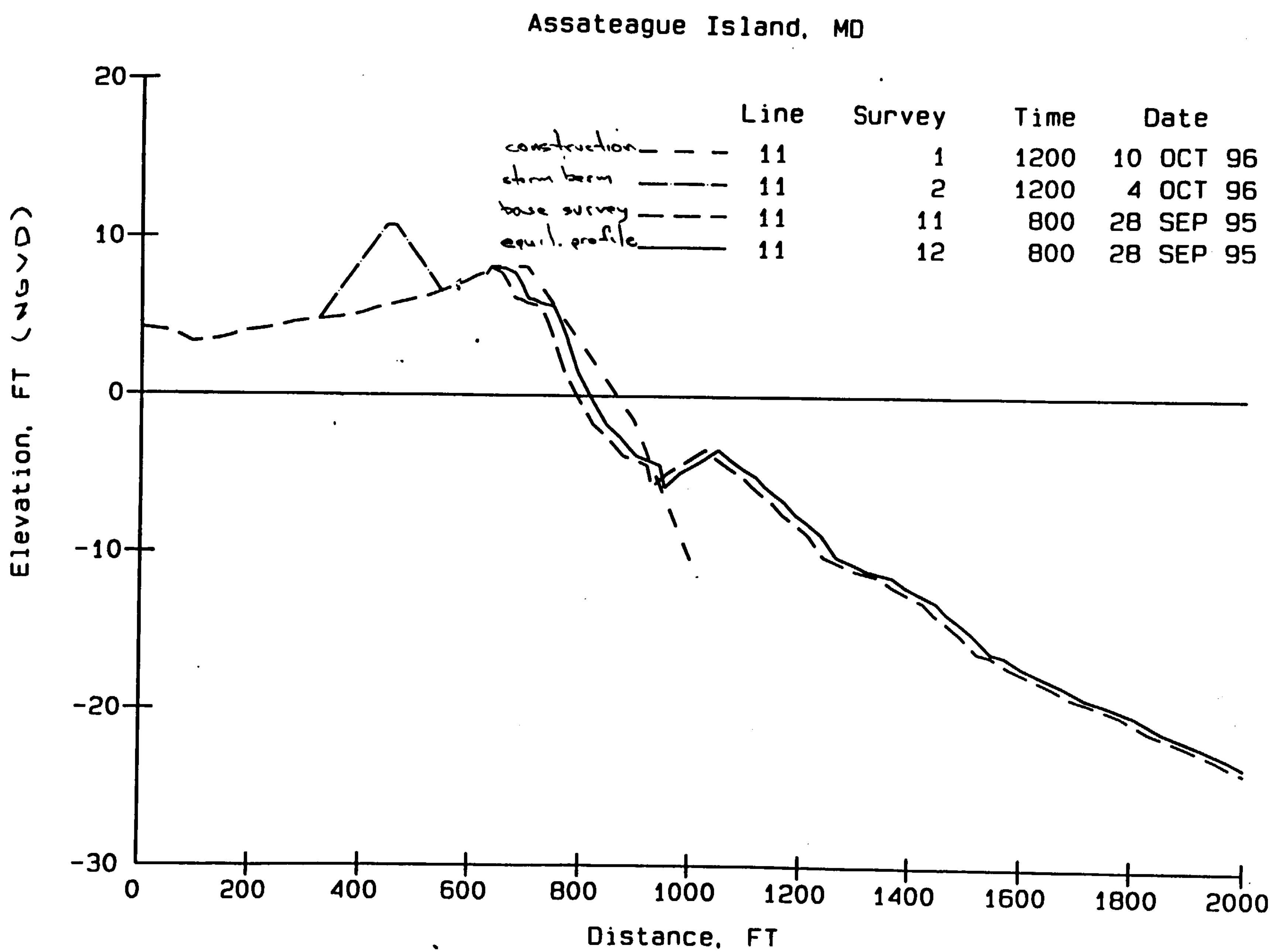

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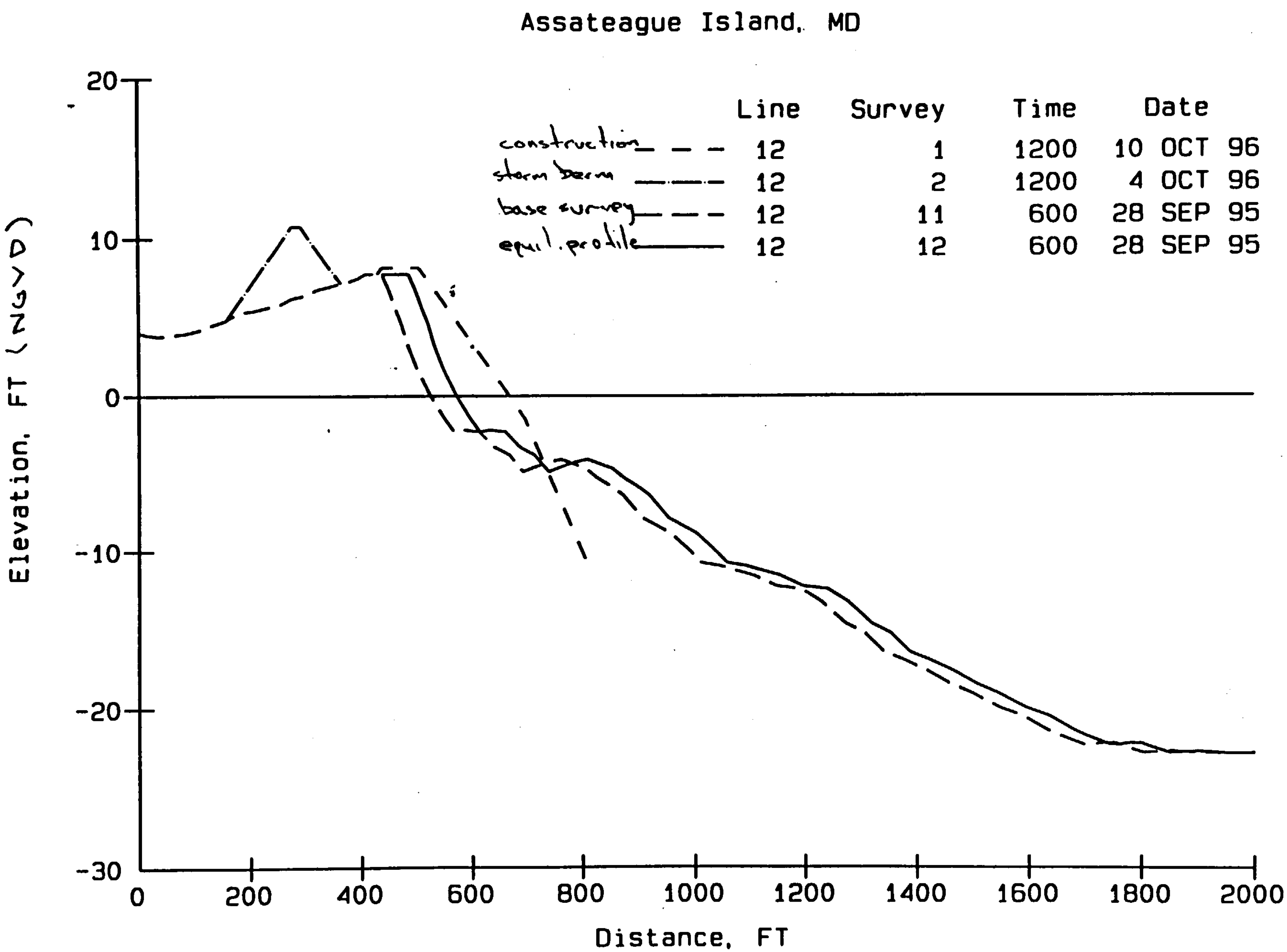

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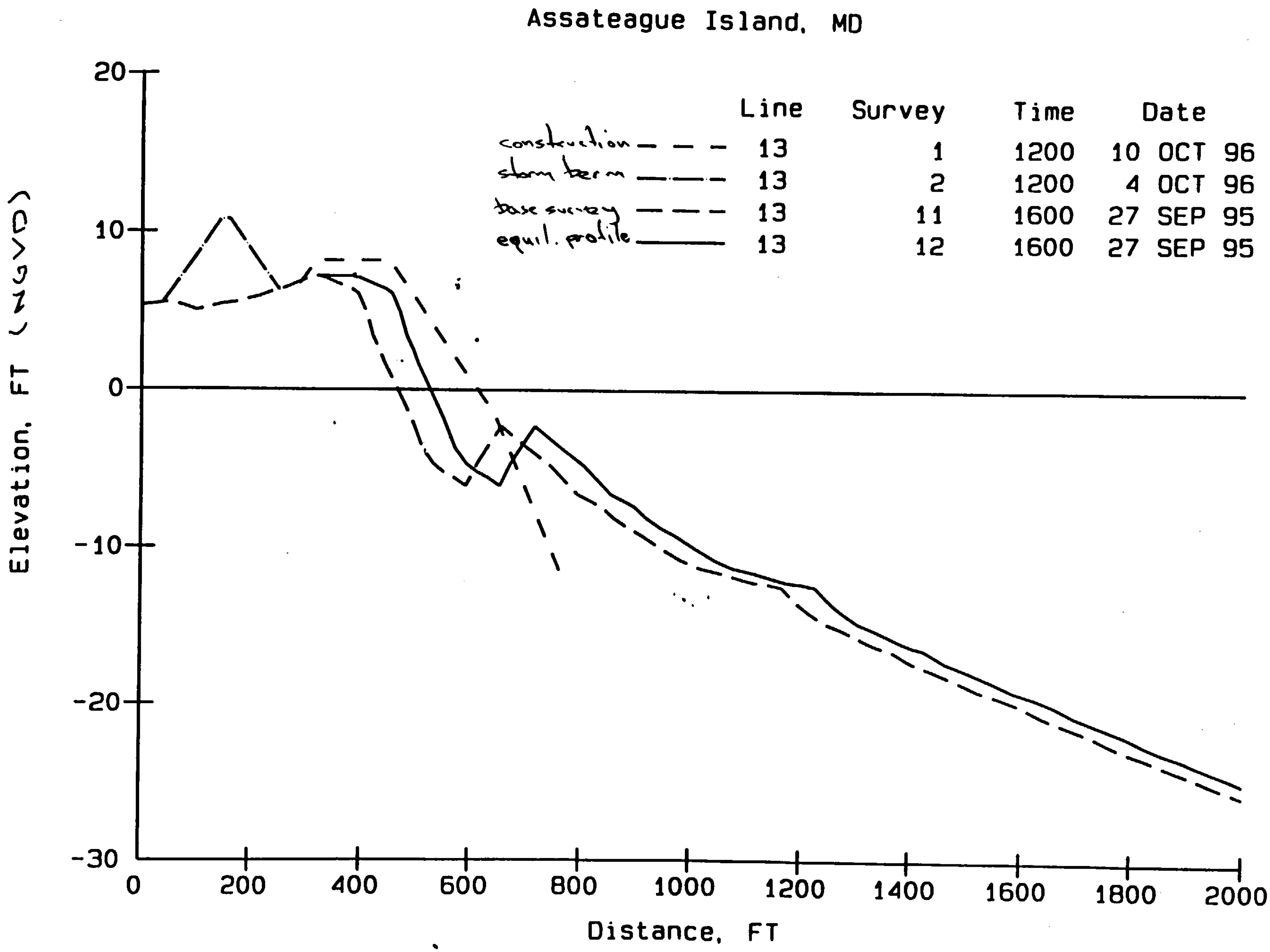
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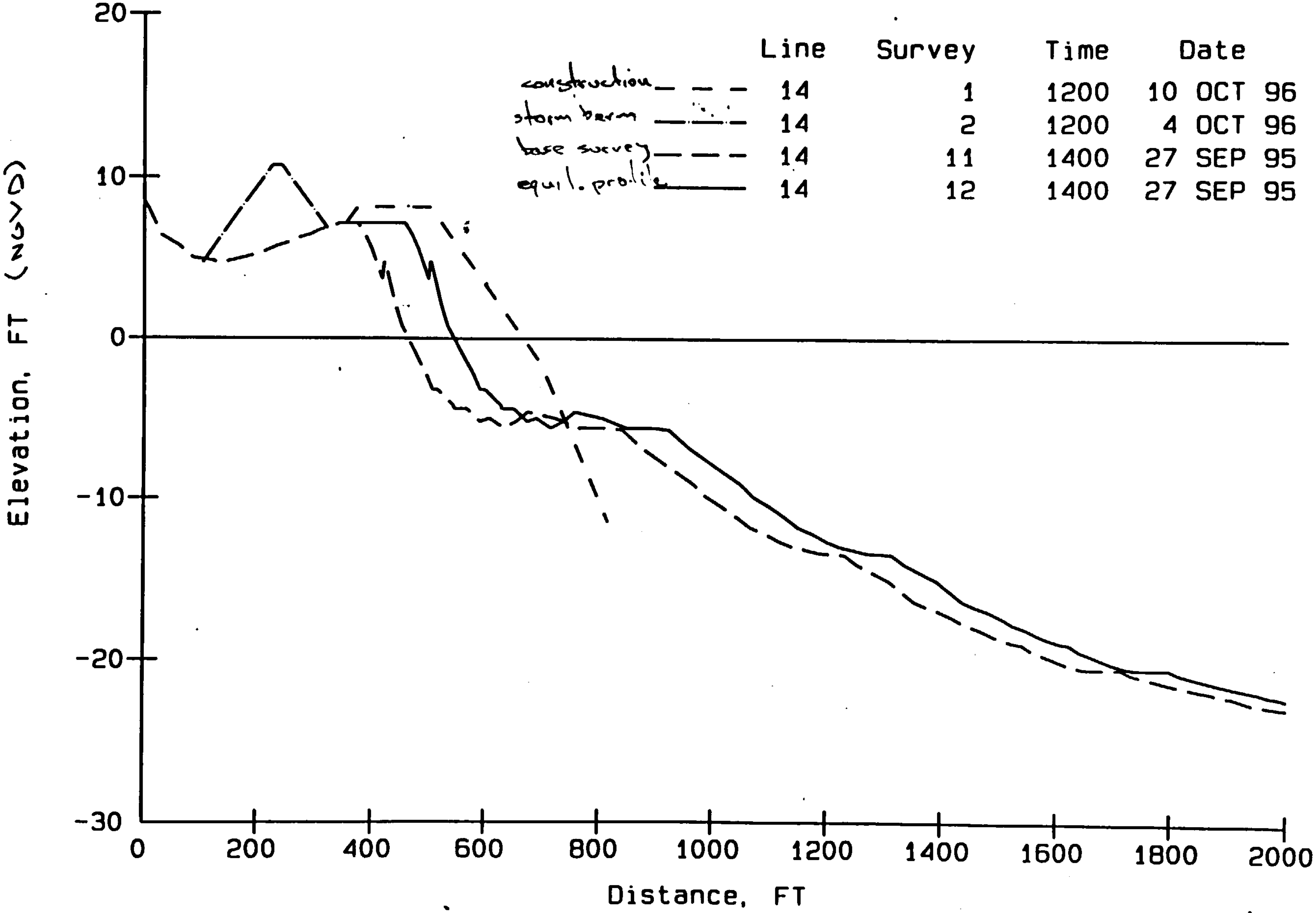
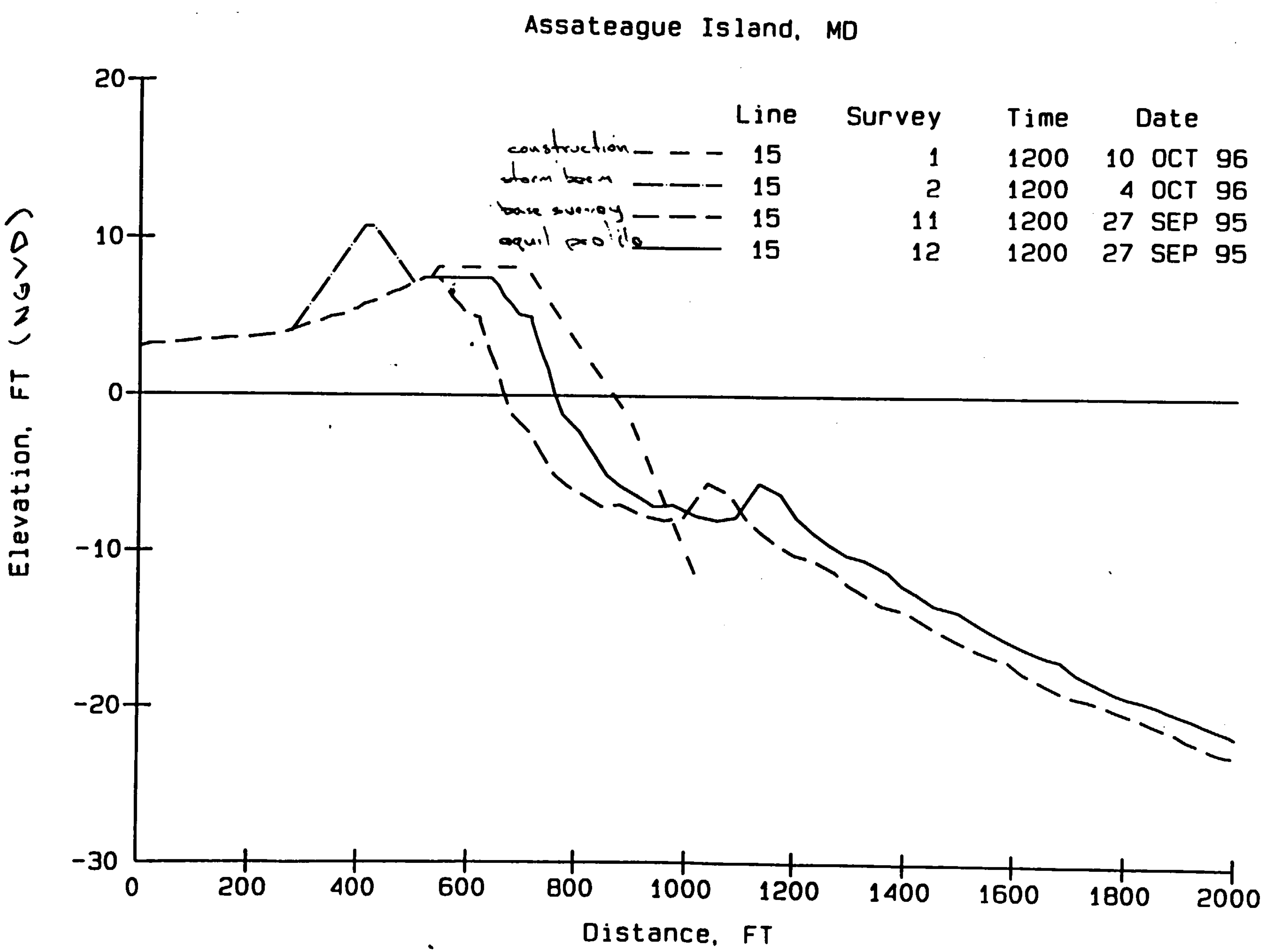
Assateague Island, MD





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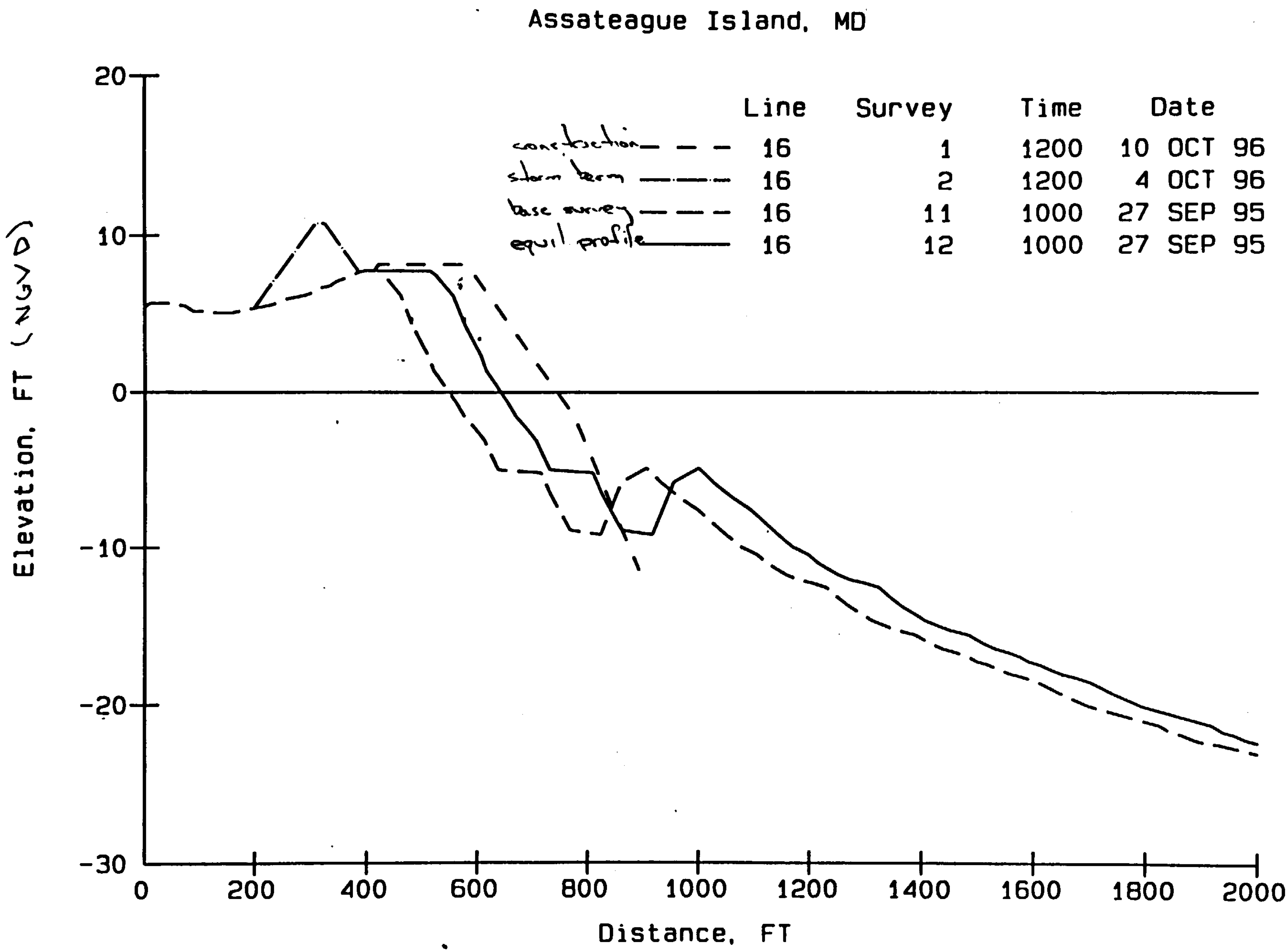

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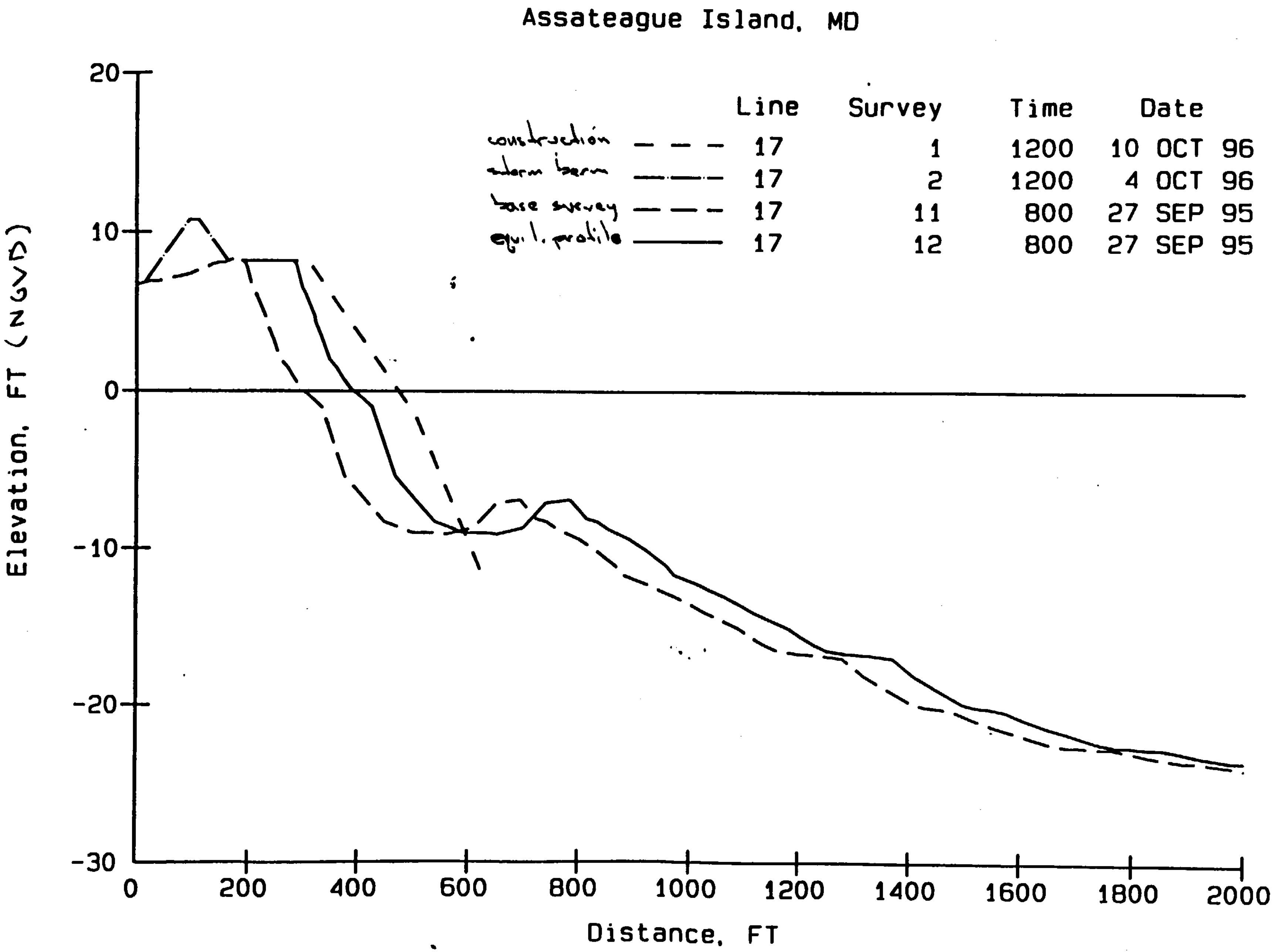
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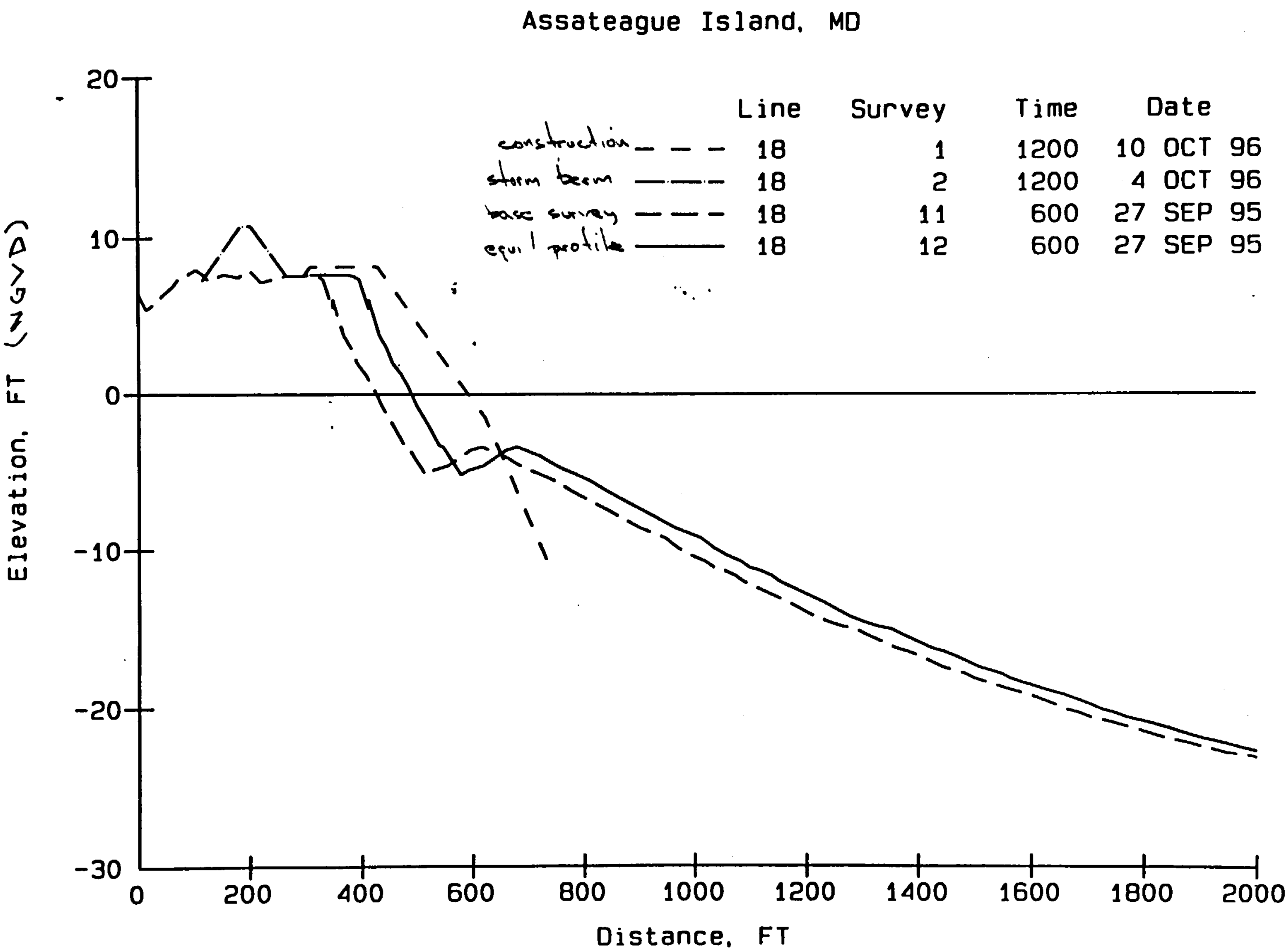

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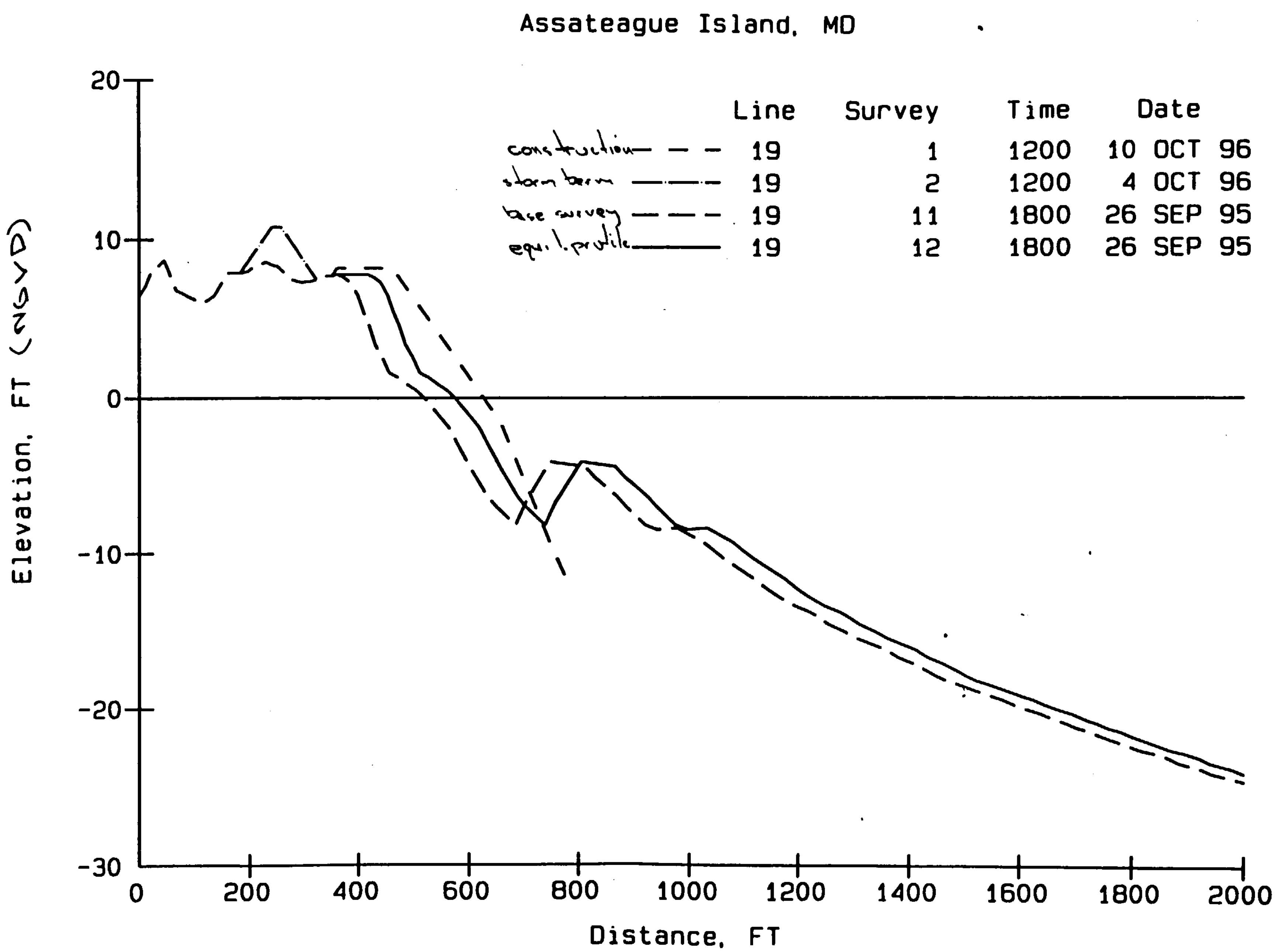

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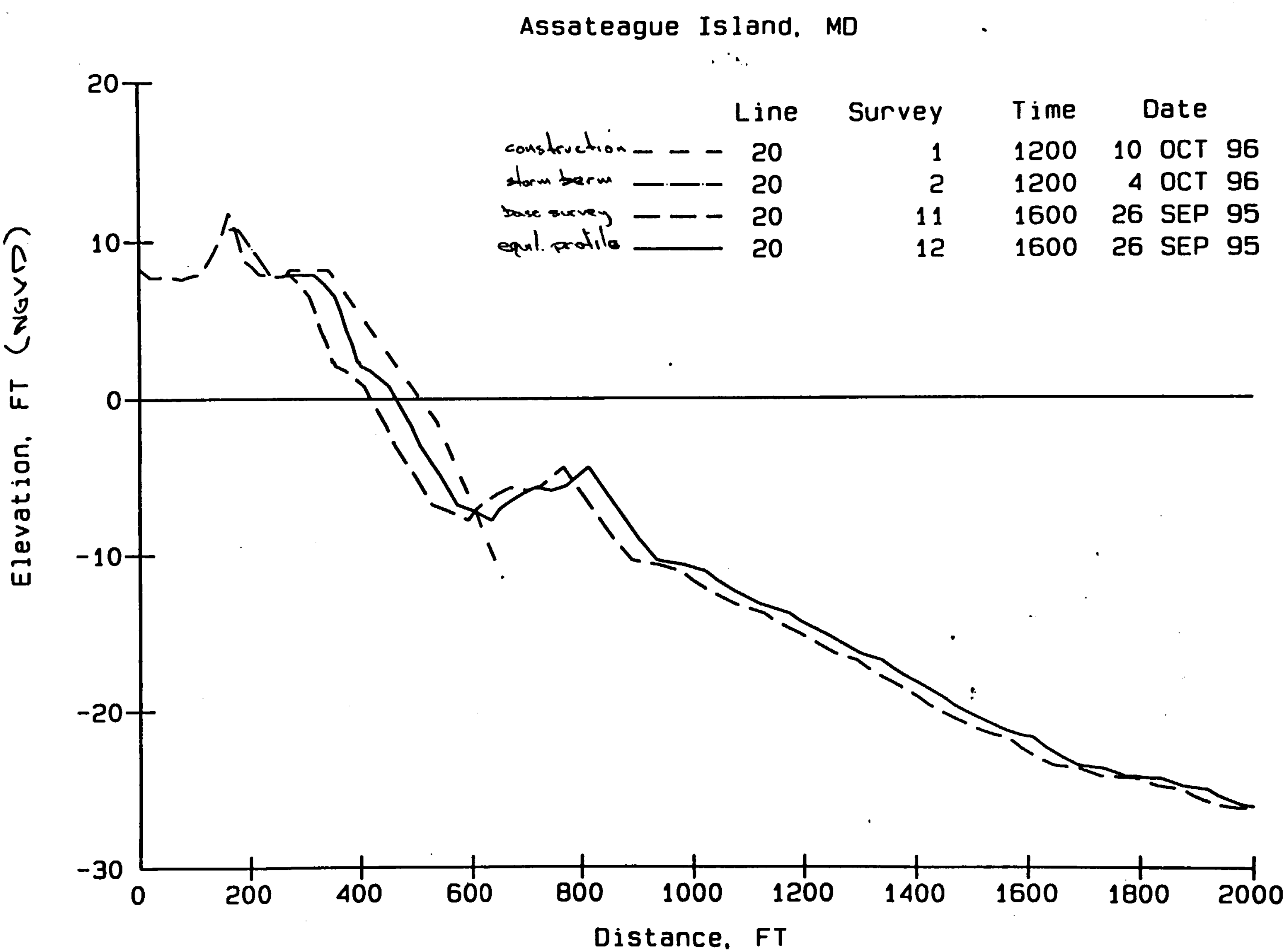
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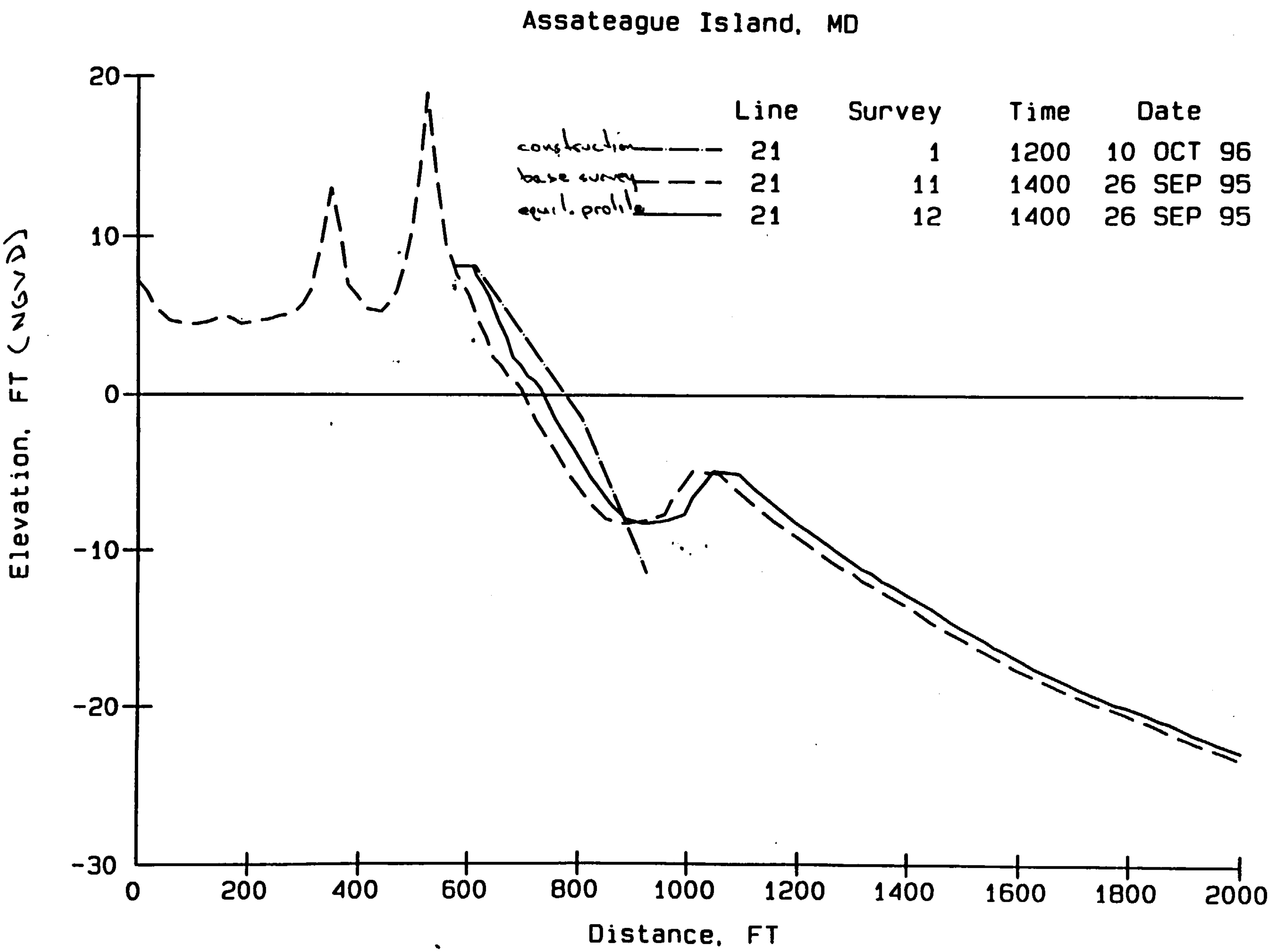

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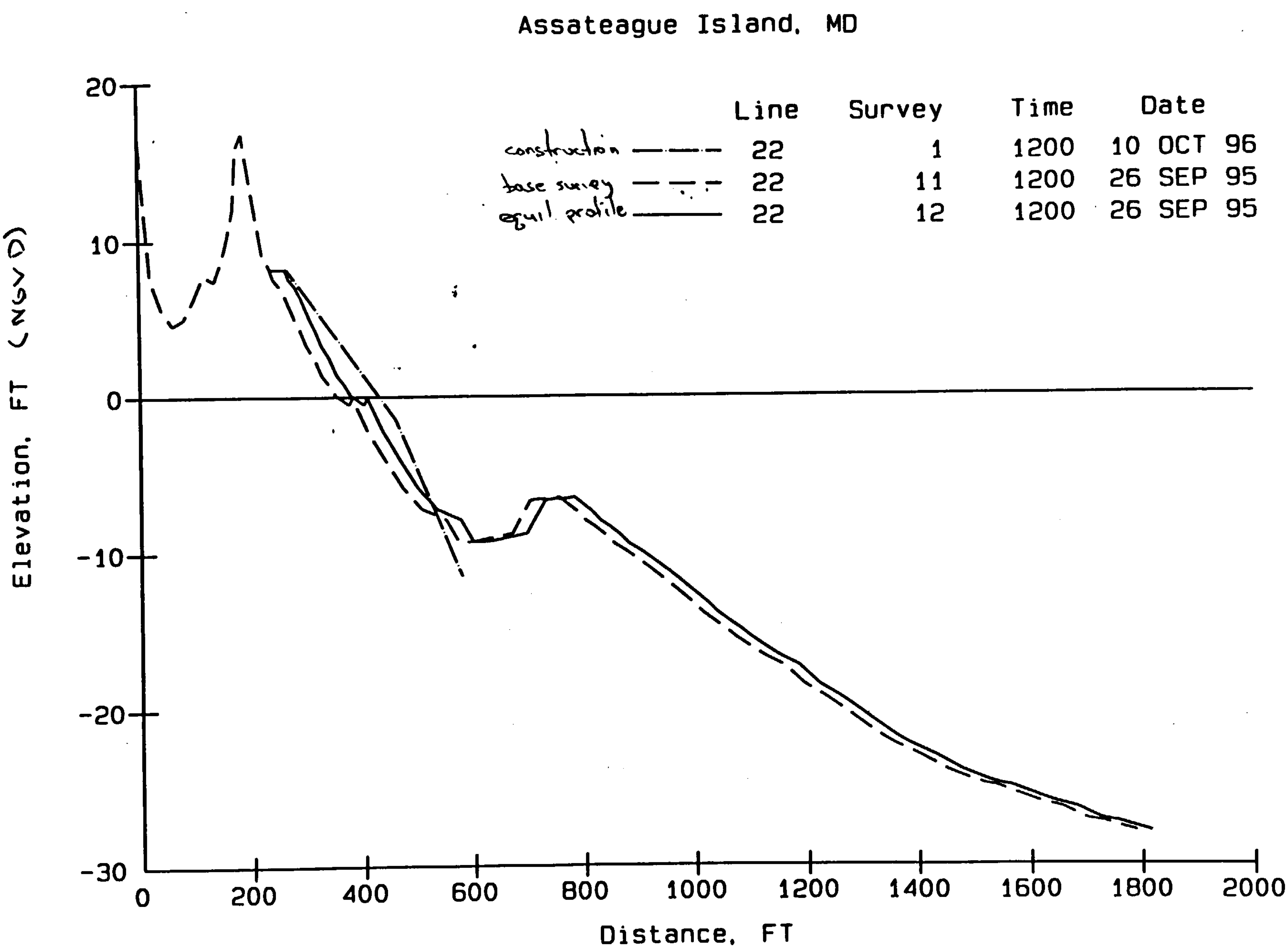

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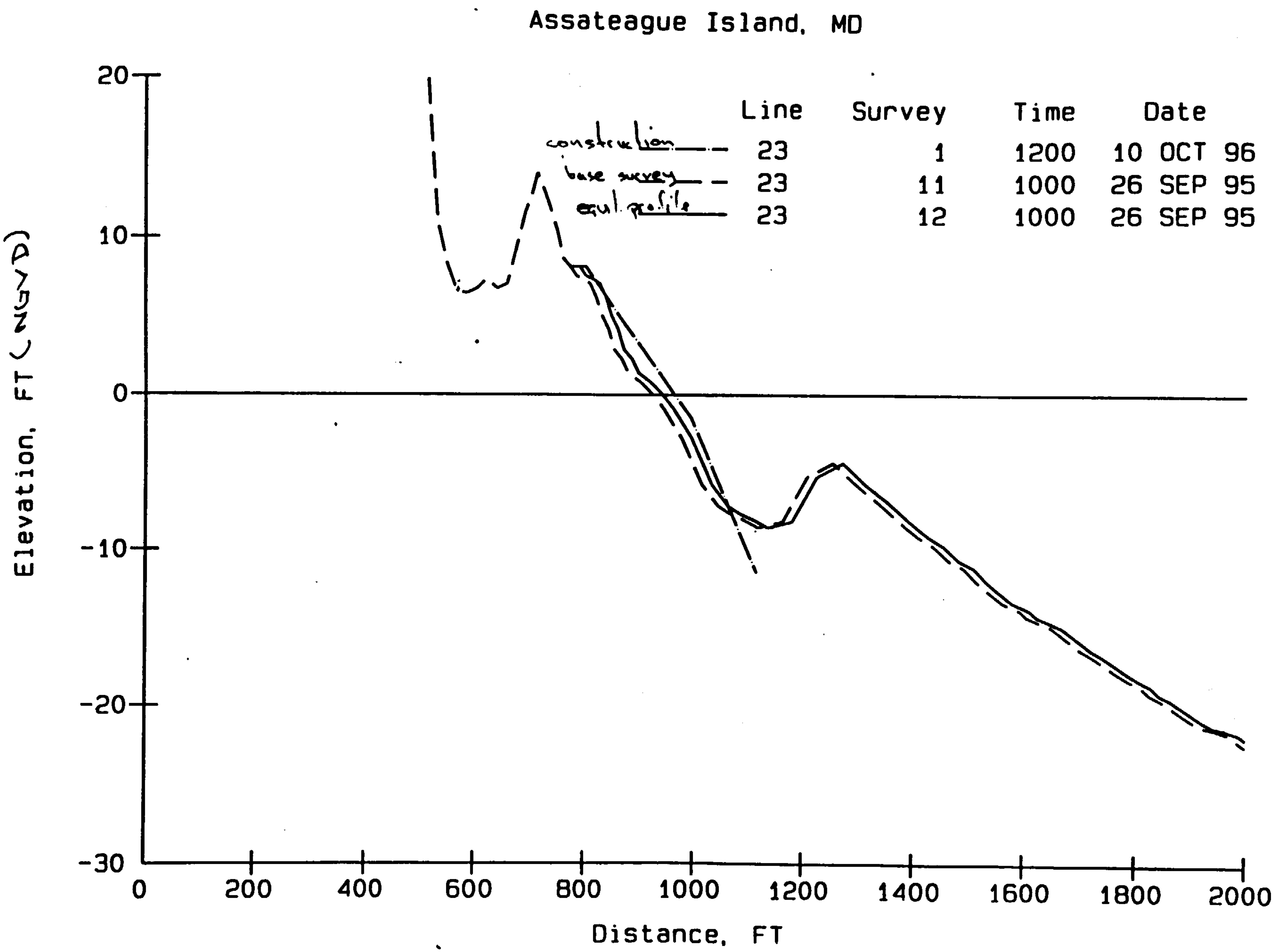
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Appendix A5 Numerical Modeling of Tidal Hydraulics and Storm Surge

Introduction

The coastal bay of Maryland and Virginia is a coastal barrier lagoon which extends from Assawoman Bay, MD. to Chincoteague Inlet, VA., and is bordered by Assateague and Fenwick Islands to the east and the Delmarva Peninsula to the west (Figure A5-1). The major tidal forcing comes from two tidal inlets: Ocean City Inlet to the north and Chincoteague Inlet to the south. The tidal range for both inlets is moderate, rarely exceeding 1.5 m, and there is a phase difference of about 30 minutes, with Ocean City Inlet ahead of Chincoteague Inlet. The freshwater inputs from Saint Martin River, Herring Creek and Trappe Creek, the major river inputs in the region, are negligible in comparison to the tidal prism transported through the inlets. Winds are generally episodic with dominant periods at around 2-7 days. In the winter months (November-February) northwesterly winds dominate; for the summer months, it is more frequently disrupted by southerly winds for several days duration. The bathymetry in the bay is generally shallower than 5 m with the exception of the Ocean City Inlet, where the scour holes reach 9 m deep.

Prior to 1933, Assateague Island was connected with Fenwick Island forming a continuous barrier spit, extending from the coastal headland of Bethany Beach, Delaware. In 1933, a hurricane breached the barrier spit. This breach cut the spit forming a barrier island to the south known today as Assateague Island and created Ocean City Inlet. Since the inlet formation, barrier width along north Assateague Island has remained relatively constant, but the entire island form has migrated landward. Consequently, the width of Sinepuxent Bay has decreased in this area. Storm processes have also created a flat overwash area as the erosion reached into the dunes (Stauble, 1994).

The objective of this study is to use the numerical model to simulate the tidal hydraulics and storm surge in the coastal bay of Maryland, focusing on (1) the potential inundation problem in the northern Assateague Island and (2) the effect of storm surge on the barrier island and Ocean City Inlet. The study will enhance the understanding of tidal and storm surge hydrodynamics in the bay, which ultimately can provide environmental managers and resources planners with sound knowledge and tools for evaluating their alternatives in managing the environmental restoration programs. In particular, this model was used to determine water surface elevations in Sinepuxent Bay adjacent to mainland communities for various storm events. This was used to predict future damage along the shoreline if a breach should occur.

To accomplish the goals, a numerical hydrodynamic model developed by Amein and Kraus (1991), Cialone and Amein (1993) was selected to conduct the study. The model is a state-of-the-art model for predicting tide-dominated velocities and water level fluctuations at an inlet and interior back-bay system. It is able to describe the multi-channel inlets, simulate the overwash process and more importantly, is easy to operate on a personal computer. The model treats the entire coast of Maryland and Virginia (Figure A5-1) as one entity instead of dividing it into separate domains. In so doing, it avoids the difficulty of specifying an open boundary condition in the interior of the bay system and provides a more reliable and accurate solution.

The following section first discusses the model formulation and is followed by the model calibration using October 1995 monitoring data. Eighteen historical storms were then selected for storm surge simulation under several scenarios including: existing condition (without-project condition), with-project conditions and two breaching conditions in the northern Assateague Island. Finally, sensitivity tests involving different breach dimensions are discussed.

Model Description

The numerical model selected for this study is DYNLET1, originally developed by Amein (1968) for floodflow routing and further modified by Amein and Kraus (1991), and Cialone and Amein (1993) for application in tidal inlets. DYNLET1 solves the full one-dimensional shallow water equation for computing the tidal and storm-induced flows in a system of inlets and bays with varied geometry where the flow field is not strongly 2-D. Under the hydrostatic approximation, the model solves for surface water elevation and depth averaged flow (or discharge). The basic equations (continuity and momentum conservation equations) in a (y,z) coordinate system may be written as :

$$\frac{\partial Q}{\partial t} + \frac{\partial}{\partial y}\left(\frac{Q^2}{A}\right) = - gAS_f + gB\tau_s - gAS_e - gA\frac{\partial z}{\partial y} \qquad (1)$$

$$\frac{\partial Q}{\partial y} + \frac{\partial A}{\partial t} - q = 0 \qquad (2)$$

where

Q = volume flow rate

t = time

y = horizontal distance (along a channel)

A = cross-sectional area

g = acceleration due to gravity

S_f = friction slope

B = width of top of channel cross section

τ_s = surface shear stress due to wind

S_e = transition loss rate with distance

z = water surface elevation

q = lateral inflow or outflow per unit channel length per unit time

Equations are solved numerically with rapid convergence using an accurate implicit scheme employing a centered finite-difference scheme and the Newton iteration method (Amein et al., 1975).

The main inputs for DYNLET1 are a grid network, cross-sectional geometry, friction factors, barrier island elevations, and external boundary conditions including forcing from both tidal elevation and wind stress. The grid network consists of cross-sections and channels which meet at junctions. Cross-sections (or nodes) are defined along the channels at locations where there is a significant change in cross-sectional geometry and each channel is defined as the conduit between the two adjacent junctions. In the coastal bay of Maryland and Virginia, a total of 86 nodes and 21 channels are defined, and are joined by 10 junctions as shown in Figure A5-2. Cross-sectional and topographic data were primarily digitized from the NOAA chart 1221 and supplemented by additional information from a detailed 1995, NAB bathymetric survey data in the vicinity of Ocean City and northern Assateague Island. For consistency, the depth and cross-section data were converted to NGVD.

The model framework allows overwash of the barrier island during storm events. The procedure for simulating barrier island overwash was implemented using a weir flow formulation as follows:

$$Q = C_w H^{1.5} B S_b \quad (3)$$

where

C_w = weir coefficient

H = water depth on the barrier island (difference between water surface elevation and barrier island elevation)

B = width of the weir section defined along the axis of the barrier island

S_b = submergence ratio

The weir coefficient used in the study is 3.0, corresponding to a broad-crested weir (King and Brater, 1963). The submergence ratio is the ratio of the ocean elevation to the bay elevation and is used to determine if water is flowing into or out of the bay. That is, as the ocean elevation rises the barrier island is overtopped and water flows into the bay. As the storm subsides, the raised bay elevation can exceed the ocean elevation and then, if the bay water elevation exceeds the weir (barrier island) elevation, flow is directed outward over the barrier island. Using this procedure, nodes (cross-sections) are defined along the barrier island and the weir elevation is designated at user-specified points along each cross-section. Each point on a cross-section then defines a sub-width that may or may not be submerged. In this manner, if a small portion of a cross-section is submerged, flow over that portion can be initiated.

The model was also implemented for simulating the breaching condition. In this case, the breach is assumed to be a permanent breakthrough and its dimensions are pre-determined. Thus, the boundary nodes need to be altered from a weir boundary node to an ocean boundary node to accommodate the permanent opening. Two breach nodes defined in the northern Assateague Island are node 44 and 51 (Figure A5-2) corresponding to profiles AI5 and AI15 (Figure A5-8). These are locations seem to be the areas most prone to breaching. When applied to the northern Assateague Island, the combined-wave-tide-storm surge elevation (plus wave set-up) was used as the forcing function at these nodes.

Model Calibration

Before model DYNLET1 could be applied to the study area, a calibration process was required in order to fine-tune the model parameters and to ensure the model accurately predicted the hydrodynamic condition within the Bay. This was accomplished by comparing DYNLET1 results with the in-situ surface elevation measurement and the NOAA tidal table data.

The accuracy of the model result is greatly influenced by the accuracy of the boundary and forcing conditions. The open-water boundaries of the coastal bay were driven by times series of water surface elevation recorded at an ocean gage located just north of Ocean City Inlet. These data were measured at 6-minute time intervals. Water levels supplied to the model were at the 6-minute interval and were updated via linear interpolation at the time step falling between the 6 minute intervals. At each time step the measured/updated water surface level was assigned uniformly across the open boundary.

The wind speed and direction data were obtained from measurements collected at Salisbury Airport, 6 miles south-west of Ocean City Inlet and supplemented by data collected at the Horn Point Environmental Laboratory, University of Maryland, resulting in a 15-min interval time series. The wind stresses calculated are uniformly assigned to the entire coastal bay as the surface boundary condition.

Although there is some flow occurring through the narrow channel connecting Assawoman and Little Assawoman Bays (USGS does not maintain a discharge gauging station), the northern boundary condition at the end of Assawoman bay was approximated by a "no" flow condition. With the quiescent initial state and the boundary forces described above, computations were made on the numerical grid for the time span which began on October 17, 1995 at 00:00 EDT and concluded at October 27, 1995 12:00 EDT.

Field data collected by a contractor working for NAB during an October, 1995 survey were provided for comparison with the model results. These data consisted of time series of water surface levels recorded at George Island Landing (station id 30236), Public Landing (station id 30269), Ocean City Coast Guard Station (station id 30056) and Upper Assawoman Bay (station id 30301), as shown in Figure A5-2. Water levels were recorded by a micro-tide gauge with a frequency of 50 samples/sec. After averaging, a time series was produced with a 6 minute time interval.

Calibration was performed primarily through adjusting the bottom friction coefficient Manning's n. In the first stage, a global coefficient was specified throughout the grid and the model was run over a wide range of values, from 0.020 to 0.045. The final values of Manning coefficient of friction 0.025 were used at nodes 1-39, 0.03 at nodes 40-54, 0.035 at nodes 55-61, 0.04 at nodes 62-65, and 0.035 at nodes 66-86.

The modeled water level data were saved at interior nodes 16, 28, 63 and 86, which correspond to the measurement stations George Island Landing, Public Landing, Ocean City Coast Guard Station and Upper Assawoman Bay respectively. Figures A5-3 - A5-6 show the comparison between simulation results and the in-situ measurements at each of the stations. Overall, the model accurately reproduces the water surface level time-histories for all the gauging stations during the calibration period. The predicted water levels were within 0.03 m of the measured water level. The correlation coefficients are 0.86, 0.90, 0.84 and 0.89 shown at the lower right corner of each figure, respectively. The comparisons of calculated tidal range and the tidal lags with previous published data (Dean et al., 1979) and data obtained from NOAA tidal tables also show reasonable agreement, as shown in Figure A5-7.

During the calibration period, the coastal bay experienced a strong wind event between day 21 through day 23 when the wind speed increased from an average of 2 m/sec to 7 m/sec (peak wind 10 m/sec) and blew persistently from the northeast. During the event, the measured mean water level experienced an approximate 0.3 m mean water level variation. The simulated water level accurately replicates the low frequency mean water surface oscillation, indicative of proper model response to the wind forcing.

Based upon the results shown above, the conclusion is that the model responds to the boundary forcing quite accurately both in terms of tidal and wind driven circulation. As a result, the confidence of the model's capability to accurately compute tidal hydraulics and storm surge was established. The model was then further applied to various scenario runs, which will be presented in the following sections.

Storm Surge Scenarios and Model Results

Storm surge is the oscillation of the water level in a coastal or inland water body that can range from a few hours to a few days, as a result of forcing from the atmospheric weather system. Tropical storms (hurricanes) and extra-tropical storms (northeasters) are not uncommon occurrences along the Middle Atlantic coast. As a barrier island protecting the Maryland and Virginia coast, northern Assateague Island has long been experiencing serious erosion, presumably due to the interruption of the longshore drift by Ocean City Inlet (Leatherman, 1979). Therefore, it is particularly susceptible to the storm surge associated with the passage of extra-tropical and tropical storms and can result in damage to the barrier island and cause inundation inside the coastal bay.

Our task here is to focus in on the issues of storm induced water level and flow rate changes in the vicinity of northern Assateague Island. This section describes the scenarios used and the results from the calibrated model. The scenarios include (1) existing condition (without-project condition) (2) with-project condition and (3) breaching conditions.

Storm Histories

Eighteen historical storms from 1933-1992 including both tropical and extra-tropical storms were simulated using numerical models by a contractor working for NAB. After being combined with the randomly selected astronomical tide, the storm-plus-tide hydrographs are used at Ocean City and Chincoteague inlets as boundary conditions. Next, the wave setup, determined from SBEACH (Larson et al.,1990; Wise et al., 1996), was added to the surge-plus-tide water elevation for each of the storms to obtain a total water level time series for each storm. Table A5-1 shows the peak values of wave height, wave period, and the combined water level and wave setup for each storm. The total water level time series were used as the boundary condition for the breach and overwash boundary nodes.

Existing Condition (Without-Project Condition)

The first set of DYNLET1 storm simulations conducted were for existing conditions (without-project condition) at northern Assateague Island. They serve as a base condition for later comparison with the other scenario runs. Topographic data measured in September, 1995 (Figure A5-8) were used to determine the maximum dune elevation along the barrier island. These data were used in DYNLET1 as the weir elevation, which serves as the threshold value for overwash. That is, when the storm water level exceeds the weir elevation, overwash will occur. Figure A5-9 shows an example of the overwash which was computed for the January 2, 1992 storm. The simulation started on December 30 at 12:00 EST and concluded at January 6, 12:00 EST. The first 60 hour is for the model spin up. The actual storm surge started on January 1 at 15:00 EST (corresponding to hour 75), peaked at 22:00 EST (corresponding to hour 82) and the entire event lasted for 3 days. It was obvious that overwash occurs only during the short duration when the wave-plus-tide-plus-storm surge exceeded the threshold value. The flow rate associated with overwash was shown ranging from 5 to 15 cm/sec at the peak value during the storm period.

With the built-in overwash algorithm, the model was used to simulate all 18 storms and results were recorded at 8 nodal locations along the northern Assateague Island (Figure A5-10). The peak water levels of each station were analyzed and shown in Table A5-2. From the table, it is seen that the peak water level at node 55 is the highest among different nodes and decreases as it goes toward other stations in the south. This gradient of water level from north to the south is an indication that the storm elevations are mainly forced by the surge through the Ocean City Inlet. The overwash, though occurred in the middle reach, its effect remained minor in determining the peak water level. During the entire 1933-1992 span, the average increase of water levels due to the storms are in the range of 0.5 m to 1.5 m with the highest water level 1.83 m (above NGVD) was recorded during the 1962 storm, followed by 1.71 m during December 1992 storm.

With-Project Condition

The second set of DYNLET1 storm simulations were made for with-project conditions, which called for raising the berm elevation from 2.5 m to 3.3 m, as shown in Figure A5-8. After modifying the barrier island with the new berm elevation, the 18 storms were simulated and the peak water levels were recorded. Table A5-3 shows the simulated water level for with-project condition and Table A5-4 shows the difference between existing condition and the with-project condition.

From the numerical model point of view, raising the berm elevation is equivalent to increasing the threshold for the overwash and hence reducing the frequency of its occurrence. By examining Tables A5-4 and A5-1, the overwash occurrence frequency was 1 out of every 2 storms for the existing condition, and none for the with-project condition, a 100% reduction. At a closer look from the result in Table A5-4 shows that the benefit mainly came from those storms which had a peak water level exceeding 2.5 m but less than 3.3 m, including storms in Jan 64, Jan 92, Mar 62, Sep 33, Sep 44, Sep 56, Nov 81, and Dec 92 . Table A5-3 again shows that the recorded storm water levels are higher in the Ocean City Inlet and lower toward the south, an indication that storm surge is coming through the Ocean City Inlet.

Breach Conditions

A breach and overwash both can occur as a result of ocean or bay storm surge. A breach allows free communication between the ocean and bay, and permits the exchange of water and sediment for a longer interval than the duration of the storm; whereas, overwash only lasts for the duration of the storm and does not occur under typical astronomical tide conditions. Furthermore, the volume of water through the breach can be much larger than overwash and hence can significantly affect both the water level and the flow rate in the bay.

In order to assess the impact of a breach on the northern Assateague Island, the two low-lying areas, profiles AI5 and AI15 shown in the Figure A5-8, were identified as the potential breaching locations. Profile AI5 was represented by node 51 (referred to as northern breach) and the profile AI15 was represented by node 44 (referred to as southern breach). It is assumed that only one breach will occur at a time and therefore the two breach scenarios, northern and southern breaches, were run as separate events. Since no breach dimensions are available, the 1962 breaching condition (570 m in width and 1.53 m in depth) was adopted and used for the all different simulations.

Northern Breach

For the northern breach scenario, the permanent breakthrough was placed at node 51 and the elevation of the barrier island remained at the existing condition. The results of peak water level for the eighteen storms are shown in Table A5-5. When compared to the existing condition, the magnitude of the peak water level was shown to increase significantly. For instance, the peak water level was 1.62 m above NGVD for existing condition during the January 1992 storm; and for the breach condition it was 2.19 m (due in part to the contribution of wave set-up), an increase of 35 %. Furthermore, the spatial distribution of the water level was also changed. The largest water level was now centered at node 49 near the breach, decreasing both to the north and the south. The implication is that there is a piling of water near the point of breach. This is in contrast to the existing and with-project condition whereby the water level gradient is from the north to the south. The time series analysis of water levels and flow rates were also conducted to show the temporal response to the January 1992 storm. Figure A5-11 shows the water elevation at node 54 peaked at 2.19 m at hour 82 which is consistent with the time of the storm's peak elevation, an evidence that excess water was pumped into the bay from the breach. The flow rate at node 54, shown in Figure A5-12, indicates that the tidal prism was overcome by a unidirectional northward net flow (represented by positive flow) toward Ocean City Inlet. The flow rate at node 64 located at Ocean City Inlet shows that while the tidal prism was partially restored, there was still a net outward velocity flow (positive velocity shown in Figure A5-13) which increases the ebb tide and deceases the flood tidal flow. When the flow rate and water elevation time series were further examined at node 67 (located at the entrance of Isle of Wight Bay north of Ocean City Inlet) the results from breaching condition does not show much differences from that of existing condition, as shown in Figure A5-14. This indicates that the breach occurred in the northern Assateague Island do not have significant effect on the tidal hydraulic north of Ocean City.

Southern Breach

The location of the southern breach is at node 44 and the elevation of barrier island again remained at the existing condition. The breach dimensions used is the same as that of northern breach. With the barrier island geometry modified, the 18 storm simulations was repeated.

The results of peak water level for the eighteen storms are shown in Table A5-6. When compared to both the existing condition and the northern breach condition, the increase of the peak water level is shown to be the most. For instance, the peak water level was 2.51 m above NGVD during December 1992 storm; which is 47% more than that for the existing condition and 7 % more than the northern breach case. During the March 1962 storm, the peak water level for the southern breach was 2.36 m, which is 29% more than existing condition and 5 % more than the northern breach. In other words, given the same storm and the breach conditions, the southern breach is more likely to generate a larger peak water elevation than other scenarios considered and thus, poses a higher risk for flooding in this region.

The spatial distribution of the water level was highest near the breach at node 41 and decreased both to the north and the south, implying the piling of water near the point of breach. An analysis of water levels and flow rates was also conducted to show the temporal response to the January 1992 storm. Figure A5-15 shows the water elevation peaked at 2.36 m at hour 82, the same time when storms peaked at the breach and water was pumped into the bay through the breach. The flow rate at node 54, shown in Figure A5-16, indicates that the tidal prism was overcome by a unidirectional northward net flow toward Ocean City Inlet. The flow rate at node 64 near Ocean City Inlet indicated that, while the tidal prism were partially restored, there was still a net outward velocity flow (positive velocity represents an outward flow) which increased the ebb flow and deceased the flood flow, as shown in Figure A5-17, similar phenomena found in the northern breach. When the flow rate and water elevation were examined at node 67 located at the entrance of Isle of

Wight Bay, north of Ocean City Inlet, again they were very little affected (Figure A5-18), indicating that the southern breach has no significant effect on the bay north of Ocean City.

Discussion and Conclusion

One of the uncertainties involved in the scenarios runs is the specification of the breach dimension. Sensitivity tests were conducted using different combinations of the breach dimensions. For each of the breach locations (northern and southern breaches), eight different cases were tested using combinations of four widths (250 m, 570 m, 750 m and 1000 m) and two depths (1.07 and 1.52 m). All sensitivity tests were conducted with the January 1992 storm. Since the amount of water flowing through the breach was generally proportional to the dimension of the breach, we expect that with increasing breakthrough area (width times depth) the peak water level will increase accordingly. The results in Table A5-7 indeed show that the peak water level increases as the breach dimension increases. However, we observe that the rate of increased water level was significantly reduced beyond the width of 750 m in the northern Assateague Island simulation.

A numerical model DYNLET1 with a built-in overwash algorithm was developed to simulate the storm surge and tidal hydraulics in the coastal bay of Maryland. The calibrated model compared well with the 1995 October data and was utilized to assess the impact of the storm surge at the northern Assateague Island. Three scenarios were conducted: existing condition, with-project condition and breaching conditions. The comparison of existing condition and the project condition shows that the increase of dune elevation, in general, reduced the threshold for overwash and subsequently reduced the frequency of overwash. However, the benefit is only obtained for large storms whose peak water level exceeds the existing low-lying level, 2.5 m. For the breach scenarios, the model results show that a breach has far more impact on the alteration of local water level and the flow rate. The breach always generates a large peak water elevation locally near the breakthrough, with the southern breach generating the largest water elevations among all conditions studied. Increases of local water levels exceeding 2 m are not uncommon in the case of breaching. The largest increase of water level for the 18 storms simulated reached a peak water level of 2.51 m during December 1992 storm at the southern breach. The change of flow rate associated with the breaches shows that when the flow enters the bay through the breach, the water level on the bay side of the breach increases first. The excess water are then discharged to the north and to the south of the breach. The flow to the north actually generates a net outward flow flushing the excess water out of Ocean City Inlet; by so doing, it practically changes the tidal prism in the Ocean City Inlet: increasing its ebb flow and decreasing the flood flow. The model showed little evidence of breaching effect being extended into the northern portion of the bay, north of Ocean City Inlet, presumably because much larger volumes of water were transported by the normal tidal prism through the northern bay region.

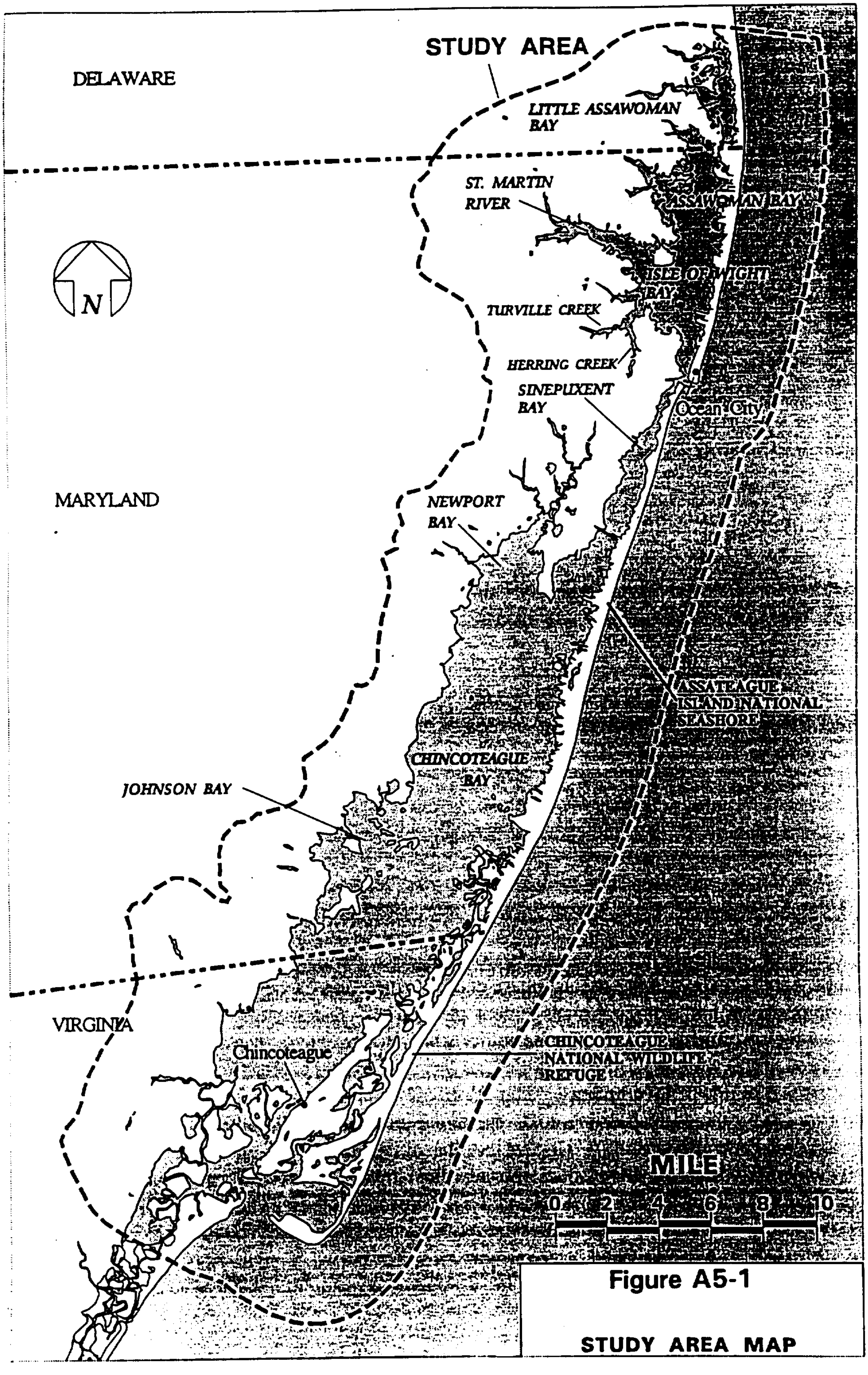


Figure A5-1

STUDY AREA MAP

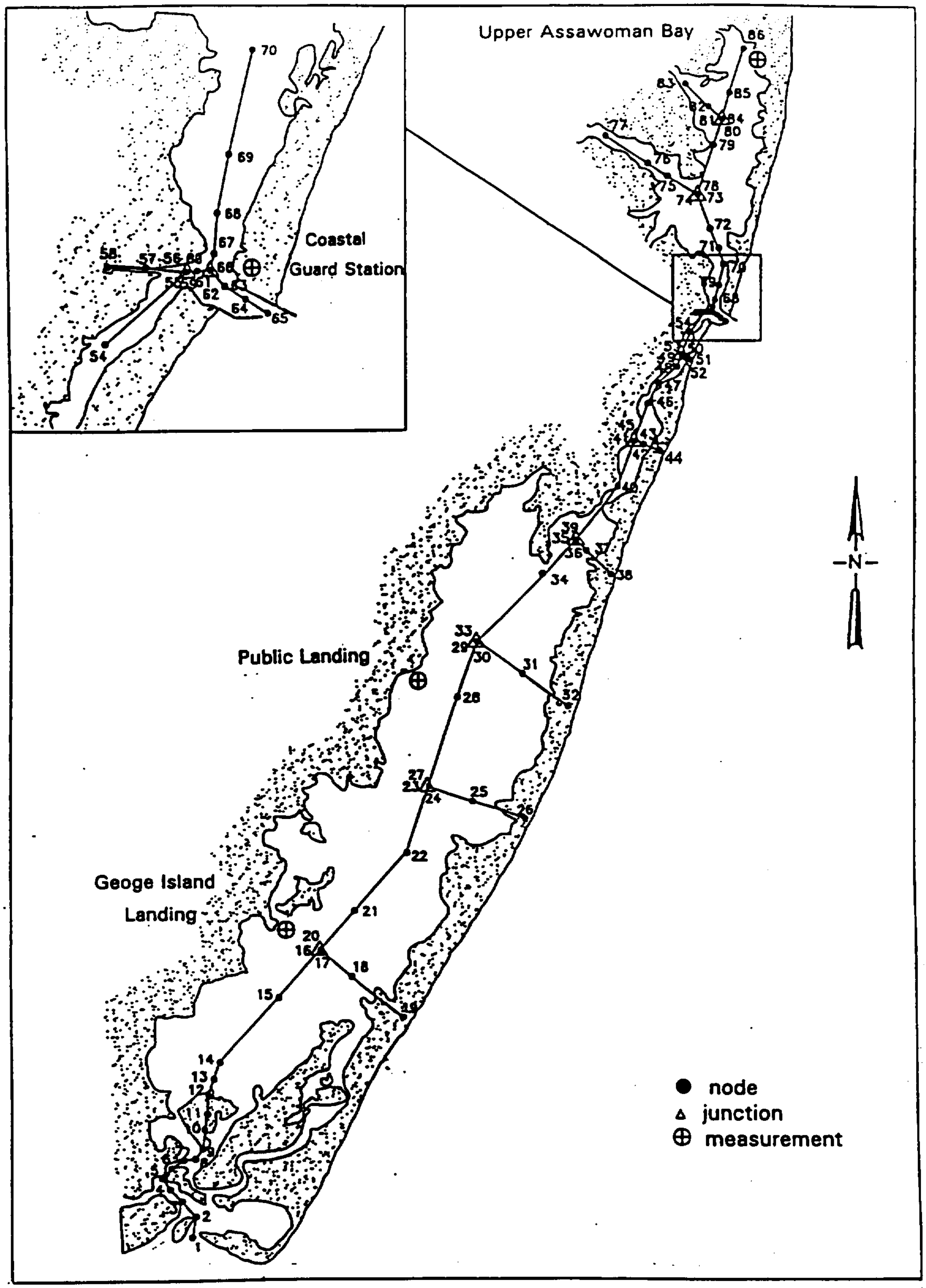


Figure A5-2. The DYNLET1 grid network for the Coastal Bay of Maryland and Virginia

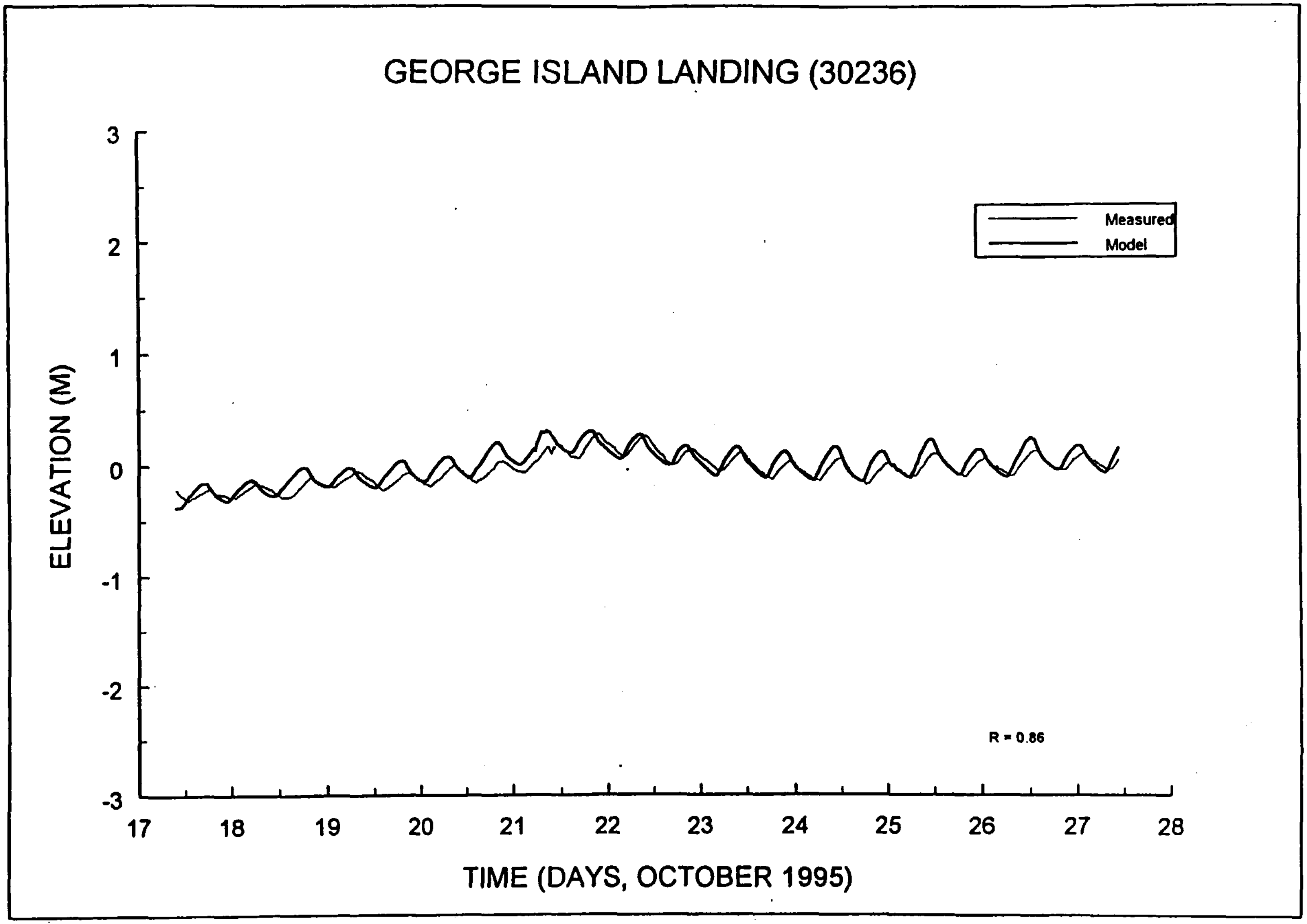


Figure A5-3. Comparison of water elevation between model simulation and measured data at George Island Landing station

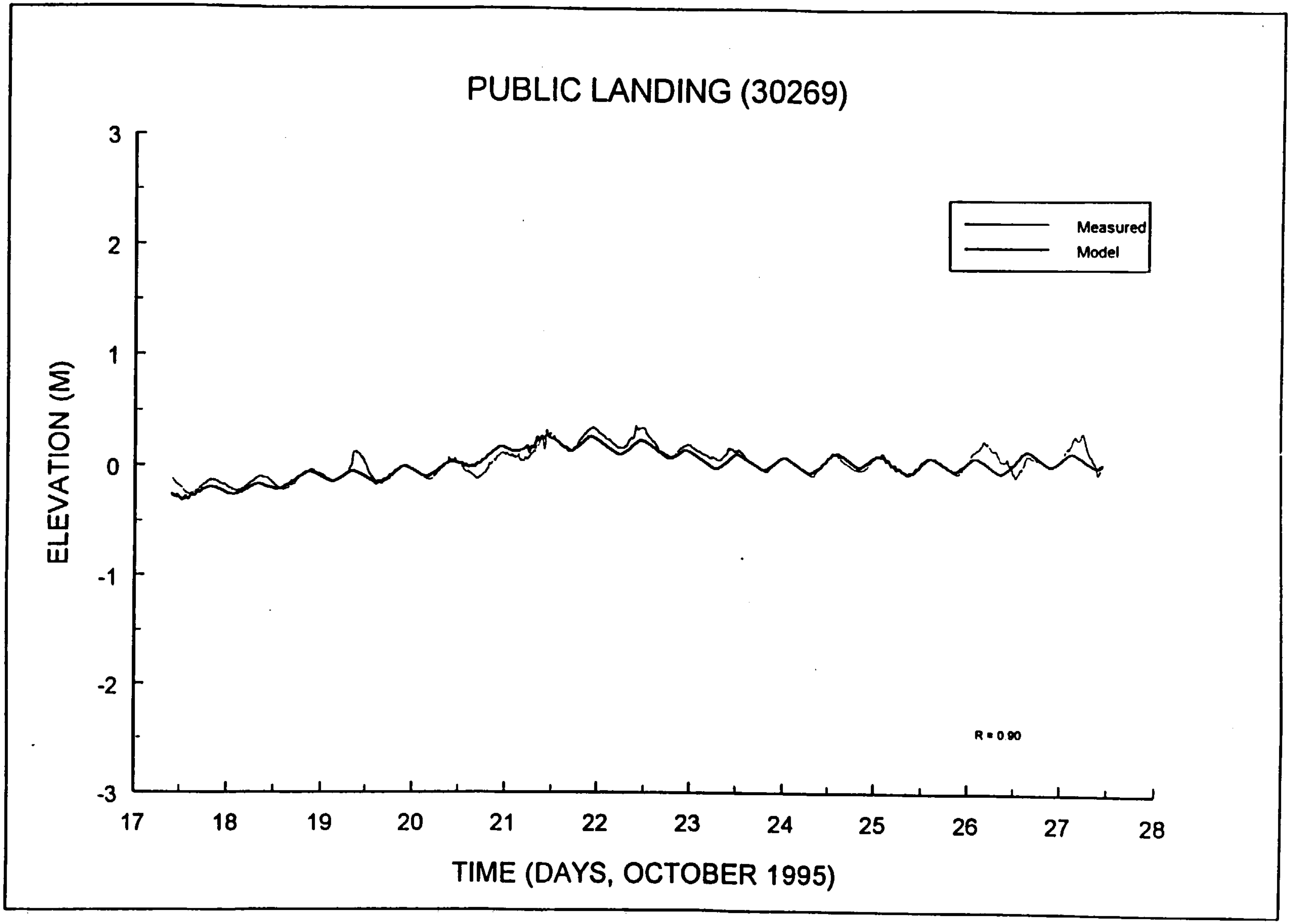


Figure A5-4. Comparison of water elevation between model simulation and measured data at Public Landing station

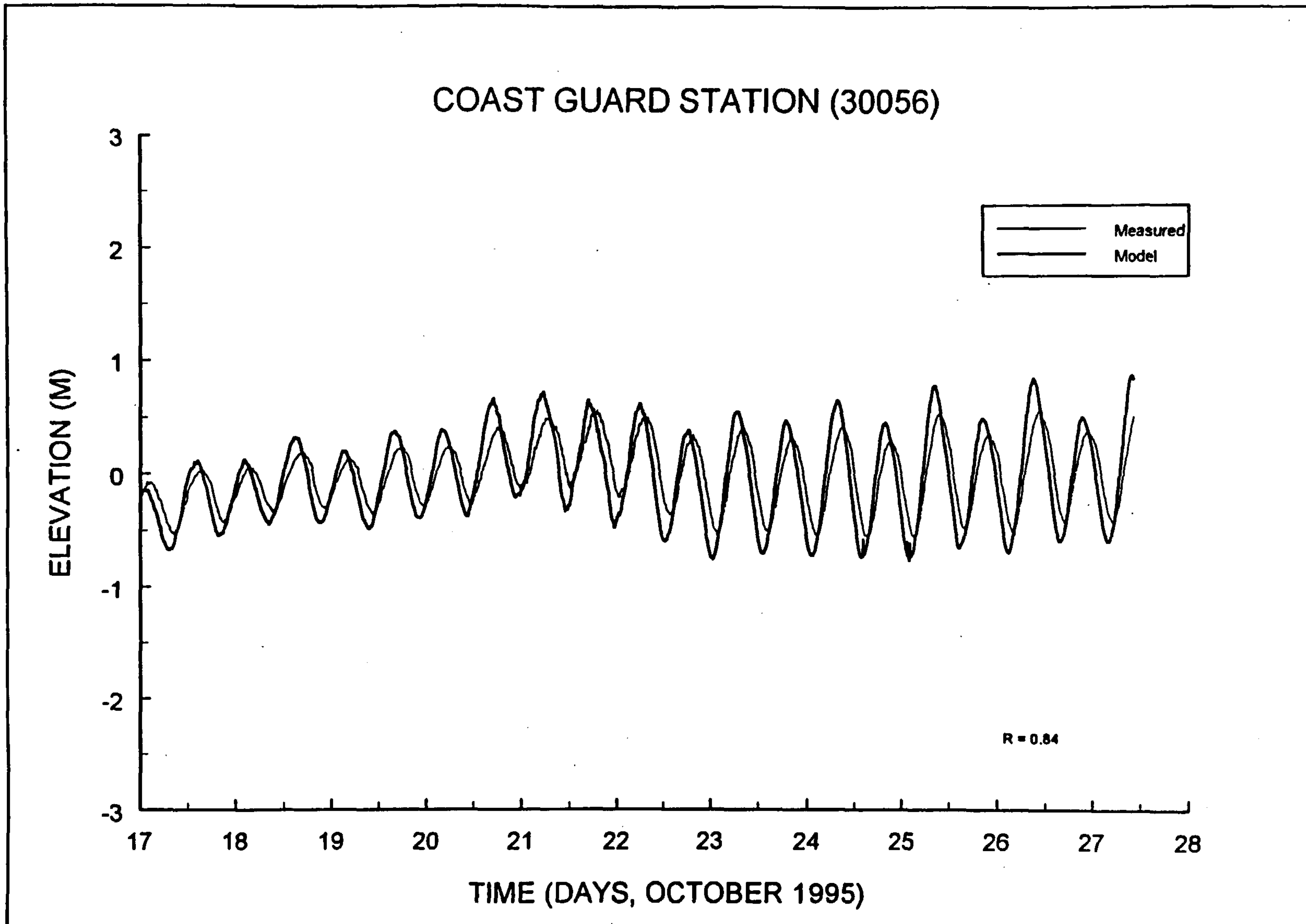


Figure A5-5. Comparison of water elevation between model simulation and measured data at Coast Guard station

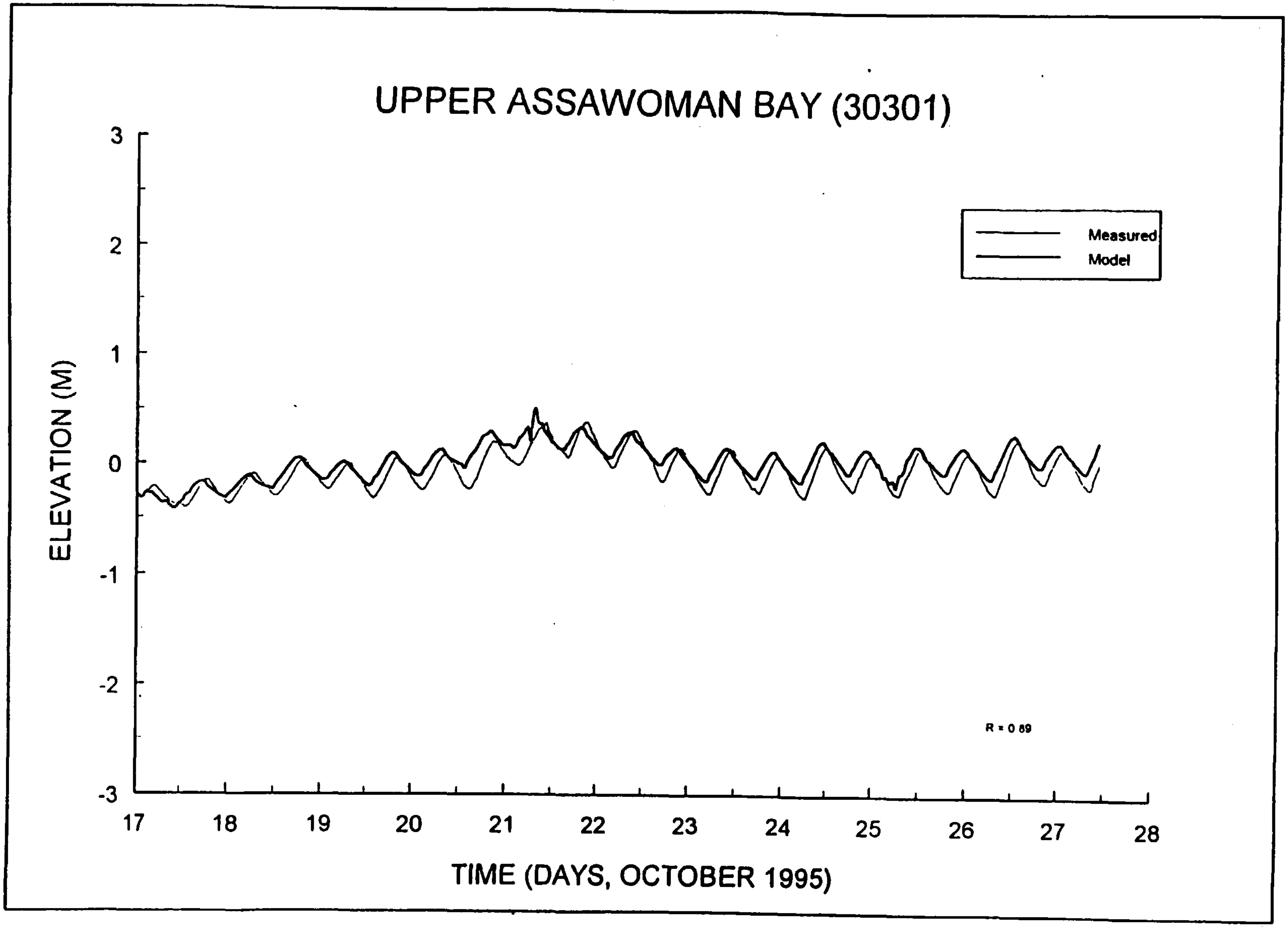
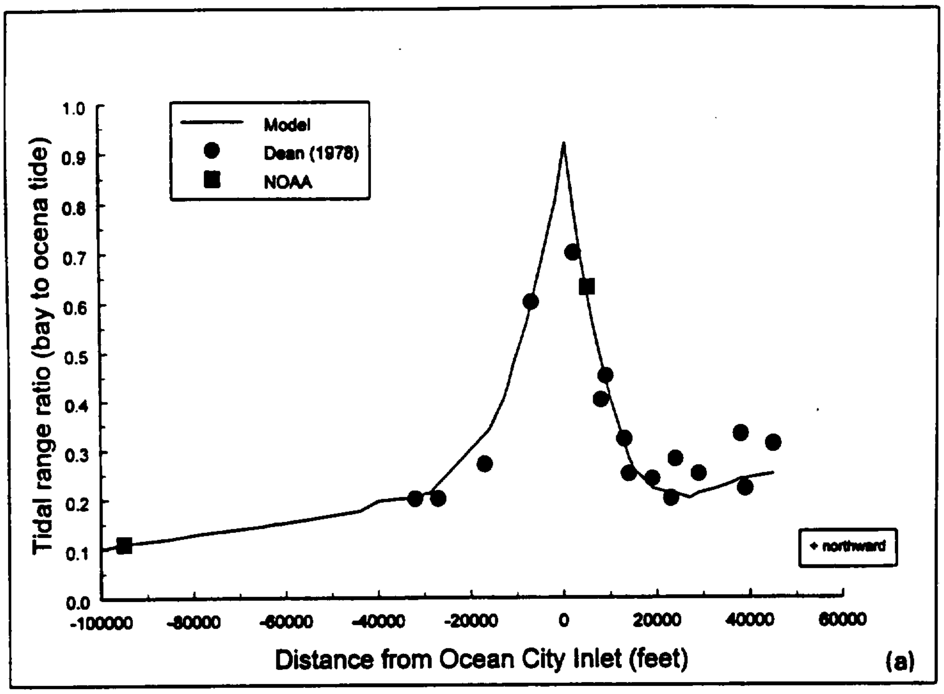


Figure A5-6. Comparison of water elevation between model simulation and measured data at Upper Assawoman station



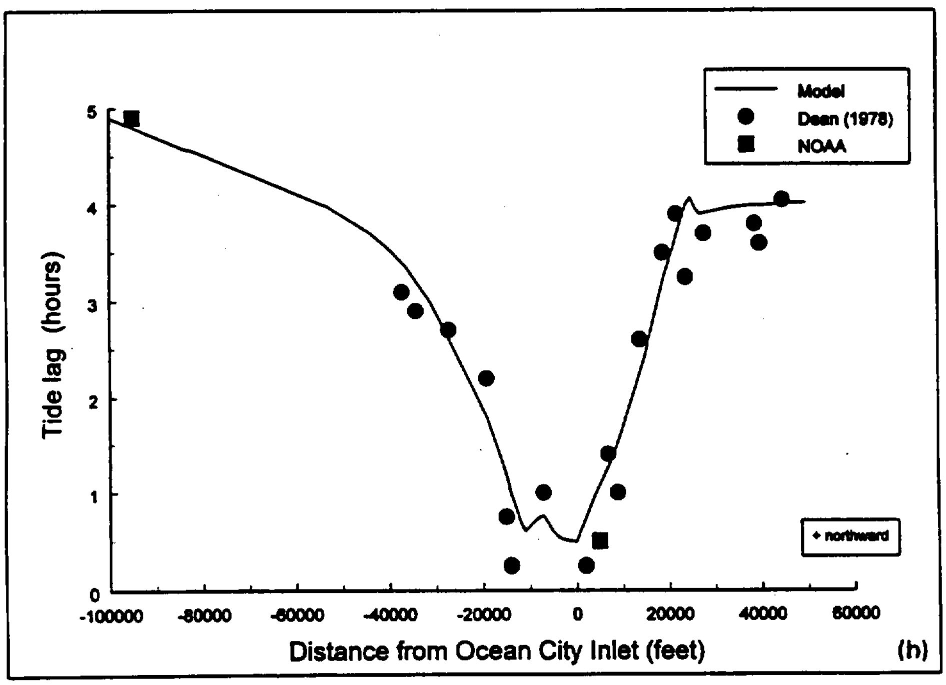


Figure A5-7. Comparison of (a) tidal range ratio (bay tide to ocean tide) and (b) tidal lag between model results and data from NOAA, Dean et al (1979) data

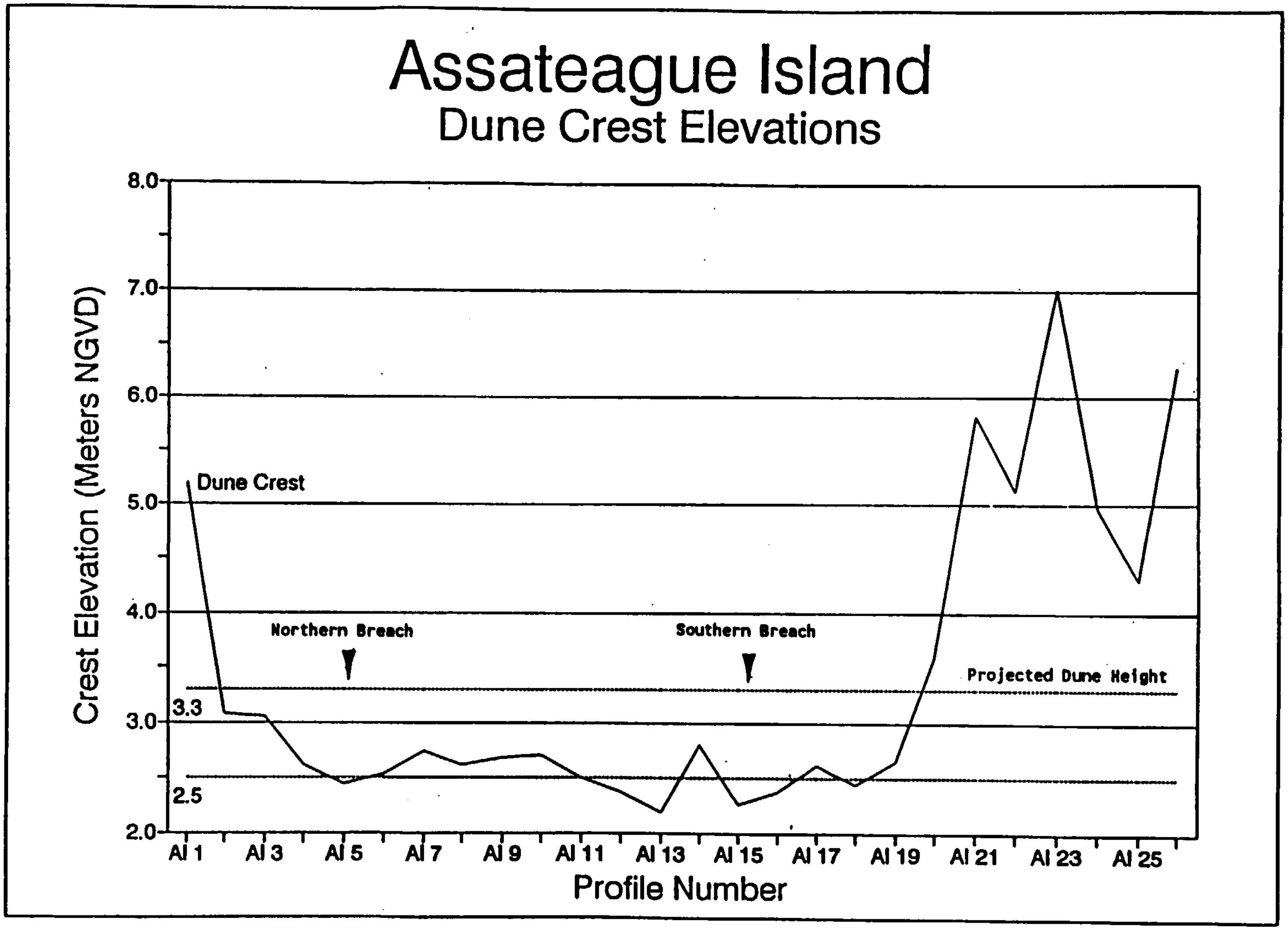


Figure A5-8. Dune crest elevation at Northern Assateague Island
Dotted line 2.5 m: Averaged low-lying height
Dotted line 3.3 m: Projected dune height

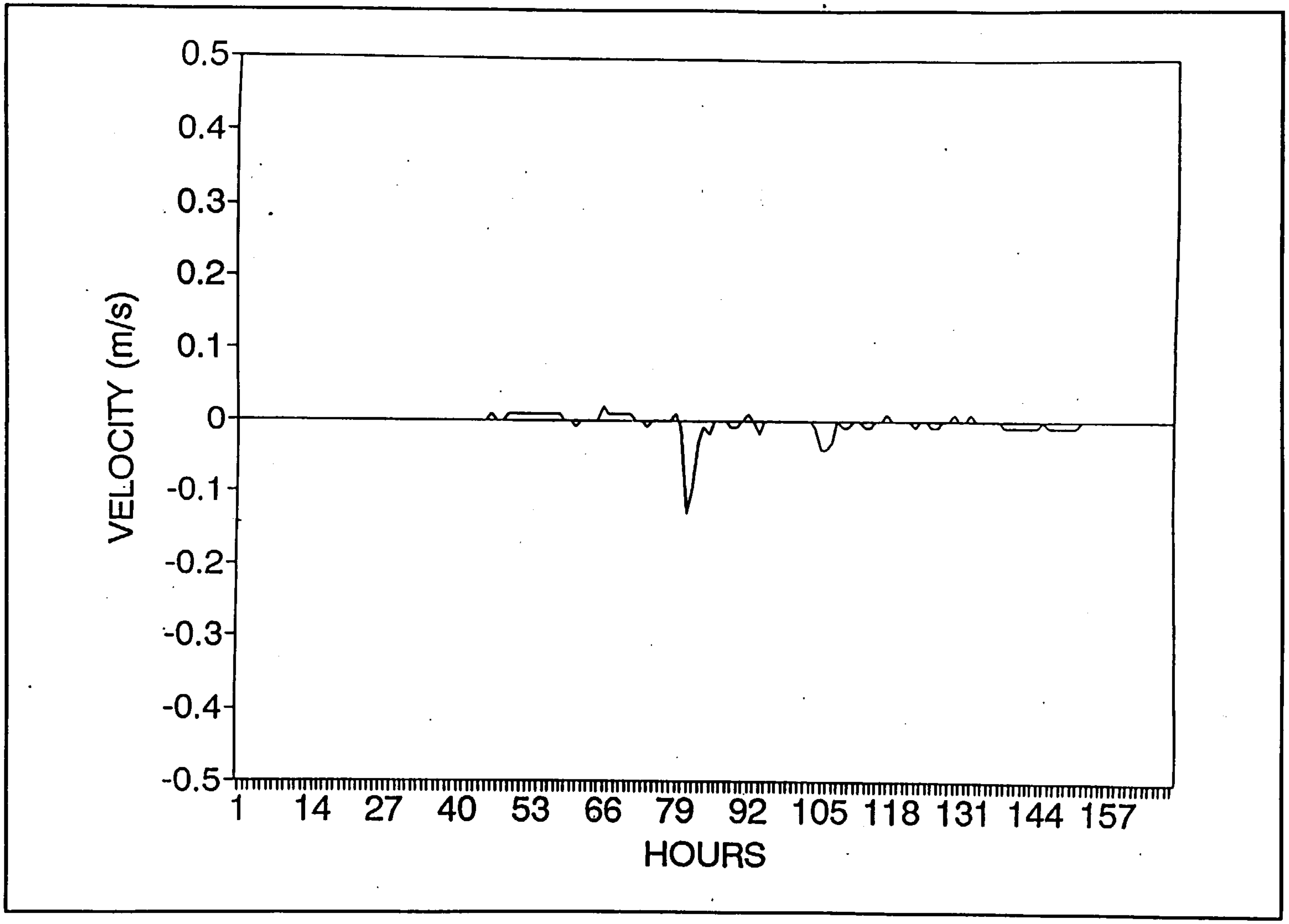


Figure A5-9. The overwash-induced velocity at node 43 for January, 1992 storm

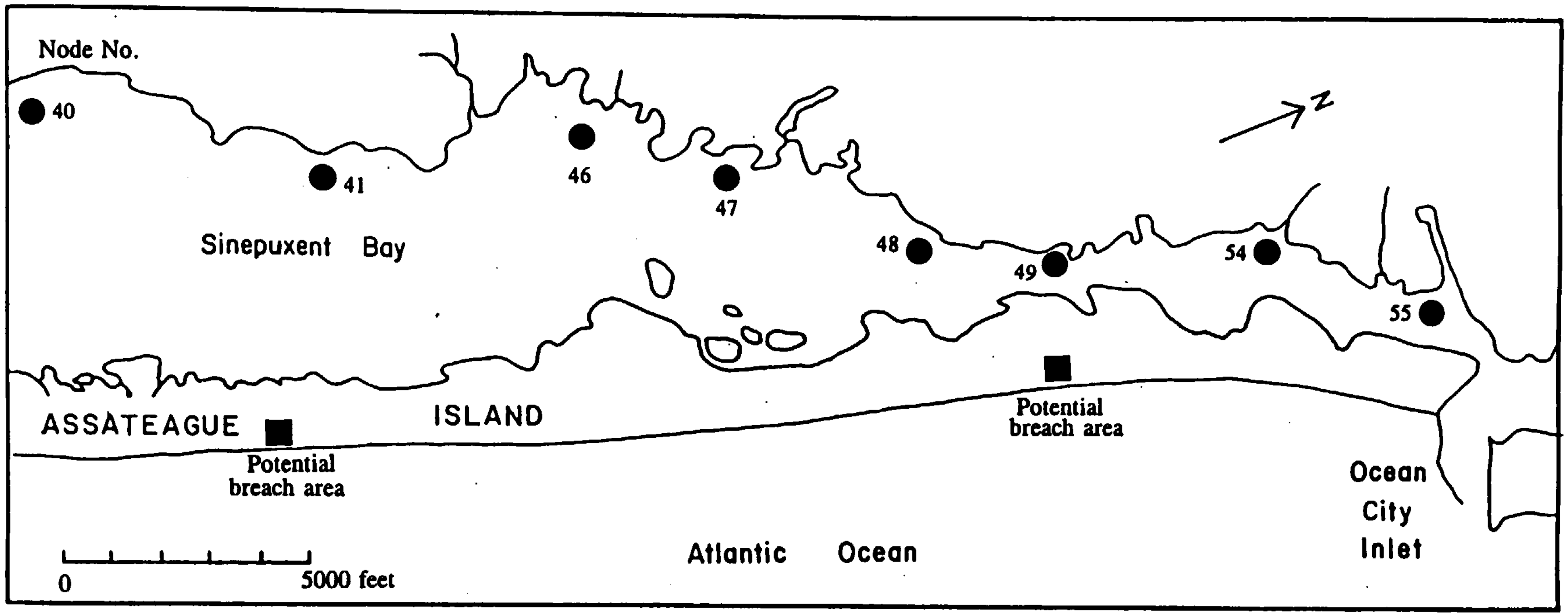


Figure A5-10 The eight locations in the northern Assateague Island where modeled information are stored.

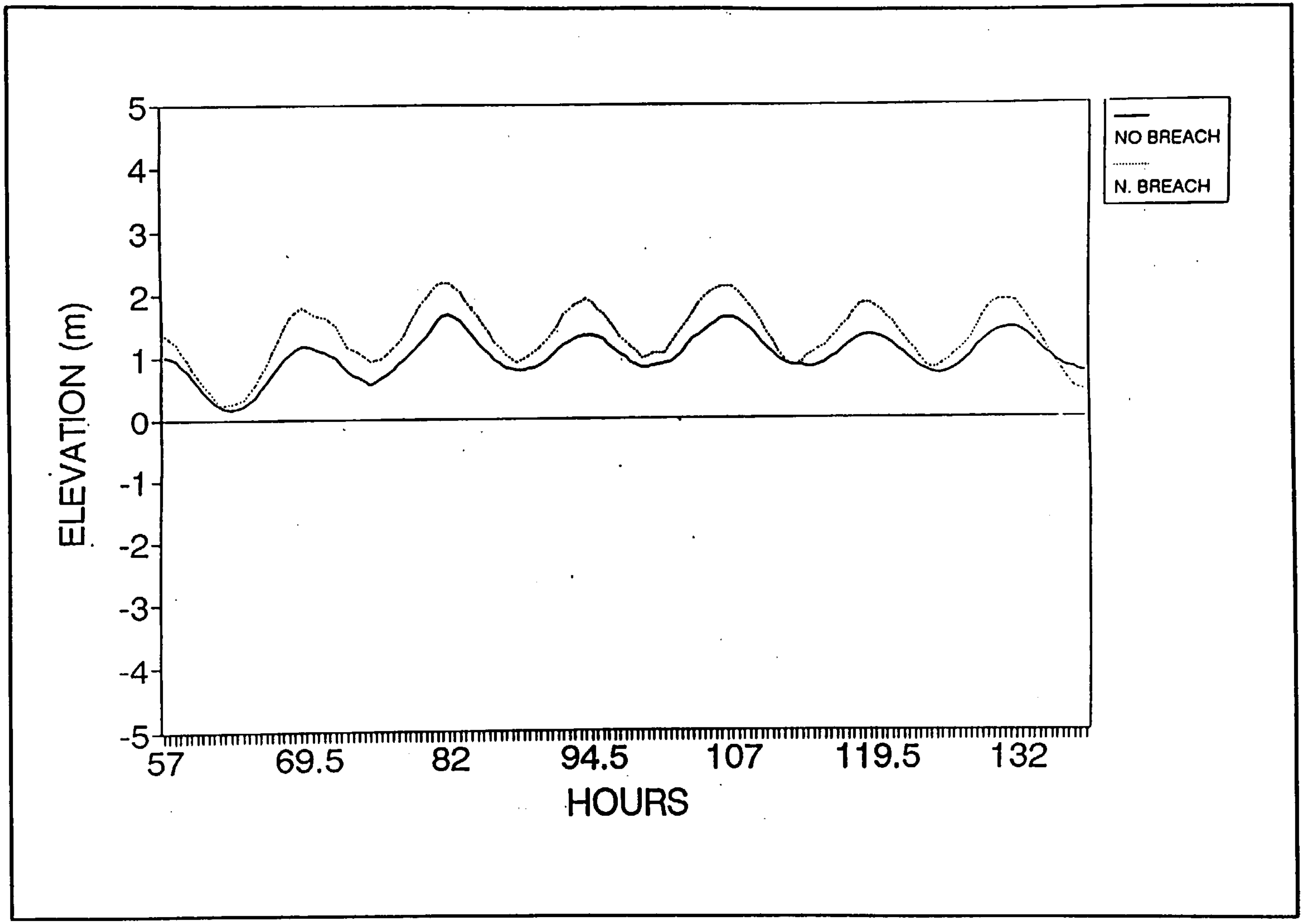


Figure A5-11. The simulated water elevation at node 54 for January, 1992 storm, northern breach

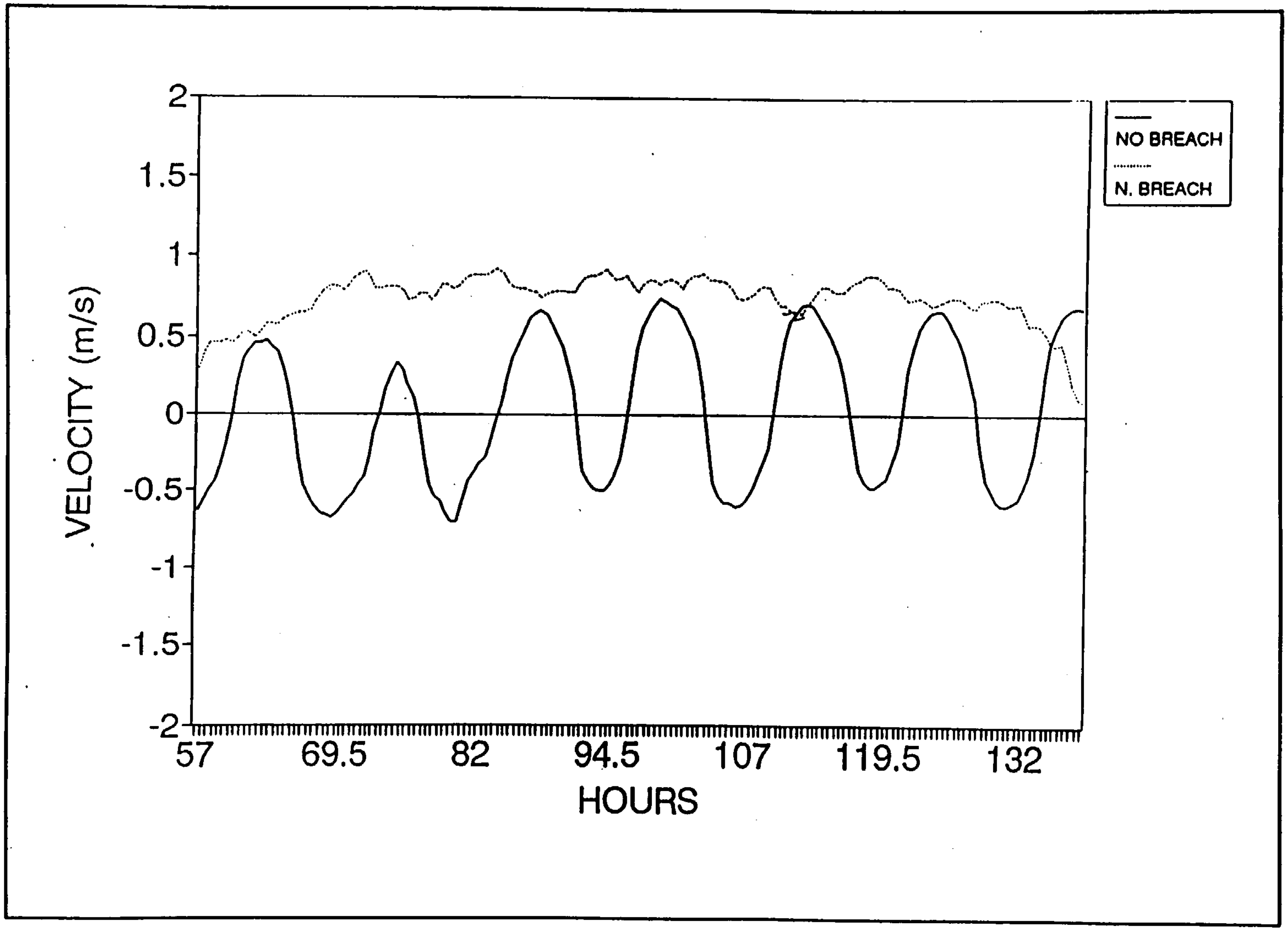


Figure A5-12. The simulated flow rate at node 54 for January, 1992 storm, northern breach

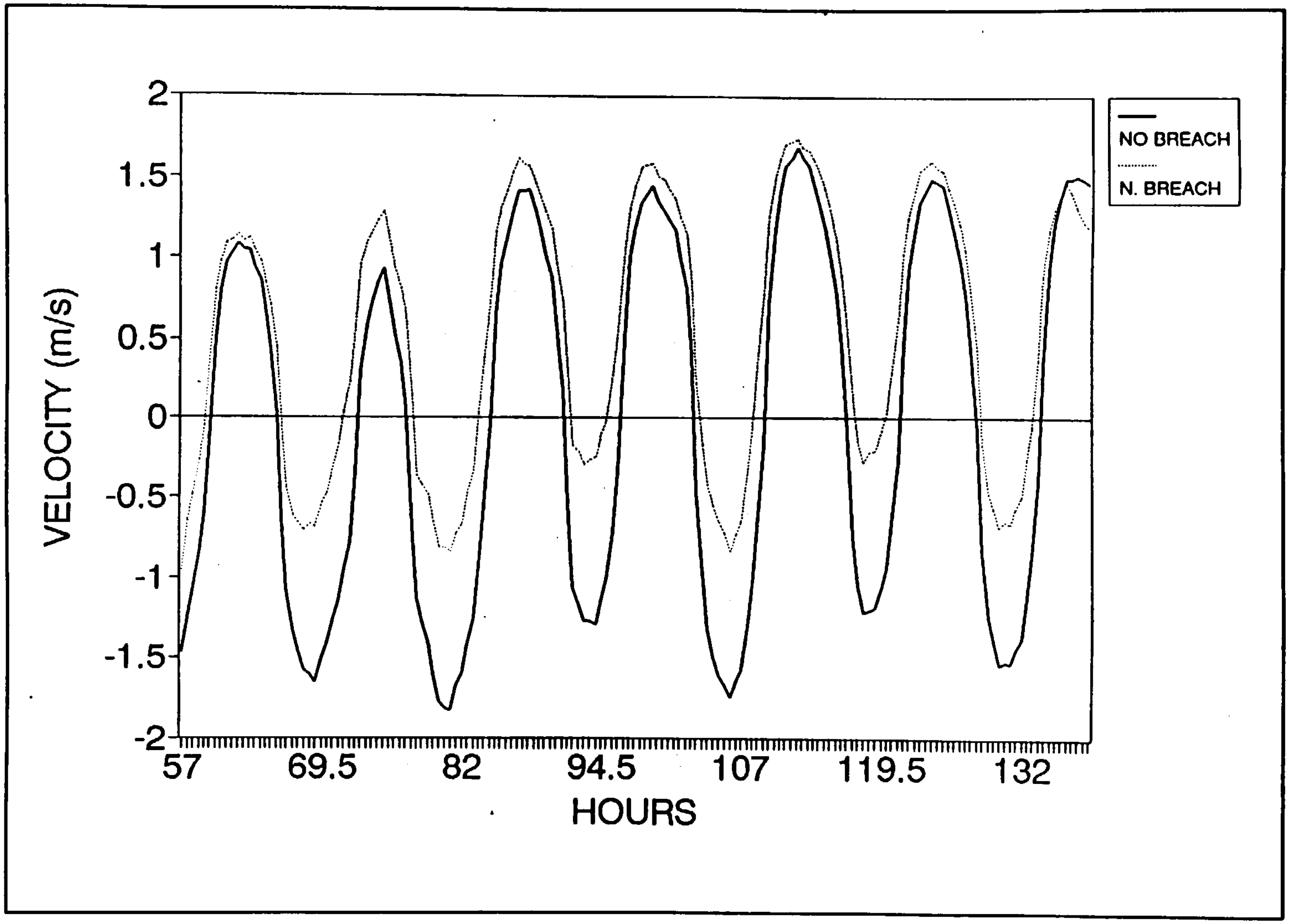


Figure A5-13. The simulated flow rate at node 64 for January, 1992 storm, northern breach

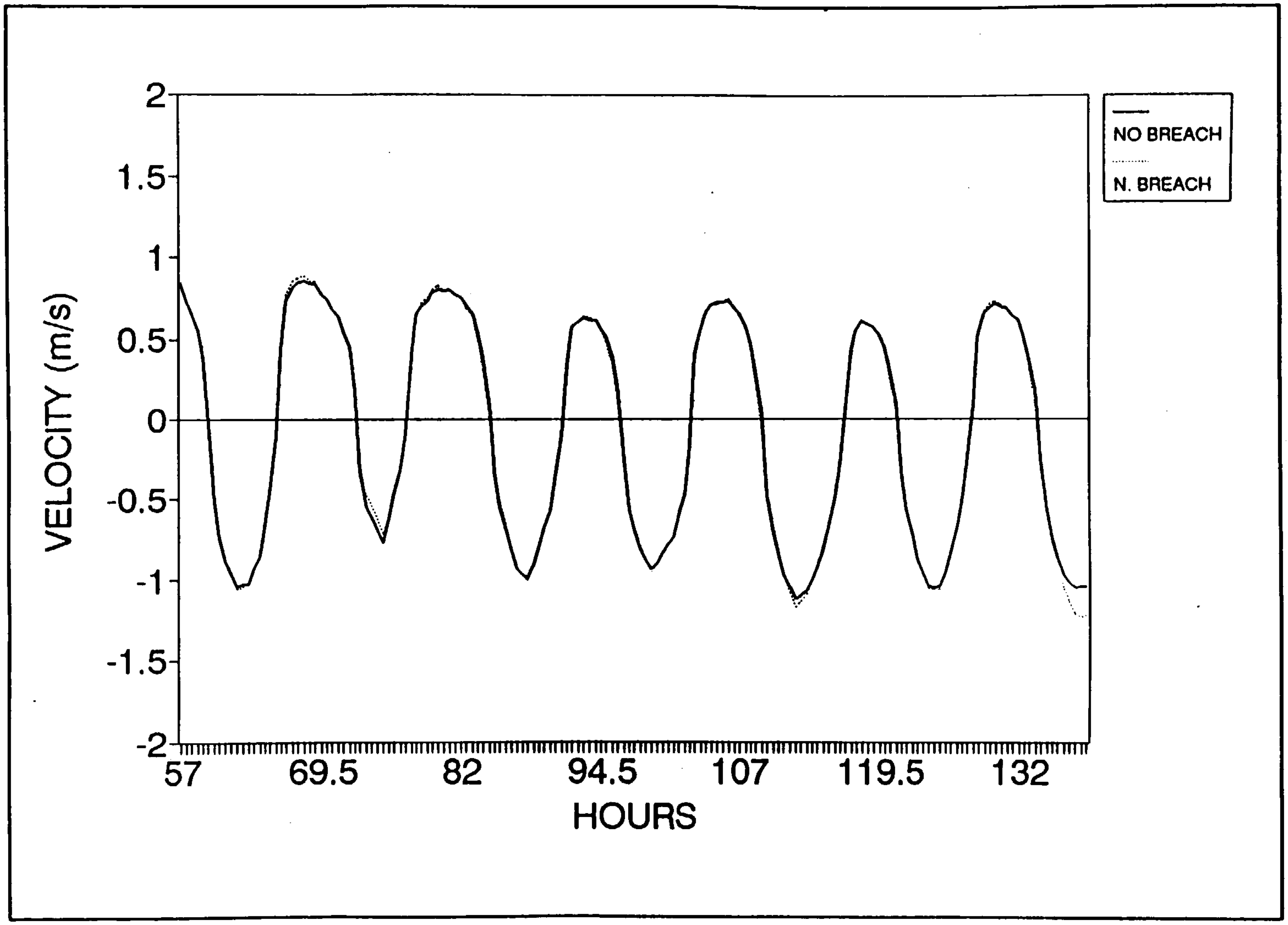


Figure A5-14. The simulated flow rate at node 67 for January, 1992 storm, northern breach

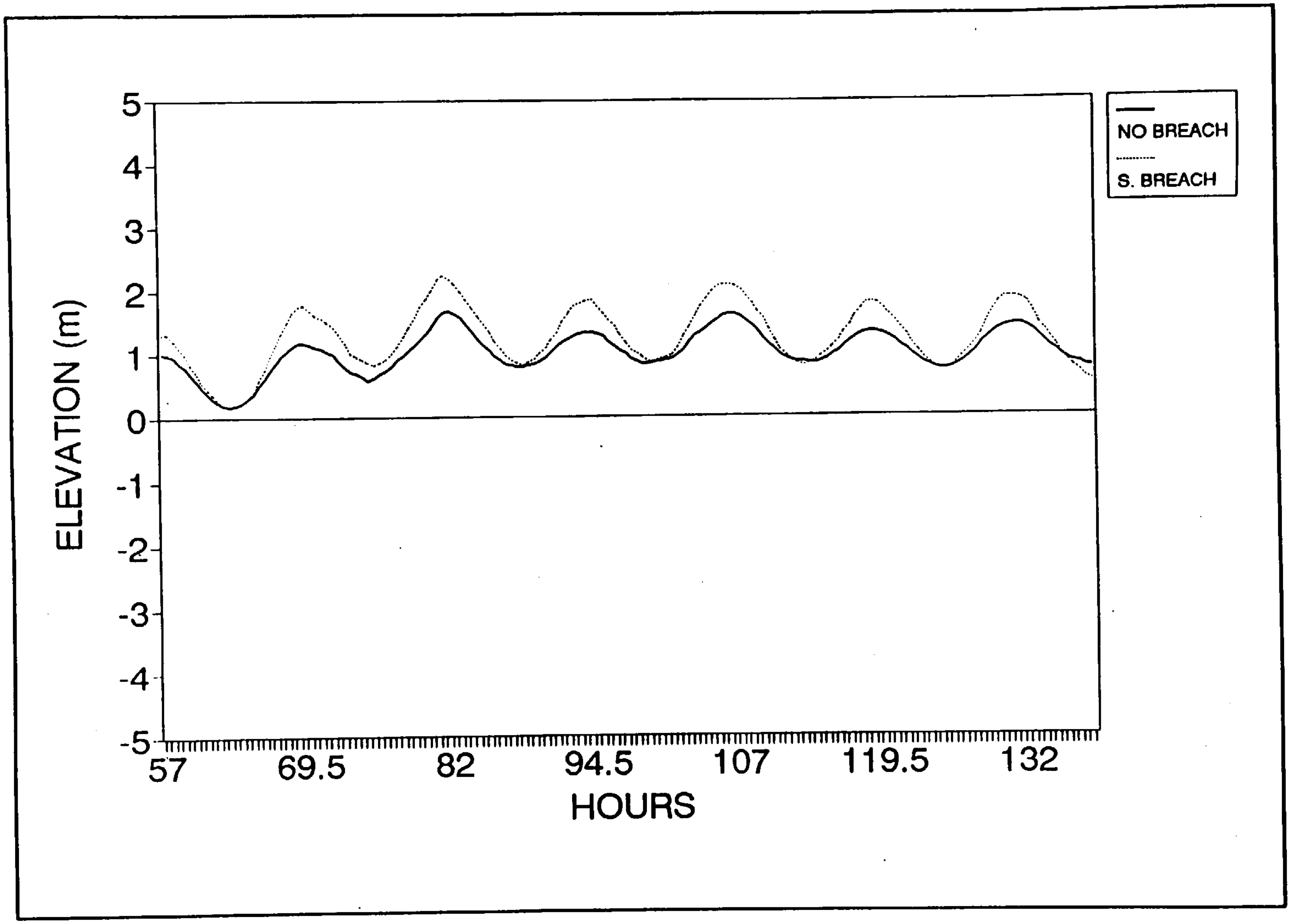


Figure A5-15. The simulated water elevation at node 54 for January, 1992 storm, southern breach

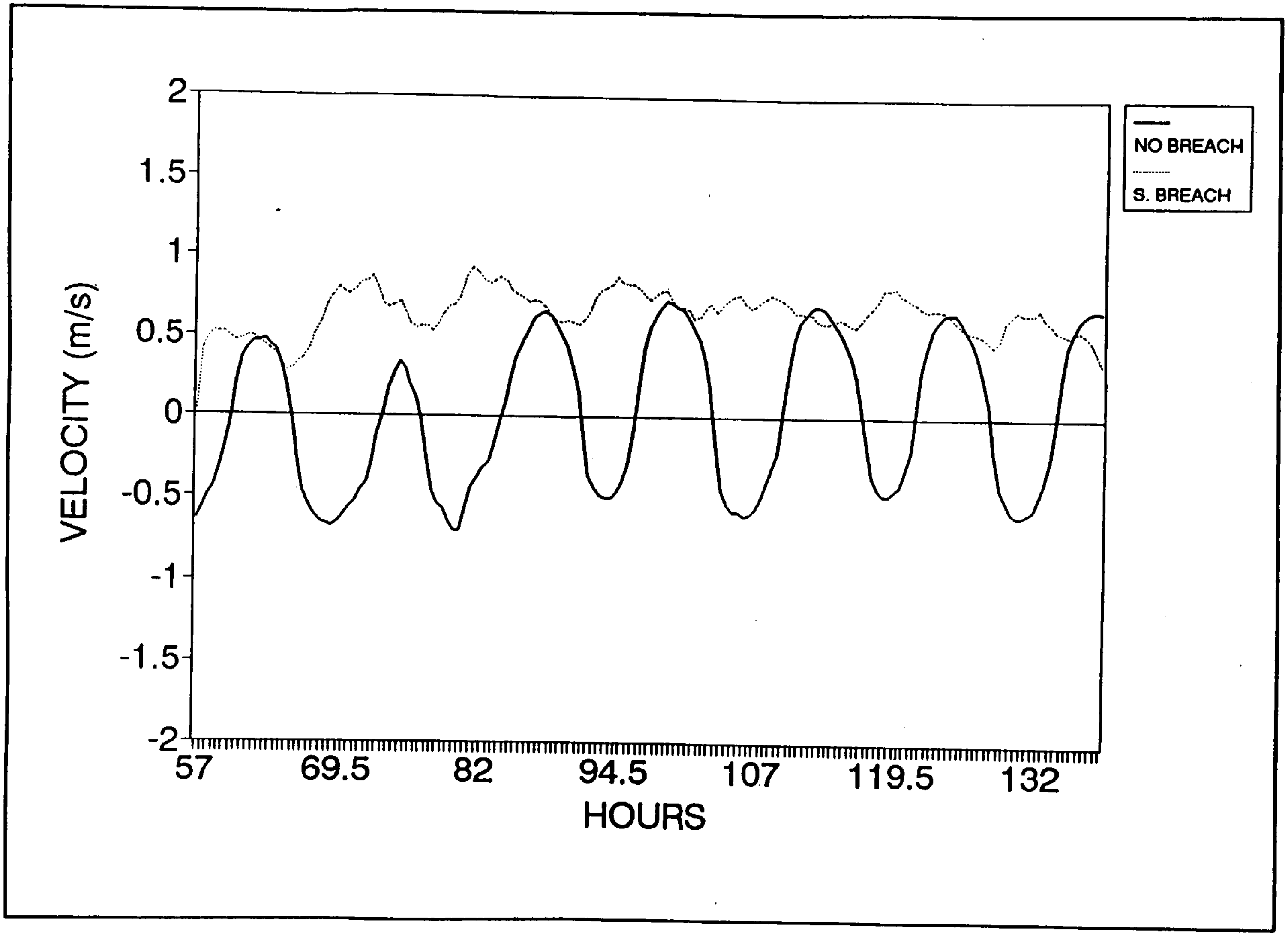


Figure A5-16. The simulated flow rate at node 54 for January, 1992 storm, southern breach

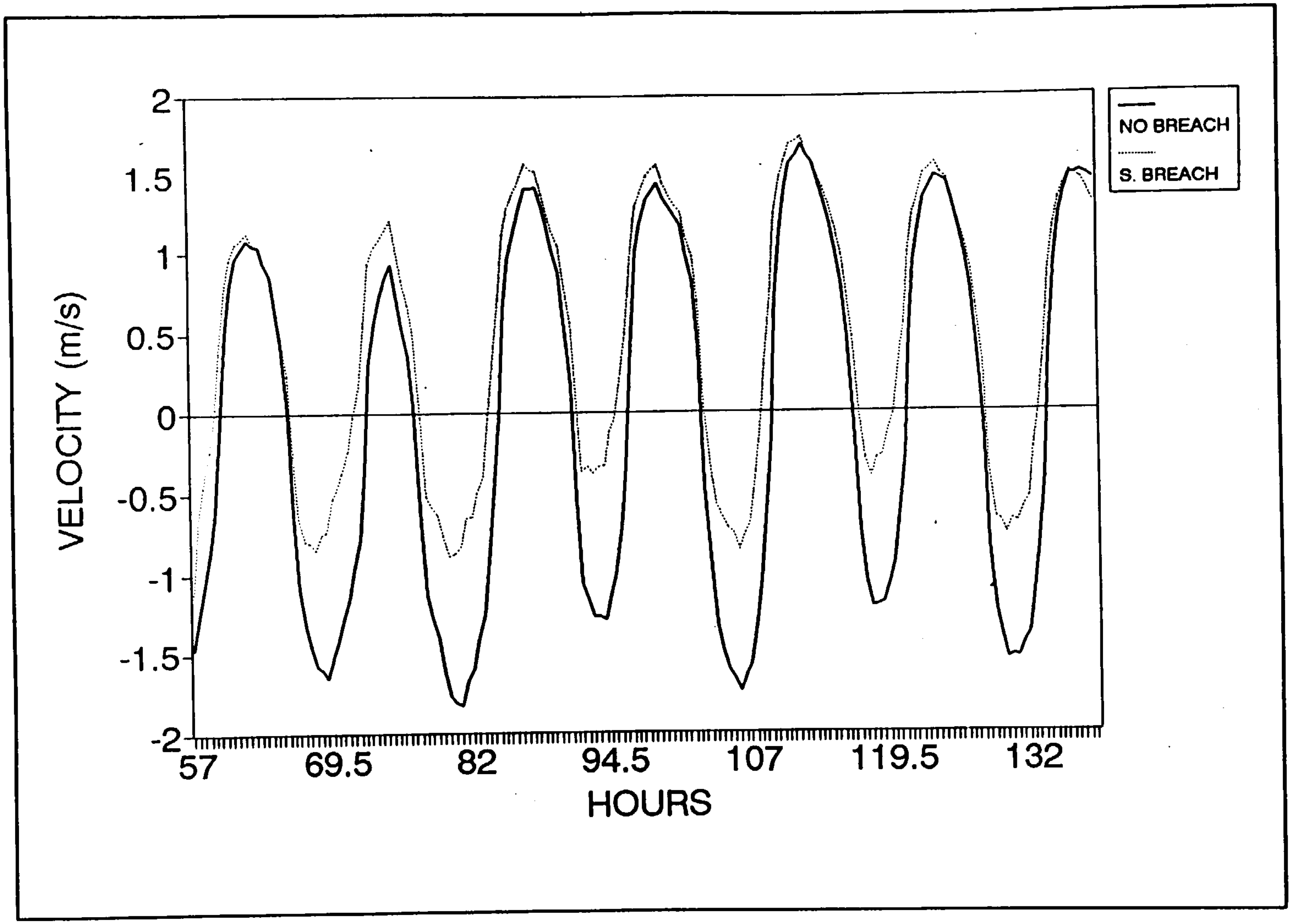


Figure A5-17. The simulated flow rate at node 64 for January, 1992 storm, southern breach

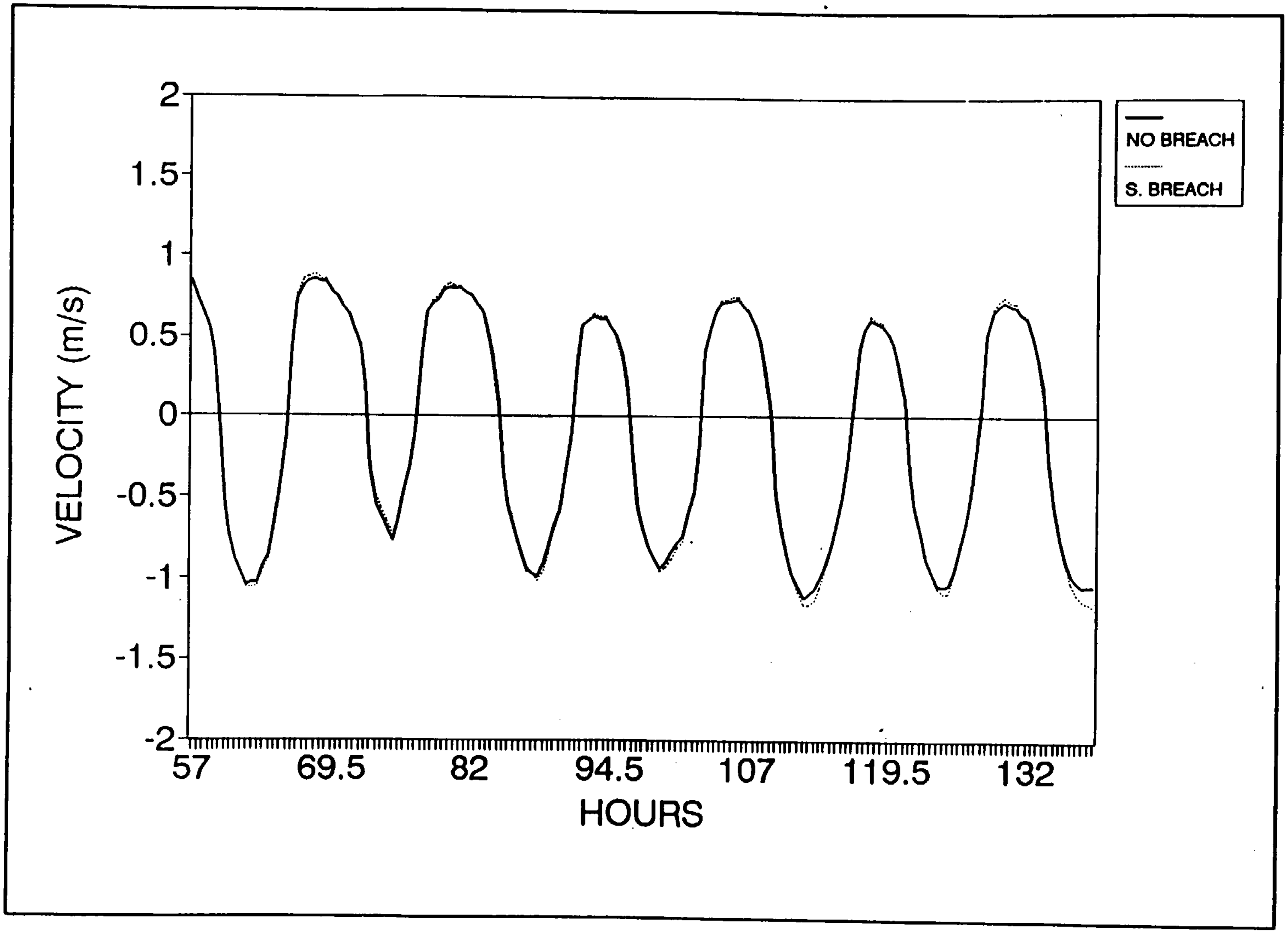


Figure A5-18. The simulated flow rate at node 67 for January, 1992 storm, southern breach

Table A5-1
Maximum wave and water level characteristics for infrequent storms

Date yr m d	Wave Hgt (m)	Wave Per (sec)	SWL (m)	SWL + Setup (m)	Run-up (m)
330914	3.8	11	1.7	2.5	3.3
440914	2.9	9	2.1	2.7	3.5
560316	2.3	6	1.3	1.8	2.7
560411	5.5	11	1.4	2.5	3.2
560925	3.9	10	1.6	2.6	3.1
600912	3.3	9	1.4	2.1	2.9
620305	5.9	17	2.2	2.7	3.8
621102	4.0	9	1.6	2.4	3.0
640112	5.2	13	1.6	2.7	3.4
710406	3.0	9	1.4	2.2	2.9
741201	3.4	13	1.2	2.1	2.8
760409	3.7	8	1.1	1.8	2.5
780206	3.3	10	1.3	1.9	2.9
811111	5.7	10	1.5	2.7	3.2
830211	3.5	9	1.5	2.3	3.1
850926	3.0	9	1.8	2.5	3.1
920102	4.1	17	2.0	2.8	3.7
921210	4.4	13	1.9	2.8	3.4

Table A5-2
Without Project. (meters/NGVD)

Storm	Node 40	Node 41	Node 46	Node 47	Node 48	Node 49	Node 54	Node 55
Jan64	0.73	0.82	0.91	0.96	1.04	1.09	1.21	1.33
Jan92	0.88	0.99	1.08	1.15	1.25	1.32	1.45	1.62
Feb78	0.59	0.61	0.69	0.74	0.82	0.88	0.99	1.09
Feb83	0.61	0.66	0.74	0.82	0.91	0.98	1.11	1.24
Mar56	0.68	0.67	0.73	0.77	0.85	0.90	1.00	1.11
Mar62	1.54	1.56	1.58	1.59	1.63	1.66	1.73	1.83
Apr56	0.54	0.56	0.62	0.70	0.81	0.87	0.98	1.13
Apr71	0.61	0.63	0.67	0.71	0.83	0.89	1.02	1.16
Apr76	0.55	0.59	0.64	0.67	0.73	0.75	0.85	0.94
Sep33	0.89	0.92	0.92	0.94	1.05	1.12	1.26	1.40
Sep44	0.75	0.88	1.03	1.12	1.25	1.37	1.53	1.69
Sep56	0.96	1.03	1.09	1.13	1.19	1.23	1.31	1.40
Sep60	0.66	0.71	0.78	0.84	0.92	0.98	1.10	1.22
Sep85	0.72	0.80	0.92	1.01	1.12	1.20	1.36	1.52
Nov62	0.95	0.97	1.00	1.02	1.05	1.07	1.19	1.32
Nov81	0.87	0.98	1.04	1.08	1.12	1.16	1.23	1.31
Dec74	0.52	0.53	0.59	0.66	0.76	0.82	0.94	1.06
Dec92	1.39	1.55	1.57	1.59	1.62	1.65	1.68	1.71

Table A5-3
With Project. (meters/NGVD)

Storm	Node 40	Node 41	Node 46	Node 47	Node 48	Node 49	Node 54	Node 55
Jan64	0.70	0.74	0.82	0.89	0.99	1.05	1.19	1.32
Jan92	0.75	0.82	0.93	1.02	1.16	1.25	1.41	1.60
Feb78	0.59	0.61	0.69	0.74	0.82	0.88	0.99	1.09
Feb83	0.61	0.66	0.74	0.82	0.91	0.98	1.11	1.24
Mar56	0.68	0.67	0.73	0.77	0.85	0.90	1.00	1.11
Mar62	1.52	1.49	1.50	1.51	1.55	1.59	1.69	1.81
Apr56	0.54	0.56	0.62	0.70	0.81	0.87	0.98	1.13
Apr71	0.61	0.63	0.67	0.71	0.83	0.89	1.02	1.16
Apr76	0.55	0.59	0.64	0.67	0.73	0.75	0.85	0.94
Sep33	0.89	0.91	0.92	0.94	1.04	1.11	1.25	1.40
Sep44	0.60	0.69	0.86	0.99	1.15	1.25	1.46	1.67
Sep56	0.93	0.98	1.05	1.09	1.16	1.20	1.29	1.40
Sep60	0.66	0.71	0.78	0.84	0.92	0.98	1.10	1.22
Sep85	0.70	0.78	0.90	0.99	1.11	1.20	1.36	1.52
Nov62	0.95	0.97	1.00	1.02	1.05	1.07	1.19	1.32
Nov81	0.83	0.82	0.87	0.92	1.00	1.05	1.16	1.28
Dec74	0.52	0.53	0.59	0.66	0.76	0.82	0.94	1.06
Dec92	1.30	1.29	1.32	1.35	1.41	1.46	1.56	1.68

Table A5-4
Difference Between With Project and Without Project Conditions. (meters/NGVD)

Storm	Node 40	Node 41	Node 46	Node 47	Node 48	Node 49	Node 54	Node 55
Jan64	.03	.08	.09	.07	.05	.04	.02	.01
Jan92	.13	.17	.15	.13	.09	.07	.04	.02
Feb78	0	0	0	0	0	0	0	0
Feb83	0	0	0	0	0	0	0	0
Mar56	0	0	0	0	0	0	0	0
Mar62	.02	.07	.08	.08	.08	.07	.04	.02
Apr56	0	0	0	0	0	0	0	0
Apr71	0	0	0	0	0	0	0	0
Apr76	0	0	0	0	0	0	0	0
Sep33	0	.01	0	0	.01	.01	.01	0
Sep44	.15	.19	.17	.13	.1	.12	.07	.02
Sep56	.03	.05	.04	.04	.03	.03	.02	0
Sep60	0	0	0	0	0	0	0	0
Sep85	.02	.02	.02	.02	.01	0	0	0
Nov62	0	0	0	0	0	0	0	0
Nov81	.04	.16	.17	.16	.12	.11	.07	.03
Dec74	0	0	0	0	0	0	0	0
Dec92	.09	.26	.25	.24	.21	.19	.12	.03

Table A5-5
North Breach. (meters/NGVD)

Storm	Node 40	Node 41	Node 46	Node 47	Node 48	Node 49	Node 54	Node 55
Jan64	1.34	1.54	1.69	1.80	1.98	2.11	1.93	1.58
Jan92	1.43	1.62	1.77	1.87	2.04	2.19	2.09	1.92
Feb78	0.83	0.95	1.10	1.22	1.38	1.48	1.39	1.24
Feb83	1.06	1.22	1.39	1.52	1.71	1.86	1.72	1.47
Mar56	0.88	1.00	1.13	1.24	1.41	1.52	1.42	1.28
Mar62	1.82	1.95	2.02	2.07	2.16	2.24	2.18	2.07
Apr56	1.00	1.15	1.35	1.49	1.73	1.89	1.71	1.39
Apr71	0.89	1.03	1.23	1.38	1.63	1.79	1.64	1.39
Apr76	0.80	0.92	1.06	1.16	1.31	1.41	1.29	1.10
Sep33	1.18	1.36	1.51	1.64	1.83	1.97	1.85	1.64
Sep44	1.24	1.42	1.62	1.78	2.05	2.24	2.16	2.00
Sep56	1.39	1.55	1.68	1.79	1.97	2.09	1.93	1.60
Sep60	0.95	1.08	1.24	1.38	1.57	1.69	1.59	1.41
Sep85	1.16	1.33	1.51	1.68	1.91	2.06	1.97	1.79
Nov62	1.22	1.35	1.51	1.63	1.83	1.96	1.82	1.55
Nov81	1.48	1.68	1.81	1.90	2.05	2.18	1.97	1.52
Dec74	0.93	1.07	1.21	1.34	1.54	1.67	1.52	1.25
Dec92	1.82	2.04	2.11	2.16	2.25	2.33	2.18	1.90

Table A5-6
South Breach. (meters/NGVD)

Storm	Node 40	Node 41	Node 46	Node 47	Node 48	Node 49	Node 54	Node 55
Jan64	2.04	2.30	2.25	2.21	2.12	2.05	1.89	1.57
Jan92	2.11	2.36	2.33	2.31	2.25	2.21	2.11	1.92
Feb78	1.37	1.57	1.53	1.51	1.46	1.43	1.35	1.24
Feb83	1.80	2.03	2.00	1.97	1.90	1.85	1.72	1.46
Mar56	1.40	1.62	1.58	1.55	1.51	1.48	1.39	1.27
Mar62	2.12	2.36	2.32	2.30	2.26	2.23	2.18	2.07
Apr56	1.83	2.02	2.01	1.97	1.89	1.82	1.63	1.37
Apr71	1.73	1.91	1.88	1.86	1.80	1.75	1.60	1.37
Apr76	1.33	1.51	1.47	1.45	1.39	1.34	1.23	1.09
Sep33	1.93	2.16	2.13	2.10	2.03	1.98	1.86	1.64
Sep44	2.16	2.42	2.40	2.38	2.33	2.30	2.20	2.01
Sep56	2.03	2.27	2.23	2.19	2.11	2.05	1.90	1.60
Sep60	1.56	1.81	1.76	1.73	1.67	1.63	1.55	1.40
Sep85	1.98	2.23	2.19	2.16	2.11	2.06	1.97	1.79
Nov62	1.88	2.13	2.08	2.03	1.97	1.92	1.78	1.55
Nov81	2.12	2.39	2.33	2.30	2.20	2.14	1.94	1.52
Dec74	1.60	1.81	1.76	1.73	1.66	1.60	1.45	1.24
Dec92	2.23	2.51	2.50	2.48	2.43	2.40	2.24	1.89

Table A5-7
Breach Sensitivity. (meters/NGVD)

North Breach		Node	Node	Node	Node	Node	Node	Node	Node
Width	Depth	40	41	46	47	48	49	54	55
250	1.07	1.31	1.49	1.65	1.74	1.87	1.95	1.93	1.87
	1.52	1.33	1.51	1.67	1.76	1.89	1.97	1.95	1.88
570	1.07	1.53	1.74	1.92	2.02	2.16	2.25	2.19	1.95
	1.52	1.54	1.75	1.92	2.01	2.16	2.26	2.19	1.96
750	1.07	1.56	1.78	1.95	2.04	2.19	2.29	2.22	1.97
	1.52	1.56	1.77	1.94	2.04	2.18	2.28	2.21	1.96
1000	1.07	1.58	1.80	1.97	2.07	2.21	2.31	2.24	1.97
	1.52	1.59	1.80	1.97	2.07	2.22	2.31	2.24	1.97
South Breach		**Node**	**Node**	**Node**	**Node**	**Node**	**Node**	**Node**	**Node**
Width	Depth	40	41	46	47	48	49	54	55
250	1.07	1.70	1.92	1.91	1.90	1.89	1.88	1.86	1.82
	1.52	1.72	1.95	1.93	1.92	1.91	1.90	1.88	1.84
570	1.07	1.99	2.24	2.21	2.18	2.14	2.12	2.07	1.91
	1.52	2.02	2.26	2.23	2.21	2.17	2.14	2.09	1.91
750	1.07	2.07	2.33	2.30	2.27	2.23	2.20	2.14	1.93
	1.52	2.08	2.33	2.30	2.28	2.24	2.22	2.16	1.93
1000	1.07	2.10	2.36	2.33	2.31	2.27	2.24	2.18	1.94
	1.52	2.10	2.35	2.32	2.30	2.26	2.24	2.17	1.94

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APPENDIX B

GEOTECHNICAL DESIGN ANALYSIS

APPENDIX B

Geotechnical Design Analysis

1. Purpose and Scope: The purpose of this study is to identify, from a geotechnical standpoint, the most appropriate source of beachfill material to utilize for the restoration of Assateague Island. The study includes an assessment of the properties of the native beach sand, and potential borrow sources for obtaining the material. Economic, environmental, and other appropriate criteria were taken into consideration in the selection process. This study was prepared in the District's Dams and Embankments Section, Geotechnical and Water Resources Branch (CENAB-EN-GD) by James R. Snyder P.E. under the supervision of Mr. O. Davis Ditman.

2. Beach Sampling and Analysis: The determination of a "composite" gradation to represent the native beach material was based on gradation data obtained from grab samples taken in November 1995. The beach samples consisted of separate samples for 13 profiles taken at the dune base, mean high water, mid tide, mean low water, in the trough, on the bar crest, and at the -3.05 and -6.10 meter (-10 and -20 foot) elevations. Composite gradations and design parameters were calculated for various combinations of the existing beachfill. The resulting mean phi values are presented in Section B-1. A composite gradation representing samples from the mean high water, mid tide, and mean low water locations was selected to represent the "native beach" material for determining the suitability of borrow sources. This selection is considered consistent with the methodology presented in Coastal Engineering Technical Note II-29, *"Native Beach Assessment Techniques for Beach Fill Design"*. As shown in Section B-1, a mean phi (ϕ_m) value of 1.62 (0.33 mm) and a standard deviation (σ_ϕ) of 0.80 phi have been selected to represent the native material in the analysis.

3. Borrow Area Analysis:

3.1 General: Only offshore areas have been considered in this study. It has been assumed that the expense of trucking material from a land based borrow and the potential disruption of the environmentally sensitive island by truck haul operations would make offshore dredging the only viable alternative. Numerous offshore shoals could be considered as potential sources for obtaining beach fill material. Several known offshore sources were eliminated from consideration for various reasons. Borrow Area 9, located about 5.6 kilometers (3.5 miles) offshore from the northern end of Ocean City, MD, has a significant quantity of material available. However, this area has previously been used and is proposed for future use for nourishment of the Ocean City beach, and may not be available for use on Assateague. The distance from the placement site would also be a significant cost factor. Borrow Area 1 (ebb tidal shoal) is located off the northern end of Assateague Island. Previous studies have shown the sand to likely be too fine grained, with mean phi values in the 1.8 to 2.0 range. Sand from the back bay areas west of Ocean City is also considered to be too fine for use as beachfill.

3.2 Potential Borrow Areas: Four shoal areas were selected for consideration as borrow sources for the project. Criteria used for the selection included: proximity to the project area; and potential for producing an adequate quantity of sand with an appropriate grain size distribution. A report published by the Maryland Geological Survey entitled *Potential Offshore Sand Resources in Central Maryland Shoal Fields* (September 1994, by Robert D. Conkwright and Rebecca A. Gast) was utilized in the initial screening. The areas selected included Little Gull Bank and Great Gull Bank shoals, which are relatively close to shore; and shoals designated as B & C, which are further off shore, but, according to the aforementioned MGS report, had a higher potential for producing adequate quantities of quality beachfill sand. The location of the shoals is presented on Figure 1-2 in the main report.

3.3 Borrow Exploration: Vibracore drilling in the four proposed borrow areas was performed during October and November 1995 by Ocean Surveys Inc., under contract to the Baltimore District. Thirty-five holes were accomplished at spacings of approximately 914 meters (3000 feet). The hole locations are shown on the fold-out plates in Sections B-2, B-3, and B-4. The vibracoring was accomplished utilizing an OSI Model 1500 Vibracore with the characteristics indicated in the notes to the logs. Refusal was defined in the field when the penetration rate was less than 0.3048 meters (1 foot) in 3 minutes. The purpose of the drilling was to determine the general characteristics of the proposed borrow areas, and to determine their suitability for use as a beachfill material source. Additional drilling will be accomplished in the selected area during the plans and specifications stage, to more accurately define the horizontal and vertical limits of suitable material.

3.4 Sample Preparation and Testing: Vibracore samples were cut into 1.524 meter (5-foot) maximum lengths and sealed by the drilling contractor prior to delivery to the District Soils Laboratory at Fort McHenry. Samples were contained in 8.38 cm (3.3 inch) diameter clear Lexan tubing (core liner). Samples were cut in half longitudinally in the lab and visually examined by a geotechnical engineer. Trench samples were obtained along the axis of one half of the core for each visually distinctive material in the core. The remaining half of each core was placed in a plastic sleeve, sealed, labeled, and archived by the Maryland Geologic Survey. Mechanical analyses were performed on each selected sample utilizing screens corresponding to the Wentworth size designations. Final drill logs are presented in Section B-5.

3.5 Analysis of Data: The proposed borrow areas were divided into sub-areas for analysis based on general mean grain size differences. These sub-areas are shown on the fold-out plates in Sections B-2, B-3, and B-4. Additional adjustments in the areas were subsequently made to eliminate from consideration areas defined as "fish havens" as indicated on the revised plates shown in Sections B-2(a), B-3(a), and B-4(a). Composite gradations representing each sub-area or combinations of sub-areas were calculated for various slice elevations, both cumulatively from the surface and for individual vertical (generally 1.524 meter (5-foot)) increments. In calculating the composites, all samples were weighted in direct proportion to the length represented by each sample falling within the vertical increment being studied. Where the total length of a gradation sample lay only partially within the study increment, only the length within the increment was considered as the weighting factor. Since the spacing of the drilling was relatively uniform, no areal weighting factor was applied. All calculations, including determinations of composite gradations, and mean and standard deviation values, were performed utilizing a program written by Thomas Ressin, CENAB-EN-G. The data base for the program includes gradation data (percent passing on designated Wentworth sieves) labeled as to hole number, sample number, and elevation limits for each sample. Equation 4-3 from the Shore Protection Manual [$M_{\varnothing} = (\varnothing_{16} + \varnothing_{50} + \varnothing_{84}) / 3$] was used for calculation of the mean diameter of the material for use in the analysis. Input for each calculation run includes holes to be considered in the study field and elevation limits of the vertical slice to be considered. Results of the analysis are presented in Sections B-2, B-3, and B-4 in the tables showing Mean Phi values (ϕ_m) and Standard Deviations (σ_ϕ) for the various areas and vertical increments. Selected gradation curves depicting "typical" composite gradations are also presented in the aforementioned sections.

4. Determination of Overfill and Renourishment Factors: The method presented in Section III of Chapter 5 in the Shore Protection Manual was used to calculate the anticipated overfill factor (Ra) and the renourishment factor (Rj) for the proposed borrow areas and sub-areas. The Automated Coastal Engineering System (ACES) program was used to perform the calculations. The results, including estimated quantities of available beach fill material, are presented in Sections B-2, B-3, and B-4.

5. Summary and Conclusions: Sand material suitable for restoring the beach on Assateague Island can be obtained from portions of Shoal B, Great Gull Bank, and Little Gull Bank. A significant quantity of material from each of these areas has a grain size distribution such that an overfill factor of 1.0 would be realized. Only the design beach fill template quantity would therefore have to be dredged and placed if any of these areas are used. Approximately 36,700,000 cubic meters (48,000,000 cubic yards) are available from Shoal B, with lesser amounts available from Great Gull and Little Gull Banks. The renourishment factors calculated for these areas is less than 1.0, indicating that the beach retreat rate would be less than the existing rate. Theoretically, after the first renourishment cycle, renourishment would be required less often than the calculated retreat rate would indicate. Material from Shoal C has been determined to be too fine for consideration as beach fill.

6. Recommendations: The initial restoration contract will require placement of approximately 1,400,000 cubic meters (1,830,000 cubic yards) of sand. Since this material is available from either Little Gull Bank or Great Gull Bank, these areas are recommended as the initial source of material. Shoal B is significantly further from shore and would be less cost effective to use. Sub area I of Great Gull Bank has been selected for use. The material from this area more closely matches the gradation of the native material than does that from Little Gull Bank. Also, Great Gull Bank is slightly further offshore than Little Gull Bank, and its mining would have minimal influence on shore erosion. (see Appendix A) Final design level drilling (vibracoring) will be accomplished in this area with hole spacings at approximately 300 meter (1000 foot) intervals during the plans and specifications stage.

SECTION B-1

NATIVE BEACH ANALYSIS

OCWR Assateague Island Mean phi values - native beach

*(phi50)

	001	002	003	004	005	006	007	008	COMPOSITE	
Profile	**Dune Base**	**MHW**	**Mid Tide**	**MLW**	**Trough**	**Bar Crest**	**EL-10**	**EL-20**	**mean phi**	**std dev**
675	1.62	2.05	1.96	-0.01	2.06	2.72	1.81	4.18	2.08	1.03
625	1.88	1.90	1.71	1.37	1.45	1.94	2.97	2.33	1.95	0.83
575	1.87	1.75	1.92	1.65	2.31	1.58	2.30	3.37	2.18	0.81
525	0.85	1.54	1.91	0.37	0.56	1.89	5.54	*5.90	1.95	2.03
475	2.07	2.03	1.80	0.87	2.46	2.65	3.32	3.27	2.43	0.89
425	1.79	1.37	1.73	1.89	2.45	2.49	*6.45	*7.35	2.31	0.95
375	1.93	2.05	1.51	2.12	1.22	1.20	*4.64	1.69	1.89	0.89
325	2.02	1.55	1.58	1.41	2.45	2.55	2.02	2.11	2.01	0.76
275	1.61	1.80	1.08	1.71	2.09	2.36	2.80	2.83	2.04	0.88
225	1.64	1.77	0.89	1.46	2.41	2.32	*7.28	2.57	2.17	1.11
175	1.41	1.67	1.64	-0.47	1.64	1.92	2.49	1.69	1.68	0.85
125	1.77	1.85	1.92	1.33	1.50	1.51	2.48	2.56	1.86	0.78
50	1.61	1.65	2.11	1.54	1.80	2.23	1.94	2.71	1.97	0.78
mean phi	1.76	1.77	1.72	1.15	2.01	2.18	2.50	2.79	2.03	
std dev	0.63	0.60	0.65	1.45	0.82	0.70	0.57	1.07		0.91

mean phi **1.62** (Staub̈le & Hoel)

std dev **0.80**

mean phi 1.80

std dev 0.81

mean phi 1.80

std dev 0.75

mean phi 1.77

std dev 0.77

MHW+Mid Tide+MLW

Holes used:

05002	05003	05004	12502	12503	12504	17502	17503	17504
22502	22503	22504	27502	27503	27504	32502	32503	32504
37502	37503	37504	42502	42503	42504	47502	47503	47504
52502	52503	52504	57502	57503	57504	62502	62503	62504
67502	67503	67504						

Analysis from 0.0 to -1.0
Total core length in samples: 39

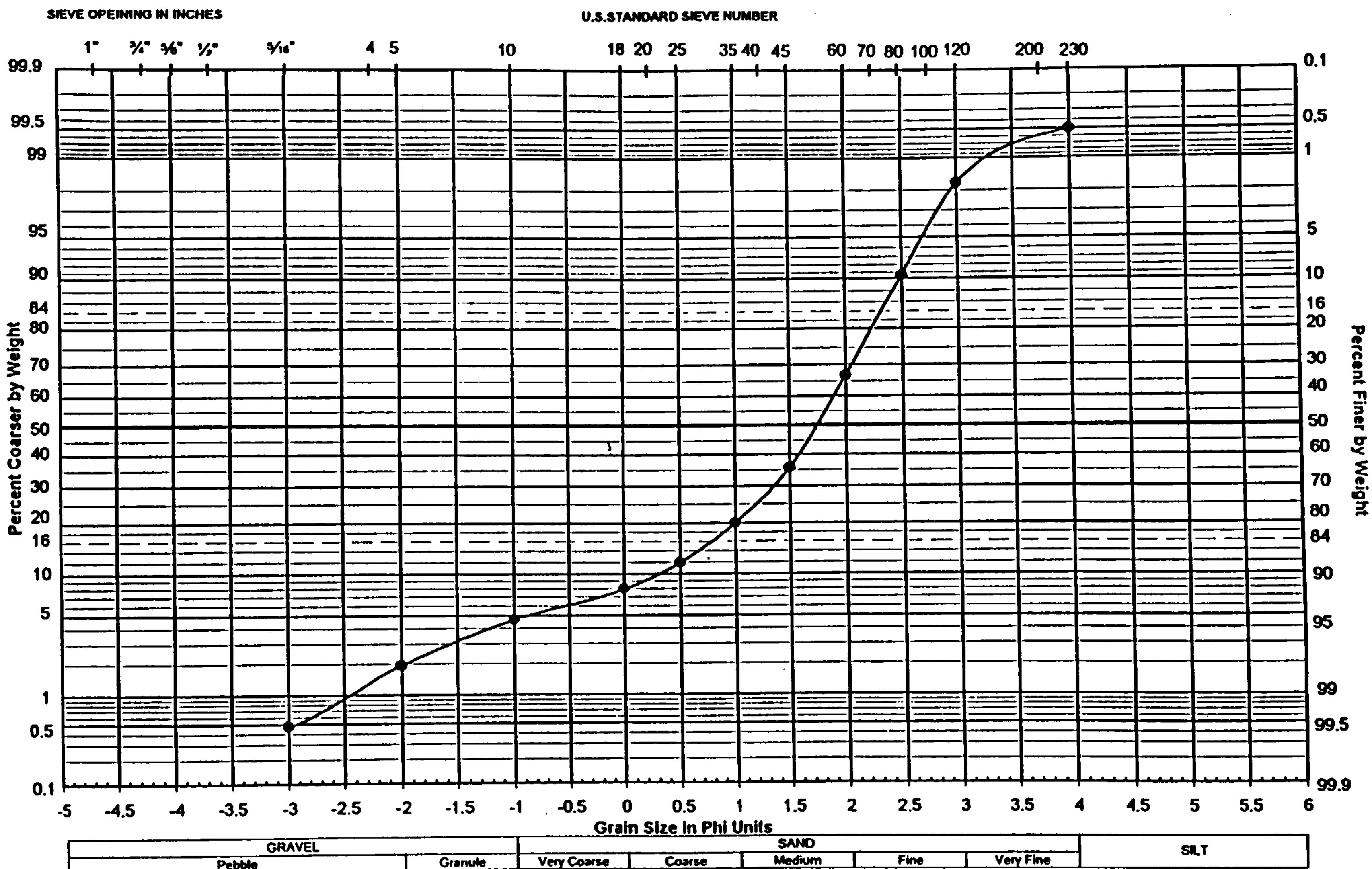
Computed Gradations

Phi Sieve Size:	-3.00	-2.00	-1.00	+0.00	+0.50	+1.00	+1.50	+2.00
Percent Finer:	99.53	98.10	95.38	92.16	88.29	80.12	64.40	33.51

Phi Sieve Size:	+2.50	+3.00	+4.00
Percent Finer:	9.63	1.75	0.51

Phi 16 = 0.76
Phi 50 = 1.73
Phi 84 = 2.37

Mean = 1.62 Phi, 0.33 mm
Standard Deviation = 0.80 Phi



Wentworth Classification System

ϕ_{16} = 0.81 ϕ_{50} = 1.75 ϕ_{84} = 2.32	M_ϕ = 1.63 σ_ϕ = 0.76
NAD FORM 798	$M_\phi = (\phi_{16}+\phi_{50}+\phi_{84})/3$ $\sigma_\phi = (\phi_{84} - \phi_{16})/2$

Ocean City Water Resources - Existing Beachfill Composite
Worcester County, MD

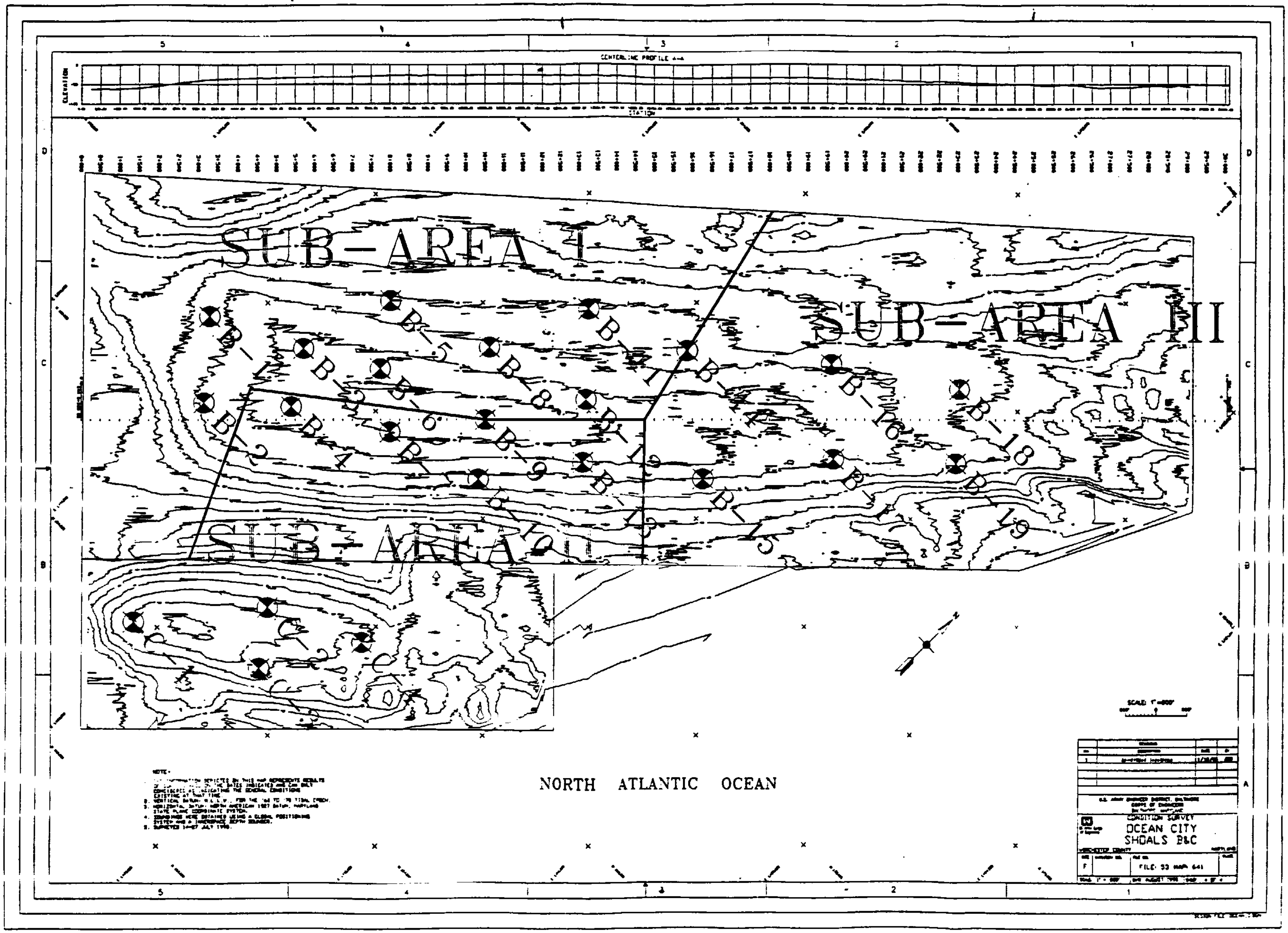
Location:	Hole No.:	Sample No.:	Depth (ft):
Assateague Island	All	MHW+MidTide+MLW	

U.S. Army Corps of Engineers
Baltimore District
Soils Laboratory

DATE: Aug. 1996

SECTION B-2

SHOALS B and C


CENTERLINE PROFILE A-A
ELEVATION
STATION
SUB-AREA I
SUB-AREA II
SUB-AREA III
B-1
B-2
B-3
B-4
B-5
B-6
B-7
B-8
B-9
B-10
B-11
B-12
B-13
B-14
B-15
B-16
B-17
B-18
B-19
C-1
C-2
C-3
NORTH ATLANTIC OCEAN
NOTE:
CONDITION SURVEY
OCEAN CITY
SHOALS B&C
FILE: 33 MAP 641

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal B

QUANTITIES

Depth Interval NGVD>>>> / Area	Quantities in 1000 Cubic Yards	-28.5 to -30	-28.5 to -35	-28.5 to -40	-28.5 to -45	-28.5 to -50	-28.5 to -55	-28.5 to -60	-30 to -35	-35 to -40	-40 to -45	-45 to -50	-50 to -55	-55 to -60
I	Borrow	84	1,480	4,973	11,105	19,902	31,323	45,813	1,396	3,493	6,132	8,797	11,421	14,490
	Net Beachfill	*84*	1,480	4,973	11,105	19,902	31,323	45,813	1,396	3,493	6,132	8,797	11,421	*14,490*
II	Borrow	152	1,597	4,278	7,909	12,246	17,182	22,779	1,445	2,681	3,631	4,337	4,936	5,597
	Net Beachfill	*152*	1,597	4,265	7,716	11,843	16,812	22,267	1,445	2,634	2,772	3,788	4,537	*104*
III	Borrow	0	407	2,520	7,344	15,560	27,089	41,923	407	2,113	4,824	8,216	11,529	14,834
	Net Beachfill		no data		5,100	10,585	18,554	29,733	no data		3,350	5,300	8,006	*10,749*
I+II	Borrow	236	3,077	9,251	19,014	32,148	48,505	68,592	2,841	6,174	9,763	13,134	16,357	20,087
	Net Beachfill	*236*	3,077	9,251	19,014	32,148	48,505	68,592	2,841	6,174	9,763	13,134	16,357	*19,693*
Total Area	Borrow	236	3,484	11,771	26,358	47,708	75,594	110,515	3,248	8,287	14,587	21,350	27,886	34,921
	*Net Beachfill	*236*	*3,484*	*11,771*	*26,358*	*47,708*	*75,594*	*110,515*	*3,248*	*8,287*	*14,587*	*21,350*	*27,886*	*34,727*

* Caution - Sub-Area III data under-represented in total

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal B

Mean PHI Value

Depth Interval NGVD>>>> / Area	-28.5 to -30	-28.5 to -35	-28.5 to -40	-28.5 to -45	-28.5 to -50	-28.5 to -55	-28.5 to -60	-30 to -35	-35 to -40	-40 to -45	-45 to -50	-50 to -55	-55 to -60
I	*1.00*	1.03	1.04	0.96	0.88	0.86	0.87	1.04	1.05	0.87	0.78	0.78	*1.04*
II	*1.00*	1.17	1.28	1.37	1.40	1.44	1.48	1.20	1.34	1.57	1.56	1.69	*2.15*
III				1.49	1.53	1.57	1.58			1.49	1.58	1.63	*1.68*
I+II	*1.00*	1.08	1.16	1.18	1.15	1.13	1.15	1.09	1.19	1.20	1.04	1.05	*1.44*
Total Area	*1.00*	1.08	1.16	1.22	1.24	1.25	1.27	1.09	1.19	1.28	1.26	1.33	*1.55*

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal B

Standard Deviation (PHI)

Depth Interval NGVD>>>> / Area	-28.5 to -30	-28.5 to -35	-28.5 to -40	-28.5 to -45	-28.5 to -50	-28.5 to -55	-28.5 to -60	-30 to -35	-35 to -40	-40 to -45	-45 to -50	-50 to -55	-55 to -60
I	*0.44*	0.53	0.57	0.60	0.64	0.66	0.68	0.56	0.58	0.62	0.69	0.73	*0.82*
II	*0.44*	0.50	0.54	0.55	0.56	0.61	0.64	0.51	0.54	0.54	0.60	0.83	*0.56*
III				0.45	0.47	0.50	0.52			0.45	0.49	0.55	*0.61*
I+II	*0.44*	0.51	0.58	0.63	0.66	0.71	0.72	0.53	0.60	0.68	0.79	0.93	*0.93*
Total Area	*0.44*	0.51	0.58	0.63	0.67	0.69	0.71	0.53	0.60	0.65	0.72	0.81	*0.84*

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal B

Overfill Ratio (Ra)

(native M-phi = 1.62)
(native sd = 0.80)

Depth Interval NGVD>>>> / Area	-28.5 to -30	-28.5 to -35	-28.5 to -40	-28.5 to -45	-28.5 to -50	-28.5 to -55	-28.5 to -60	-30 to -35	-35 to -40	-40 to -45	-45 to -50	-50 to -55	-55 to -60
I	*1.00*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	*1.00*
II	*1.00*	1.00	1.003	1.025	1.034	1.022	1.023	1.00	1.018	1.31	1.145	1.088	*53.6*
III				1.44	1.47	1.46	1.41			1.44	1.55	1.44	*1.38*
I+II	*1.00*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	*1.02*
Total Area	*1.00*	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	*1.005*

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal B

Renourishment Factor (Rj)

(native M-phi = 1.62)
(native sd = 0.80)

Depth Interval NGVD>>>> / Area	-28.5 to -30	-28.5 to -35	-28.5 to -40	-28.5 to -45	-28.5 to -50	-28.5 to -55	-28.5 to -60	-30 to -35	-35 to -40	-40 to -45	-45 to -50	-50 to -55	-55 to -60
I	*0.65*	0.63	0.62	0.54	0.48	0.45	0.45	0.62	0.62	0.48	0.40	0.38	*0.47*
II	*0.65*	*0.8	0.86	0.95	0.98	0.98	1.005	*1.0	0.92	1.23	1.16	1.05	*2.50*
III				1.20	1.24	1.27	1.27			1.20	1.30	1.32	*1.33*
I+II	*1.00*	0.68	0.71	0.70	0.66	0.60	0.61	0.68	0.73	0.68	0.49	0.41	*0.67*
Total Area	*0.65*	0.68	0.71	0.73	0.72	0.72	0.72	0.68	0.73	0.78	0.70	0.69	*0.87*

* est. from Fig. 5-4 SPM

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal C

QUANTITIES

Depth Interval NGVD>>>> / Area	Quantities in 1000 Cubic Yards	-33.9 to -35	-33.9 to -40	-33.9 to -45	-33.9 to -50	-33.9 to -55	-33.9 to -60	-45 to -50	-50 to -55	-55 to -60
Total Area	Borrow	9	448	1,766	4,248	8,346	14,324	2,483	4,098	5,978
	Net Beachfill	no data		901	1,940	4,111	6,631	1,022	2,239	1,513

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal C

Mean PHI Value

Depth Interval NGVD>>>> / Area	-33.9 to -35	-33.9 to -40	-33.9 to -45	-33.9 to -50	-33.9 to -55	-33.9 to -60	-45 to -50	-50 to -55	-55 to -60
Total Area	NO DATA		1.77	1.82	1.82	1.84	1.85	1.83	2.02

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal C

Standard Deviation (PHI)

Depth Interval NGVD>>>> / Area	-33.9 to -35	-33.9 to -40	-33.9 to -45	-33.9 to -50	-33.9 to -55	-33.9 to -60	-45 to -50	-50 to -55	-55 to -60
Total Area	NO DATA		0.57	0.58	0.60	0.60	0.58	0.64	0.61

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal C

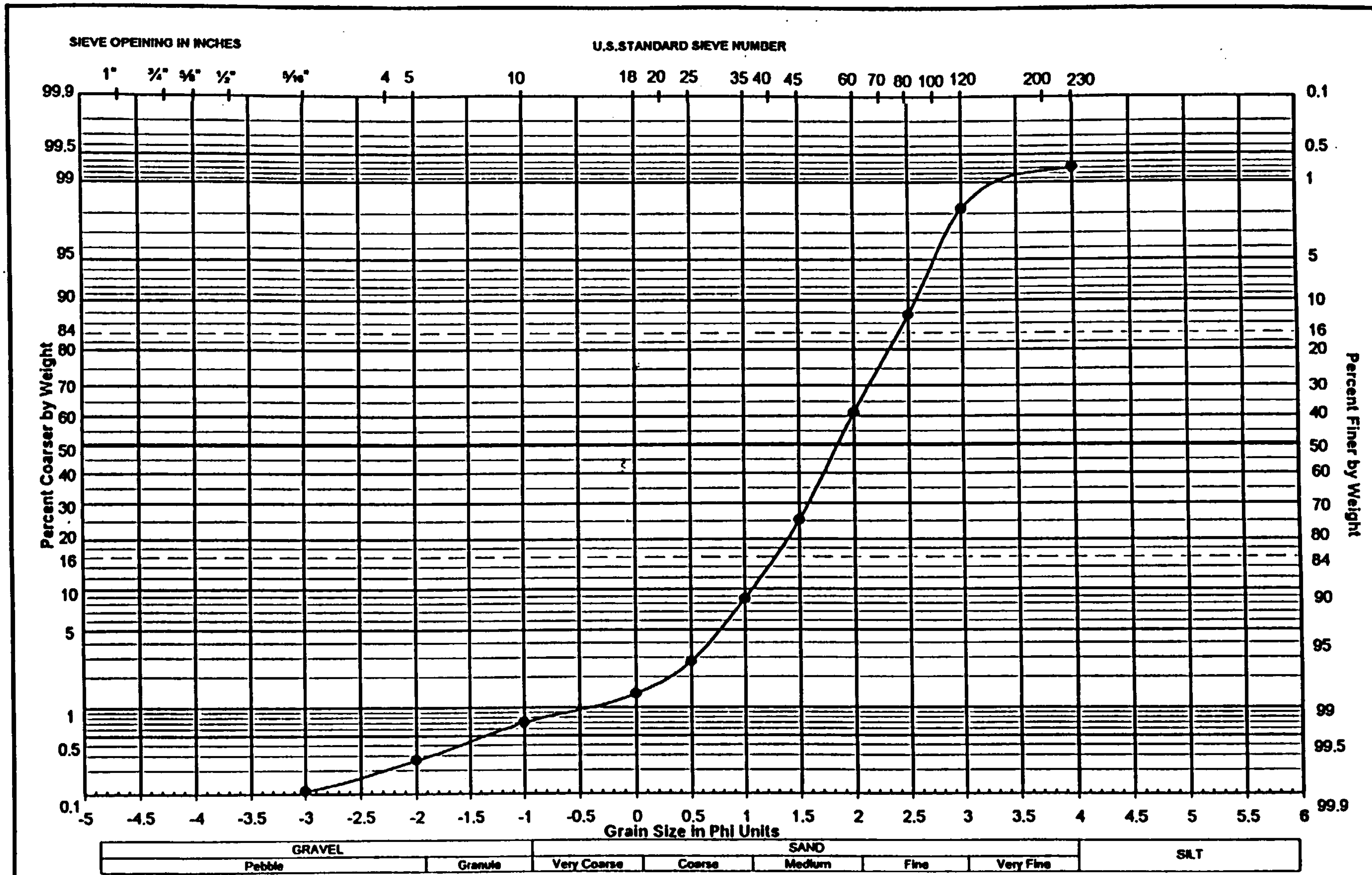
Overfill Ratio (Ra)
(native M-phi = 1.62)
(native sd = 0.80)

Depth Interval NGVD>>>> Area	-33.9 to -35	-33.9 to -40	-33.9 to -45	-33.9 to -50	-33.9 to -55	-33.9 to -60	-45 to -50	-50 to -55	-55 to -60
Total Area	NO DATA		1.96	2.19	2.03	2.16	2.43	1.83	3.95

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal C

Renourishment Factor (Rj)
(native M-phi = 1.62)
(native sd = 0.80)

Depth Interval NGVD>>>> / Area	-33.9 to -35	-33.9 to -40	-33.9 to -45	-33.9 to -50	-33.9 to -55	-33.9 to -60	-45 to -50	-50 to -55	-55 to -60
Total Area	NO DATA		1.54	1.63	1.60	1.64	1.69	1.56	2.03

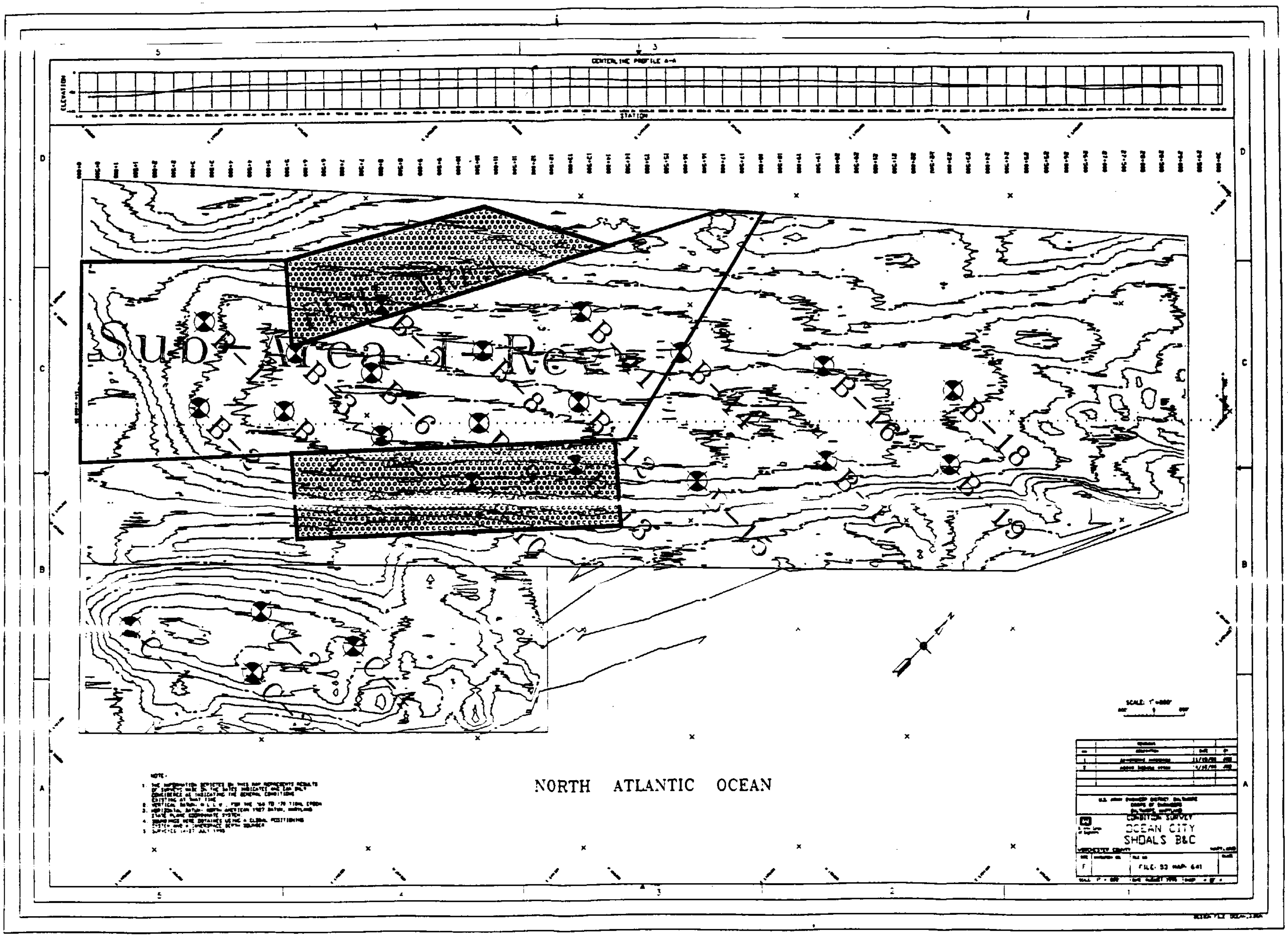


Wentworth Classification System		Ocean City Water Resources - Borrow Area Composite Worcester County, MD			
$\varnothing_{16}$ = 1.29 $\varnothing_{50}$ = 1.85 $\varnothing_{84}$ = 2.42	$M_\varnothing$ = 1.85 $\sigma_\varnothing$ = 0.56	Location: Shoal C	Hole No.: Composite	Sample No.: Total Area	Elevation (ft): -33.9 to -60.0
NAD FORM 798	$M_\varnothing = (\varnothing_{16}+\varnothing_{50}+\varnothing_{84})/3$ $\sigma_\varnothing = (\varnothing_{84} - \varnothing_{16})/2$	U.S. Army Corps of Engineers Baltimore District Soils Laboratory		DATE:	Aug. 1996

SECTION B-2(a)

SHOAL B - REVISED

(to exclude fishing areas)



Sub-Area 1-Rev
B-1
B-3
B-6
B-8
B-18
B-19
NORTH ATLANTIC OCEAN
CONDITION SURVEY
OCEAN CITY
SHOALS B&C

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal B
Revised - Eliminate fishing areas [illegible]

QUANTITIES

Depth Interval NGVD>>>> / Area	Quantities in 1000 Cubic Yards	-28.5 to -30	-28.5 to -35	-28.5 to -40	-28.5 to -45	-28.5 to -50	-28.5 to -55	-28.5 to -60	-30 to -35	-35 to -40	-40 to -45	-45 to -50	-50 to -55	-55 to -60
I-Rev	Borrow	191	2,674	7,682	15,211	24,846	35,974	48,427	2,483	5,008	7,530	9,635	11,129	12,452
	Net Beachfill	*191*	2,674	7,682	15,211	24,846	35,974	48,427	2,483	5,008	7,530	9,635	11,129	*12,452*

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal B

Mean PHI Value

Revised - eliminate fishing areas

Depth Interval NGVD>>>> / Area	-28.5 to -30	-28.5 to -35	-28.5 to -40	-28.5 to -45	-28.5 to -50	-28.5 to -55	-28.5 to -60	-30 to -35	-35 to -40	-40 to -45	-45 to -50	-50 to -55	-55 to -60
I-Rev	*1.00*	1.08	1.13	1.14	1.12	1.08	1.08	1.09	1.16	1.15	1.01	0.90	*1.08*

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal B
Revised - Eliminate fishing areas

Standard Deviation (PHI)

Depth Interval NGVD>>>> / Area	-28.5 to -30	-28.5 to -35	-28.5 to -40	-28.5 to -45	-28.5 to -50	-28.5 to -55	-28.5 to -60	-30 to -35	-35 to -40	-40 to -45	-45 to -50	-50 to -55	-55 to -60
I-Rev	0.44	0.51	0.58	0.62	0.63	0.66	0.66	0.53	0.61	0.68	0.71	0.73	0.81

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal B

Revised - Eliminate fishing areas

Overfill Ratio (Ra)
(native M-phi = 1.62)
(native sd = 0.80)

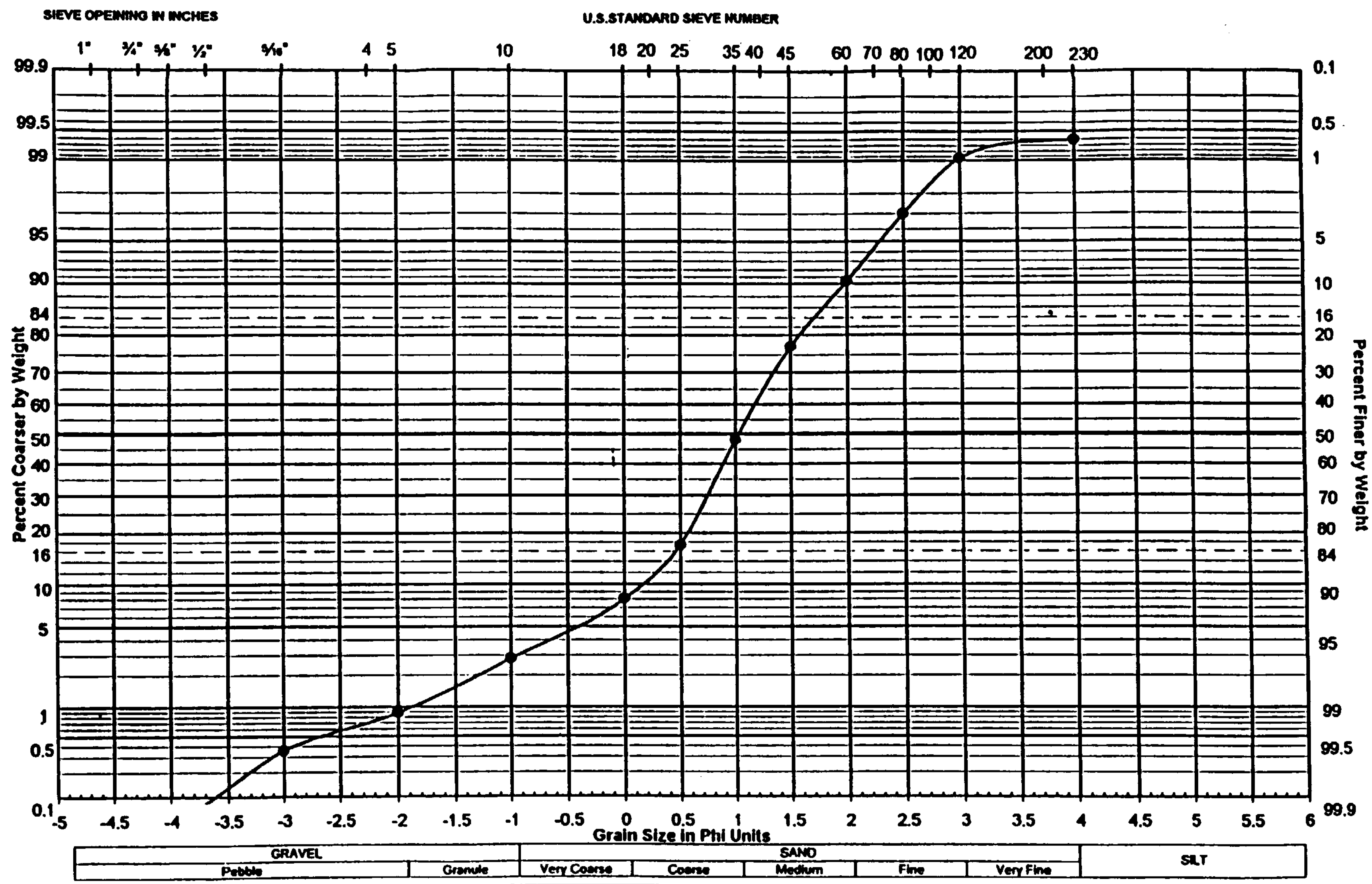
Depth Interval NGVD>>>> / Area	-28.5 to -30	-28.5 to -35	-28.5 to -40	-28.5 to -45	-28.5 to -50	-28.5 to -55	-28.5 to -60	-30 to -35	-35 to -40	-40 to -45	-45 to -50	-50 to -55	-55 to -60
I-Rev	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Shoal B
Revised - Eliminate fishing area

Renourishment Factor (Rj)

(native M-phi = 1.62)
(native sd = 0.80)

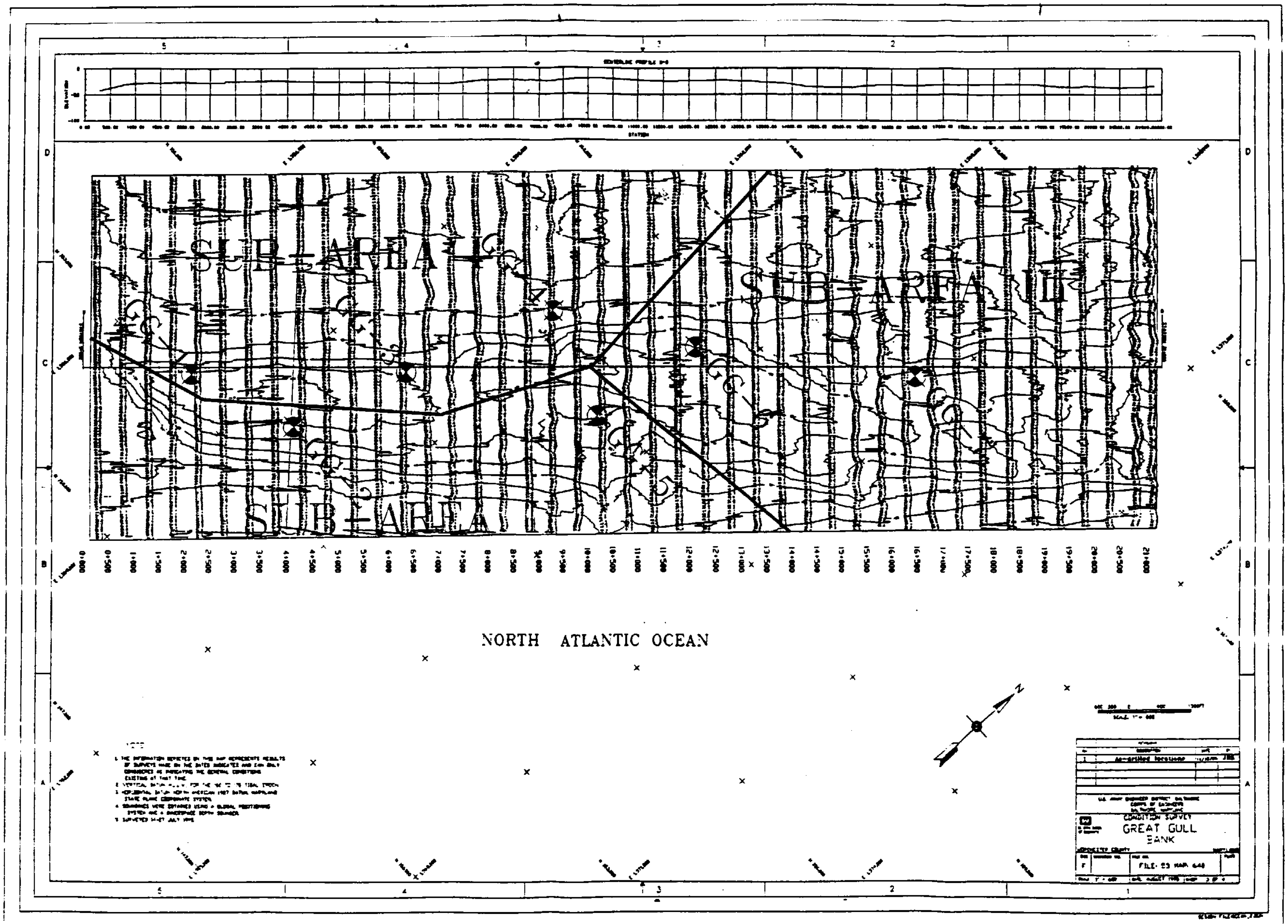
Depth Interval NGVD>>>> Area	-28.5 to -30	-28.5 to -35	-28.5 to -40	-28.5 to -45	-28.5 to -50	-28.5 to -55	-28.5 to -60	-30 to -35	-35 to -40	-40 to -45	-45 to -50	-50 to -55	-55 to -60
I-Rev	0.65	0.69	0.69	0.67	0.65	0.60	0.60	0.68	0.69	0.64	0.52	0.44	0.50



Wentworth Classification System		Ocean City Water Resources - Borrow Area Composite Worcester County, MD			
Ø16 = 0.46 Ø50 = 1.03 Ø84 = 1.72	$M_ø$ = 1.07 $σ_ø$ = 0.63	Location: Shoal B	Hole No.: Composite	Sample No.: Sub Area I (Rev.)	Elevation (ft): -28.5 to -60.0
NAD FORM 798	$M_ø = (ø_{16}+ø_{50}+ø_{84})/3$ $σ_ø = (ø_{84} - ø_{16})/2$	U.S. Army Corps of Engineers Baltimore District Soils Laboratory		DATE:	Aug. 1996

SECTION B-3

GREAT GULL BANK


SUB-AREA I
SUB-AREA II
SUB-AREA
NORTH ATLANTIC OCEAN
N
CONDITION SURVEY
GREAT GULL
BANK

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Great Gull Bank

QUANTITIES

Depth Interval NGVD>>>> / Area	Quantities in 1000 Cubic Yards	-18.4 to -20	-18.4 to -25	-18.4 to -30	-18.4 to -35	-18.4 to -40	-18.4 to -45	-18.4 to -50	-20 to -25	-25 to -30	-30 to -35	-35 to -40	-40 to -45	-45 to -50
I	Borrow	21	524	1,674	3,351	5,945	10,263	17,065	503	1,150	1,677	2,594	4,318	6,802
	Net Beachfill	no data	524	1,671	3,351	5,945	10,263	17,065	no data	1,143	1,677	2,594	4,318	6,802
II	Borrow	0	212	1,096	2,824	5,259	8,500	12,741	212	884	1,728	2,435	3,241	4,241
	Net Beachfill	no data		559	1,370	3,187	5,152	no data	no data	451	839	1,752	1,863	no data
III	Borrow	2	384	1,690	4,468	8,976	15,127	23,451	382	1,306	2,778	4,508	6,151	8,324
	Net Beachfill	no data		1,207	2,828	4,905	8,046	no data	no data	288	1,462	689	2,500	no data
I+II	Borrow	21	736	2,770	6,175	11,204	18,763	29,806	715	2,034	3,405	5,029	7,559	11,043
	Net Beachfill	no data	736	2,759	6,169	11,204	18,763	29,766	no data	2,006	3,234	4,568	7,536	11,043
Total Area	Borrow	23	1,120	4,460	10,643	20,180	33,890	53,257	1,097	3,340	6,183	9,537	13,710	19,367
	Net Beachfill	(not calculated)												

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Great Gull Bank

Mean PHI Value

Depth Interval NGVD>>>> / Area	-23.7 to -25	-23.7 to -30	-23.7 to -35	-23.7 to -40	-23.7 to -45	-23.7 to -50	-25 to -30	-30 to -35	-35 to -40	-40 to -45	-45 to -50
I	*1.15*	0.79	1.12	1.19	1.15	1.17	0.72	1.39	1.41	0.99	1.30
II		1.82	1.85	1.80	1.80	NO DATA	1.82	1.85	1.75	1.81	NO DATA
III		1.55	1.74	1.83	1.84		1.55	1.81	2.08	1.92	
I+II	*1.15*	1.05	1.44	1.50	1.49	*1.48*	1.02	1.62	1.64	1.47	*1.30*
Total Area	(not calculated)										

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Great Gull Bank

Standard Deviation (PHI)

Depth Interval NGVD>>>> / Area	-23.7 to -25	-23.7 to -30	-23.7 to -35	-23.7 to -40	-23.7 to -45	-23.7 to -50	-25 to -30	-30 to -35	-35 to -40	-40 to -45	-45 to -50
I	*0.63*	1.05	0.87	0.83	0.83	0.83	1.12	0.69	0.66	0.80	0.84
II		0.61	0.62	0.65	0.65	NO DATA	0.61	0.62	0.68	0.64	NO DATA
III		0.50	0.61	0.64	0.64		0.34	0.61	0.59	0.63	
I+II	*0.63*	1.00	0.86	0.82	0.83	0.84	1.08	0.73	0.71	0.86	*0.84*
Total Area	(not calculated)										

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Great Gull Bank

Overfill Ratio (Ra)

(native M-phi = 1.62)

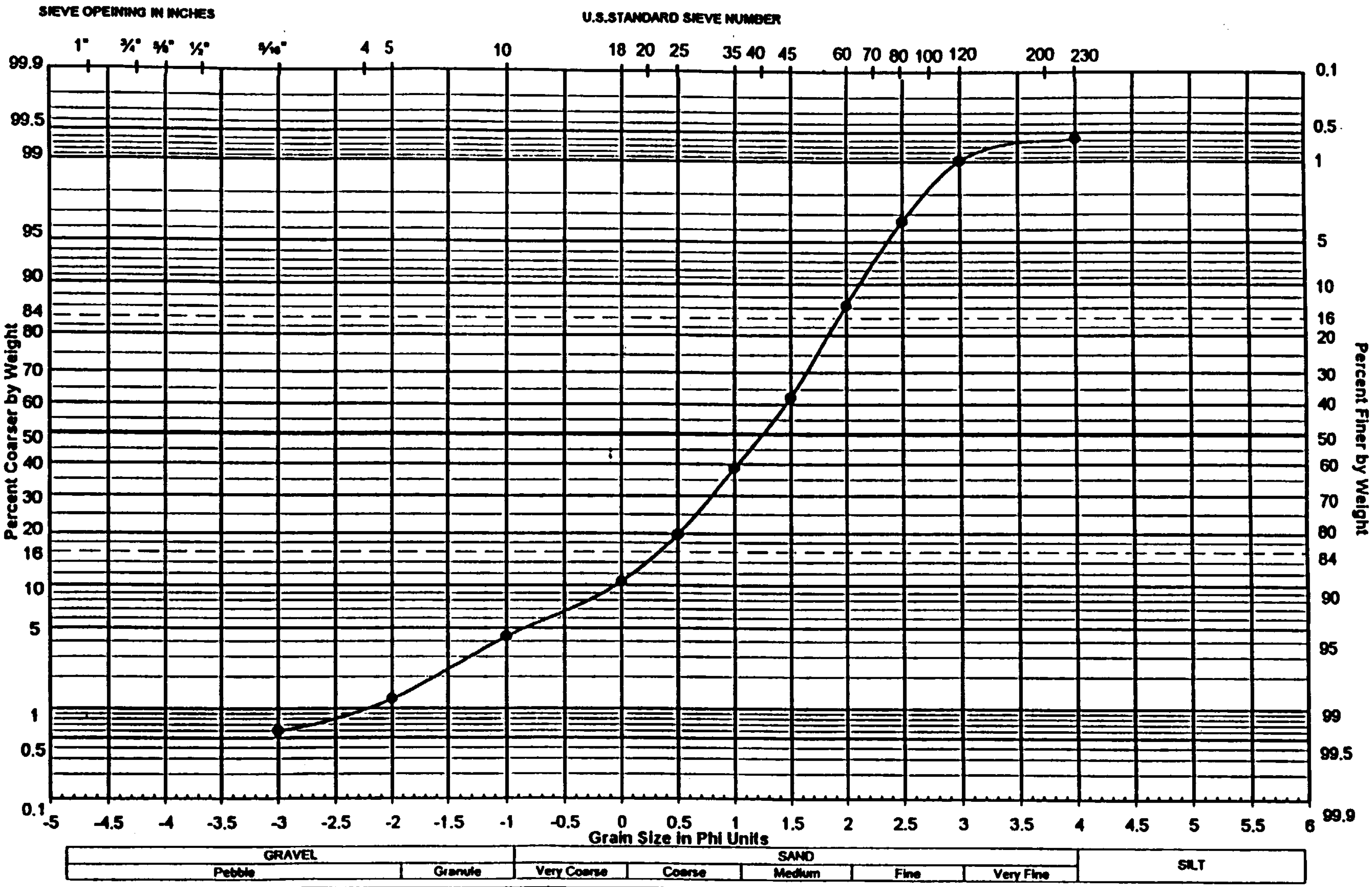
(native sd = 0.80)

Depth Interval NGVD>>>> / Area	-23.7 to -25	-23.7 to -30	-23.7 to -35	-23.7 to -40	-23.7 to -45	-23.7 to -50	-25 to -30	-30 to -35	-35 to -40	-40 to -45	-45 to -50
I	*1.00*	1.002	1.00	1.00	1.00	1.00	1.006	1.00	1.00	1.00	1.00
II		1.96	2.06	1.65	1.65	NO DATA	1.96	2.06	1.39	1.74	NO DATA
III		1.40	1.58	1.83	1.88		*4.54*	1.90	6.54	2.46	
I+II	*1.00*	1.004	1.001	1.00	1.00	*1.001*	1.014	1.053	1.101	1.003	*1.00*
Total Area	(not calculated)										

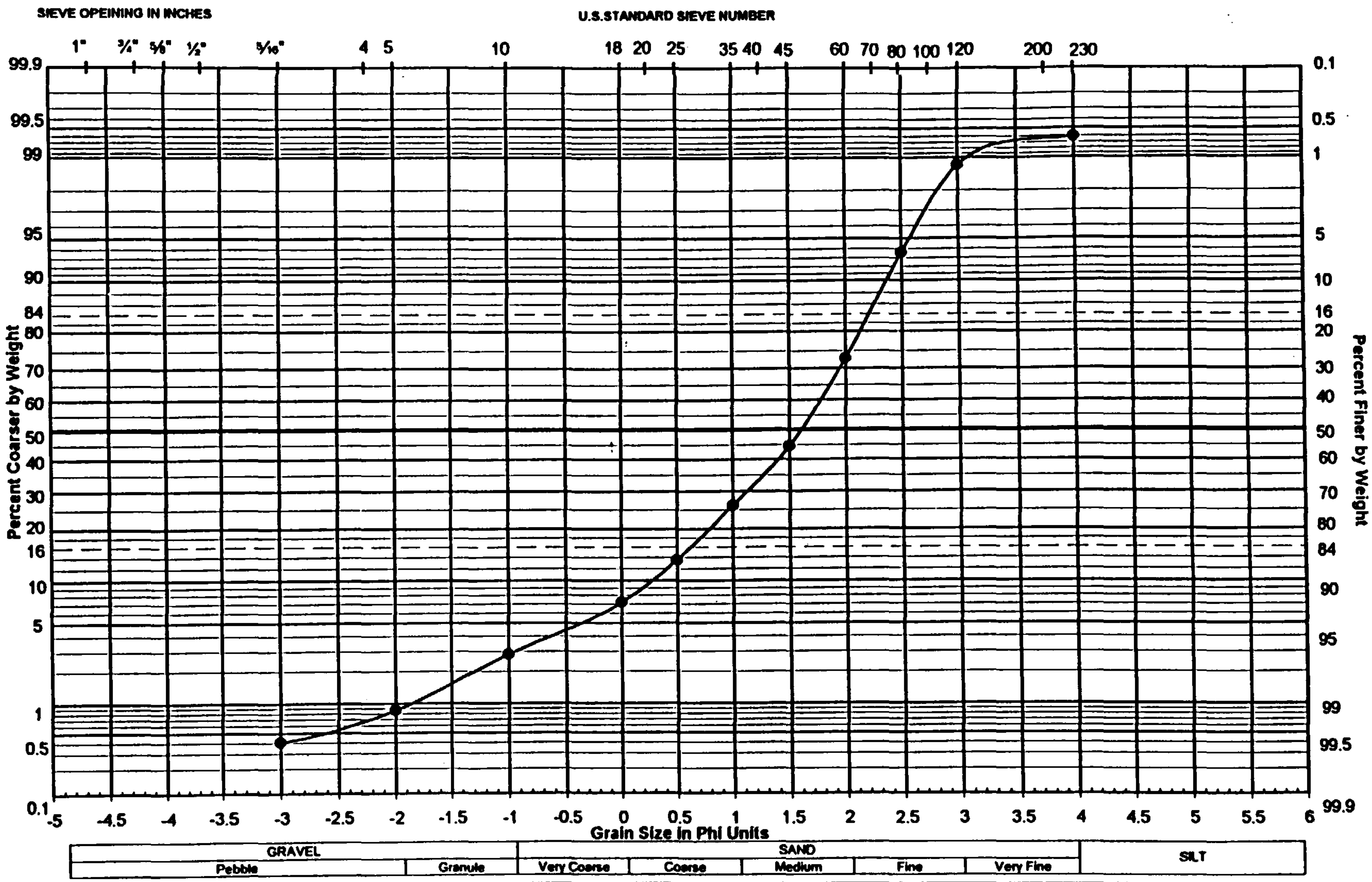
Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Great Gull Bank

Renourishment Factor)Rj
(native M-phi = 1.62)
(native sd = 0.80)

Depth Interval NGVD>>>> / Area	-23.7 to -25	-23.7 to -30	-23.7 to -35	-23.7 to -40	-23.7 to -45	-23.7 to -50	-25 to -30	-30 to -35	-35 to -40	-40 to -45	-45 to -50
I	*0.67*	0.25	0.49	0.56	0.54	0.55	0.20	0.85	0.90	*0.5	0.64
II		1.58	1.63	1.48	1.48	NO DATA	1.58	1.63	1.35	1.52	NO DATA
III		1.24	1.43	1.56	1.58		1.38	1.56	2.23	1.76	
I+II	*0.67*	0.37	0.74	0.84	0.82	*0.80*	0.31	1.09	1.14	0.77	0.64
Total Area	(not calculated)							* est. from Fig. 5-4 SPM			



Wentworth Classification System		Ocean City Water Resources - Borrow Area Composite Worcester County, MD			
$\varnothing_{16}$ = 0.35	$M_\varnothing$ = 1.18	Location: Great Gull Bank	Hole No.: Composite	Sample No.: Sub Area I	Elevation (ft): -23.7 to -50.0
$\varnothing_{50}$ = 1.26	$\sigma_\varnothing$ = 0.80				
$\varnothing_{84}$ = 1.94					
NAD FORM 798	$M_\varnothing = (\varnothing_{16}+\varnothing_{50}+\varnothing_{84})/3$ $\sigma_\varnothing = (\varnothing_{84} - \varnothing_{16})/2$	U.S. Army Corps of Engineers Baltimore District Soils Laboratory		DATE:	Aug. 1996



Wentworth Classification System	
ϕ_{16} = 0.63	M_{ϕ} = 1.49
ϕ_{50} = 1.61	σ_{ϕ} = 0.79
ϕ_{84} = 2.21	
NAD FORM 798	$M_{\phi} = (\phi_{16}+\phi_{50}+\phi_{84})/3$ $\sigma_{\phi} = (\phi_{84} - \phi_{16})/2$

Ocean City Water Resources - Borrow Area Composite
Worcester County, MD

Location:	Hole No.:	Sample No.:	Elevation (ft):
Great Gull Bank	Composite	Sub Areas I & II	-23.7 to -45.0

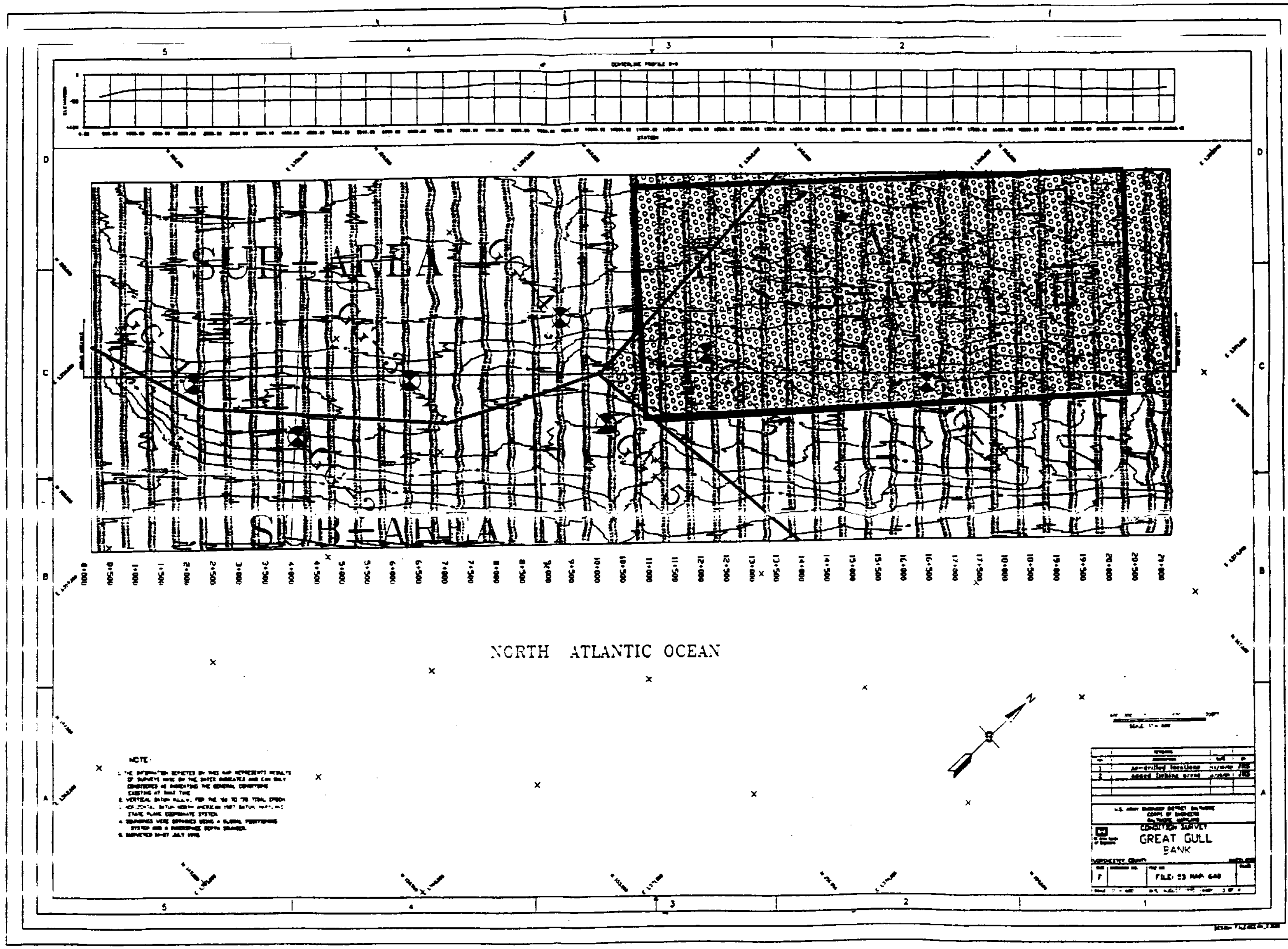
U.S. Army Corps of Engineers
Baltimore District
Soils Laboratory

DATE: Aug. 1996

SECTION B-3(a)

GREAT GULL BANK - REVISED

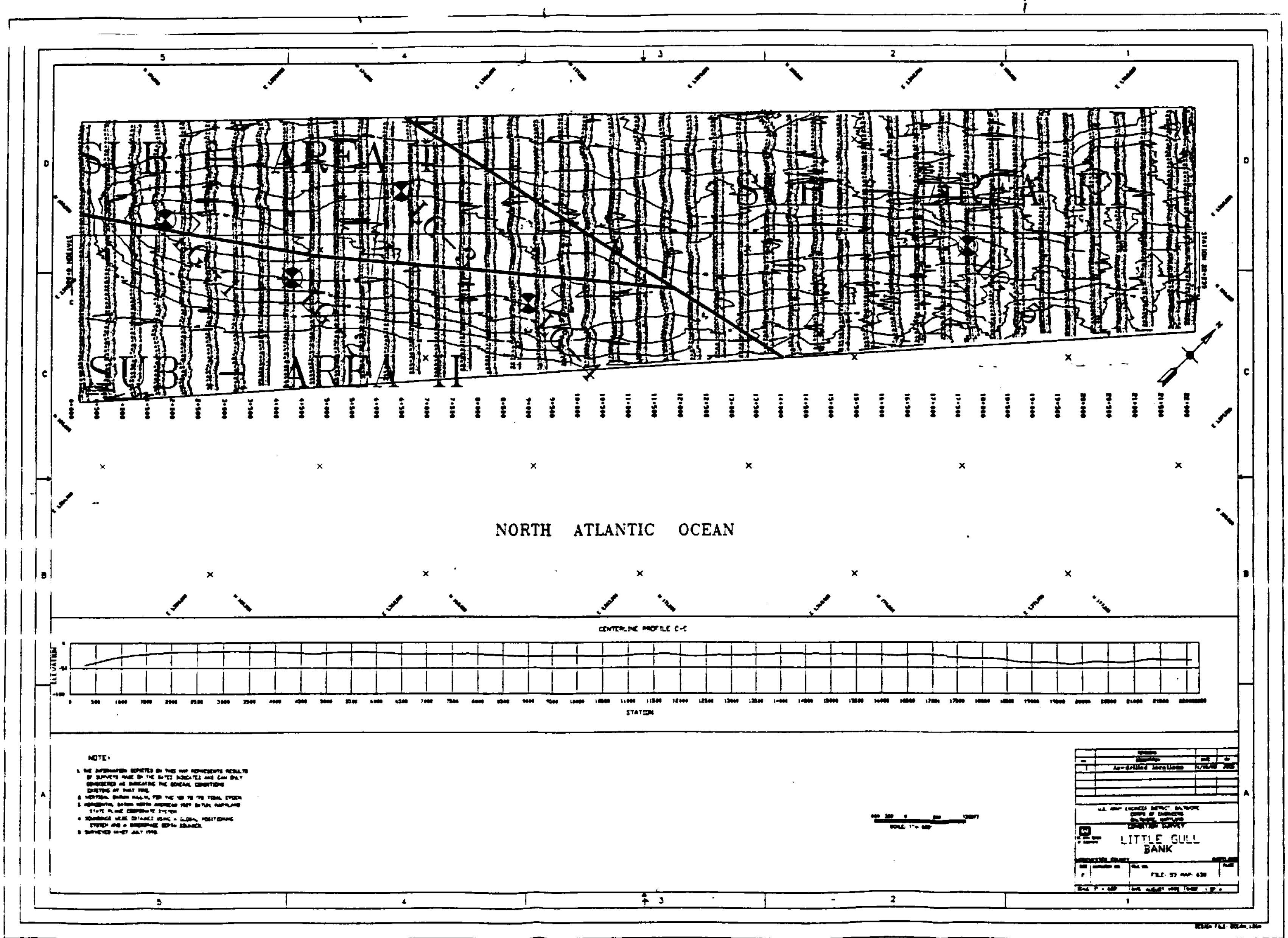
(to exclude fishing area)


SUB-AREA
SUB-AREA
NORTH ATLANTIC OCEAN
NOTE:
CONDITION SURVEY
GREAT GULL
BANK

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Great Gull Bank
(excludes fishing area)

QUANTITIES

Depth Interval NGVD>>>> / Area	Quantities in 1000 Cubic Yards	-18.4 to -20	-18.4 to -25	-18.4 to -30	-18.4 to -35	-18.4 to -40	-18.4 to -45	-18.4 to -50	-20 to -25	-25 to -30	-30 to -35	-35 to -40	-40 to -45	-45 to -50
I	Borrow	21	524	1,674	3,351	5,938	10,178	16,625	503	1,150	1,677	2,587	4,240	6,447
	Net Beachfill	no data	524	1,671	3,351	5,938	10,178	16,625	no data	1,143	1,677	2,587	4,240	6,447
II	Borrow	0	212	1,096	2,824	5,259	8,500	12,741	212	884	1,728	2,435	3,241	4,241
	Net Beachfill	no data		559	1,370	3,187	5,152	no data	no data	451	839	1,752	1,863	no data
III	Borrow	2	122	630	1,820	3,755	6,350	9,503	120	508	1,190	1,935	2,595	3,153
	Net Beachfill	no data		450	1,152	2,052	3,378	no data	no data	112	626	296	1,055	no data
I+II	Borrow	21	736	2,770	6,175	11,197	18,678	29,366	715	2,034	3,405	5,022	7,481	10,688
	Net Beachfill	no data	736	2,759	6,169	11,197	18,678	29,337	no data	2,006	3,234	4,561	7,459	10,688
Total Area	Borrow	23	858	3,400	7,995	14,952	25,028	38,869	835	2,542	4,595	6,957	10,076	13,841
	Net Beachfill	(not calculated)												


SUB - AREA I
SUB - AREA III
SUB - AREA II
NORTH ATLANTIC OCEAN
CENTERLINE PROFILE C-C
ELEVATION
STATION
NOTE:
LITTLE GULL
BANK

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Little Gull Bank

QUANTITIES

Depth Interval NGVD>>>> / Area	Quantities in 1000 Cubic Yards	-17 to -20	-17 to -25	-17 to -30	-17 to -35	-17 to -40	-17 to -45	-20 to -25	-25 to -30	-30 to -35	-35 to -40	-40 to -45
I	Borrow	94	1,041	3,011	5,641	8,848	12,719	947	1,970	2,630	3,207	3,871
	Net Beachfill	no data	1,041	3,011	5,641	8,848	no data	947	1,970	2,630	3,207	no data
II	Borrow	35	525	1,784	3,763	6,359	9,725	490	1,259	1,979	2,596	3,366
	Net Beachfill	no data		1,056	2,688	5,047	no data	no data		1,571	2,426	no data
III	Borrow	0	375	1,686	4,202	8,562	15,301	375	1,311	2,516	4,360	6,739
	Net Beachfill	0	no data	*822*	*2,050*	*4,810*	no data	no data		*1,264*	*2,795*	no data
I+II	Borrow	129	1,566	4,795	9,404	15,207	22,444	1,437	3,229	4,609	5,803	7,237
	Net Beachfill	no data	1,566	4,795	9,404	15,207	no data	1,437	3,229	4,609	5,803	no data
Total Area	Borrow	129	1,941	6,481	13,606	23,769	37,745	1,812	4,540	7,125	10,163	13,976
	Net Beachfill	(not calculated)										

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Little Gull Bank

Mean PHI Value

Depth Interval NGVD>>>> / Area	-20 to -25	-20 to -30	-20 to -35	-20 to -40	-20 to -45	-25 to -30	-30 to -35	-35 to -40	-40 to -45
I	0.95	1.06	0.89	0.87	NO DATA	1.13	0.52	0.73	NO DATA
II		1.68	1.64	1.60			1.61	1.51	
III		*1.86*	*1.86*	*1.85*			*1.86*	*1.83*	
I+II	0.95	1.26	1.21	1.23		1.35	1.14	1.27	
Total Area	*(not calculated)*								

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Little Gull Bank

Standard Deviation (PHI)

Depth Interval NGVD>>>> / Area	-20 to -25	-20 to -30	-20 to -35	-20 to -40	-20 to -45	-25 to -30	-30 to -35	-35 to -40	-40 to -45
I	0.54	0.57	0.75	0.77	NO DATA	0.59	1.11	0.95	NO DATA
II		0.54	0.57	0.58			0.59	0.61	
III		*0.63*	*0.64*	*0.67*			*0.64*	*0.71*	
I+II	0.54	0.65	0.74	0.74		0.64	0.88	0.75	
Total Area	*(not calculated)*								

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Little Gull Bank

Overfill Ratio (Ra)

(native M-phi = 1.62)

(native sd = 0.80)

Depth Interval NGVD>>>> / Area	-20 to -25	-20 to -30	-20 to -35	-20 to -40	-20 to -45	-25 to -30	-30 to -35	-35 to -40	-40 to -45
I	1.00	1.00	1.00	1.00	NO DATA	1.00	1.00	1.00	NO DATA
II		1.69	1.40	1.26			1.26	1.07	
III		*2.05*	*2.05*	*1.78*			*1.99*	*1.56*	
I+II	1.00	1.00	1.00	1.00		1.00	1.00	1.00	
Total Area	*(not calculated)*								

(((

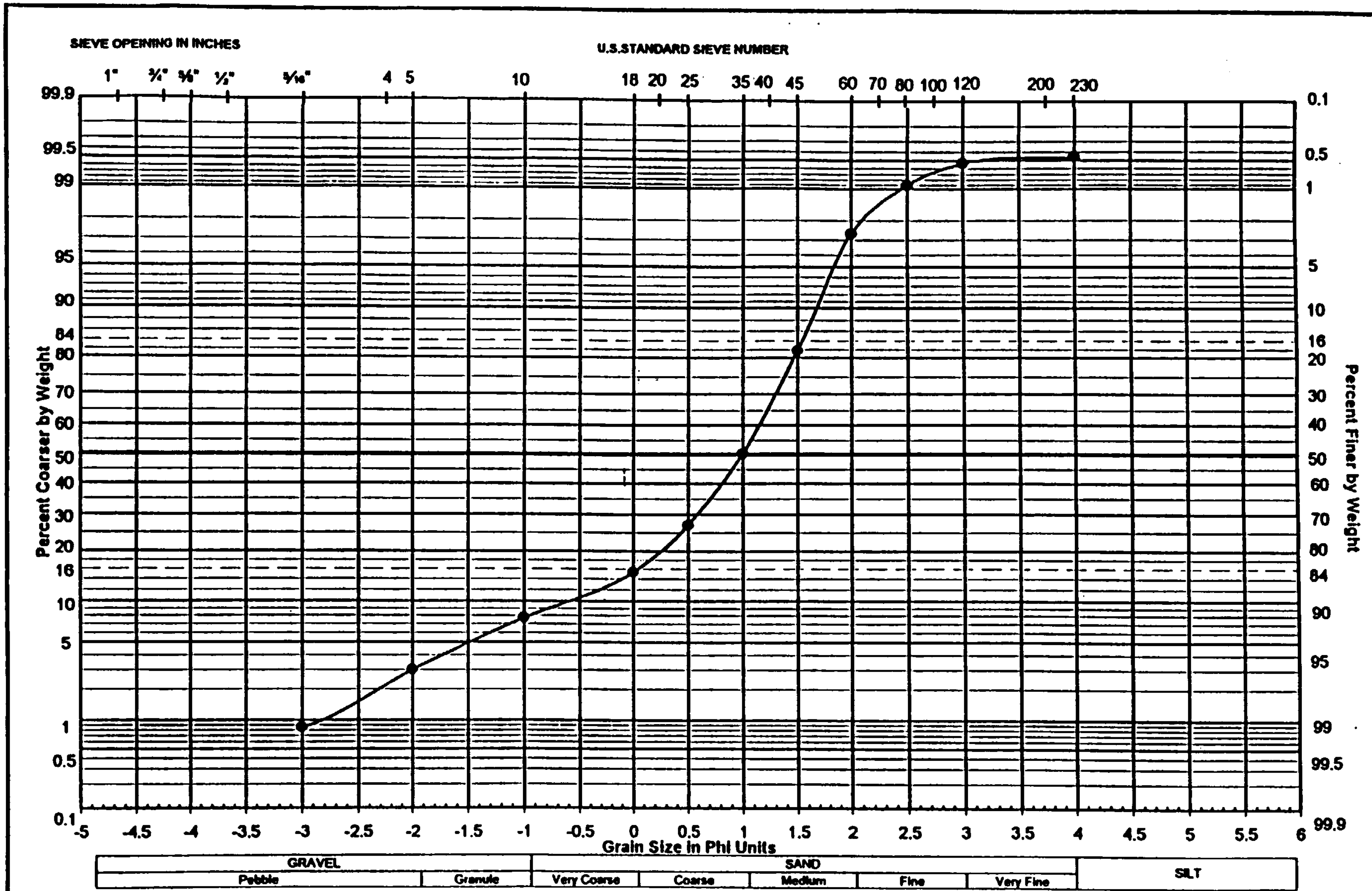
Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Little Gull Bank

Renourishment Factor (Rj)

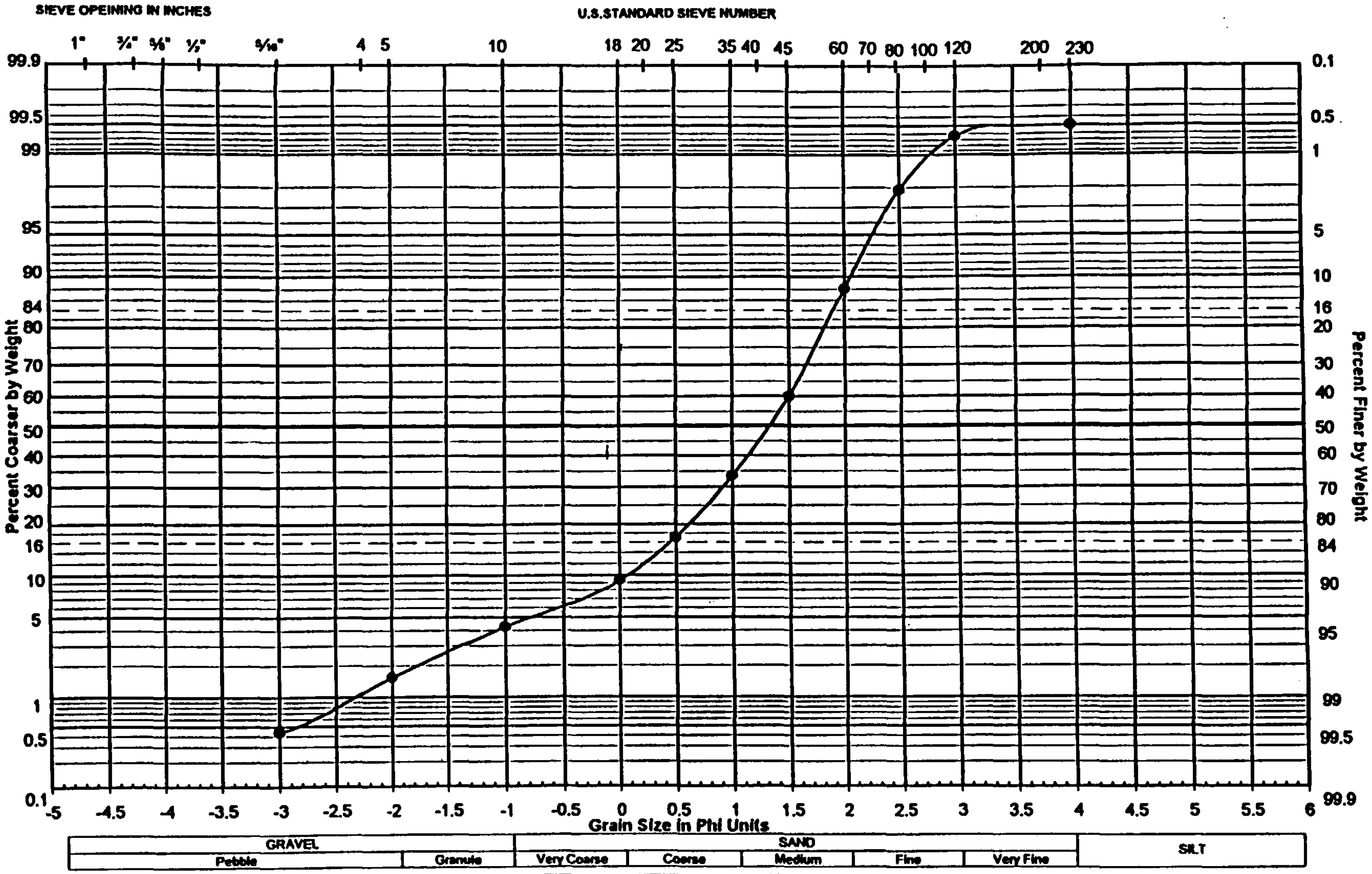
(native M-phi = 1.62)

(native sd = 0.80)

Depth Interval NGVD>>>> / Area	-20 to -25	-20 to -30	-20 to -35	-20 to -40	-20 to -45	-25 to -30	-30 to -35	-35 to -40	-40 to -45
I	0.57	0.64	0.43	0.41	NO DATA	0.68	0.16	0.27	NO DATA
II		1.42	1.31	1.24			1.24	1.07	
III		*1.63*	*1.63*	*1.55*			*1.62*	*1.45*	
I+II	0.57	0.76	0.64	0.66		*0.9	0.49	0.69	
Total Area	*(not calculated)*					* est. from Fig. 5-4 SPM			



Wentworth Classification System		Ocean City Water Resources - Borrow Area Composite, Worcester County, MD			
ϕ_{16} = 0.05	M_ϕ = 0.87	Location:	Hole No.:	Sample No.:	Elevation (ft):
ϕ_{50} = 1.00	σ_ϕ = 0.75	Little Gull Bank	Composite	Sub Area I	-20.0 to -40.0
ϕ_{84} = 1.55					
NAD FORM 798	$M_\phi = (\phi_{16}+\phi_{50}+\phi_{84})/3$ $\sigma_\phi = (\phi_{84} - \phi_{16})/2$	U.S. Army Corps of Engineers, Baltimore District, Soils Laboratory		DATE:	Aug. 1996



Wentworth Classification System	
ϕ_{16} = 0.46	M_ϕ = 1.23
ϕ_{50} = 1.33	σ_ϕ = 0.72
ϕ_{84} = 1.90	
NAD FORM 798	$M_\phi = (\phi_{16}+\phi_{50}+\phi_{84})/3$ $\sigma_\phi = (\phi_{84} - \phi_{16})/2$

Ocean City Water Resources - Borrow Area Composite
Worcester County, MD

Location:	Hole No.:	Sample No.:	Elevation (ft):
Little Gull Bank	Composite	Sub Areas I & II	-20.0 to -40.0

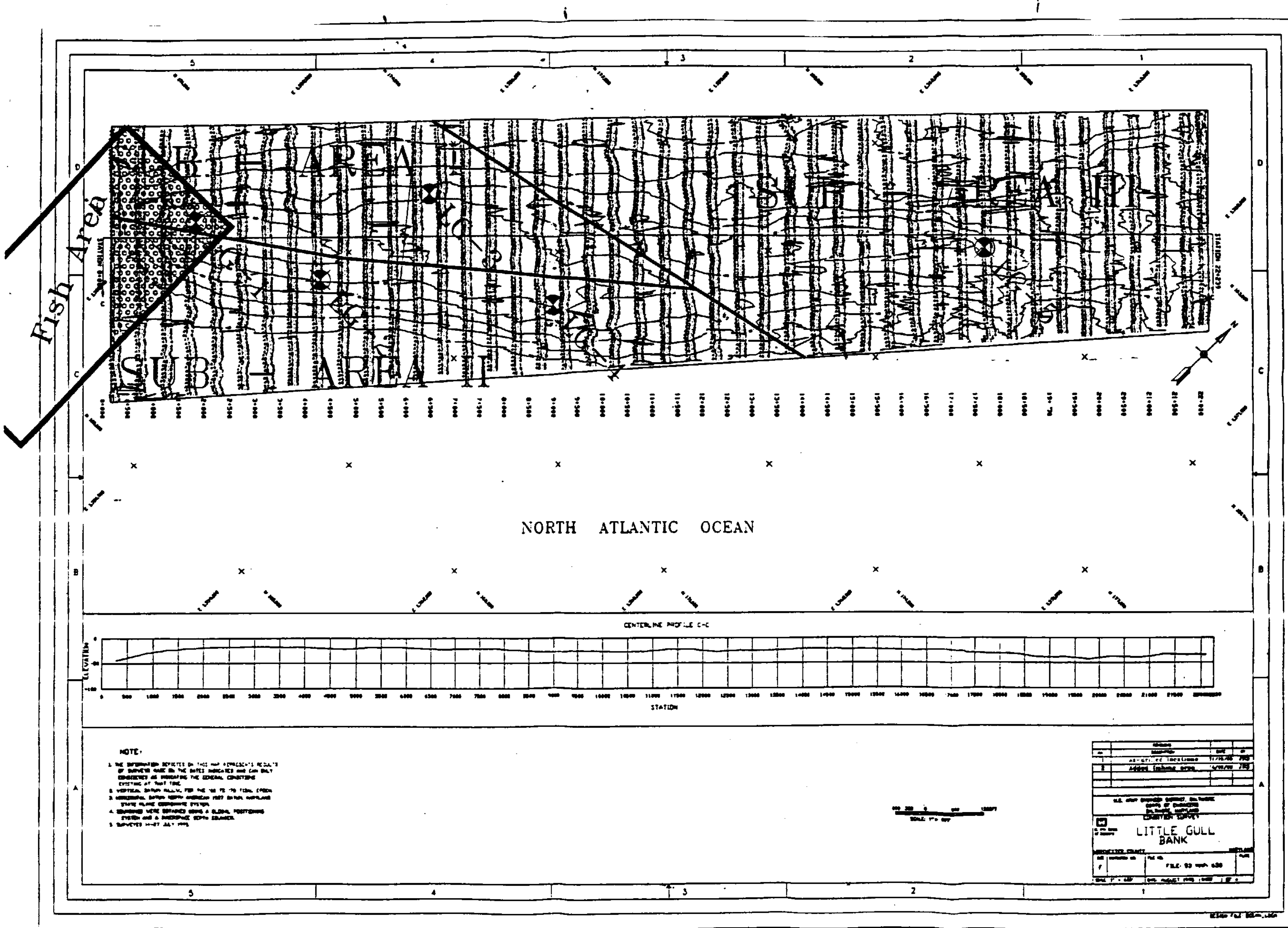
U.S. Army Corps of Engineers
Baltimore District
Soils Laboratory

DATE: Aug. 1996

SECTION B-4(a)

LITTLE GULL BANK - REVISED

(to exclude fishing area)



Fish Area
SUB — AREA II
SUB — AREA II
SUB — AREA I
NORTH ATLANTIC OCEAN
CENTERLINE PROFILE C-C
ELEVATION
STATION
NOTE:
LITTLE GULL
BANK

Ocean City Water Resources
Assateague Island Restoration
Borrow Area - Little Gull Bank

QUANTITIES

(excludes fishing area)

Depth Interval NGVD>>>> / Area	Quantities in 1000 Cubic Yards	-17 to -20	-17 to -25	-17 to -30	-17 to -35	-17 to -40	-17 to -45	-20 to -25	-25 to -30	-30 to -35	-35 to -40	-40 to -45
I	Borrow	80	944	2,762	5,173	8,075	11,521	864	1,818	2,411	2,902	3,446
	Net Beachfill	no data	944	2,762	5,173	8,075	no data	864	1,818	2,411	2,902	no data
II	Borrow	30	485	1,634	3,442	5,800	8,760	455	1,149	1,808	2,358	2,960
	Net Beachfill	no data		967	2,459	4,603	no data	no data		1,435	2,204	no data
III	Borrow	0	375	1,686	4,202	8,562	15,301	375	1,311	2,516	4,360	6,739
	Net Beachfill	0	no data	*822*	*2,050*	*4,810*	no data	no data		*1,264*	*2,795*	no data
I+II	Borrow	110	1,429	4,396	8,615	13,875	20,281	1,319	2,967	4,219	5,260	6,406
	Net Beachfill	no data	1,429	4,396	8,615	13,875	no data	1,319	2,967	4,219	5,260	no data
Total Area	Borrow	110	1,804	6,082	12,817	22,437	35,582	1,694	4,278	6,735	9,620	13,145
	Net Beachfill	(not calculated)										

SECTION B-5

LOGS OF SUBSURFACE EXPLORATION

<u>SUBSURFACE EXPLORATION NOTES</u>

OCEAN CITY WATER RESOURCES PROJECT

ASSATEAGUE ISLAND RESTORATION

1. Exploration was performed during October and November 1995.

2. Boring was sampled with a pneumatic vibracore. A 20 foot long, 4 inch I.D., Steel barrel containing a 3.625 inch I.D. Cellulose buterate tube (wall thickness: 0.125") was pneumatically vibrated below channel floor. The 20 foot cellulose buterate tube was cut into 5 foot lengths and sequentially labeled, e.g. (A thru D), top to bottom.

    - Denotes area unsampled

   [10YR 7/3 - light gray] - Denotes MUNSELL color

3. Characteristics of OSI Model 1500 Vibracore:

   - Energy source - NAVCO BH-8 vibratory powered by a 185 cfm air compressor operating at 125 psi.
   - Method of vibration - Impact, reciprocating piston
   - Piston Stroke - 2 inches
   - Piston Weight - 220 lbs
   - Diameter Of Piston - 8 inches
   - Stand type - 4 folding legs
   - Core barrel 4 inch pipe, 20 feet long
   - Core liner - 3.5 inch I.D. Lexan tubing, 20 feet long
   - Penetrometer Sensor - Geared Potentiometer
   - Penetrometer Recorder - Soltec VP6723S strip chart recorder

4. Classification: Soil descriptions are laboratory classifications based on the unified soil classification system (MIL-STD-619b) or (ASTM D2487). Initial colors are based on a moist or wet condition as extracted from buterate tube. The color description of oven dried material in brackets [ ] is based on the MUNSELL color chart.

5. Penetration rates shown are as indicated during drilling operation and may not correspond exactly with sample elevations.

6. Mean and Standard Deviation values are based on PHI values determined by the Wentworth Classification System.

7. Elevations shown on the vibracore logs are tidal surface elevations at the time of exploration. Tide information was obtained from a tide software program produced by MIRCONAUTICS; Rockport, Maine.

8. Coordinates for each boring were obtained using a Magellan base station GPS/GIS data collection system. Coordinates were referenced to the national geodetic vertical datum, 1929 (NGVD 29).

9. Vibracore boring locations are shown on the fold-out plates in this appendix.

Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

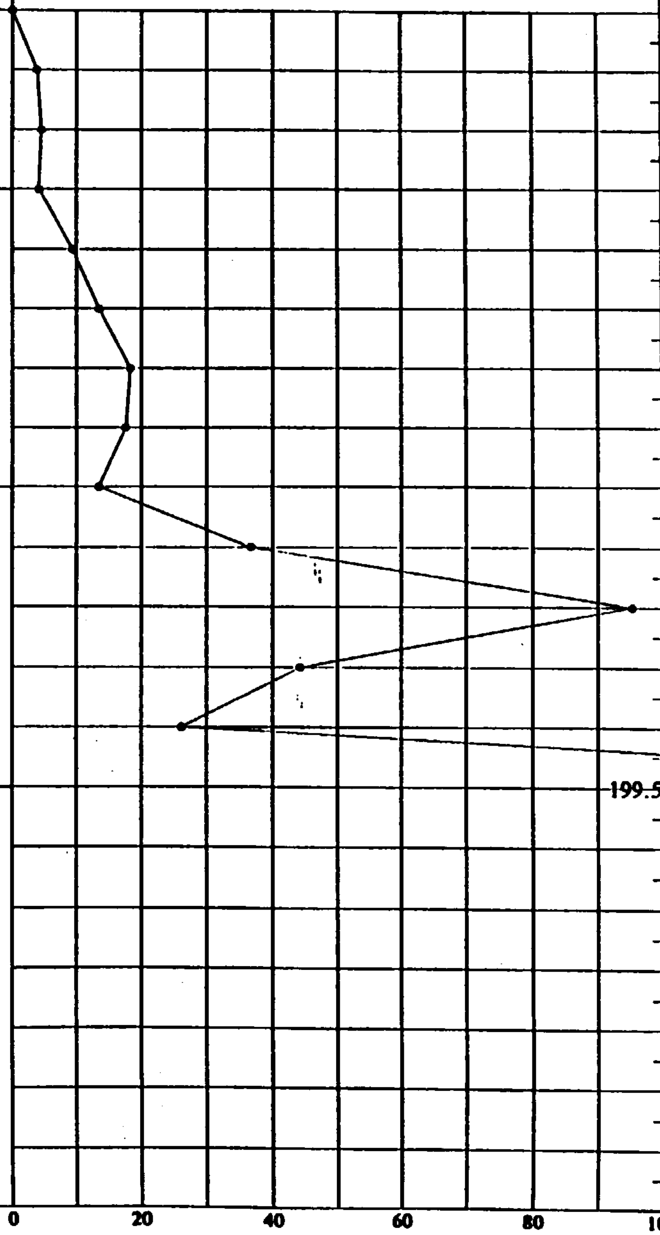
Hole No.	B-1	Date:	October 4, 1995
Coordinates N	170695.0	Driller:	Ocean Surveys, Inc.
E	1399196.0	Inspector:	J.Snyder/M.StClair

Elevation: -42.9 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Leg.	Classification USCS	No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
		1		Brown poorly graded coarse SAND w/ shell & tr. of gravel (SP) [10YR 6/3 - pale brown]	1	0.63	0.07	-1.03	-0.11	0.83				
-45.9	3.0	2		Brown poorly graded coarse SAND w/ shell & tr. of gravel (SP) [10YR 6/3 - pale brown]	2	0.70	-0.11	-1.06	-0.16	0.88				
-50.9	8.0	3		Brown poorly graded coarse SAND w/ shell & tr. of gravel (SP) [10YR 6/3 - pale brown]	3	1.44	0.09	-0.99	0.18	1.12				
				Bottom of Hole										

Depth scale: 5, 10, 15, 20

Penetration In Seconds



Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

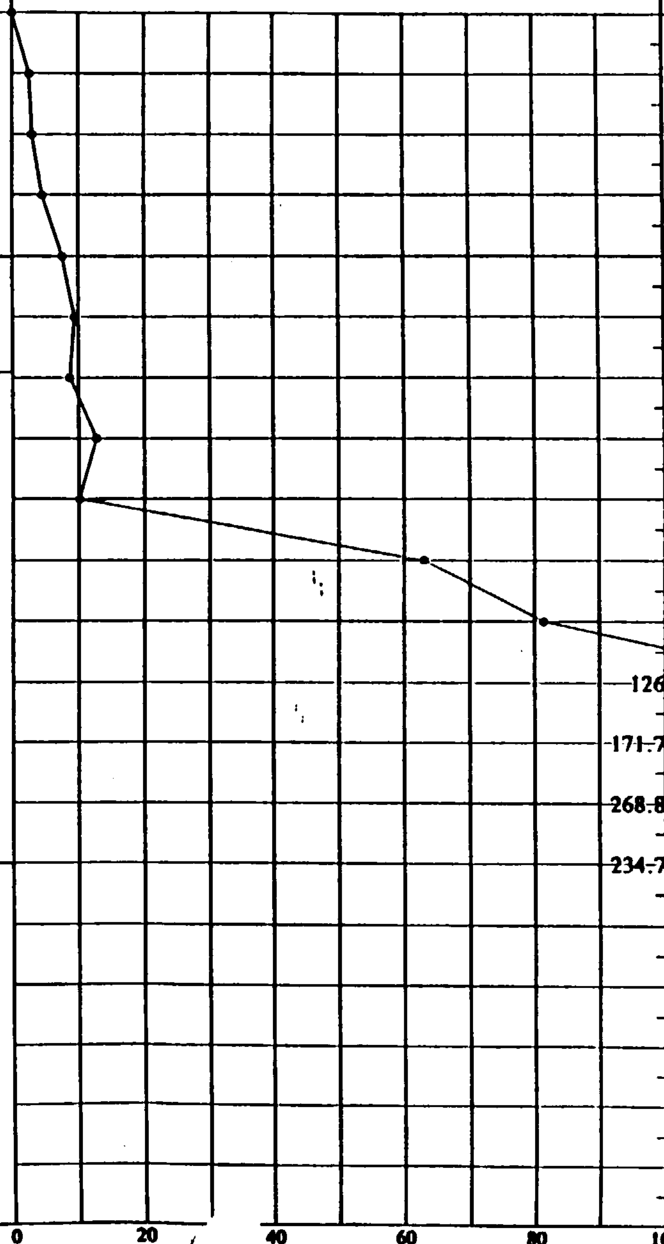
Hole No. B-2
Coordinates N 168995.0
E 1400686.0

Date: October 4, 1995
Driller: Ocean Surveys, Inc.
Inspector: J.Snyder/M.StClair

Elevation: -39.2 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS
		1	Brown poorly graded medium coarse SAND w/ shell (SP) [10YR 7/3 - very pale brown]
-43.2	4.0	2	Brown poorly graded medium coarse SAND w/ shell (SP) [10YR 7/4 - very pale brown]
-45.1	5.9	3	Brown poorly graded medium coarse SAND w/ shell (SP) [10YR 7/4 - very pale brown]
			Bottom of Hole

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	1.15	0.80	0.53	0.83	0.31				
2	1.09	0.77	0.47	0.78	0.31				
3	1.26	0.84	0.54	0.88	0.36				

Depth scale: 5, 10, 15, 20

GEO-4 OCSHB 7/30/96 13:24

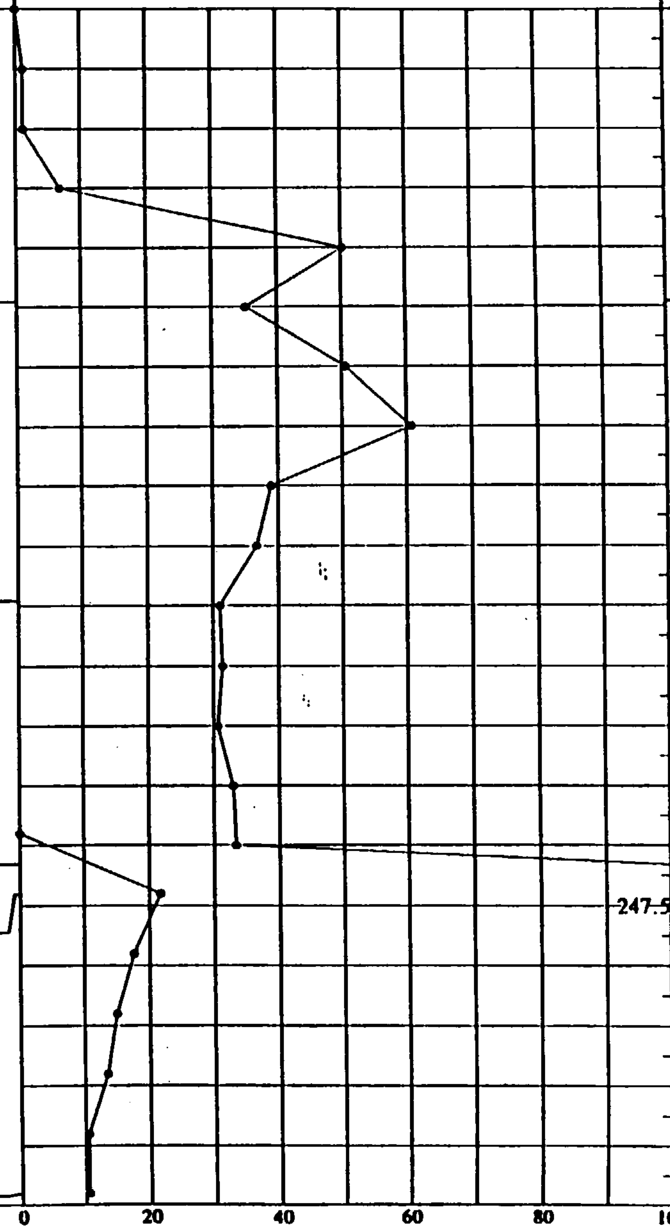
Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

Hole No.	B-3	Date:	October 4, 1995
Coordinates N	171821.0	Driller:	Ocean Surveys, Inc.
E	1401506.0	Inspector:	J.Snyder/M.StClair

Elevation: -32.9 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS
	0	1	Brown poorly graded coarse SAND w/ shell & tr. of gravel (SP) [10YR 6/3 - pale brown]
-37.8	4.9	2	Brown poorly graded coarse SAND w/ shell & tr. of gravel (SP) [10YR 6/3 - pale brown]
-42.8	9.9	3	Brown poorly graded coarse SAND w/ shell (SP) [10YR 7/3 - very pale brown]
-47.2	14.3	1R	Brown & gray poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]
-47.7	14.8	2R	Brown poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]
	20		Bottom of Hole

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	1.12	0.64	0.01	0.59	0.55				
2	0.96	0.59	-0.12	0.48	0.54				
3	1.26	0.73	0.18	0.73	0.54				
1R	1.39	0.87	0.53	0.93	0.43				
2R	1.39	0.80	0.45	0.88	0.47				

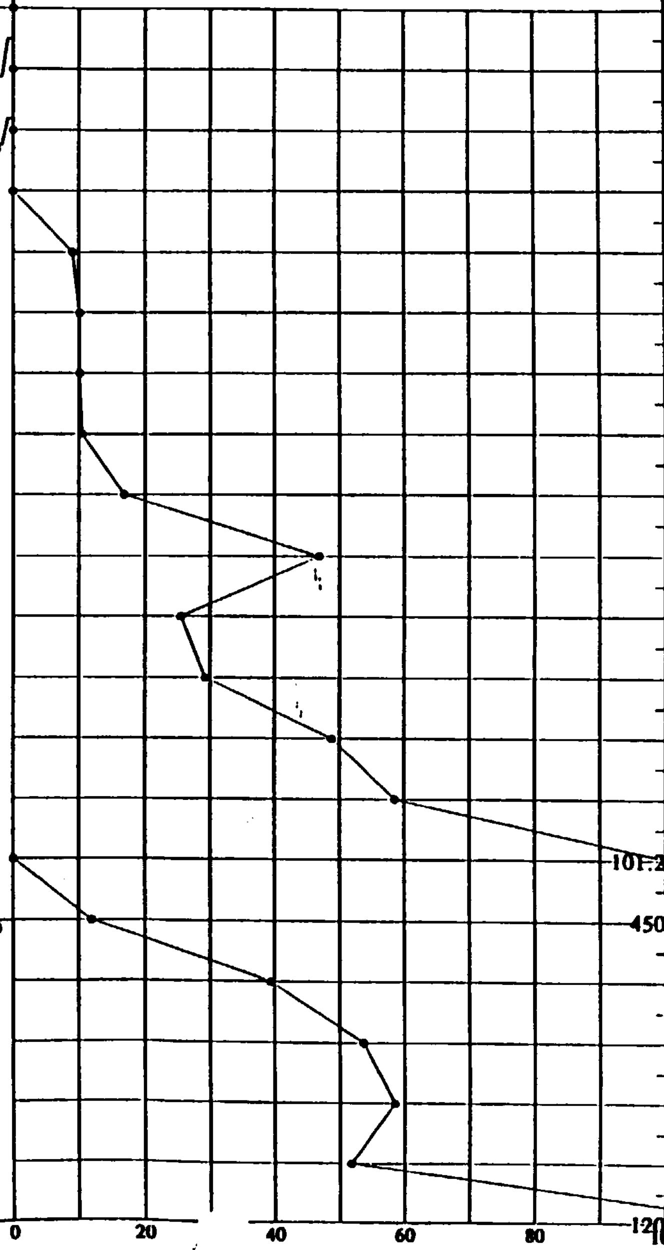
GEO-4 OCSHB 7/30/96 13:15

Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

Hole No.	B-4	Date:	October 4, 1995
Coordinates N	170515.0	Driller:	Ocean Surveys, Inc.
E	1402350.0	Inspector:	J.Snyder/M.StClair
Elevation:	-33.3 Ft. NGVD	Remarks:	
		Remarks:	

Elevation NGVD	Depth FT.	Sample	Classification USCS
-33.8	0.5	1	Brown poorly graded medium SAND w/ tr. of shell (SP) [10YR 6/3 - pale brown]
-35.1	1.8	2	Gray brown poorly graded medium SAND w/ tr. of shell (SP) [10YR 6/3 - pale brown]
		3	Gray poorly graded medium fine SAND w/ tr. of shell (SP) [10YR 7/2 - light gray]
-48.3	15.0	1R	Moist brown poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]
	20		Bottom of Hole

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	2.10	1.31	0.73	1.38	0.69				
2	2.08	1.26	0.72	1.35	0.68				
3	2.19	1.65	1.06	1.63	0.56				
1R	1.74	1.00	0.65	1.13	0.54				

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Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

Hole No. B-5
Coordinates N 174316.0
E 1402238.0

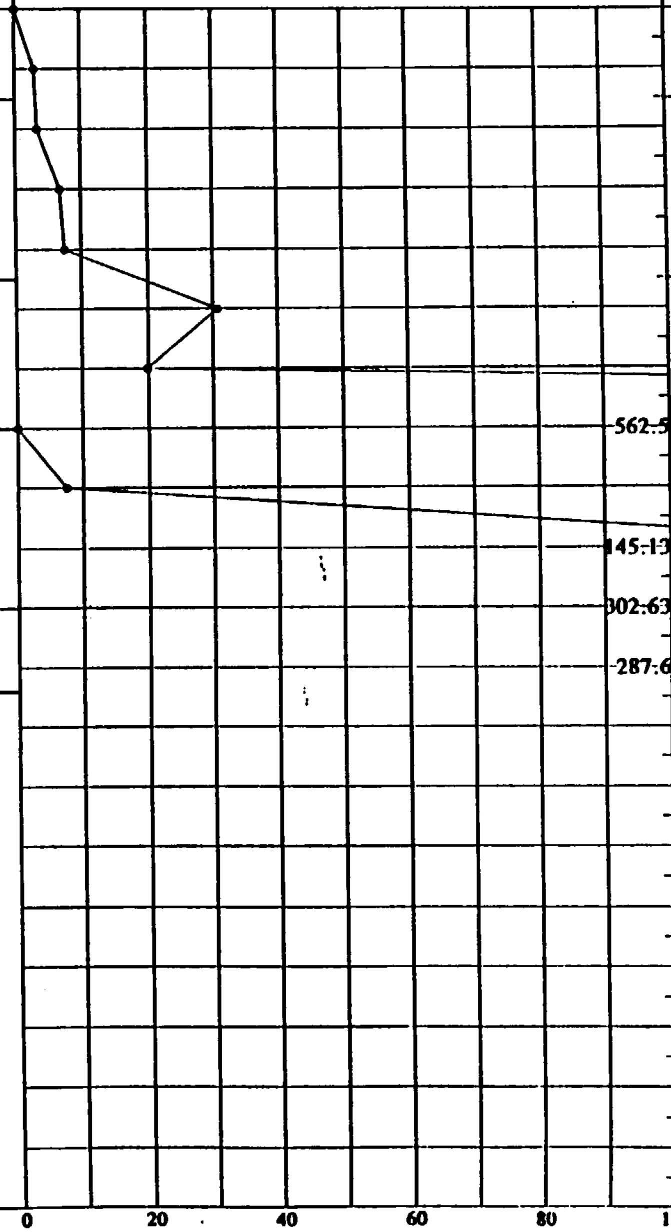
Date: October 4, 1995
Driller: Ocean Surveys, Inc.
Inspector: J.Snyder/M.StClair

Elevation: -44.2 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS
		1	Brown poorly graded coarse SAND w/ shell frags. & tr. of gravel (SP) [10YR 7/4 - very pale brown]
-45.7	1.5	2	Brown poorly graded medium coarse SAND w/ shell frags. & tr. of gravel (SP) [10YR 7/4 - very pale brown]
-48.7	4.5	3	Brown gray poorly graded medium coarse SAND w/ shell & tr. of gravel (SP) [10YR 7/4 - very pale brown]
-51.2	7.0	1R	Brown poorly graded medium coarse SAND w/ shell frags. & tr. of gravel (SP) [2.5Y 7/2 - light gray]
-54.2	10.0	2R	Gray poorly graded medium SAND w/ shell (SP) [2.5Y 7/2 - light gray]
			Bottom of Hole

Depth FT.: 5, 10, 15, 20

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	0.87	0.42	-0.56	0.24	0.72				
2	0.93	0.50	-0.18	0.42	0.55				
3	0.92	0.50	-0.26	0.39	0.59				
1R	0.90	0.51	-0.17	0.42	0.54				
2R	1.09	0.60	0.06	0.59	0.52				

GEO-4 OCSHB 7/30/96 13:16

Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

Hole No. B-6
Coordinates N 172874.0
E 1403307.0

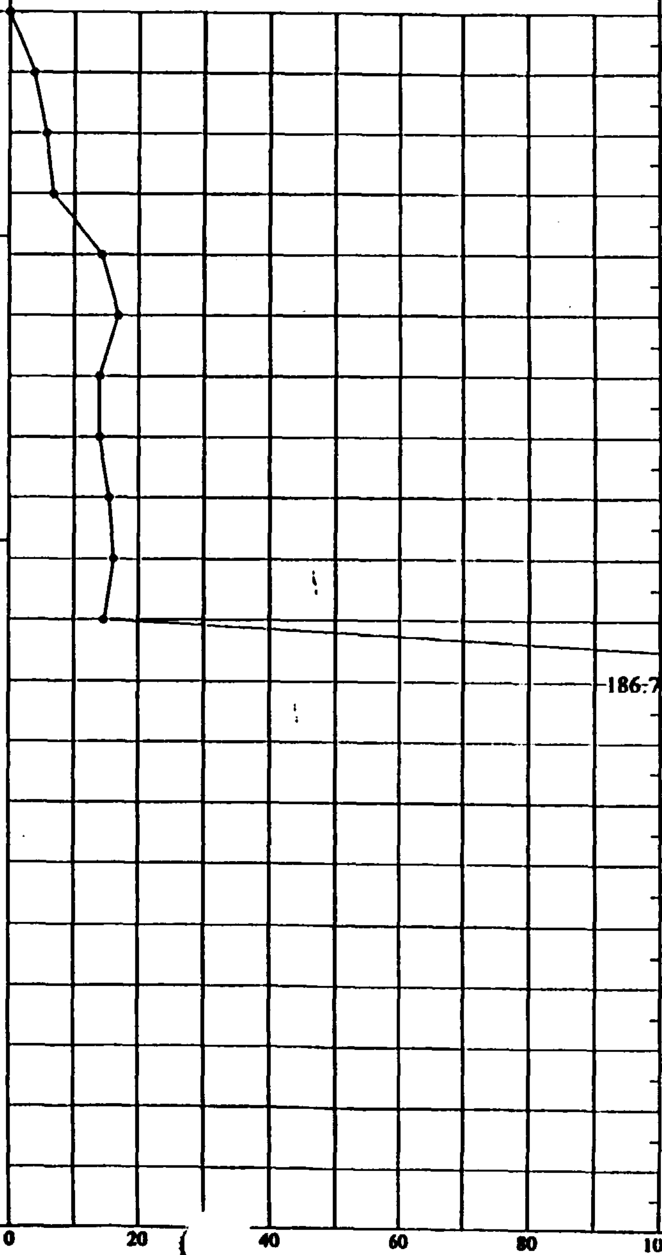
Date: October 7, 1995
Driller: Ocean Surveys, Inc.
Inspector: J.Snyder/M.StClair

Elevation: -32.3 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS
		1	Brown poorly graded medium coarse SAND w/ shell frags. (SP) [10YR 7/3 - very pale brown]
-36.0	3.7	2	Brown poorly graded medium fine SAND w/ shell frags. (SP) [2.5Y 7/2 - light gray]
			Bottom of Hole

Depth scale (FT.): 5, 10, 15, 20

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	1.29	0.83	0.36	0.83	0.46				
2	1.83	1.31	0.86	1.33	0.49				

GEO-4 OCSHB 7/25/96 15:12

Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

Hole No. B-7
Coordinates N 171878.0
E 1404650.0

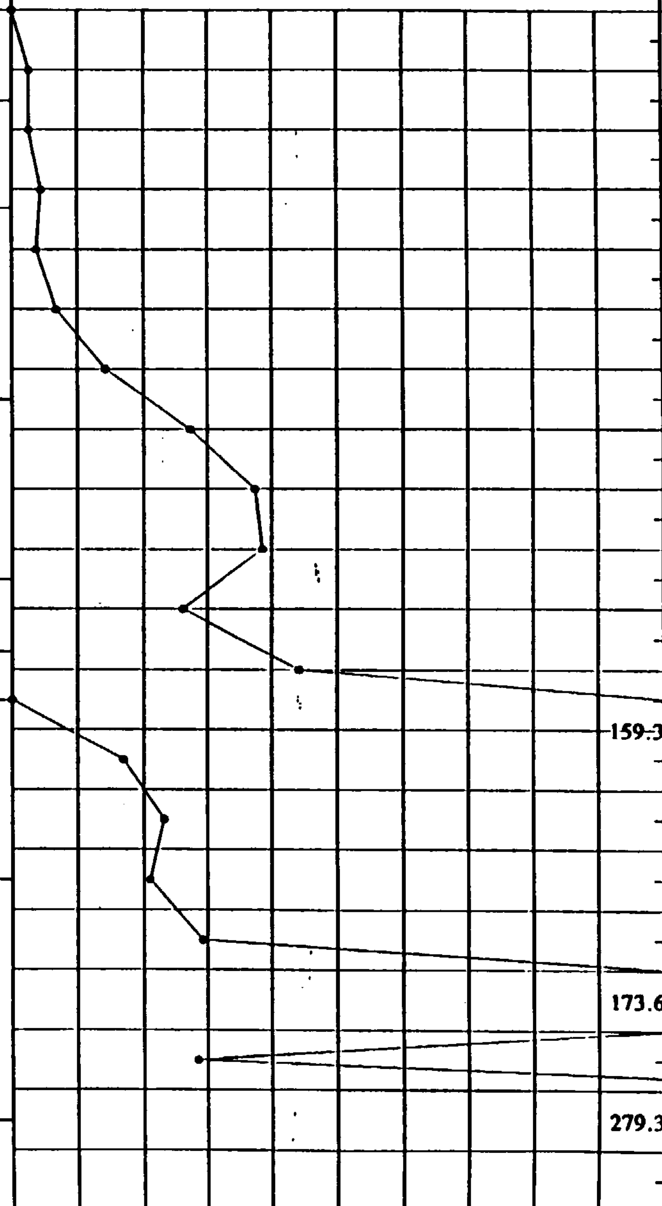
Date: October 7, 1995
Driller: Ocean Surveys, Inc.
Inspector: J.Snyder/M.StClair

Elevation: -30.2 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS	No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
-31.7	1.5	1	Wet gray poorly graded medium SAND w/ shell (SP) [10YR 7/3 - very pale brown]	1	1.46	1.13	0.78	1.12	0.34				
-33.5	3.3	2	Brown poorly graded medium SAND (SP) [10YR 7/3 - very pale brown]	2	1.44	1.12	0.76	1.11	0.34				
-36.7	6.5	3	Brown gray poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]	3	1.44	1.11	0.73	1.10	0.36				
-39.7	9.5	4	Brown poorly graded medium SAND w/ shell w/ tr. of gravel (SP) [10YR 7/3 - very pale brown]	4	1.38	1.03	0.66	1.02	0.36				
-40.9	10.7	5	Gray brown poorly graded medium fine SAND (SP) [10YR 7/3 - very pale brown]	5	1.88	1.48	1.04	1.47	0.42				
-41.7	11.5	6	Gray poorly graded fine SAND (SP) [2.5Y 7/2 - light gray]	6	2.30	1.83	1.33	1.82	0.48				
-44.7	14.5		Not Sampled										
		1R	Brown poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]	1R	1.75	1.33	0.98	1.35	0.39				
			Bottom of Hole										

Depth scale: 5, 10, 15, 20

Penetration In Seconds



GEO-4 OCSHB 7/30/96 13:18

Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

Hole No. B-8
Coordinates N 175306.0
E 1404946.0

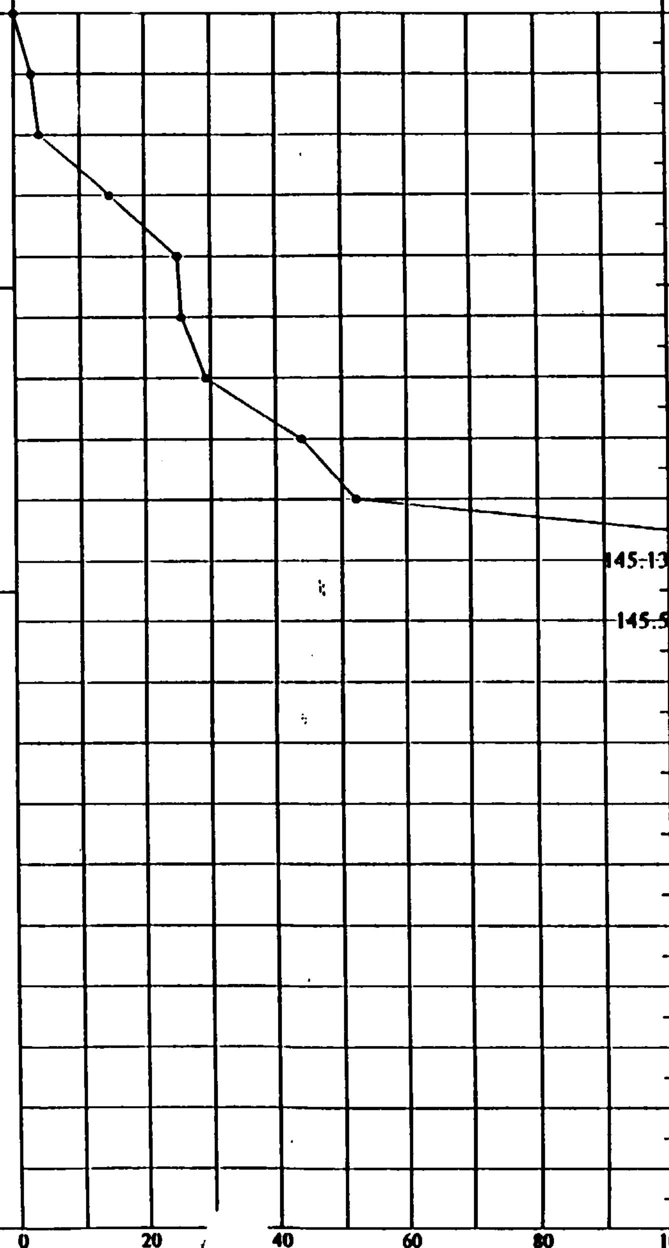
Date: October 7, 1995
Driller: Ocean Surveys, Inc.
Inspector: J.Snyder/M.StClair

Elevation: -40.1 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Leg.	Classification USCS
		1		Brown poorly graded coarse SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]
-44.6	4.5	2		Brown poorly graded coarse SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]
				Bottom of Hole

Depth scale: 5, 10, 15, 20

Penetration In Seconds



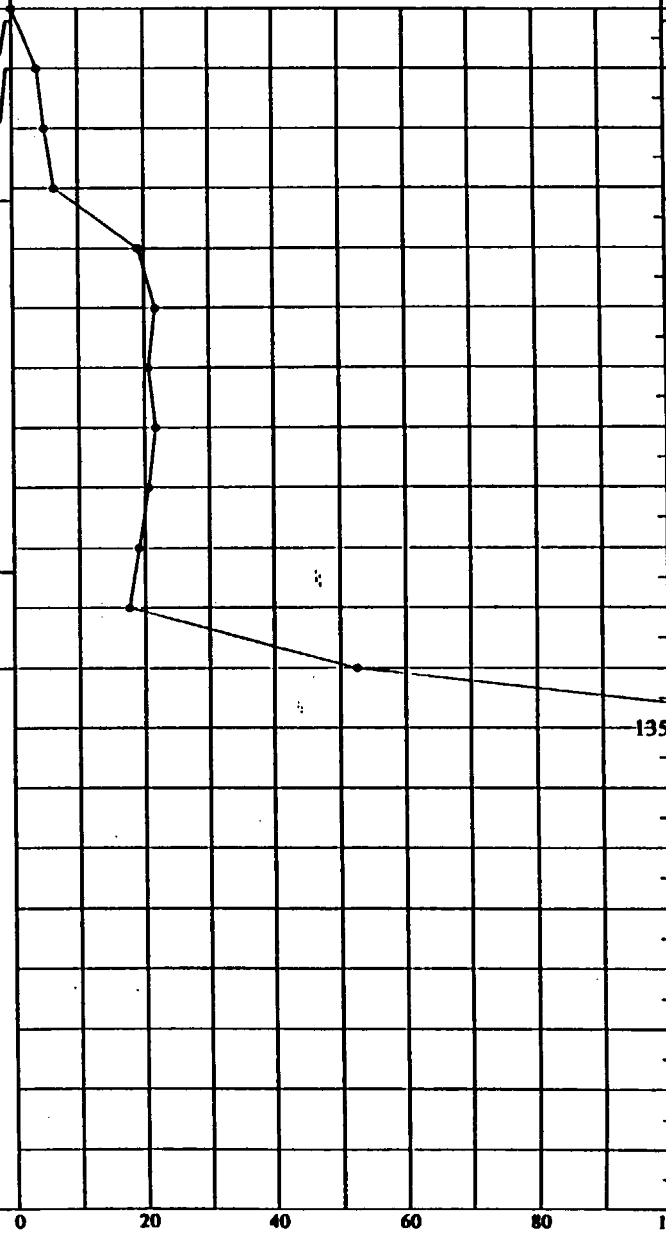
No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	1.42	0.93	0.57	0.97	0.43				
2	1.46	0.95	0.56	0.99	0.45				

GEO-4 OCSHB 7/25/96 15:13

Ocean City Water Resources Project **Assateague Island Restoration** **Shoal B**	Hole No. B-9 Coordinates N 173889.0 E 1406206.0	Date: October 7, 1995 Driller: Ocean Surveys, Inc. Inspector: J.Snyder/M.StClair	Elevation: -28.5 Ft. NGVD Remarks: Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS	No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
-28.7	0.2	1	Brn. poorly graded med. SAND (SP) [10YR 7/3 - very pale brown]	1	1.64	1.29	0.99	1.31	0.33				
-29.5	1.0	2	Gray brown poorly graded medium SAND w/ tr. of shell & gravel (SP) [2.5Y 7/3 - pale yellow]	2	1.31	0.95	0.48	0.92	0.42				
		3	Brown poorly graded medium coarse SAND w/ tr. of shell (SP) [2.5Y 7/3 - pale yellow]	3	1.35	1.00	0.62	0.99	0.36				
-31.7	3.2	4	Gray brown poorly graded medium coarse SAND w/ tr. of shell (SP) [2.5Y 7/2 - light gray]	4	1.77	1.36	0.97	1.37	0.40				
-37.9	9.4	5	Brown Gray poorly graded coarse SAND (SP) [2.5Y 7/2 - light gray]	5	1.54	1.21	0.85	1.20	0.34				
			Bottom of Hole										

Penetration In Seconds



Depth scale: 5, 10, 15, 20

GEO-4 OCSHB 7/25/96 15:13

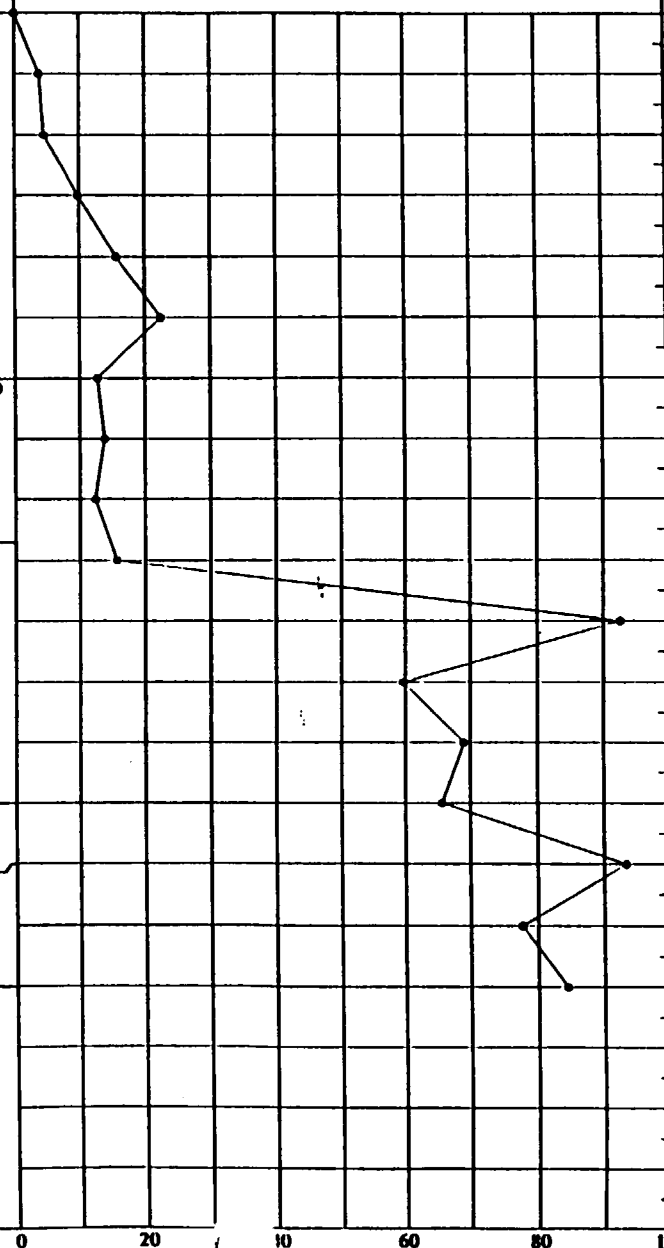
Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

Hole No. B-10	Date: November 1, 1995	Elevation: -43.0 Ft. NGVD	
Coordinates N 172650.0	Driller: Ocean Surveys, Inc.	Remarks:	
E 1407178.0	Inspector: J.Snyder/M.StClair	Remarks:	

Elevation NGVD	Depth FT.	Sample	Leg.	Classification USCS
		1		Gray brown poorly graded medium SAND w/ tr. of shell (SP) [2.5Y 7/2 - light gray]
-49.0	6.0	2		Lt. gray poorly graded medium fine SAND w/ tr. of shell & gravel (SP) [2.5Y 7/2 - light gray]
-51.7	8.7	3		Brown poorly graded fine SAND w/ tr. of shell (SP) [2.5Y 7/2 - light gray]
-56.0	13.0	4		Brown poorly graded fine SAND w/ shell (SP) [2.5Y 7/2 - light gray]
-57.0	14.0	5		Gray brown poorly graded fine SAND w/ tr. of shell (SP) [2.5Y 7/2 - light gray]
				Bottom of Hole

Depth scale: 5, 10, 15, 20

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	2.33	1.70	1.24	1.76	0.55				
2	2.53	2.00	1.40	1.98	0.57				
3	2.64	2.19	1.66	2.17	0.49				
4	2.60	2.14	1.47	2.07	0.56				
5	2.63	2.18	1.63	2.15	0.50				

GEO-4 OCSHB 7/25/96 15:08

Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

Hole No. B-11
Coordinates N 177866.0
E 1406115.0

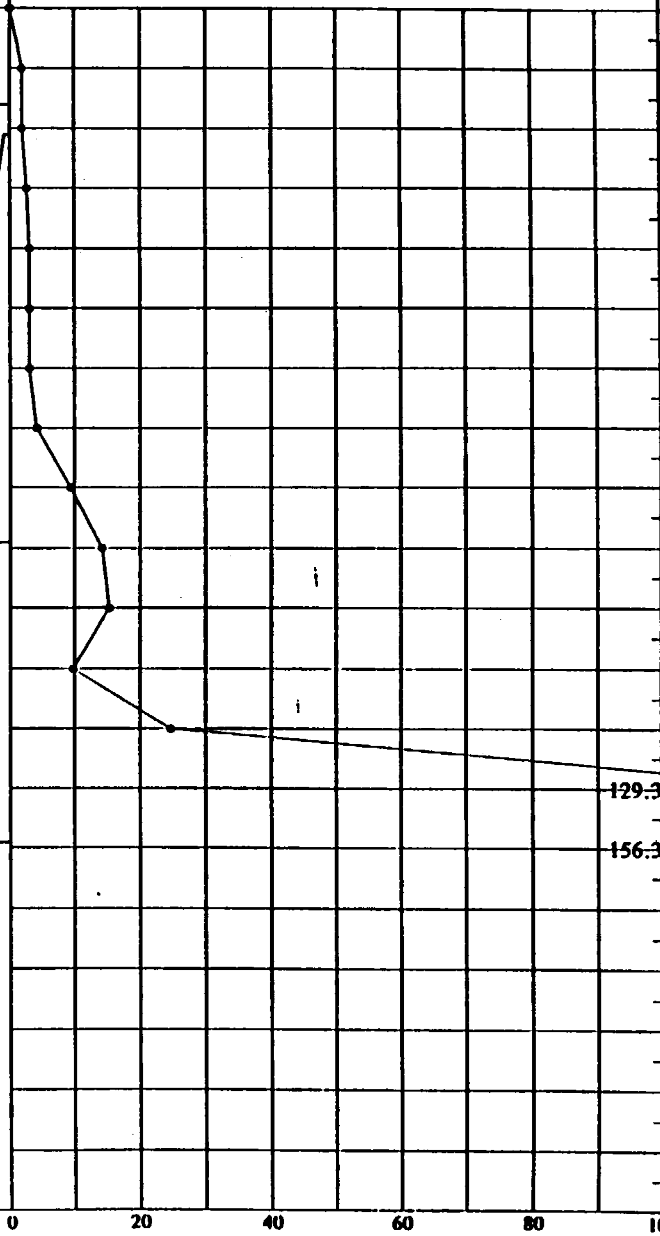
Date: November 1, 1995
Driller: Ocean Surveys, Inc.
Inspector: J.Snyder/M.StClair

Elevation: -45.6 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS
		1	Gray poorly graded coarse SAND w/ tr. of shell (SP) [10YR 7/2 - light gray]
-47.2	1.6	2	Brown poorly graded coarse SAND w/ tr. of shell (SP) [10YR 7/2 - light gray]
-47.7	2.1	3	Gray brown poorly graded coarse SAND w/ tr. of shell (SP) [10YR 7/2 - light gray]
-54.5	8.9	4	Brown gray poorly graded coarse SAND w/ tr. of gravel & shells (SP) [10YR 7/2 - light gray]
			Bottom of Hole

Depth scale: 5, 10, 15, 20

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	1.71	0.97	0.61	1.10	0.55				
2	1.67	0.98	0.60	1.08	0.53				
3	1.56	0.94	0.56	1.02	0.50				
4	2.00	1.00	0.52	1.17	0.74				

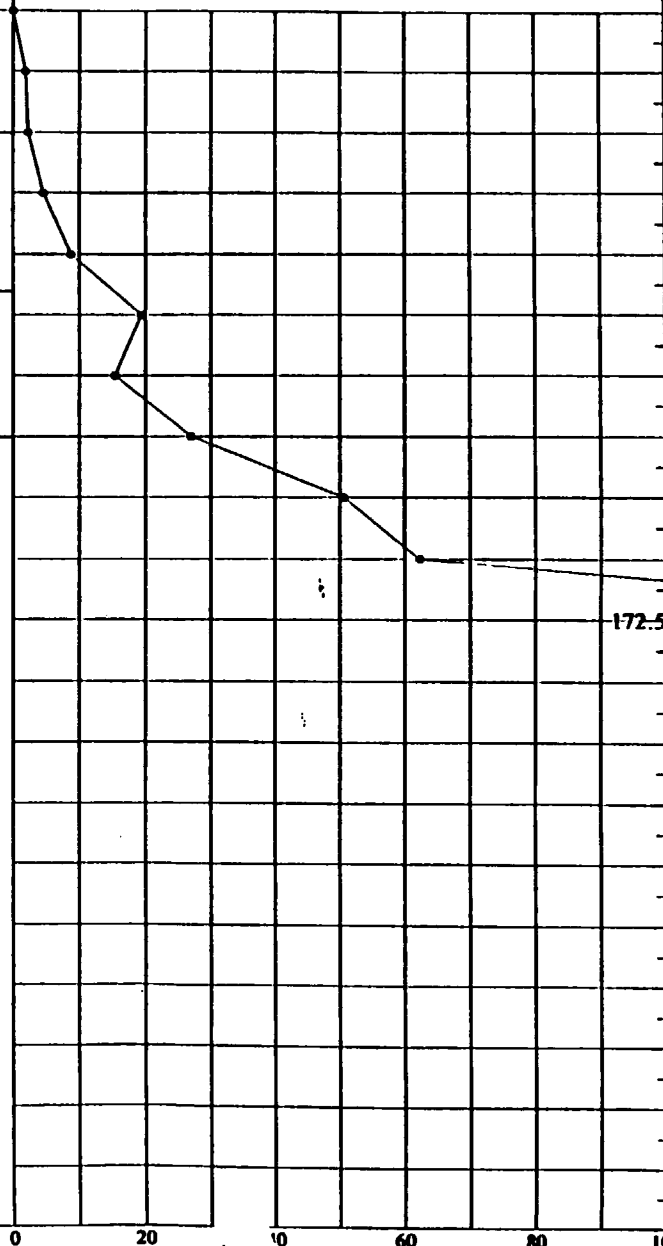
GEO-4 OCSHB 7/25/96 15:09

Ocean City Water Resources Project Assateague Island Restoration Shoal B	Hole No. B-12 Coordinates N 176155.0 E 1407732.0	Date: November 1, 1995 Driller: Ocean Surveys, Inc. Inspector: J.Snyder/M.StClair	Elevation: -32.8 Ft. NGVD Remarks: Remarks:

Elevation NGVD	Depth FT.	Sample	Leg.	Classification USCS
		1		Brown poorly graded coarse SAND w/ tr. of gravel & shell (SP) [10YR 7/3 - very pale brown]
-34.8	2.0	2		Brown poorly graded coarse SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]
-37.4	4.6	3		Gray brown poorly graded medium to coarse SAND w/ tr. of shell (SP) [10YR 7/2 - light gray]
				Bottom of Hole

Depth scale: 5, 10, 15, 20

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	1.35	0.94	0.22	0.83	0.57				
2	1.55	1.16	0.77	1.16	0.39				
3	1.84	1.43	1.05	1.44	0.39				

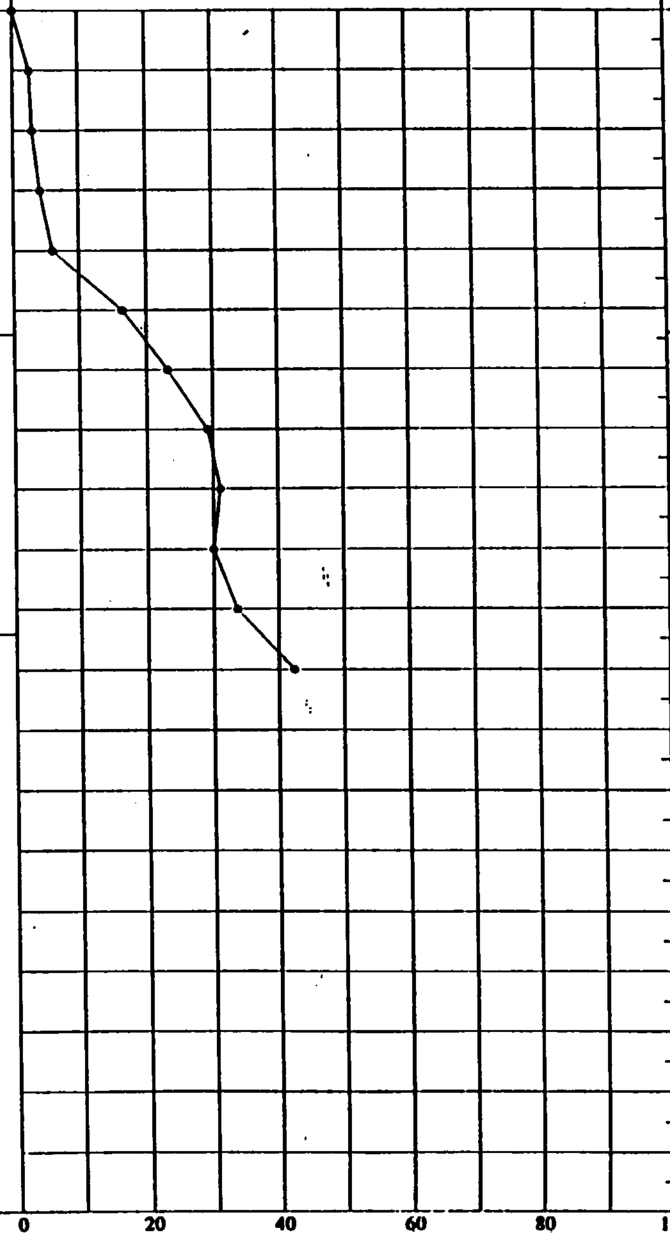
GEO-4 OCSHB 7/25/96 15:09

Ocean City Water Resources Project **Assateague Island Restoration** **Shoal B**	Hole No. B-13 Coordinates N 174935.0 E 1408835.0	Date: October 30, 1995 Driller: Ocean Surveys, Inc. Inspector: J.Snyder/M.StClair	Elevation: -35.1 Ft. NGVD Remarks: Remarks:

Elevation NGVD	Depth FT.	Sample	Leg.	Classification USCS
		1		Gray brown poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]
-40.5	5.4	2		Gray brown poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]
				Bottom of Hole

Depth scale: 5, 10, 15, 20

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	1.77	1.38	1.03	1.39	0.37				
2	1.79	1.37	1.05	1.40	0.37				

GEO-4 OCSHB 7/25/96 15:09

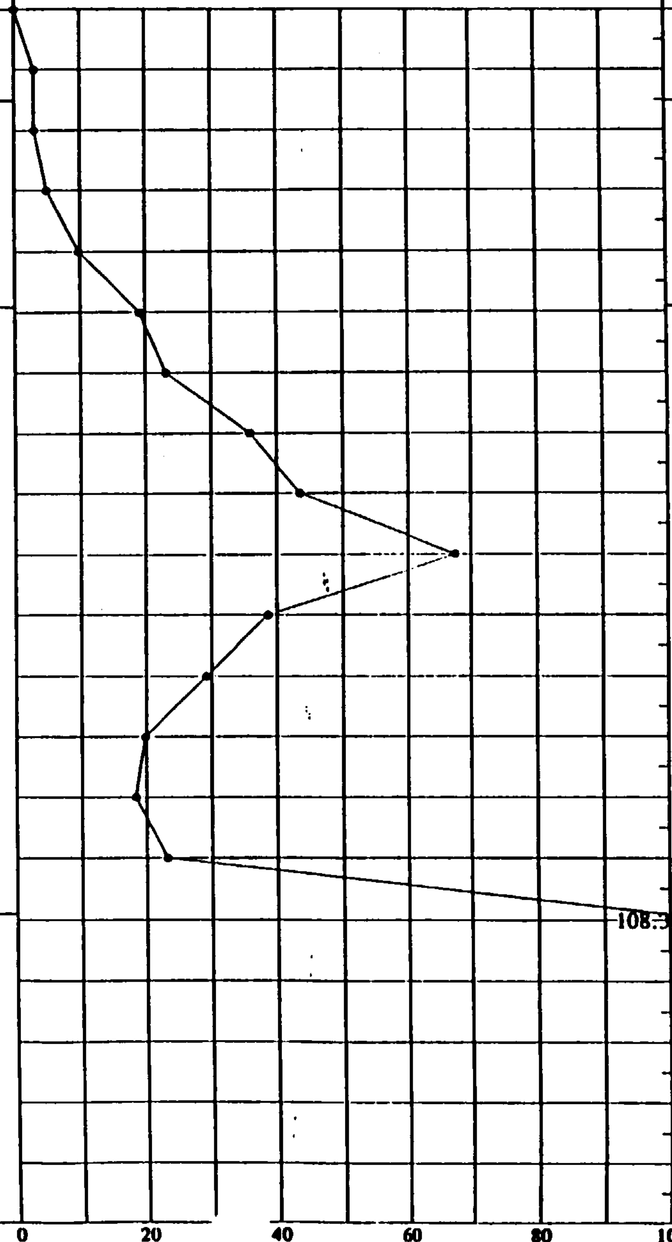
Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

Hole No.	B-14	Date: October 31, 1995	Elevation: -41.7 Ft. NGVD
Coordinates N	178947.0	Driller: Ocean Surveys, Inc.	Remarks:
E	1408711.0	Inspector: J.Snyder/M.StClair	Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS
		1	Brown poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]
-43.2	1.5	2	Gray poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]
-46.6	4.9	3	Gray brown poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/2 - light gray]
	15		Bottom of Hole

Depth scale: 5, 10, 15, 20

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	1.69	1.26	0.89	1.28	0.40				
2	1.74	1.28	0.92	1.31	0.41				
3	1.80	1.22	0.85	1.29	0.48				

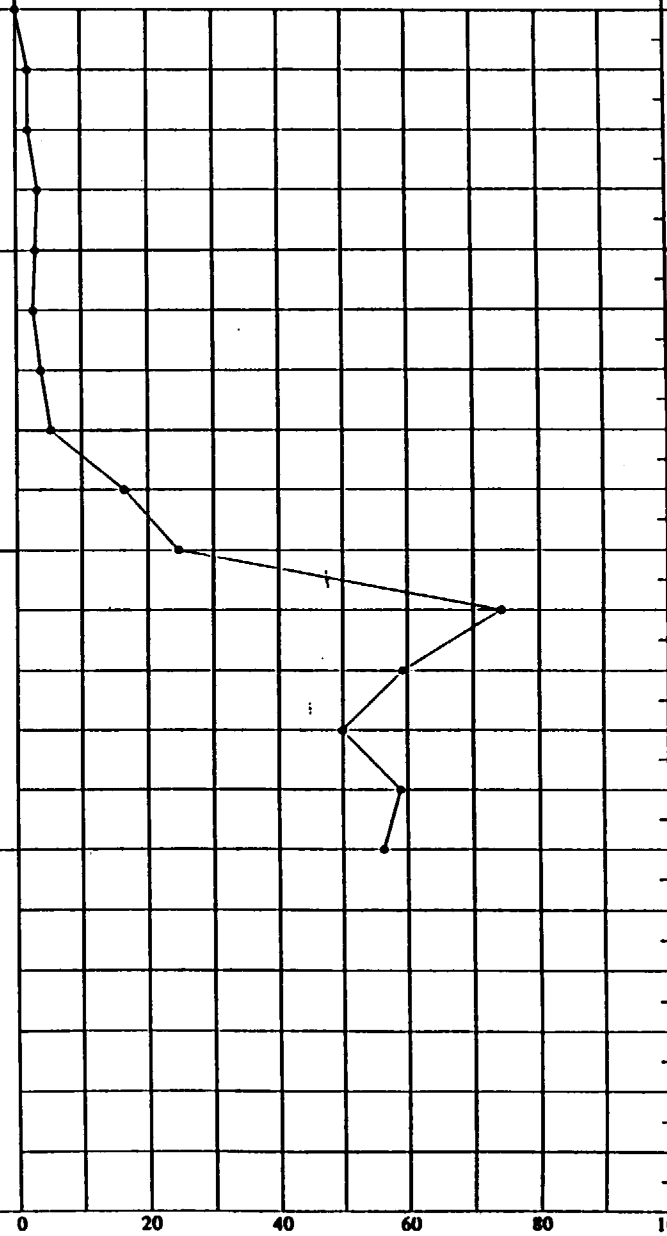
GEO-4 OCSHB 7/25/96 15:09

Ocean City Water Resources Project	Hole No. B-15	Date: October 30, 1995	Elevation: -40.3 Ft. NGVD
Assateague Island Restoration	Coordinates N 176858.0	Driller: Ocean Surveys, Inc.	Remarks:
Shoal B	E 1411383.0	Inspector: J.Snyder/M.StClair	Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS	No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
		1	Gray brown poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]	1	1.89	1.48	1.13	1.50	0.38				
-44.3	4.0	2	Brown gray poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]	2	1.88	1.48	1.12	1.49	0.38				
-49.3	9.0	3	Brown gray poorly graded medium to fine SAND (SP) [2.5Y 7/2 - light gray]	3	2.26	1.85	1.53	1.88	0.36				
			Bottom of Hole										

Depth scale: 5, 10, 15, 20

Penetration In Seconds



GEO-4 OCSHB 7/25/96 15:10

Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

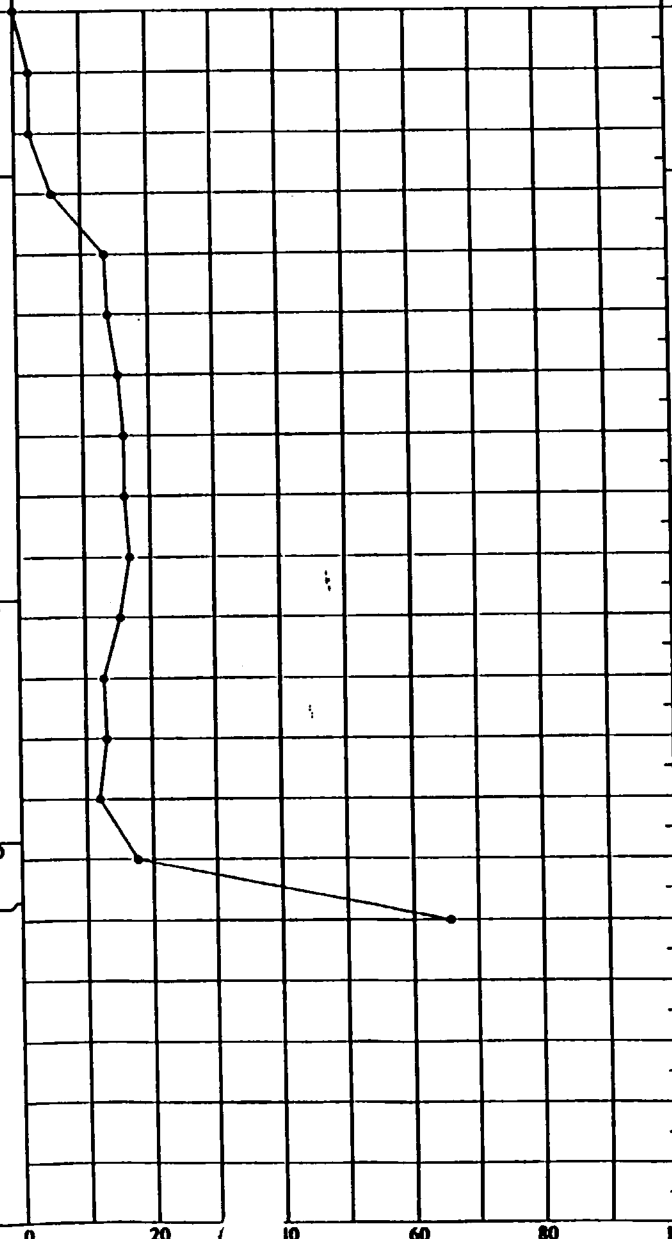
Hole No.	B-16	Date:	October 30, 1995
Coordinates N	181351.0	Driller:	Ocean Surveys, Inc.
E	1411623.0	Inspector:	J.Snyder/M.StClair

Elevation: -41.5 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS
		1	Gray brown poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]
-44.2	2.7	2	Gray brown poorly graded medium to fine SAND w/ tr. of shell (SP) [2.5Y 7/2 - light gray]
-51.2	9.7	3	Gray brown poorly graded medium to fine SAND (SP) [2.5Y 7/2 - light gray]
-55.2	13.7	4	Gray brown poorly graded medium SAND (SP) [10YR 7/3 - very pale brown]
			Bottom of Hole

Depth scale: 5, 10, 15, 20

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	1.90	1.43	0.93	1.42	0.49				
2	2.12	1.71	1.30	1.71	0.41				
3	2.06	1.54	0.87	1.49	0.59				
4	1.93	1.42	0.79	1.38	0.57				

GEO-4 OCSHB 7/25/96 15:10

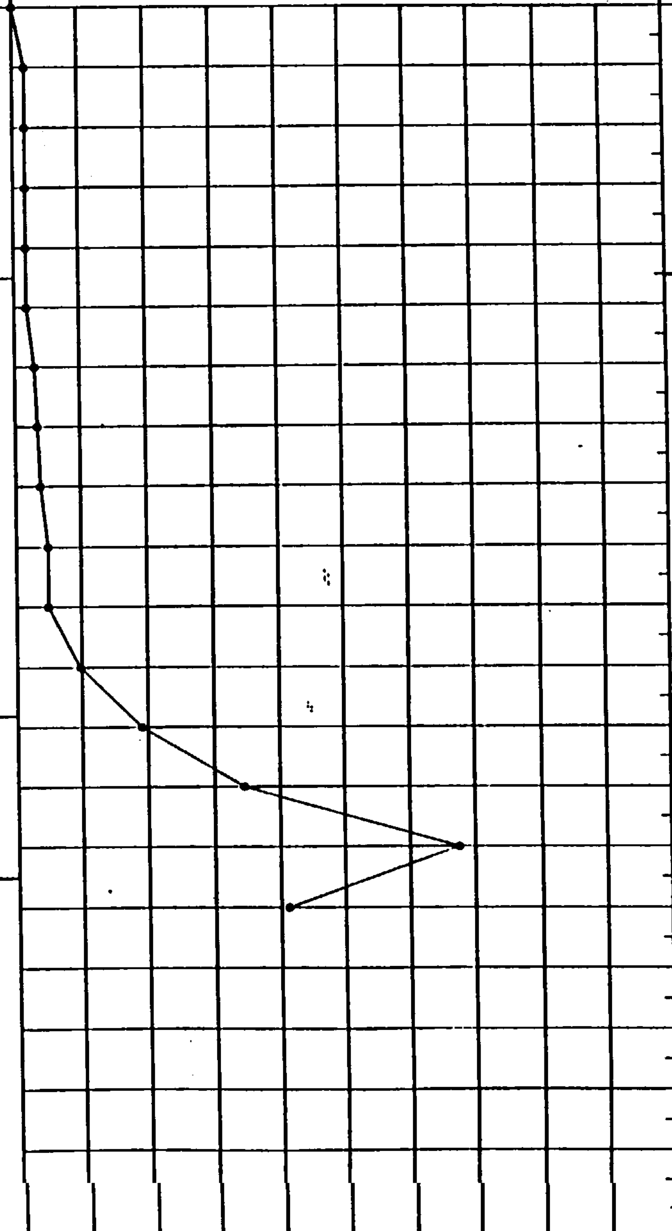
Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

Hole No. B-17	**Date:** October 30, 1995	**Elevation:** -40.3 Ft. NGVD
Coordinates N 179637.0	**Driller:** Ocean Surveys, Inc.	**Remarks:**
E 1413424.0	**Inspector:** J.Snyder/M.StClair	**Remarks:**

Elevation NGVD	Depth FT.	Sample	Leg.	Classification USCS
		1		Brown gray poorly graded medium to coarse SAND w/ tr. of shell (SP) [10YR 7/2 - light gray]
-44.8	4.5	2		Brown gray poorly graded medium to coarse SAND w/ tr. of shell (SP) [10YR 7/2 - light gray]
-52.1	11.8	3		Brown gray poorly graded medium to coarse SAND w/ tr. of gravel and tr. of shell (SP) [2.5Y 7/2 - light gray]
				Bottom of Hole

Depth scale: 5, 10, 15, 20

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	1.90	1.55	1.12	1.52	0.39				
2	1.88	1.53	1.09	1.50	0.40				
3	1.99	1.66	1.28	1.64	0.36				

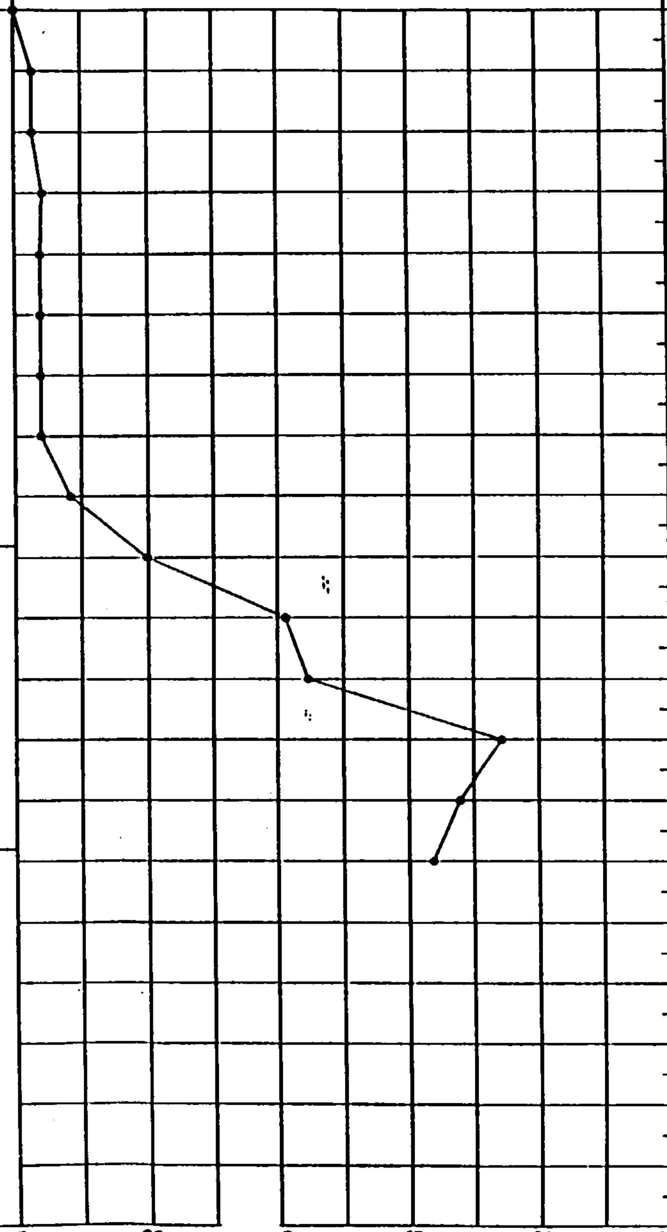
Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

Hole No.	B-18	Date:	October 30, 1995
Coordinates N	183320.0	Driller:	Ocean Surveys, Inc.
E	1414500.0	Inspector:	J.Snyder/M.StClair
Elevation:	-42.4 Ft. NGVD	Remarks:	
		Remarks:	

Elevation NGVD	Depth FT.	Sample	Leg.	Classification USCS
		1		Brown poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]
-51.2	8.8	2		Brown poorly graded medium SAND w/ tr. of shell (SP) [10YR 7/2 - light gray]
				Bottom of Hole

Depth scale: 5, 10, 15, 20

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	1.90	1.56	1.20	1.55	0.35				
2	1.98	1.58	1.16	1.57	0.41				

GEO-4 OCSHB 7/25/96 15:11

Ocean City Water Resources Project
Assateague Island Restoration
Shoal B

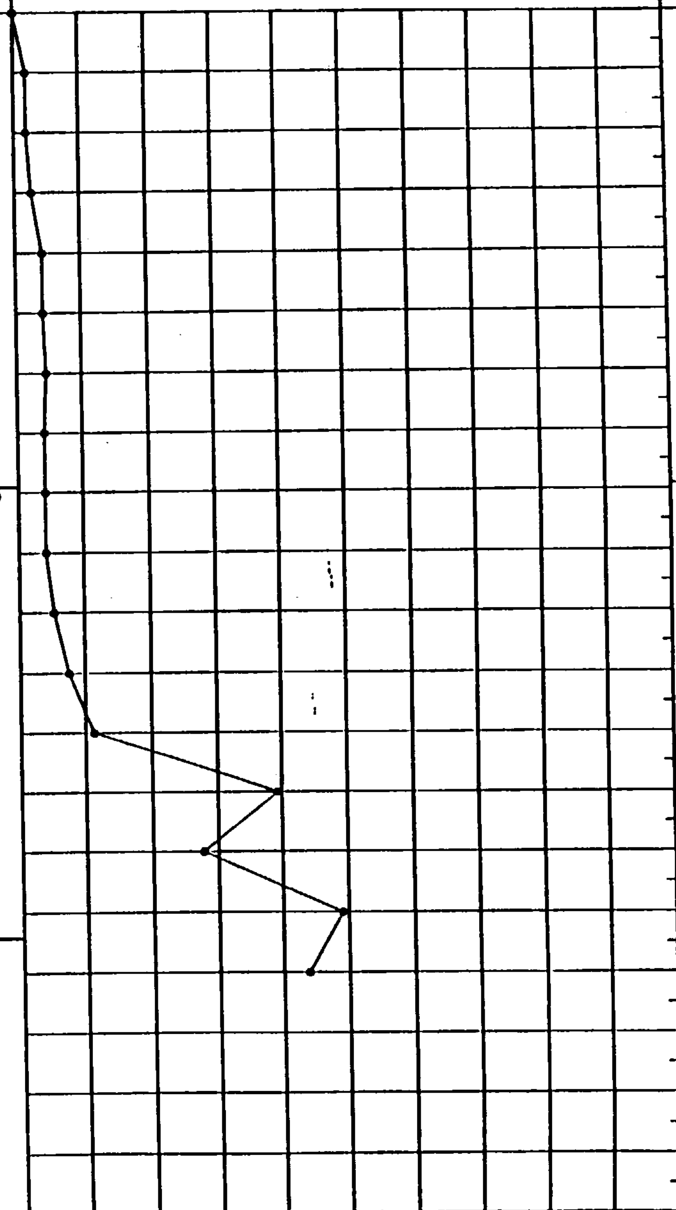
Hole No. B-19
Coordinates N 181876.0
E 1415810.0

Date: October 30, 1995
Driller: Ocean Surveys, Inc.
Inspector: J.Snyder/M.StClair

Elevation: -44.3 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS
	0–7.9	1	Brown gray poorly graded medium SAND w/ tr. of shell (SP) [2.5Y 7/2 - light gray]
-52.2	7.9	2	Gray brown poorly graded medium SAND w/ tr. of shell (SP) [2.5Y 7/2 - light gray]
	15.5		Bottom of Hole

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	2.28	1.88	1.45	1.87	0.41				
2	2.33	1.90	1.45	1.90	0.44				

Depth scale: 5, 10, 15, 20

GEO-4 OCSHB 7/25/96 15:11

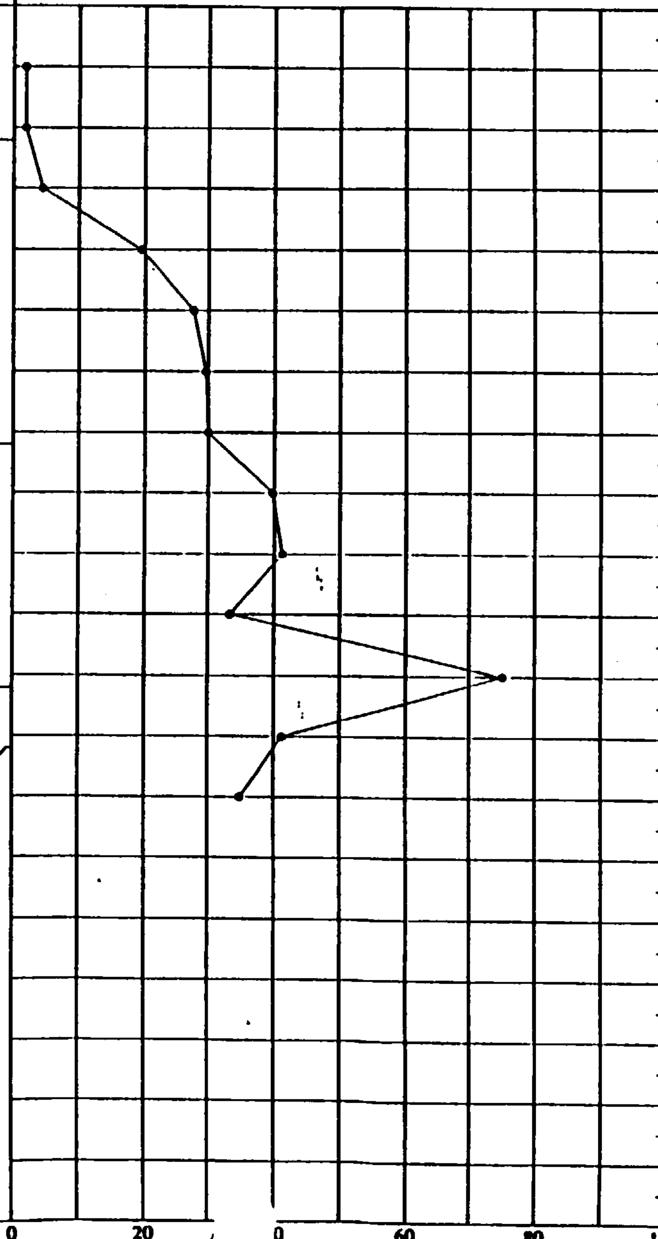
Ocean City Water Resources Project
Assateague Island Restoration
Shoal C

Hole No.	C-1
Coordinates N	163670.0
E	1403472.0
Date:	November 3, 1995
Driller:	Ocean Surveys, Inc.
Inspector:	J.Snyder/M.StClair
Elevation:	-40.1 Ft. NGVD
Remarks:	
Remarks:	

Elevation NGVD	Depth FT.	Sample	Leg.	Classification USCS
		1		Brn. gray poorly graded med. SAND (SP) [2.5Y 7/2 - light gray]
-42.3	2.2	2		Brn. gray poorly graded medium SAND (SP) [2.5Y 7/2 - light gray]
-47.3	7.2	3		Brn. gray poorly graded med. SAND (SP) [2.5Y 7/2 - light gray]
-51.3	11.2	4		Brn. poorly graded med. to coarse SAND (SP) [2.5Y 7/2 - light gray]
				Bottom of Hole

Depth scale: 5, 10, 15, 0

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	2.19	1.79	1.33	1.77	0.43				
2	2.13	1.77	1.42	1.78	0.36				
3	2.37	1.92	1.57	1.95	0.40				
4	2.21	1.71	1.19	1.70	0.51				

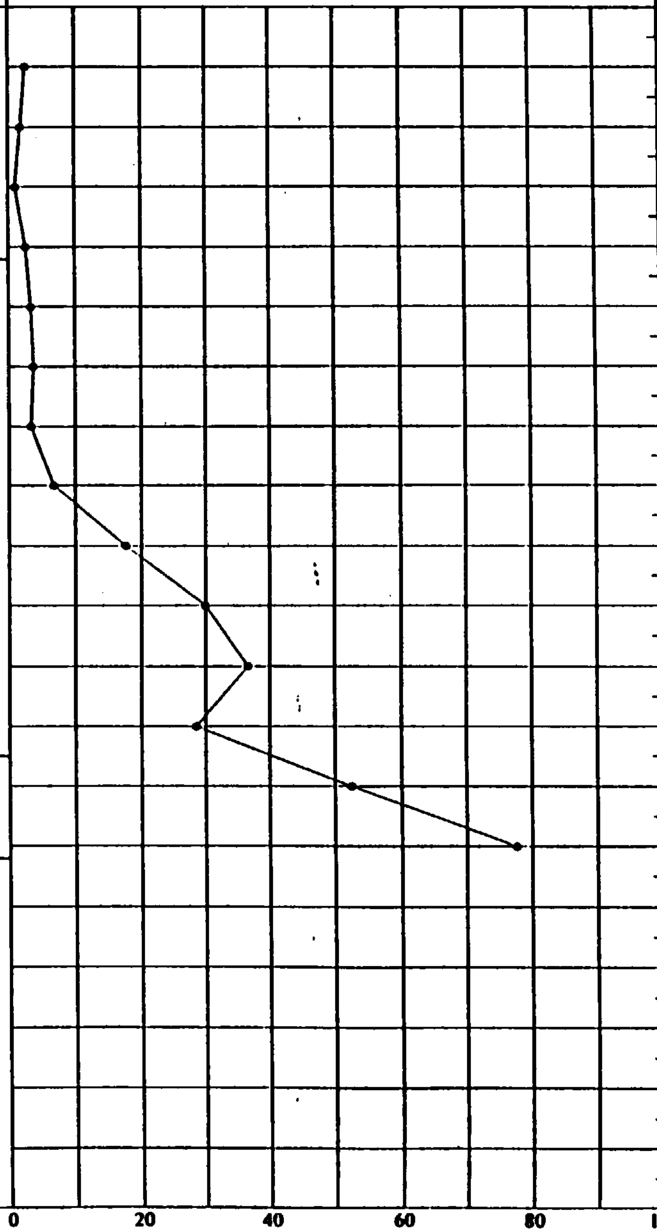
GEO-4 OCSHC 7/16/96 13:49

Ocean City Water Resources Project **Assateague Island Restoration** **Shoal C**	**Hole No.** C-2 **Coordinates N** 166345.0 **E** 1405631.0	**Date:** November 1, 1995 **Driller:** Ocean Surveys, Inc. **Inspector:** J.Snyder/M.StClair
Elevation: -41.2 Ft. NGVD **Remarks:** **Remarks:**		

Elevation NGVD	Depth FT.	Sample	Classification USCS	No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
-45.4	4.2	1	Gray brn. poorly graded med. SAND (SP) [10YR 7/2 - light gray]	1	1.91	1.53	1.04	1.49	0.43				
-53.7	12.5	2	Gray brn. poorly graded med. SAND (SP) [10YR 7/2 - light gray]	2	1.98	1.54	1.04	1.52	0.47				
		3	Brn. poorly graded coarse SAND w/shells & tr. of gravel (SP) [10YR 7/3 - very pale brown]	3	1.69	1.07	0.24	1.00	0.73				
			Bottom of Hole										

Depth scale: 5, 10, 15, 20

Penetration In Seconds



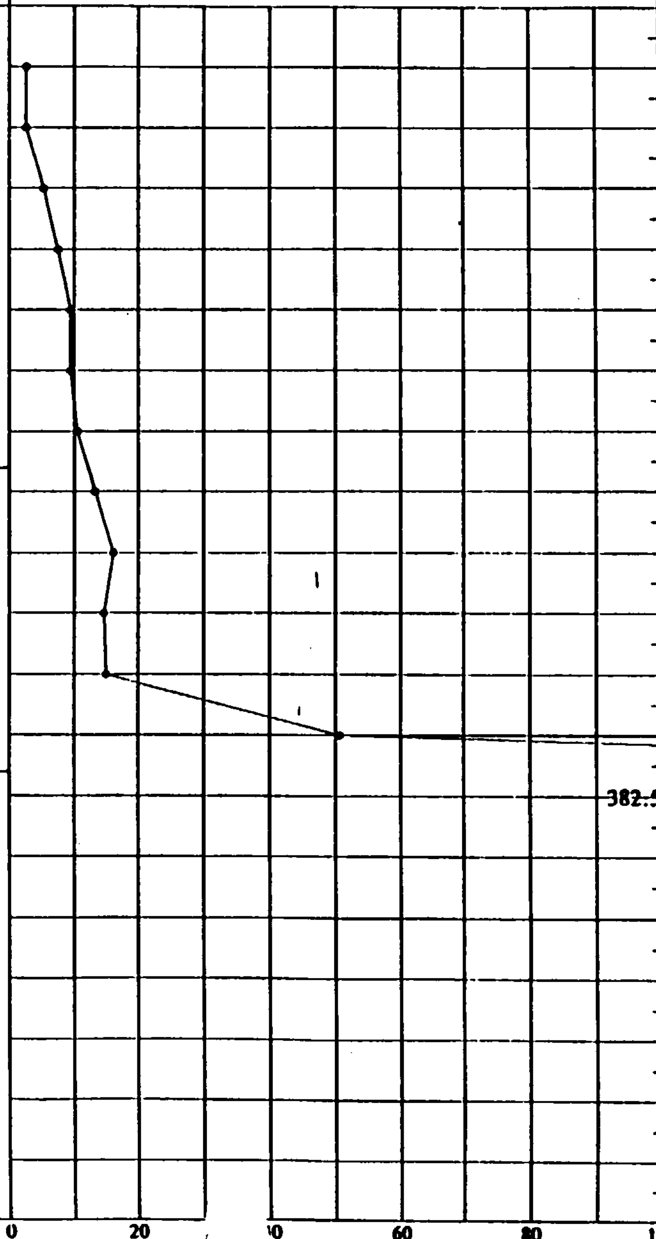
GEO-4 OCSHC 7/16/96 13:49

Ocean City Water Resources Project Assateague Island Restoration Shoal C	Hole No. C-3 Coordinates N 165065.0 E 1406597.0	Date: October 5, 1995 Driller: Ocean Surveys, Inc. Inspector: J.Snyder/M.StClair	Elevation: -41.8 Ft. NGVD Remarks: Remarks:

Elevation NGVD	Depth FT.	Sample	Leg.	Classification USCS	No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
		1		Gray poorly graded med. fine SAND (SP) [2.5Y 7/1 - light gray]	1	2.58	2.13	1.56	2.09	0.51				
-49.4	7.6	2		Brn. poorly graded med. fine SAND (SP) [2.5Y 7/1 - light gray]	2	2.61	2.21	1.68	2.16	0.46				
				Bottom of Hole										

Depth scale: 5, 10, 15, 20

Penetration In Seconds



GEO-4 OCSHC 7/16/96 13:50

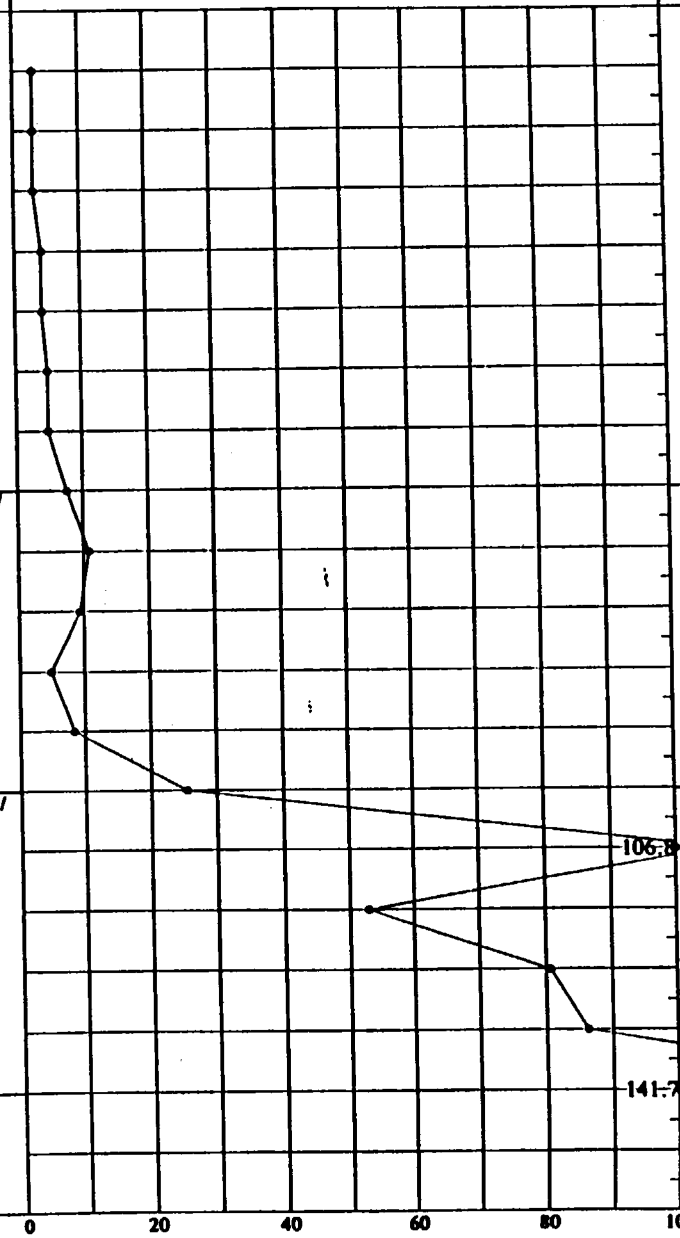
Ocean City Water Resources Project
Assateague Island Restoration
Shoal C

Hole No.	C-4	Date:	November 1, 1995
Coordinates N	167444.0	Driller:	Ocean Surveys, Inc.
E	1408030.0	Inspector:	J.Snyder/M.StClair

Elevation: -46.4 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS
		1	Brn. gray poorly graded med. to fine SAND (SP) [2.5Y 7/2 - light gray]
-54.4	8.0	2	Gray poorly graded med. to fine SAND w/ tr. of gravel (SP) [2.5Y 7/2 - light gray]
-59.4	13.0	3	Gray poorly graded med. to fine SAND w/ some shell (SP) [5Y 6/1 - gray]
			Bottom of Hole

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	2.47	1.98	1.50	1.99	0.49				
2	2.55	2.00	1.57	2.04	0.49				
3	2.85	2.50	1.88	2.41	0.48				

Depth scale: 5, 10, 15, 20

GEO-4 OCSHC 7/16/96 13:50

Ocean City Water Resources Project
Assateague Island Restoration
Little Gull Bank

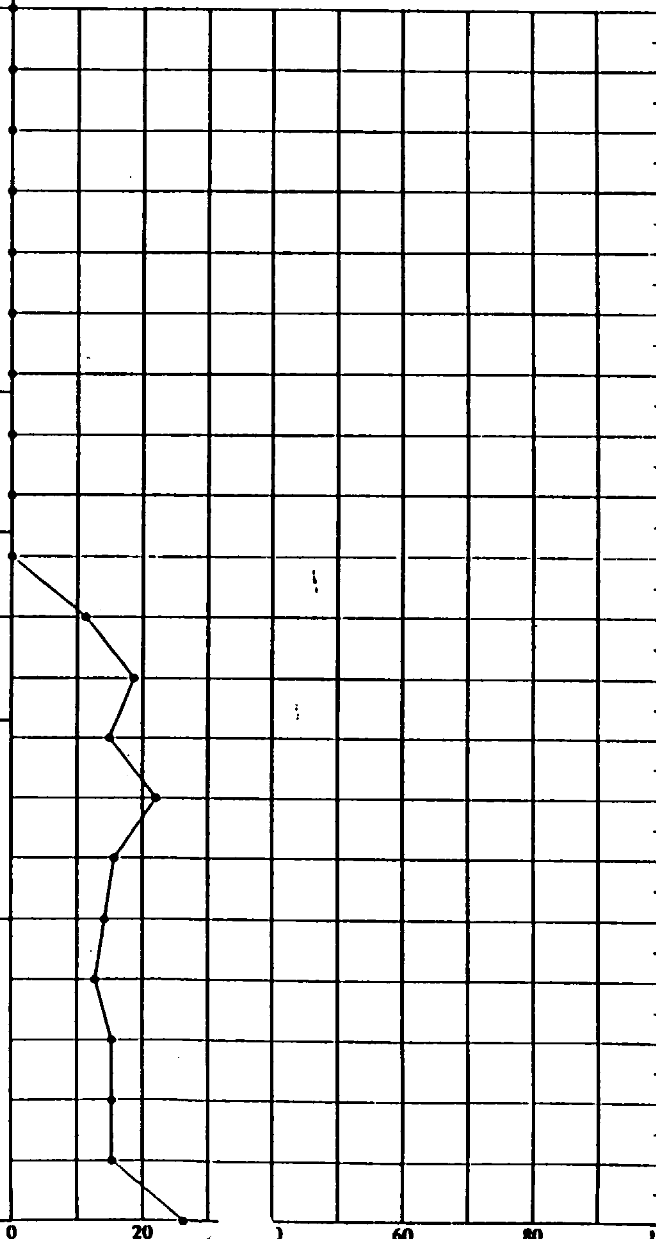
Hole No.	LG-1	Date:	October 26, 1995
Coordinates N	169298.0	Driller:	Ocean Surveys, Inc.
E	1353439.0	Inspector:	J.Snyder/M.StClair

Elevation: -20.4 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS	No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
		1	Brown poorly graded coarse SAND (SP) [10YR 7/3 - very pale brown]	1	1.43	1.02	0.42	0.95	0.51				
-26.7	6.3	2	Gray poorly graded medium coarse SAND (SP) [10YR 7/3 - very pale brown]	2	1.51	1.14	0.72	1.12	0.39				
-29.0	8.6	3	Brown poorly graded coarse SAND w/ tr. of gravel (SP) [10YR 7/3 - very pale brown]	3	1.31	0.57	-0.71	0.39	1.01				
-30.4	10.0	4	Brown poorly graded medium coarse SAND (SP) [10YR 7/3 - very pale brown]	4	1.37	0.94	0.50	0.94	0.43				
-32.1	11.7	5	Gray brown poorly graded coarse SAND w/ shell & tr. of gravel (SP) [10YR 7/3 - very pale brown]	5	1.47	0.72	-0.44	0.58	0.95				
-35.4	15.0	6	Brown gray poorly graded coarse SAND w/ tr. of shell & gravel (SP) [10YR 7/3 - very pale brown] (Shell layer @ 18.2') Bottom of Hole	6	1.58	0.93	-0.18	0.77	0.88				

Depth scale: 5, 10, 15, 20

Penetration In Seconds



GEO-4 OCLGB 7/16/96 14:46

Ocean City Water Resources Project
Assateague Island Restoration
Little Gull Bank

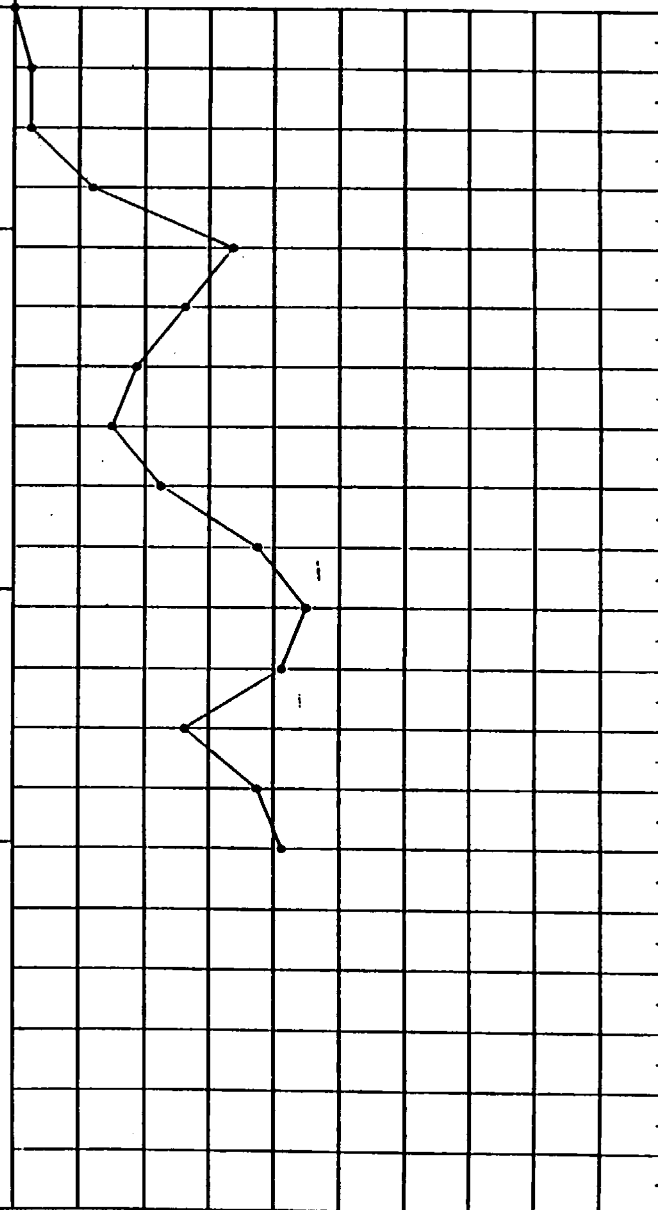
Hole No.	LG-2	Date:	October 26, 1995
Coordinates N	170221.0	Driller:	Ocean Surveys, Inc.
E	1355997.0	Inspector:	J.Snyder/M.StClair

Elevation: -26.4 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS
		1	Gray brown poorly graded medium SAND (SP) [2.5Y 7/2 - light gray]
-30.1	3.7	2	Brown poorly graded medium coarse SAND (SP) [2.5Y 7/2 - light gray]
-36.1	9.7	3	Brown poorly graded coarse SAND (SP) [2.5Y 7/2 - light gray] (1 shell @ 11.9')
			Bottom of Hole

Depth scale: 5, 10, 15, 20

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	2.00	1.66	1.14	1.60	0.43				
2	1.89	1.51	0.85	1.42	0.52				
3	1.76	1.38	0.87	1.34	0.45				

GEO-4 OCLGB 8/1/96 16:06

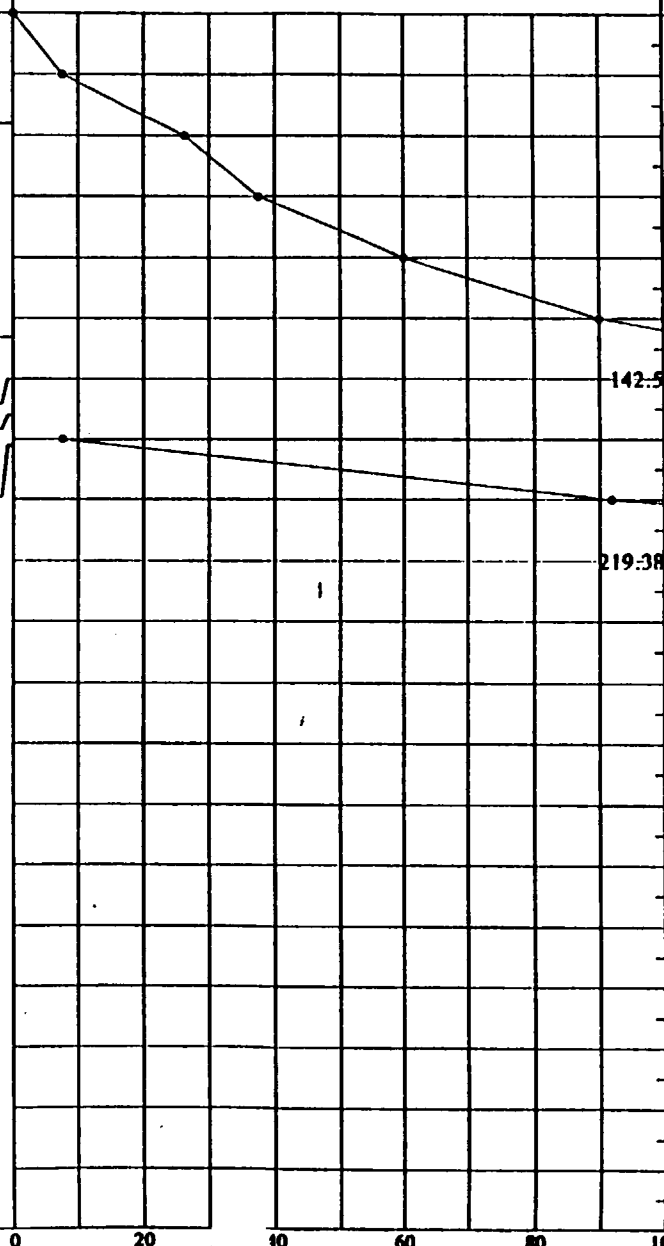
Ocean City Water Resources Project
Assateague Island Restoration
Little Gull Bank

Hole No. LG-3	Date: October 26, 1995	Elevation: -27.3 Ft. NGVD	
Coordinates N 172959.0	Driller: Ocean Surveys, Inc.	Remarks:	
E 1356344.0	Inspector: J.Snyder/M.StClair	Remarks:	

Elevation NGVD	Depth FT.	Sample	Classification USCS
		1	Brown poorly graded medium SAND (SP) [10YR 7/3 - very pale brown]
-29.1	1.8	2	Brown poorly graded coarse SAND (SP) [10YR 7/3 - very pale brown]
-32.6	5.3	3	Brn. poorly graded very coarse SAND w/ gravel, cobbles & shells (SP) [10YR 7/4 - very pale brown]
-33.3	6.0		Not Sampled
-33.9	6.6	1R	Poorly graded coarse SAND w/ gravel, cobbles & shells (SP) [2.5Y 7/2 - light gray]
			Bottom of Hole

Depth scale: 5, 10, 15, 20

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	1.84	1.53	1.13	1.50	0.35				
2	1.63	1.13	0.36	1.04	0.63				
3	1.00	-0.40	-2.24	-0.55	1.62				
1R	1.63	-1.34							

GEO-4 OCLGB 7/16/96 14:47

Ocean City Water Resources Project
Assateague Island Restoration
Little Gull Bank

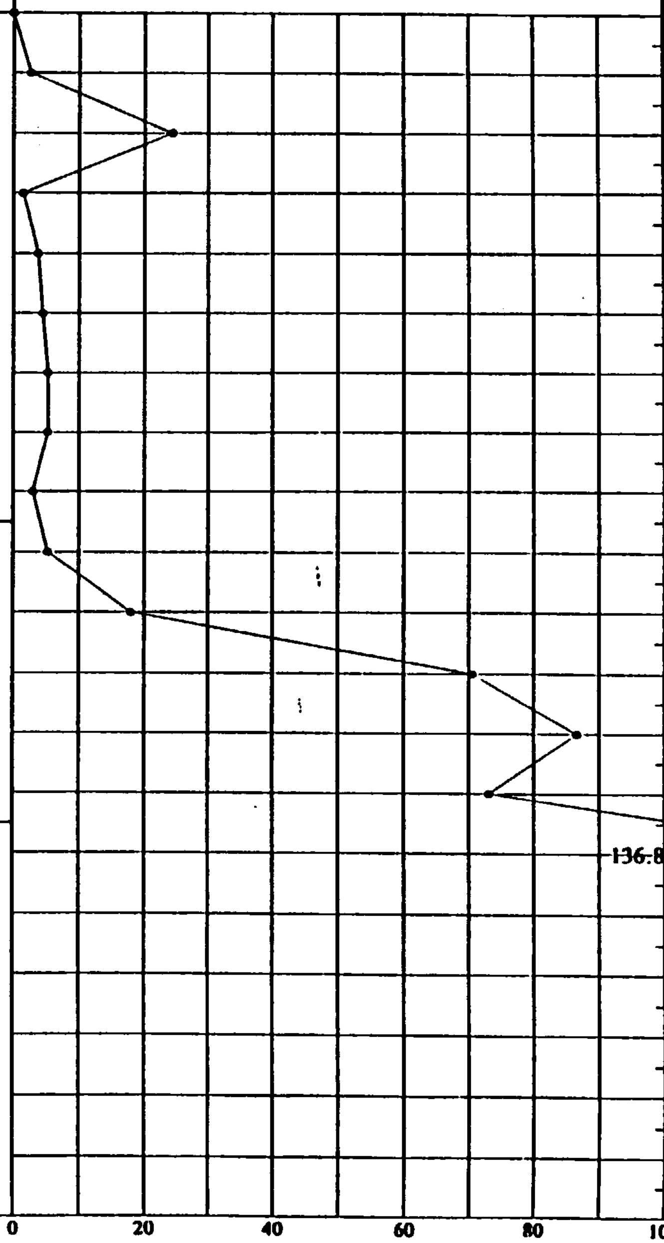
Hole No. LG-4
Coordinates N 173183.0
E 1359677.0

Date: October 8, 1995
Driller: Ocean Surveys, Inc.
Inspector: J.Snyder/M.StClair

Elevation: -27.3 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Leg.	Classification USCS
	0–8.5 (5)	1		Brown gray poorly graded medium to fine SAND (SP) [2.5Y 7/2 - light gray]
-35.8	8.5 (10)	2		Brown poorly graded medium to fine SAND (SP) [2.5Y 7/2 - light gray]
	(15, 20)			Bottom of Hole

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	2.24	1.83	1.25	1.78	0.49				
2	2.20	1.77	0.94	1.64	0.63				

GEO-4 OCLGB 7/16/96 14:47

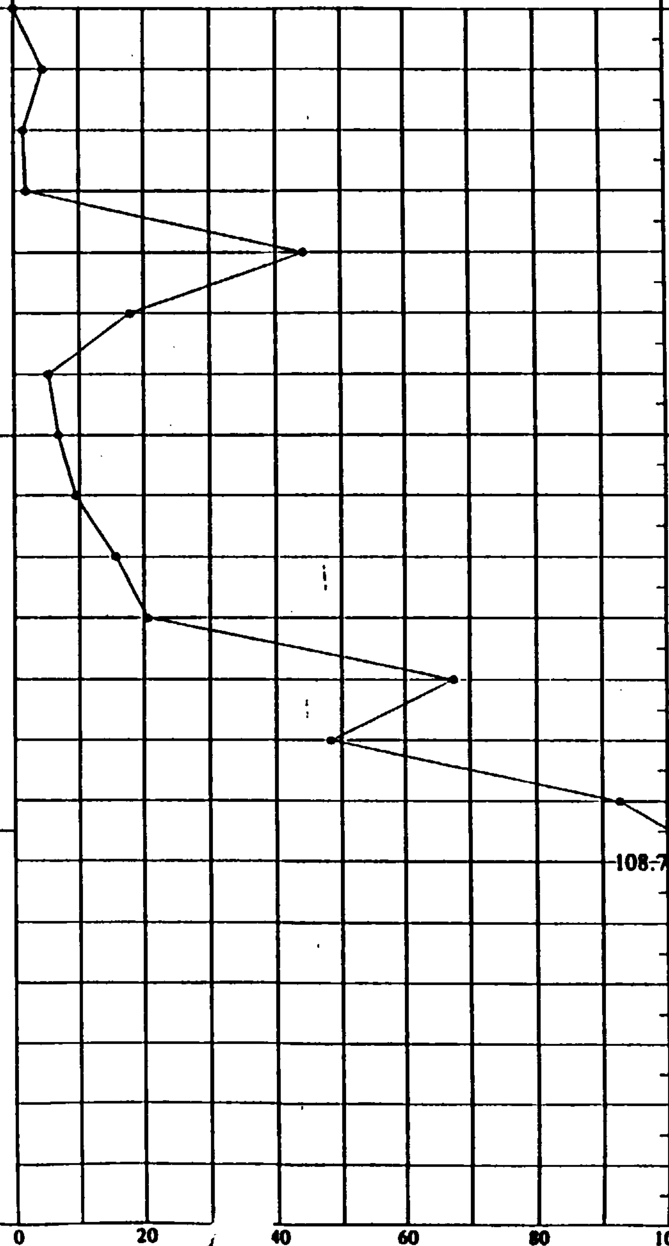
Ocean City Water Resources Project
Assateague Island Restoration
Little Gull Bank

Hole No.	LG-5	Date:	October 8, 1995	Elevation:	-27.1 Ft. NGVD
Coordinates N	180119.0	Driller:	Ocean Surveys, Inc.	Remarks:	
E	1365045.0	Inspector:	J.Snyder/M.StClair	Remarks:	

Elevation NGVD	Depth FT.	Sample	Leg.	Classification USCS	No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
		1		Brownish gray poorly graded medium to fine SAND (SP) [2.5Y 7/2 - light gray]	1	2.39	1.99	1.22	1.87	0.59				
-34.1	7.0	2		Brownish gray poorly graded medium to fine SAND (SP) [2.5Y 7/2 - light gray]	2	2.43	2.00	1.04	1.82	0.69				
				Bottom of Hole										

Depth scale: 5, 10, 15, 20

Penetration In Seconds



GEO-4 OCLGB 7/16/96 14:47

Ocean City Water Resources Project
Assateague Island Restoration
Great Gull Bank

Hole No. GG-1
Coordinates N 153386.0
E 1357771.0

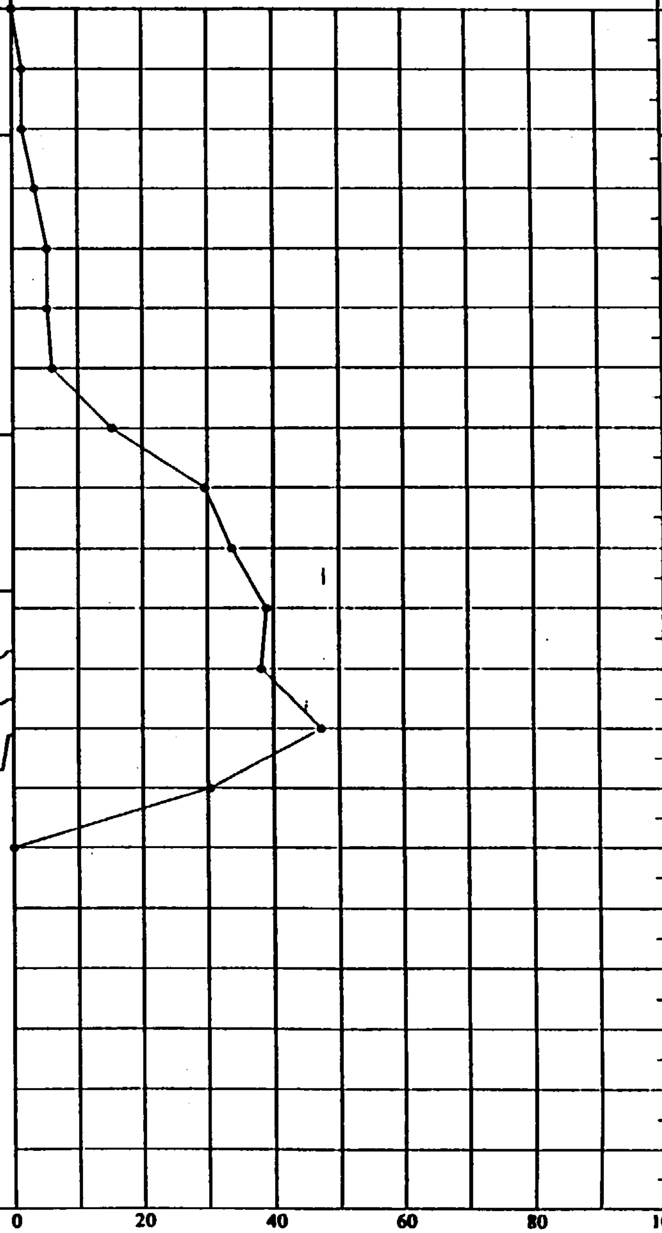
Date: November 2, 1995
Driller: Ocean Surveys, Inc.
Inspector: J.Snyder/M.StClair

Elevation: -23.7 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS	No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
		1	Brn. gray poorly graded coarse SAND w/ tr. of shell (SP) [10YR 7/3 - very pale brown]	1	1.70	1.17	0.51	1.13	0.60				
-25.8	2.1	2	Brn. gray poorly graded very coarse SAND w/ tr. of gravel (SP) [10YR 7/3 - very pale brown]	2	1.16	0.29	-1.01	0.15	1.08				
-30.8	7.1	3	Gray poorly graded med. SAND (SP) [2.5Y 7/2 - light gray]	3	2.12	1.71	1.16	1.66	0.48				
-33.4	9.7	4	Brn. poorly graded med. coarse SAND (SP) [10YR 7/3 - very pale brown]	4	2.00	1.25	0.57	1.27	0.72				
-34.4	10.7	5	Brn. gray poorly graded med. SAND (SP) [2.5Y 7/2 - light gray]	5	2.26	1.84	1.14	1.74	0.56				
-35.2	11.5	6	Brn. poorly graded very coarse SAND w/ tr. of gravel (SP) [10YR 7/3 - very pale brown]	6	1.56	0.38	-0.77	0.39	1.17				

Bottom of Hole

Penetration In Seconds



GEO-4 OCCGGB 7/16/96 11:48

Ocean City Water Resources Project
Assateague Island Restoration
Great Gull Bank

Hole No. GG-2
Coordinates N 154158.0
E 1359887.0

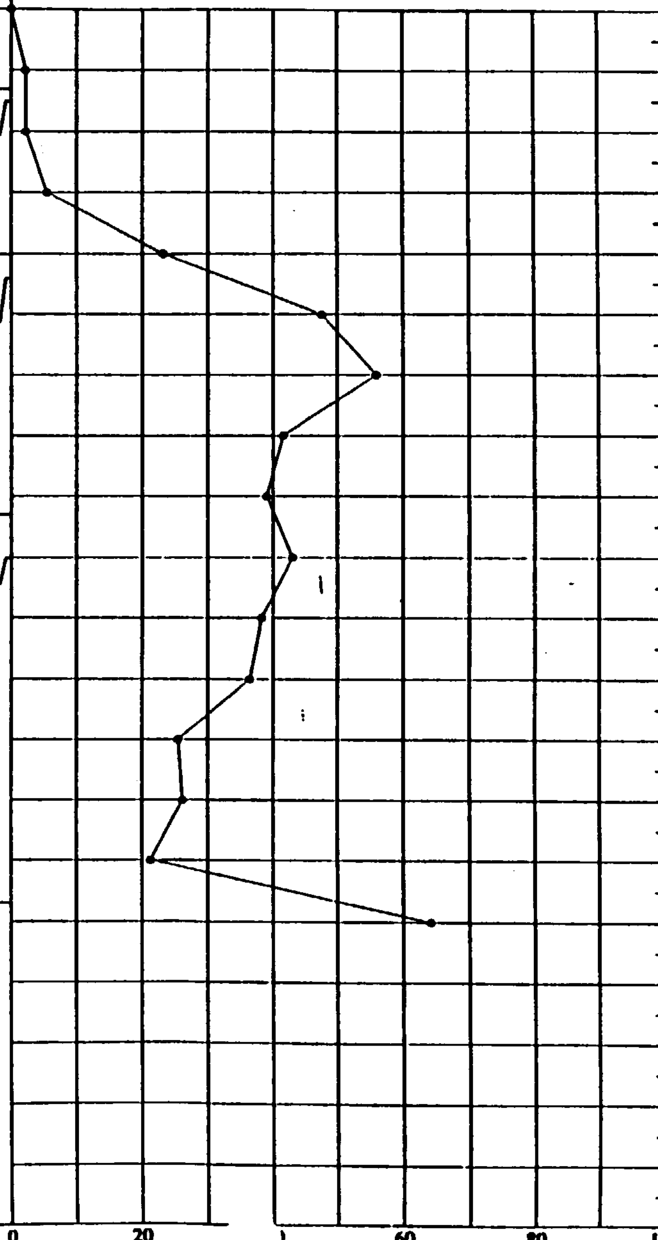
Date: November 2, 1995
Driller: Ocean Surveys, Inc.
Inspector: J.Snyder/M.StClair

Elevation: -24.4 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS
		1	Gray brn. poorly graded med. SAND (SP) [2.5Y 7/2 - light gray]
-25.7	1.3	2	Brn. poorly graded med. coarse SAND (SP) [10YR 7/2 - light gray]
-25.9	1.5	3	Gray poorly graded med. SAND (SP) [2.5Y 7/2 - light gray]
-28.4	4.0	4	Gray poorly graded med. coarse SAND w/ shell and tr. of gravel (SP) [10YR 7/2 - light gray]
-28.8	4.4	5	Gray brown poorly graded med. fine SAND (SP) [2.5Y 7/2 - light gray]
-32.7	8.3	6	Brn. poorly graded med. SAND w/ shell (SP) [2.5Y 7/2 - light gray]
-33.4	9.0	7	Brn. poorly graded med. SAND (SP) [2.5Y 7/2 - light gray]
			Bottom of Hole

Depth scale: 5, 10, 15, 20

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	2.35	1.96	1.38	1.90	0.48				
2	1.89	[illegible]	[illegible]	[illegible]	0.89				
3	2.36	1.97	1.41	1.92	0.48				
4	1.93	1.12	0.26	1.11	0.83				
5	2.33	1.88	1.38	1.86	0.47				
6	2.19	1.58	0.44	1.40	0.87				
7	2.13	1.64	1.08	1.62	0.52				

GEO-4 OCGGB 7/16/96 11:48

Ocean City Water Resources Project
Assateague Island Restoration
Great Gull Bank

Hole No. GG-3
Coordinates N 156513.0
E 1360584.0

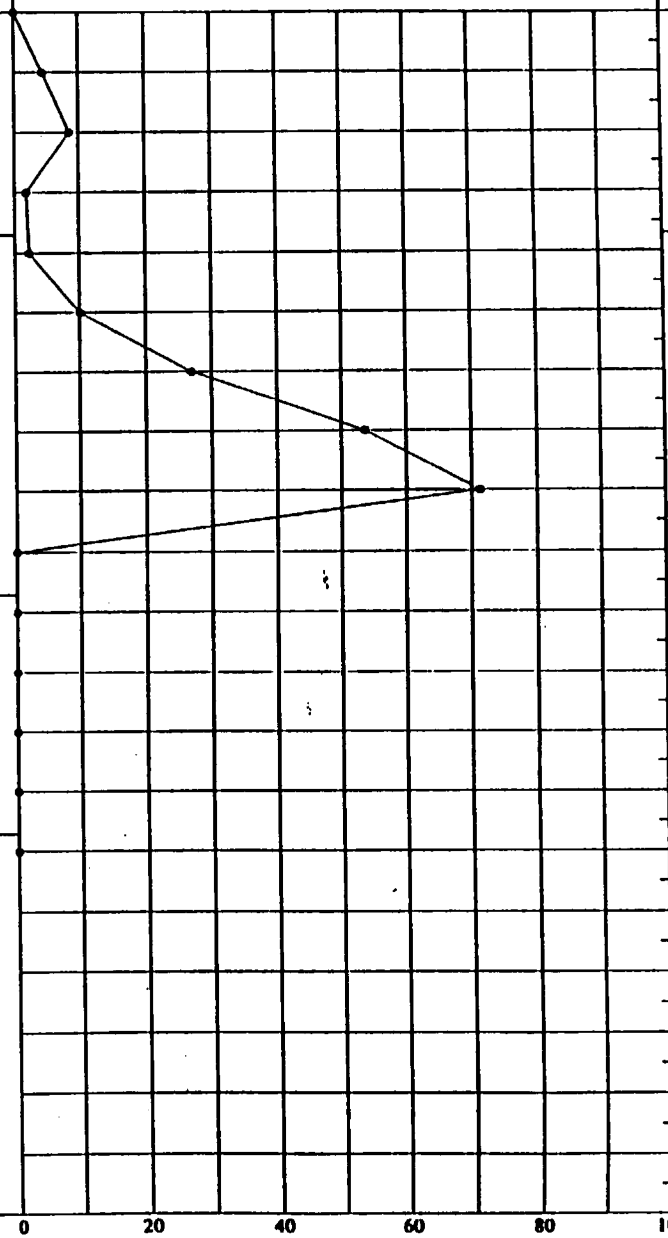
Date: November 2, 1995
Driller: Ocean Surveys, Inc.
Inspector: J.Snyder/M.StClair

Elevation: -27.0 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS
		1	Brn. gray poorly graded med. SAND w/ tr. of shell (SP) [2.5Y 7/2 - light gray]
-30.7	3.7	2	Brn. gray poorly graded med. SAND (SP) [2.5Y 7/2 - light gray]
-36.7	9.7	3	Gray poorly graded med. fine SAND (SP) [2.5Y 7/2 - light gray]
			Bottom of Hole

Depth scale: 5, 10, 15, 20

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	1.98	1.45	0.73	1.39	0.63				
2	1.93	1.43	0.77	1.38	0.58				
3	2.08	1.64	1.12	1.61	0.48				

GEO-4 OCGGB 7/16/96 11:49

Ocean City Water Resources Project
Assateague Island Restoration
Great Gull Bank

Hole No. GG-4
Coordinates N 159495.0
E 1361686.0

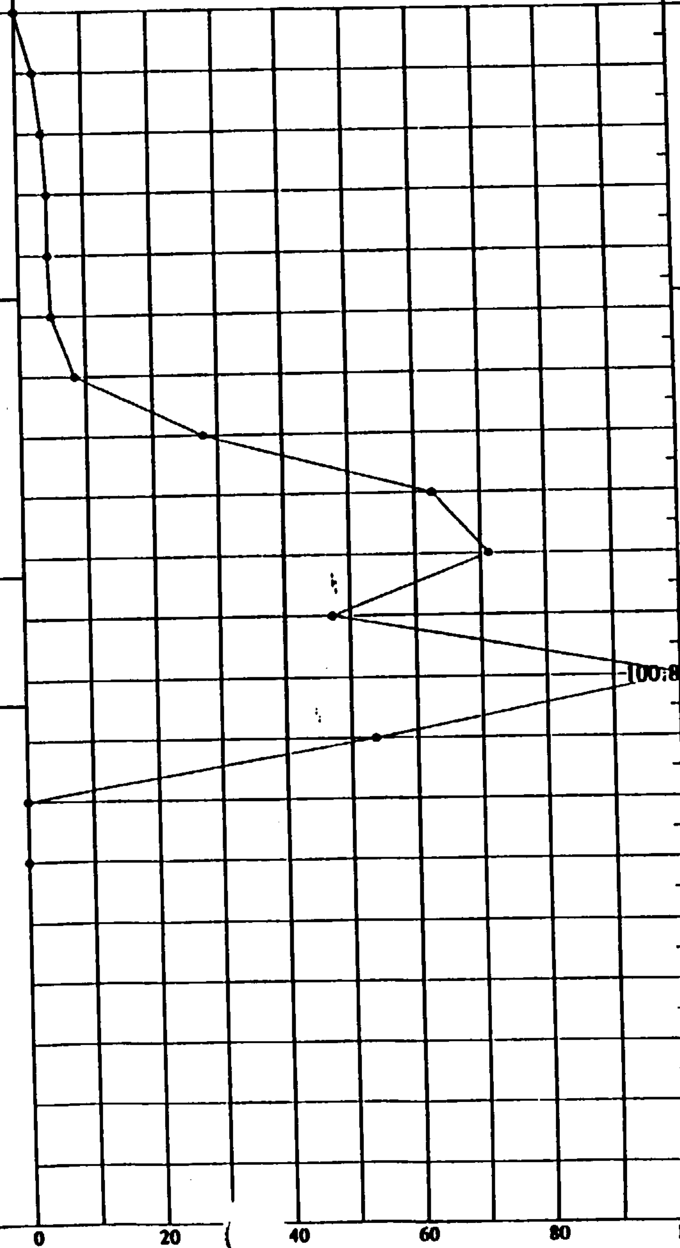
Date: October 31, 1995
Driller: Ocean Surveys, Inc.
Inspector: J.Snyder/M.StClair

Elevation: -39.7 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS
	0	1	Brn. gray poorly graded coarse SAND w/ tr. of cobbles & gravel (SP) [10YR 7/2 - light gray]
-44.4	4.7	2	Brn. gray poorly graded coarse SAND (SP) [10YR 7/2 - light gray]
-49.0	9.3	3	Gray poorly graded fine SAND (SP) [2.5Y 7/1 - light gray]
			Bottom of Hole

Depth scale: 5, 10, 15, 20

Penetration In Seconds



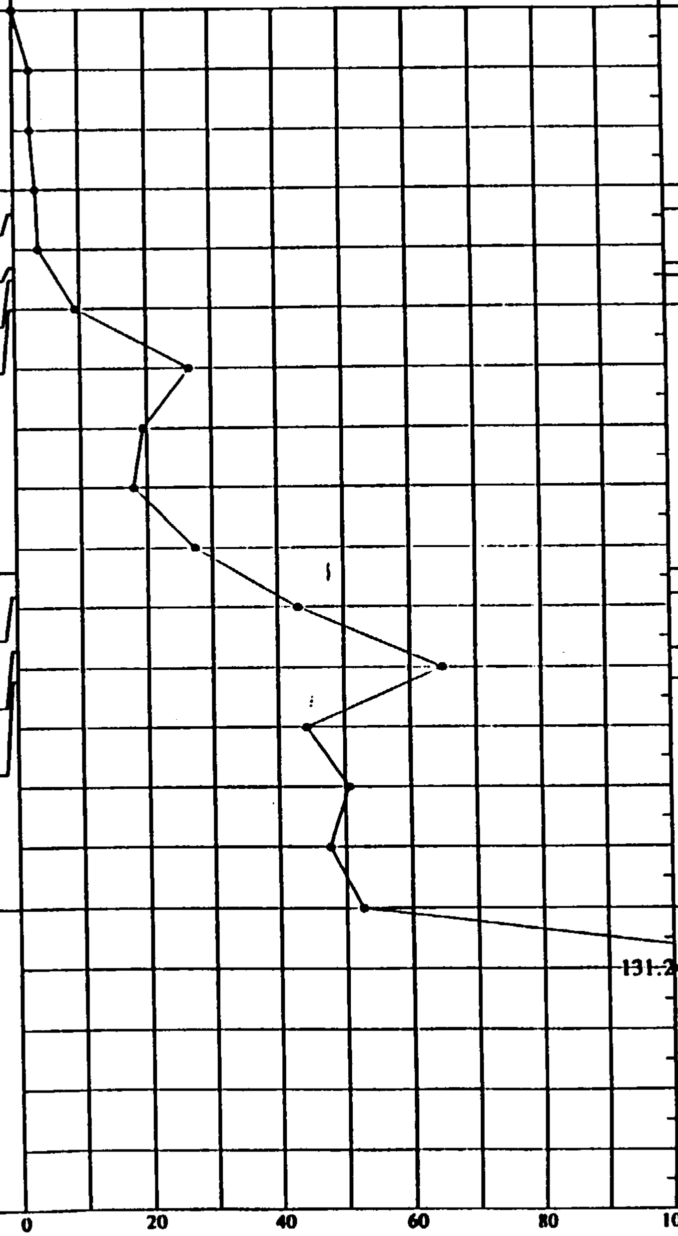
No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	1.59	0.89	0.11	0.87	0.74				
2	1.70	1.06	0.40	1.05	0.65				
3	2.66	2.20	1.48	2.11	0.59				

GEO-4 OCGGB 7/16/96 11:49

Ocean City Water Resources Project	Hole No. GG-5	Date: October 26, 1995	Elevation: -30.0 Ft. NGVD
Assateague Island Restoration	Coordinates N 158756.0	Driller: Ocean Surveys, Inc.	Remarks:
Great Gull Bank	E 1363815.0	Inspector: J.Snyder/M.StClair	Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS
		1	Gray brn. poorly graded med. SAND (SP) [2.5Y 7/2 - light gray]
-33.0	3.0	2	Brn. poorly graded coarse SAND (SP) [2.5Y 7/2 - light gray]
-33.4	3.4	3	Gray brn. poorly graded med. SAND [2.5Y 7/2 - light gray]
-34.3	4.3	4	
-34.5	4.5	5	Brn. poorly graded med. coarse SAND (SP) [2.5Y 7/2 - light gray]
-35.0	5.0	6	Brn. poorly graded med. SAND (SP) [2.5Y 7/2 - light gray]
			Brn. poorly graded fine SAND (SP) [2.5Y 7/2 - light gray]
-39.4	9.4	7	Dark gray poorly graded SAND w/ tr. of gravel (SP) w/ lense of fat clay [2.5Y 6/1 - gray]
-39.8	9.8	8	
-40.7	10.7	9	Brn. gray poorly graded med. fine SAND (SP) [2.5Y 7/1 - light gray]
-41.2	11.2	10	Brn. poorly graded coarse SAND w/ shell (SP) [10YR 7/3 - very pale brown]
			Brn. gray poorly graded med. fine SAND (SP) [2.5Y 7/2 - light gray]
	15		Bottom of Hole

Penetration In Seconds



No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
1	2.47	2.06	1.42	1.98	0.53				
2	2.33	1.73	0.38	1.48	0.98				
3	2.45	1.98	1.20	1.88	0.62				
4	2.39	2.07	0.60	1.69	0.89				
5	2.46	1.99	1.13	1.86	0.67				
6	2.48	2.04	1.26	1.93	0.61				
7	2.26	1.06	-0.82	0.83	1.54				
8	2.59	2.16	1.59	2.11	0.50				
9	1.93	0.38	-0.62	0.56	1.27				
10	2.42	2.05	1.57	2.01	0.42				

GEO-4 OCGGB 7/16/96 13:02

Ocean City Water Resources Project
Assateague Island Restoration
Great Gull Bank

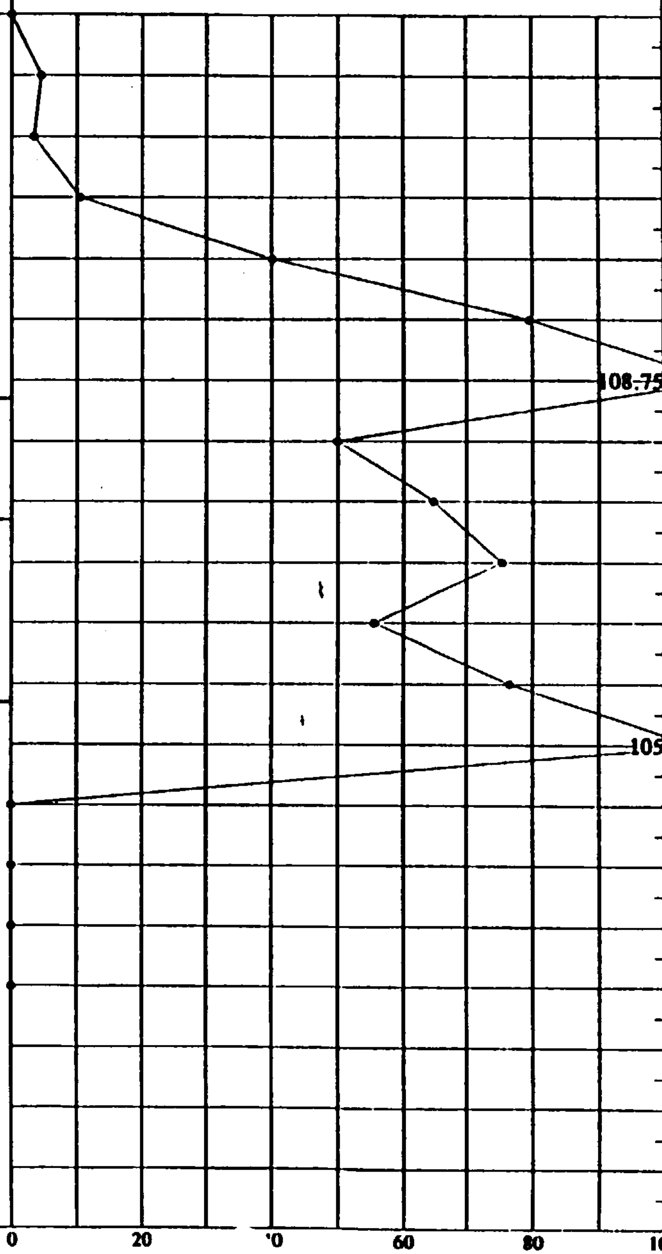
Hole No. GG-6
Coordinates N 161096.0
E 1364129.0

Date: October 26, 1995
Driller: Ocean Surveys, Inc.
Inspector: J.Snyder/M.StClair

Elevation: -25.8 Ft. NGVD
Remarks:
Remarks:

Elevation NGVD	Depth FT.	Sample	Classification USCS	No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
		1	Gray brn. poorly graded med. SAND (SP) [10YR 7/2 - light gray]	1	2.02	1.59	1.05	1.55	0.49				
-32.1	6.3	2	Brn. poorly graded med. SAND (SP) [10YR 7/2 - light gray]	2	2.15	1.59	0.80	1.51	0.67				
-34.1	8.3	3	Brn. poorly graded fine SAND (SP) [2.5Y 7/2 - light gray]	3	2.71	2.35	1.91	2.32	0.40				
			Bottom of Hole										

Penetration In Seconds



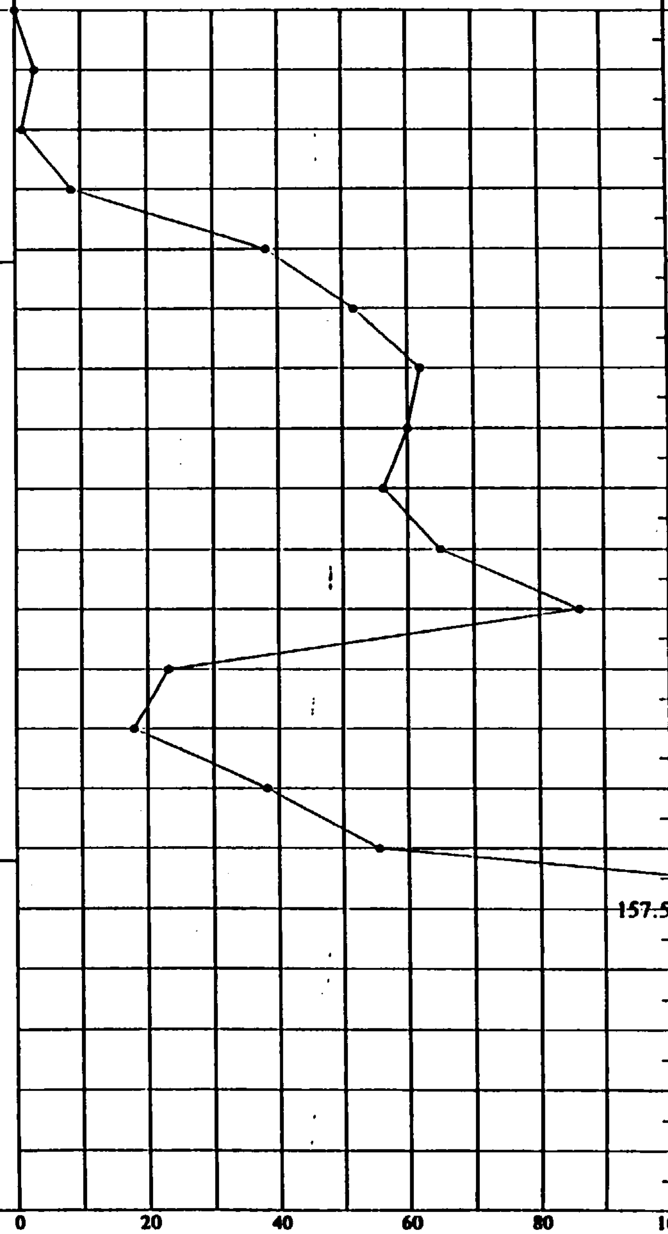
GEO-4 OCGGB 7/16/96 11:49

Ocean City Water Resources Project Assateague Island Restoration Great Gull Bank	Hole No. GG-7 Coordinates N 163913.0 E 1367478.0	Date: October 26, 1995 Driller: Ocean Surveys, Inc. Inspector: J.Snyder/M.StClair	Elevation: -30.4 Ft. NGVD Remarks: Remarks:

Elevation NGVD	Depth FT.	Sample	Leg.	Classification USCS	No.	phi 84	phi 50	phi 16	Mean phi	STD DEV	LL	PL	PI	O.C.
		1		Brn. gray poorly graded med. fine SAND [2.5Y 7/2 - light gray]	1	2.43	1.96	1.54	1.98	0.44				
-34.6	4.2	2		Brn. gray poorly graded med. SAND (SP) [2.5Y 7/2 - light gray]	2	2.51	1.98	1.32	1.94	0.59				
				bottom of Hole										

Depth scale (FT.): 5, 10, 15, 20

Penetration In Seconds



GEO-4 OCGGB 7/16/96 11:50

APPENDIX C

DETAILED COST ESTIMATE

Cost Engineering

1. General. The following methodology was used in the preparation of the Baseline Cost Estimate for the Assateague Island Short Term Restoration Feasibility Study:

a. The estimate is in accordance with the guidance contained in ER 11102-1302, Civil Works Cost Engineering.

b. The estimate is presented in the standard Work Breakdown Structure.

c. The price level for the estimate is October 1996.

d. Construction cost developed by Cost Engineering Branch are based on input/quantities from the Geotechnical Branch and the Hydrology & Hydraulics Section . Unit costs were developed using the Cost Engineering Dredge Estimating Program (CEDEP). The estimates are documented with notes to explain the specific information used to develop the costs.

e. The labor costs are based on the prevailing Davis-Bacon wage rates for dredging.

f. PPMD provided costs for Construction Management and Engineering and Design.

g. Lands and Damages costs were provided by Civil Projects Support Branch, Real Estate Division.

2. Estimate Scope. The estimate reflects the cost for providing approximately 1,800,000 cubic yards of sand beachfill along the Assateague Island shoreline. The Great Gull Bank will be used as the borrow area for the beachfill. Two Island Class hopper dredges with pumpout capability would be used. The project would be constructed in two phases. Project construction would start in the southern end and work toward the northern end. Construction in the National Park will be limited to two months per year due to environmental and weather conditions. The first phase of construction would start in July 1998 and continue through October 1998. During this phase, work would be limited to the area south of the National Park until after 1 September 1998. The second phase of construction would start on or about 1 September 1999 to be completed by 31 October 1999.

3. Contingency. Contingency amounts for the construction cost items are based on uncertainties within individual project elements. Considering these uncertainties, contingencies were assigned to individual cost items or groups of related cost items to protect against the risk of potential cost increases. The following is a list by element of the uncertainties that were identified and the corresponding contingency percentages.

a. Dredging Cost Items -- 20%

The uncertainty associated with the quantities are relatively high since they are based on preliminary designs and are subject to change. For now a contingency of 20 percent is reasonable.

b. Lands and Damages -- 20%

Contingency amounts were developed for lands and damages based on EM 1110-2-1301 Appendix C, EC 1110-2-2,: 113, and EC 1110-2-538. For lands and estates, administrative and contract costs, a contingency of 20 percent is considered reasonable to offset the effects of counter-offers and uneconomic remnants incurred during the acquisition process for the project.

TOTAL PROJECT COST SUMMARIES
ALL CONTRACTS
THIS ESTIMATE IS BASED ON THE DRAFT FEASIBILITY STUDY, DATED

PROJECT: ASSATEAGUE ISLAND SHORT TERM RESTORATION PROJECT
LOCATION : ASSATEAGUE ISLAND, MARYLAND

PREPARED BY : CENAB-EN-C OLIVER LEIMBACH
P.O.C.: RONALD J. MAJ P.E., CHIEF, COST ENGINEERING BRANCH

ACCOUNT NUMBER	ITEM DESCRIPTION	CURRENT MCACES ESTIMATE 7 MAR 97 EFFECTIVE PRICING LEVEL 1OCT 96				AUTHORIZ./BUDGET YEAR 1996 EFFECTIVE PRICING LEVEL: 1 OCT 96			FULLY FUNDED ESTIMATE		
		COST ($K)	CNTG ($K)	CNTG %	TOTAL ($K)	COST ($K)	CNTG ($K)	TOTAL ($K)	COST ($K)	CNTG ($K)	FULL ($K)
17	BEACH REPLENISHMENT	$10,515	$2,103	20.0%	$12,619	$10,515	$2,103	$12,619	$10,799	$2,160	$12,959
	TOTAL CONSTRUCTION COST	$10,515	$2,103	20.0%	$12,619	$10,515	$2,103	$12,619	$10,799	$2,160	$12,959
01	LANDS AND DAMAGES	$239	$45	18.7%	$283	$239	$45	$283	$249	$47	$295
30	PLANNING, ENGINEERING AND DESIGN	$1,878	$0	0.0%	$1,878	$1,878	$0	$1,878	$1,956	$0	$1,957
31	CONSTRUCTION MANAGEMENT	$1,800	$0	0.0%	$1,800	$1,800	$0	$1,800	$1,876	$0	$1,876
	TOTAL PROJECT COST	$14,431	$2,148	14.9%	$16,579	$14,431	$2,148	$16,580	$14,880	$2,207	$17,087

DISTRICT APPROVED:

________________ CHIEF, COST ENGINEERING BRANCH

________________ CHIEF, REAL ESTATE DIVISION

________________ CHIEF, PLANNING DIVISION

________________ CHIEF, ENGINEERING DIVISION

________________ CHIEF, CONSTRUCTION DIVISION

________________ CHIEF, PROGRAMS MANAGEMENT BRANCH

________________ PROJECT MANAGER

________________ DDE (PM)

DIVISION APPROVED:

CHIEF, COST ENGINEERING ________________

DIRECTOR REALESTATE ________________

CHIEF, PROGRAMS MANAGEMENT ________________

DIRECTOR OF PPMD ________________

APPROVED DATE: ________________

Assateague Island Restoration
Short Term
Feasibility Level Cost Estimate
with
Operation and Maintenance

Designed By: U.S. Army Corps of Engineers
Estimated By: Baltimore District

Prepared By: CENAB-EN-C
Oliver Leimbach

Preparation Date: 04/30/97
Effective Date of Pricing: 10/01/96

Sales Tax: 5.00%

SUMMARY REPORTS — SUMMARY PAGE

DETAILED ESTIMATE — DETAIL PAGE

BACKUP REPORTS — BACKUP PAGE

* * * END TABLE OF CONTENTS * * *

		QUANTITY	UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT COST
AA	Operation and Maintenance	1.00	EA	55,564	11,113	1,800	68,477	68476.61
CC	Recommended Plan	1.00	EA	14,431,496	2,147,799	507,051	17,086,347	17086346.83
TOTAL	Assateague Island Restoration	1.00	EA	14,487,060	2,158,912	508,852	17,154,823	17154823.45

	QUANTITY	UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT COST
AA Operation and Maintenance							
AA 17 Beach Replenishment	1.00	EA	55,564	11,113	1,800	68,477	68476.61
TOTAL Operation and Maintenance	1.00	EA	55,564	11,113	1,800	68,477	68476.61
CC Recommended Plan							
CC 01 Lands and Damages	1.00	EA	238,500	44,700	11,894	295,094	295094.40
CC 17 Beach Replenishment	1.00	EA	10,515,496	2,103,099	340,702	12,959,297	12959297.43
CC 30 Planning, Engineering and Design	1.00	EA	1,877,500	0	78,855	1,956,355	1956355.00
CC 31 Construction Management	1.00	EA	1,800,000	0	75,600	1,875,600	1875600.00
TOTAL Recommended Plan	1.00	EA	14,431,496	2,147,799	507,051	17,086,347	17086346.83
TOTAL Assateague Island Restoration	1.00	EA	14,487,060	2,158,912	508,852	17,154,823	17154823.45

	QUANTITY	UOM	CONTRACT	CONTINGN	ESCALATN	TOTAL COST	UNIT COST
AA Operation and Maintenance							
AA 17 Beach Replenishment							
AA 17 70 Beach fill	1.00	EA	55,564	11,113	1,800	68,477	68476.61
TOTAL Beach Replenishment	1.00	EA	55,564	11,113	1,800	68,477	68476.61
TOTAL Operation and Maintenance	1.00	EA	55,564	11,113	1,800	68,477	68476.61
CC Recommended Plan							
CC 01 Lands and Damages							
CC 01 01 Acquisition Documents	1.00	EA	2,000	400	101	2,501	2500.80
CC 01 02 Acquistions	1.00	EA	76,500	15,300	3,856	95,656	95655.60
CC 01 03 Condemnations	1.00	EA	128,000	25,600	6,451	160,051	160051.20
CC 01 05 Appraisals	1.00	EA	17,000	3,400	857	21,257	21256.80
CC 01 15 Real Estate Payments	1.00	EA	15,000	0	630	15,630	15630.00
TOTAL Lands and Damages	1.00	EA	238,500	44,700	11,894	295,094	295094.40
CC 17 Beach Replenishment							
CC 17 01 Mobilization, Demobilization	1.00	EA	2,004,932	400,986	64,960	2,470,878	2470878.20
CC 17 17 Hopper dredging	1800000	CY	7,272,000	1,454,400	235,613	8,962,013	4.98
CC 17 70 Beach Fill	1800000	CY	1,238,564	247,713	40,129	1,526,406	0.85
TOTAL Beach Replenishment	1.00	EA	10,515,496	2,103,099	340,702	12,959,297	12959297.43
CC 30 Planning, Engineering and Design	1.00	EA	1,877,500	0	78,855	1,956,355	1956355.00
CC 31 Construction Management	1.00	EA	1,800,000	0	75,600	1,875,600	1875600.00
TOTAL Recommended Plan	1.00	EA	14,431,496	2,147,799	507,051	17,086,347	17086346.83
TOTAL Assateague Island Restoration	1.00	EA	14,487,060	2,158,912	508,852	17,154,823	17154823.45

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
AA Operation and Maintenance	1.00	EA	55,564	0	0	0	0	55,564	55563.63
CC Recommended Plan	1.00	EA	14,431,496	0	0	0	0	14,431,496	14431496.13
TOTAL Assateague Island Restoration	1.00	EA	14,487,060	0	0	0	0	14,487,060	14487059.76
CONTINGENCY								2,158,912	
SUBTOTAL								16,645,972	
ESCALATION								508,852	
TOTAL INCL OWNER COSTS								17,154,823	

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
AA Operation and Maintenance									
AA 17 Beach Replenishment	1.00	EA	55,564	0	0	0	0	55,564	55563.63
TOTAL Operation and Maintenance	1.00	EA	55,564	0	0	0	0	55,564	55563.63
CC Recommended Plan									
CC 01 Lands and Damages	1.00	EA	238,500	0	0	0	0	238,500	238500.00
CC 17 Beach Replenishment	1.00	EA	10,515,496	0	0	0	0	10,515,496	10515496.13
CC 30 Planning, Engineering and Design	1.00	EA	1,877,500	0	0	0	0	1,877,500	1877500.00
CC 31 Construction Management	1.00	EA	1,800,000	0	0	0	0	1,800,000	1800000.00
TOTAL Recommended Plan	1.00	EA	14,431,496	0	0	0	0	14,431,496	14431496.13
TOTAL Assateague Island Restoration	1.00	EA	14,487,060	0	0	0	0	14,487,060	14487059.76
CONTINGENCY								2,158,912	
SUBTOTAL								16,645,972	
ESCALATION								508,852	
TOTAL INCL OWNER COSTS								17,154,823	

	QUANTITY	UOM	DIRECT	OVERHEAD	HOME OFC	PROFIT	BOND	TOTAL COST	UNIT COST
AA Operation and Maintenance									
AA 17 Beach Replenishment									
AA 17 70 Beach fill	1.00	EA	55,564	0	0	0	0	55,564	55563.63
TOTAL Beach Replenishment	1.00	EA	55,564	0	0	0	0	55,564	55563.63
TOTAL Operation and Maintenance	1.00	EA	55,564	0	0	0	0	55,564	55563.63
CC Recommended Plan									
CC 01 Lands and Damages									
CC 01 01 Acquisition Documents	1.00	EA	2,000	0	0	0	0	2,000	2000.00
CC 01 02 Acquistions	1.00	EA	76,500	0	0	0	0	76,500	76500.00
CC 01 03 Condemnations	1.00	EA	128,000	0	0	0	0	128,000	128000.00
CC 01 05 Appraisals	1.00	EA	17,000	0	0	0	0	17,000	17000.00
CC 01 15 Real Estate Payments	1.00	EA	15,000	0	0	0	0	15,000	15000.00
TOTAL Lands and Damages	1.00	EA	238,500	0	0	0	0	238,500	238500.00
CC 17 Beach Replenishment									
CC 17 01 Mobilization, Demobilization	1.00	EA	2,004,932	0	0	0	0	2,004,932	2004932.00
CC 17 17 Hopper dredging	1800000	CY	7,272,000	0	0	0	0	7,272,000	4.04
CC 17 70 Beach Fill	1800000	CY	1,238,564	0	0	0	0	1,238,564	0.69
TOTAL Beach Replenishment	1.00	EA	10,515,496	0	0	0	0	10,515,496	10515496.13
CC 30 Planning, Engineering and Design	1.00	EA	1,877,500	0	0	0	0	1,877,500	1877500.00
CC 31 Construction Management	1.00	EA	1,800,000	0	0	0	0	1,800,000	1800000.00
TOTAL Recommended Plan	1.00	EA	14,431,496	0	0	0	0	14,431,496	14431496.13
TOTAL Assateague Island Restoration	1.00	EA	14,487,060	0	0	0	0	14,487,060	14487059.76
CONTINGENCY								2,158,912	
SUBTOTAL								16,645,972	
ESCALATION								508,852	
TOTAL INCL OWNER COSTS								17,154,823	

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
AA Operation and Maintenance	1.00	EA	1,206	27,329	28,234	0	0	55,564	55563.63
CC Recommended Plan	1.00	EA	15,840	4,398,669	740,895	0	9,291,932	14,431,496	14431496.13
TOTAL Assateague Island Restoration	1.00	EA	17,046	4,425,999	769,129	0	9,291,932	14,487,060	14487059.76
CONTINGENCY								2,158,912	
SUBTOTAL								16,645,972	
ESCALATION								508,852	
TOTAL INCL OWNER COSTS								17,154,823	

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
AA Operation and Maintenance									
AA 17 Beach Replenishment	1.00	EA	1,206	27,329	28,234	0	0	55,564	55563.63
TOTAL Operation and Maintenance	1.00	EA	1,206	27,329	28,234	0	0	55,564	55563.63
CC Recommended Plan									
CC 01 Lands and Damages	1.00	EA	0	223,500	0	0	15,000	238,500	238500.00
CC 17 Beach Replenishment	1.00	EA	15,840	497,669	740,895	0	9,276,932	10,515,496	10515496.13
CC 30 Planning, Engineering and Design	1.00	EA	0	1,877,500	0	0	0	1,877,500	1877500.00
CC 31 Construction Management	1.00	EA	0	1,800,000	0	0	0	1,800,000	1800000.00
TOTAL Recommended Plan	1.00	EA	15,840	4,398,669	740,895	0	9,291,932	14,431,496	14431496.13
TOTAL Assateague Island Restoration	1.00	EA	17,046	4,425,999	769,129	0	9,291,932	14,487,060	14487059.76
CONTINGENCY								2,158,912	
SUBTOTAL								16,645,972	
ESCALATION								508,852	
TOTAL INCL OWNER COSTS								17,154,823	

	QUANTITY	UOM	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
AA Operation and Maintenance									
AA 17 Beach Replenishment									
AA 17 70 Beach fill	1.00	EA	1,206	27,329	28,234	0	0	55,564	55563.63
TOTAL Beach Replenishment	1.00	EA	1,206	27,329	28,234	0	0	55,564	55563.63
TOTAL Operation and Maintenance	1.00	EA	1,206	27,329	28,234	0	0	55,564	55563.63
CC Recommended Plan									
CC 01 Lands and Damages									
CC 01 01 Acquisition Documents	1.00	EA	0	2,000	0	0	0	2,000	2000.00
CC 01 02 Acquistions	1.00	EA	0	76,500	0	0	0	76,500	76500.00
CC 01 03 Condemnations	1.00	EA	0	128,000	0	0	0	128,000	128000.00
CC 01 05 Appraisals	1.00	EA	0	17,000	0	0	0	17,000	17000.00
CC 01 15 Real Estate Payments	1.00	EA	0	0	0	0	15,000	15,000	15000.00
TOTAL Lands and Damages	1.00	EA	0	223,500	0	0	15,000	238,500	238500.00
CC 17 Beach Replenishment									
CC 17 01 Mobilization, Demobilization	1.00	EA	0	0	0	0	2,004,932	2,004,932	2004932.00
CC 17 17 Hopper dredging	1800000	CY	0	0	0	0	7,272,000	7,272,000	4.04
CC 17 70 Beach Fill	1800000	CY	15,840	497,669	740,895	0	0	1,238,564	0.69
TOTAL Beach Replenishment	1.00	EA	15,840	497,669	740,895	0	9,276,932	10,515,496	10515496.13
CC 30 Planning, Engineering and Design	1.00	EA	0	1,877,500	0	0	0	1,877,500	1877500.00
CC 31 Construction Management	1.00	EA	0	1,800,000	0	0	0	1,800,000	1800000.00
TOTAL Recommended Plan	1.00	EA	15,840	4,398,669	740,895	0	9,291,932	14,431,496	14431496.13
TOTAL Assateague Island Restoration	1.00	EA	17,046	4,425,999	769,129	0	9,291,932	14,487,060	14487059.76
CONTINGENCY								2,158,912	
SUBTOTAL								16,645,972	
ESCALATION								508,852	
TOTAL INCL OWNER COSTS								17,154,823	

AA 17. Beach Replenishment		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST

AA. Operation and Maintenance
AA 17. Beach Replenishment

AA 17 70. Beach fill

AA 17 70 02. Site Work

AA 17 70 02 03. Corrective Beach Grading
Assume that corrective action will require 21 day of work. The work will be accomplished with a XXQND D7 dozer crew and a USURC survey crew.

		QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AB <	> Grading beach material					14.00	354.94	528.35	0.00	0.00	883.29	
		21.00	DAY	XXQND	0.13	294	9,291	13,831	0	0	23,122	1101.06
USR AB <	> Survey Crew					32.00	402.96	70.51	0.00	0.00	473.47	
		21.00	DAY	USURC	0.13	672	10,548	1,846	0	0	12,394	590.20
L USR AB <	> Lowboy w/truck for Mob/demob					1.00	20.58	41.29	0.00	0.00	61.87	
		16.00	HR	UTDHA2	1.00	16	410	824	0	0	1,234	77.13
USR AB <	> Mob/demob Dozer					14.00	354.94	528.35	0.00	0.00	883.29	
	(ADD BLADE & ATTACHMENTS)	16.00	HR	XXQND	0.13	224	7,079	10,538	0	0	17,617	1101.06
UPB AB <	> DOZER,CWLR, D-7H,PS					0.00	0.00	59.97	0.00	0.00	59.97	
	(ADD BLADE & ATTACHMENTS)	16.00	HR	T15CA013	1.00	0	0	1,196	0	0	1,196	74.75
	TOTAL Corrective Beach Grading	1.00	EA			1,206	27,329	28,234	0	0	55,564	55563.63
	TOTAL Site Work	1.00	CY			1,206	27,329	28,234	0	0	55,564	55563.63
	TOTAL Beach fill	1.00	EA			1,206	27,329	28,234	0	0	55,564	55563.63
	TOTAL Beach Replenishment	1.00	EA			1,206	27,329	28,234	0	0	55,564	55563.63
	TOTAL Operation and Maintenance	1.00	EA			1,206	27,329	28,234	0	0	55,564	55563.63

CC 01. Lands and Damages	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
CC. Recommended Plan											
The work will consist of placing 1,800,000 Cy's of sand on the beach.											
CC 01. Lands and Damages											
CC 01 01. Acquisition Documents											
USR < > Cadastral prep					0.00	2000.00	0.00	0.00	0.00	2000.00	
of Real Estate Requirements	1.00	EA		0.00	0	2,000	0	0	0	2,000	2000.00
Mapping											
TOTAL Acquisition Documents	1.00	EA			0	2,000	0	0	0	2,000	2000.00
CC 01 02. Acquistions											
CC 01 02 01. By Government											
CC 01 02 01 01. Survey & Legals											
USR < > Survey & Legals					0.00	1500.00	0.00	0.00	0.00	1500.00	
	17.00	EA		0.00	0	25,500	0	0	0	25,500	1500.00
TOTAL Survey & Legals	17.00	EA			0	25,500	0	0	0	25,500	1500.00
CC 01 02 01 02. Title Evidence											
USR < > Title Evidence					0.00	1000.00	0.00	0.00	0.00	1000.00	
	17.00	EA		0.00	0	17,000	0	0	0	17,000	1000.00
TOTAL Title Evidence	17.00	EA			0	17,000	0	0	0	17,000	1000.00
CC 01 02 01 03. Negotiations											
USR < > Negotiations					0.00	2000.00	0.00	0.00	0.00	2000.00	
	17.00	EA		0.00	0	34,000	0	0	0	34,000	2000.00
TOTAL Negotiations	17.00	EA			0	34,000	0	0	0	34,000	2000.00
TOTAL By Government	1.00	EA			0	76,500	0	0	0	76,500	76500.00
TOTAL Acquistions	1.00	EA			0	76,500	0	0	0	76,500	76500.00

CC 01. Lands and Damages	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
CC 01 03. Condemnations											
CC 01 03 01. By Government											
USR < > By Government					0.00	8000.00	0.00	0.00	0.00	8000.00	
	16.00	EA		0.00	0	128,000	0	0	0	128,000	8000.00
TOTAL By Government	16.00	EA			0	128,000	0	0	0	128,000	8000.00
TOTAL Condemnations	1.00	EA			0	128,000	0	0	0	128,000	128000.00
CC 01 05. Appraisals											
CC 01 05 01. By Government											
USR < > By Government					0.00	1000.00	0.00	0.00	0.00	1000.00	
	17.00	EA		0.00	0	17,000	0	0	0	17,000	1000.00
TOTAL By Government	17.00	EA			0	17,000	0	0	0	17,000	1000.00
TOTAL Appraisals	1.00	EA			0	17,000	0	0	0	17,000	17000.00
CC 01 15. Real Estate Payments											
CC 01 15 01. Land Payments											
CC 01 15 01 01. By Government											
USR < > Land Payment Contingency					0.00	0.00	0.00	0.00	15000.00	15000.00	
	1.00	EA		0.00	0	0	0	0	15,000	15,000	15000.00
TOTAL By Government	17.00	EA			0	0	0	0	15,000	15,000	882.35
TOTAL Land Payments	1.00	EA			0	0	0	0	15,000	15,000	15000.00
TOTAL Real Estate Payments	1.00	EA			0	0	0	0	15,000	15,000	15000.00
TOTAL Lands and Damages	1.00	EA			0	223,500	0	0	15,000	238,500	238500.00

CC 17. Beach Replenishment		QUANTY UOM CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST

CC 17. Beach Replenishment

CC 17 01. Mobilization, Demobilization

The costs were developed using the Corps of Engineers Dredge Estimating Program for Hopper Dredge Estimating. The following assumptions were made:
1. Two years will be required to complete the project.
2. Two dredges will be mob/demob the first year.

CC 17 01 01. Mob/Demob First Year

The costs were developed using the Corps of Engineers Dredge Estimating Program for Hopper Dredge Estimating. The following assumptions were made:
1. Two years will be required to complete the project.
2. Two dredges will be mob/demob the first year.

		QUANTY UOM CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA <	> Mob/Demob Hopper Dredge Costs were developed using the Cost Engineering Dredge Estimating Program. This cost includes mob/demob of the scotts buoy.	1.00 EA	0.00	0.00 0	0.00 0	0.00 0	0.00 0	777559.00 777,559	777559.00 777,559	777559.00
USR AA <	> Mob/Demob Second Hopper Dredge Costs were developed using the Cost Engineering Dredge Estimating Program.	1.00 EA	0.00	0.00 0	0.00 0	0.00 0	0.00 0	449814.00 449,814	449814.00 449,814	449814.00
	TOTAL Mob/Demob First Year	1.00 EA		0	0	0	0	1,227,373	1,227,373	1227373.00

CC 17 01 02. Mob/Demob Second Year

The costs were developed using the Corps of Engineers Dredge Estimating Program for Hopper Dredge Estimating. The following assumptions were made:
1. Two years will be required to complete the project.
2. One dredge will be mob/demob for the second year.

		QUANTY UOM CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
USR AA <	> Mob/Demob Hopper Dredge Costs were developed using the Cost Engineering Dredge Estimating Program. This cost includes mob/demob of the scotts buoy.	1.00 EA	0.00	0.00 0	0.00 0	0.00 0	0.00 0	777559.00 777,559	777559.00 777,559	777559.00
	TOTAL Mob/Demob Second Year	1.00 EA		0	0	0	0	777,559	777,559	777559.00
	TOTAL Mobilization, Demobilization	1.00 EA		0	0	0	0	2,004,932	2,004,932	2004932.00

CC 17. Beach Replenishment	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
CC 17 17. Hopper dredging											
The cost for the dredging cost were developed using the Corp of Engineers Dredge Estimating Program for Hopper Dredge Estimating. Dredging in parts of the National Park will be limited to two months per year due to environmental and weather conditions. Assume that two Island class dredges with pump out capability would be used. The borrow area used for the estimate was the Great Gull Banks. Construction would start on the southern end of the project in could start in late July to early August. Work in the National Park area would begin on or about 1 September.											
CC 17 17 02. Site Work											
CC 17 17 02 01. First Year											
USR AA < > Hopper Dredging					0.00	0.00	0.00	0.00	4.04	4.04	
The unit cost are from the COEDEP program and include all markups.	1370000	CY		0.00	0	0	0	0	5,534,800	5,534,800	4.04
TOTAL First Year	1370000	CY			0	0	0	0	5,534,800	5,534,800	4.04
CC 17 17 02 02. Second Year											
USR AA < > Hopper Dredging					0.00	0.00	0.00	0.00	4.04	4.04	
The unit cost are from the COEDEP program and include all markups.	430000	CY		0.00	0	0	0	0	1,737,200	1,737,200	4.04
TOTAL Second Year	430000	CY			0	0	0	0	1,737,200	1,737,200	4.04
TOTAL Site Work	1800000	CY			0	0	0	0	7,272,000	7,272,000	4.04
TOTAL Hopper dredging	1800000	CY			0	0	0	0	7,272,000	7,272,000	4.04
CC 17 70. Beach Fill											
CC 17 70 02. Site Work											
CC 17 70 02 01. First Year											
L USR AB <02225 4252 > Beach Shaping					0.01	0.22	0.33	0.00	0.00	0.55	
	1370000	CY	XXQND	200.00	12,056	378,782	563,903	0	0	942,685	0.69
TOTAL First Year	1370000	CY			12,056	378,782	563,903	0	0	942,685	0.69

CC 17. Beach Replenishment	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
CC 17 70 02 02. Second Year											
L USR AB <02225 4252 > Beach Shaping					0.01	0.22	0.33	0.00	0.00	0.55	
	430000	CY	XXQND	200.00	3,784	118,888	176,992	0	0	295,879	0.69
TOTAL Second Year	430000	CY			3,784	118,888	176,992	0	0	295,879	0.69
TOTAL Site Work	1800000	CY			15,840	497,669	740,895	0	0	1,238,564	0.69
TOTAL Beach Fill	1800000	CY			15,840	497,669	740,895	0	0	1,238,564	0.69
TOTAL Beach Replenishment	1.00	EA			15,840	497,669	740,895	0	9,276,932	10,515,496	10515496.13

CC 30. Planning, Engineering and Design	QUANTY UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
CC 30. Planning, Engineering and Design										
USR < > Total PED				0.00	525000.00	0.00	0.00	0.00	525000.00	
	1.00 EA		0.00	0	525,000	0	0	0	525,000	525000.00
USR < > Monitoring after construction.				0.00	1352500	0.00	0.00	0.00	1352500.00	
Work to cover a five year period.	1.00 EA		0.00	0	1,352,500	0	0	0	1,352,500	1352500.00
TOTAL Planning, Engineering and Design	1.00 EA			0	1,877,500	0	0	0	1,877,500	1877500.00

CC 31. Construction Management	QUANTY	UOM	CREW ID	OUTPUT	MANHRS	LABOR	EQUIPMNT	MATERIAL	OTHER	TOTAL COST	UNIT COST
CC 31. Construction Management											
USR < > Construction Management					0.00	1800000	0.00	0.00	0.00	1800000.00	
	1.00	EA		0.00	0	1,800,000	0	0	0	1,800,000	1800000.00
TOTAL Construction Management	1.00	EA			0	1,800,000	0	0	0	1,800,000	1800000.00
TOTAL Recommended Plan	1.00	EA			15,840	4,398,669	740,895	0	9,291,932	14,431,496	14431496.13
TOTAL Assateague Island Restoration	1.00	EA			17,046	4,425,999	769,129	0	9,291,932	14,487,060	14487059.76

SRC	ITEM ID		DESCRIPTION	NO.	UOM	RATE	**** LABOR **** HOURS	COST	**** EQUIP **** HOURS	COST	TOTAL COST
	USURC		4 FC-suryr + 4x4 Suburban + Small Tools			PROD = 100%			CREW HOURS =		168
FOP	FC-SURYC	L	Surveyors, Chief	1.00	HR	14.82	1.00	14.82			14.82
FOP	FC-SURYR	L	Surveyors	3.00	HR	11.85	3.00	35.55			35.55
MIL	XMIXX020	E	Small Tools	1.50	HR	1.57			1.50	2.36	2.36
MIL	T50GM005	E	TRK,HWY, 8,600GVW,4X4, SUBURBAN	0.67	HR	8.71			0.67	5.84	5.84
MIL	T50GM005	U	TRK,HWY, 8,600GVW,4X4, SUBURBAN	0.33	HR	1.89			0.33	0.62	0.62
	TOTAL						4.00	50.37	2.50	8.81	59.18
	* UTDHA2		1 Tractor & Lowbed Trailer			PROD = 100%			CREW HOURS =		16
MIL	B-TRKDVRHV	L	Truck Drivers, Heavy	1.00	HR	20.58	1.00	20.58			20.58
MIL	T45XX019	E	TRLR,LOWBOY, 75T, 3 AXLE(ADD TR	1.00	HR	9.60			1.00	9.60	9.60
MIL	T50KE004	E	TRK,HWY, 50,000 GVW, 6X4, 3 AXL	1.00	HR	31.70			1.00	31.70	31.70
	TOTAL						1.00	20.58	2.00	41.29	61.87
	XXQND		1 X-eqoprhvy + 1 Dozer, Cat D-7H, 215 Hp			PROD = 100%			CREW HOURS =		9296
MIL	T10CA013	E	BLADE, UNIVERSAL, HYDR (FOR D7	1.00	HR	6.08			1.00	6.08	6.08
MIL	T15CA013	E	DOZER,CWLR, D-7H,PS (ADD BLADE	1.00	HR	59.97			1.00	59.97	59.97
MIL	X-LABORER	L	Outside Laborers, (Semi-Skilled	0.50	HR	20.36	0.50	10.18			10.18
MIL	X-EQOPRMED	L	Outside Equip. Operators, Mediu	1.00	HR	27.25	1.00	27.25			27.25
MIL	X-EQOPRMED	F	Outside Equip. Operators, Mediu	0.25	HR	27.75	0.25	6.94			6.94
	TOTAL						1.75	44.37	2.00	66.04	110.41

SRC	LABOR ID	DESCRIPTION	BASE	OVERTM	TXS/INS	FRNG	TRVL	RATE	UOM	UPDATE	**** TOTAL **** DEFAULT	HOURS
MIL	B-TRKDVRHV	Truck Drivers, Heavy	20.58	0.0%	0.0%	0.00	0.00	20.58	HR	07/20/95	20.58	16
FOP	FC-SURYC	Surveyors, Chief	14.82	0.0%	0.0%	0.00	0.00	14.82	HR	07/20/25	14.82	168
FOP	FC-SURYR	Surveyors	11.85	0.0%	0.0%	0.00	0.00	11.85	HR	07/20/95	11.85	504
MIL	X-EQOPRMED	Outside Equip. Operators, Medium	27.25	0.0%	0.0%	0.00	0.00	27.25	HR	07/20/95	27.25	11620
MIL	X-LABORER	Outside Laborers, (Semi-Skilled)	20.36	0.0%	0.0%	0.00	0.00	20.36	HR	07/20/95	20.36	4648

SRC	ID.NO.	EQUIPMENT DESCRIPTION	DEPR	FCCM	FUEL	FOG	TR WR	TR REP	EQ REP	TOTAL RATE		** TOTAL ** HOURS
UPB	T10CA013	BLADE, UNIVERSAL, HYDR, D-7	2.58	0.92		0.08			2.50	6.08	HR	9296
UPB	T15CA013	DOZER,CWLR, D-7H,PS	17.36	6.83	6.54	2.28			26.95	59.97	HR	9312
UPB	T45XX019	TRLR,LOWBOY, 75T, 3 AXLE	3.41	1.71		0.50	1.32	0.19	2.47	9.60	HR	16
UPB	T50GM005	TRK,HWY, 8,600GVW,4X4, SUBURBAN	2.39	0.70	2.51	0.68	0.23	0.03	2.17	8.71	HR	168
UPB	T50KE004	TRK,HWY, 50,000 GVW, 6X4, 3 AXLE	10.03	2.97	8.08	2.19	0.44	0.06	7.92	31.70	HR	16
UPB	XMIXX020	SMALL TOOLS	0.50	0.22	0.16	0.07			0.63	1.57	HR	252